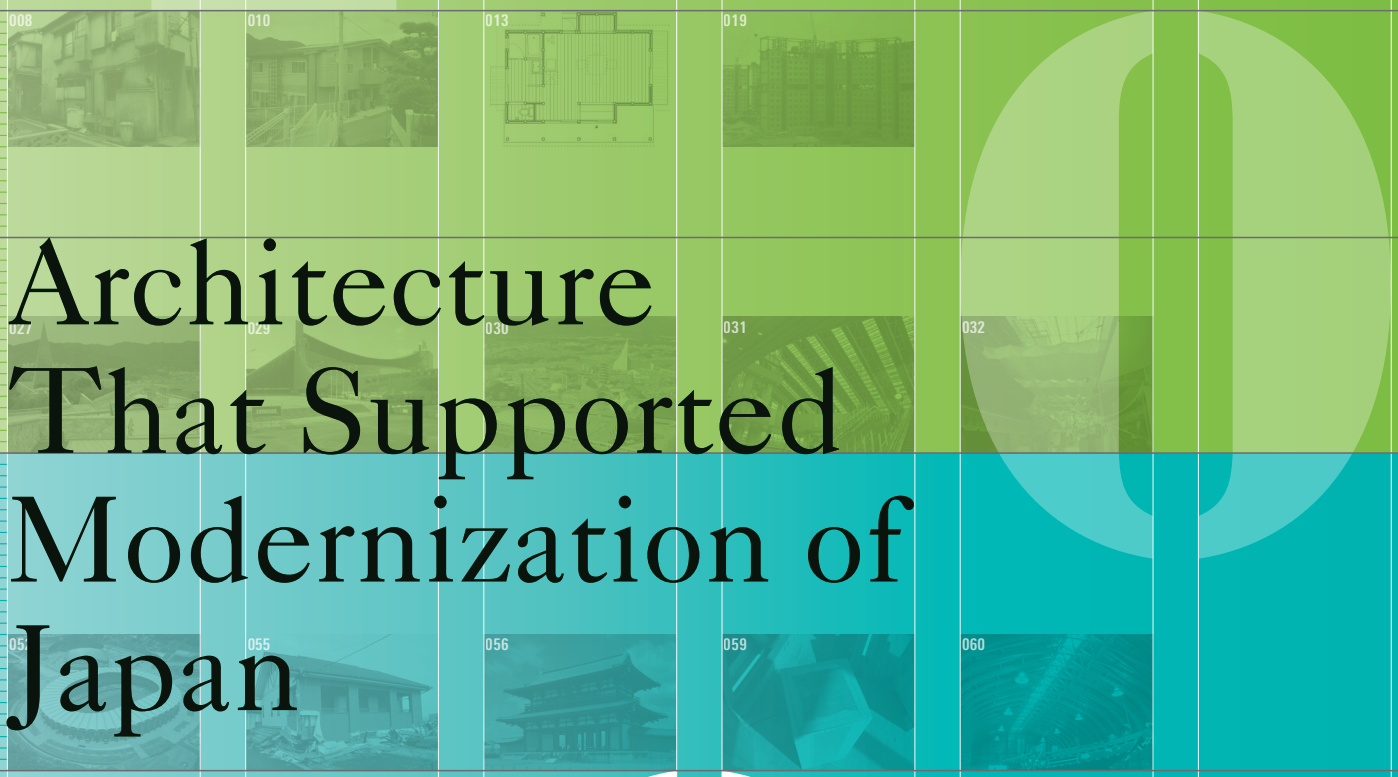
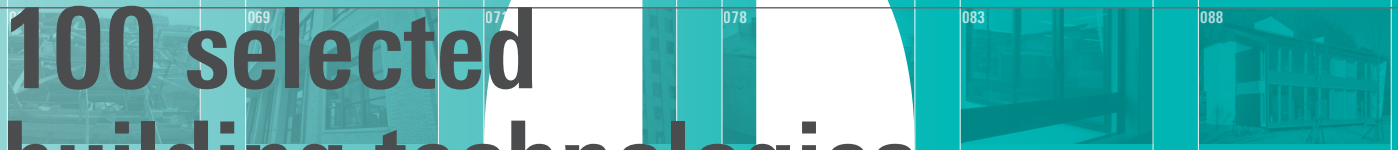
100th Anniversary of Enactment of City Planning Act and Building Standard Law



Architecture That Supported Modernization of Japan

100 selected building technologies

An English Summary



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Preface

FUKAO Seiichi　Chairperson

2019 marks the 100th year since the enactment of the Urban Building Law, the predecessor of the Building Standard Law, and of the City Planning Act.

The Urban Building Law is considered to be the first established building legislation in Japan, which proceeded the current Building Standard Law after several amendments.

During this period, we have experienced drastic changes occurred in the political and economic sectors and in society as a whole. Accordingly, cities and architectures also changed, which were supported by the innovation of building technologies. All of these changes eventually brought about a remarkable reform in our lifestyles.

To shed light on the advancement of building technologies that have supported modern and current Japan and provided a basis for these changes, we asked not only architects, but many experts of various disciplines, such as sociology, economics, history, urban planning and journalism, as well, to identify "100 Key Terms" related to Japanese architecture and building technologies. The selected "100 Key Terms" were classified into five categories: "Housing, "Buildings, "Structural Methods", Building Production/Facilities" and "Policy/Regional Planning". We then asked 91 experts who specialize in these areas to write about the "100 Key Terms" from the viewpoint of a history of the technological progress of construction, newly developed building spaces that resulted from technological progress, and their influences on our lives and on society in general.

"Architecture that Supported the Modernization of Japan – 100 selected building technologies" is a book that was compiled as a publication to commemorate the 100th Anniversary of the enactment of the City Planning Act and the Building Standard Law.

This English translation of the original Japanese summary of the booklet was made so that people in other countries might appreciate the accomplishments mentioned within it.

We will be pleased if the "100 Key Terms" gives you a good overall picture of the Japanese architecture and building technologies that have been developed over the last 100 years, along with their uniqueness. We hope that the wisdom and ingenuity of the people who created these things becomes evident to all of the readers.

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(as of end/March 2019)

Overview:

Modern and Contemporary Japan Supported by Architecture

For this booklet, 100 key technical terms were selected in order to holistically review the progress of Japanese architecture and building technologies over the last 100 years. Each selected technology was developed and introduced to materialize buildings required of the respective time. There have been many cases, on the other hand, when structures built with new technologies had a significant impact on society, which eventually brought about important social changes.

We have roughly classified the 100 technologies into four periods over the last 100 years, in order to reflect the historical changes of technologies. This was done with a view to clarifying what society expected from architecture and buildings in each of those periods, and what these building technologies provided for society. Please note that this classification of technologies is not limited to the four periods, as some of the technologies have been in use for a long time.

Part 1
1868–1935

Establishment of Modern Japan and Building Technologies

Beginning in the modern Japan, Japan proceeded to establish a modern nation, under the slogan of "Enrich the Country, Strengthen the Army", following the development of the U.S. and European nations as models. This also meant to establish cities which were not in the least inferior to those in the Western nations.

Modernization of urban areas, as seen in the fields other than urban development, began with advanced technologies that were adopted by Japan through the efforts of a number of foreign professionals employed by the Japanese government, and of Japanese students sent to Western countries to study. After the 1900s, Japan gradually modified these imported technologies to make them more suitable for Japanese culture, and situations unique to Japan, and eventually developed its own technologies and applied them to practical applications.

In this period, many government buildings and cultural facilities were built using these modern building technologies as symbols of the modernization of urban cities.

In accordance with industrial development, business activity increased dramatically, and many financial and commercial systems were developed, which required construction of modern buildings in urban areas as centers of business activities. To respond to the need for such buildings, innovative technologies became indispensable, such as reinforced concrete structures, steel structures, elevators, and technologies related to electric equipment, lighting appliances and so on.

Also, an increasing number of people started working for newly established companies in urban areas, who, together with military officers and government officials, formed a new social stratum. For these people, a new style of housing was provided in areas such as residential suburbs, which were equipped with newly developed facilities, such as modern kitchens and flush toilets.

The economic growth of the period enriched people's lives, which led to increased consumption and more opportunities for recreational activities. Commercial and entertainment centers were developed to satisfy people's needs and new types of buildings, such as a station building with a shopping center, were constructed.

Prevention of infectious diseases was one of the most serious issues that was addressed by urban policies in Western nations, and so it was in Japan, which led to the introduction of modern medicine. For buildings, the importance of a good hygienic environment was recognized, which facilitated the improvement of toilets and provided rat-proof measures to prevent the plague. These efforts, along with improved medical services, people's awareness of sanitation and better nutrition, resulted in the successful reduction of the number of deaths due to cholera, dysentery and the plague, which had been prevalent in Japan until the beginning of the 20th century. [**Fig. 1**]

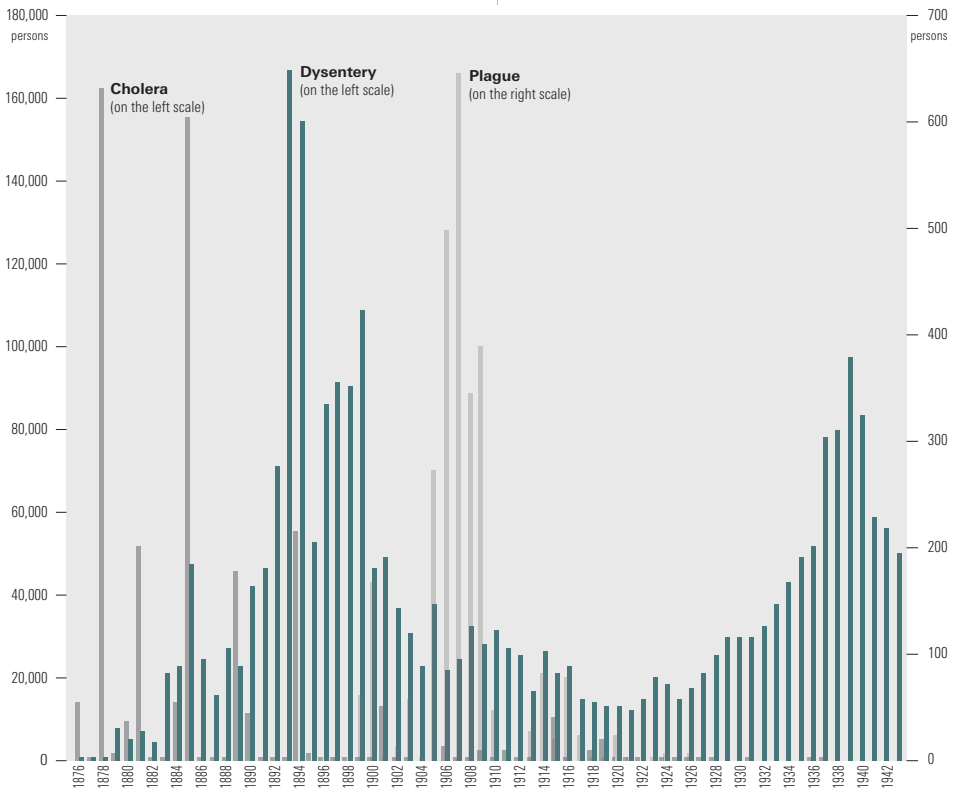

Fig. 1—Change in Number of Deaths by Infectious Disease
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Many lives were lost before the middle of 20th century in Japan by infectious disease, which were rampant due to poor health standards and poor hygiene.
[Source: Infectious Disease Statistics, compiled by the Ministry of Health, Labor and Welfare]

The Great Kanto Earthquake occurred in 1923; the first large disaster to hit Japan after modernization. This had a huge effect on building technology. Since the beginning of the modernization, Japan introduced Western style building techniques, mainly the brick-structure method, which, however, did not secure sufficient strength against large earthquakes. Since then, many other structural methods have been adopted, such as a reinforced concrete structure, a steel structure and a steel-encased reinforced concrete structure, together with seismic design technology. The effectiveness of seismic designs against earthquakes was proved through the experience of the Great Kanto Earthquake, and in 1924, seismic design provisios were incorporated in the Japanese building standards for the first time, which were called the Enforcement Regulation of Urban Building Law. This provision can be said to be a significant result of the development of modern building technologies that had been accumulated in Japan since its modernization, which was praised as the world's leading building regulation at the time.

After the Great Kanto Earthquake, the most seriously damaged building structure was a post-and-beam wooden structure. The number of completely collapsed buildings was 130,000. From this experience, installation of diagonal braces was found to be effective in enhancing structural strength against earthquakes. This was stipulated in the building standards and is now used in all wooden housing.

Historically, urban areas of Japan, where most of the buildings are of wooden structure, have suffered a number of conflagrations. In the Great Kanto Earthquake, as one example, most of the deaths were due to large fires. In view of this fact, lath-mortar construction, which was a fireproof technique for wooden housing, became the prevailing method for the fireproofing of wooden housing.

Additionally, "*Dojun-kai*", a public housing corporation that was established for the rebuilding of housing after the Great Kanto Earthquake, played a large role in the construction of multi-unit residential buildings, which were well received by the masses.

Part 2
1935–1955

The War - Slumped Period of Building Technology

The prolonged Sino-Japanese War, followed later on by the Pacific War, had a huge influence on building technology in Japan. Supply of all materials was strictly controlled by government, as they were needed to produce military supplies, which severely constrained the development of building technologies. Thus, provision of housing for the labor force became a problem, such as for coal miners. This issue continued after the Wold War II, when a priority production system went into effect.

The most critical subjects of research and development in this period were an air defense technology and a system to prevent conflagration in urban areas in order to mitigate the damage caused by the war. This research regretfully did not produce effective results during the war but yielded great results after the war in regard to preventing extensive urban fires.

Throughout the country, a number of cities were burned to ashes during the war, which created a housing shortage of 4.2 million units . Moreover, there was a severe shortage of building materials, such as wood, due to an acute demand for rebuilding on the destroyed property, including industrial facilities. This period may be considered to be the most difficult time for building technology in Japan. Under such circumstances, efforts were made to overcome this difficulty by developing building techniques such as designs for minimal houses and alternative building materials including bamboo-reinforced concrete.

Part 3
1955–1990

Building Technologies Supporting Economic Growth and Affluent Living

In 1955, when the first stage of restoration activities was almost completed, the Japanese economy recovered to reach the peak level before the World War II, which occurred in the latter half of the 1930s. An economic white paper that was produced in 1956 noted that, "It is not the post-war period anymore". The Japanese economy entered a full-fledged growth period, which brought about great changes in society. In the building sector, engineers were faced with the challenge of innovation in building technology.

Economic growth brought about a vast demand for building construction, which was intended to create new concepts of space and of town planning. To satisfy the demand with limited time, labor and material resources, a variety of technologies were developed to rationalize building production and construction processes.

Large Supply of New Style Housing

Immediately after the war, the Japanese population was less than 80 million, but rapidly increased to 90 million, by 1956, and in 1967, it reached 100 million. Accordingly, population concentrations from local areas to large cities had become conspicuous, in line with economic growth. [**Fig. 2, 3**] Thus, new technologies were required in order to supply housing to those new urban inhabitants. To address this issue, a new housing policy was formulated that encouraged land development for large-scale residential projects and development of building technologies for housing under the initiative of the public sector. This was led by the public sector; Japan Housing Corporation (currently, Urban Renaissance Agency) and Publicly Operated Housing Corporations in each region. The private sector also was quite active, and the housing industry established new housing-supply systems in the form of condominiums and multi-units housing for rent, in addition to the conventional detached-housing supply.

After the World War II, Japan experienced significant conceptual reformation concerning "family". One was the nuclear-family trend, and the other was the spread of post-war democracy, which emphasized the importance of the individual and one's independence. Accordingly, in the housing sector, new designs were introduced for public housing, based on the idea of "separation of the dining room from rooms for sleeping" and "separation of bedrooms for parerents and for children". This basic idea has continued to have a great influence on Japanese housing to this day.

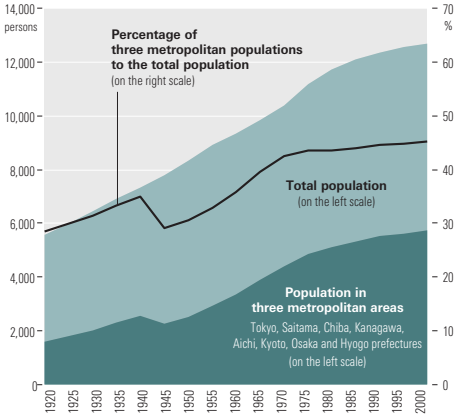

Fig. 2–Change in Total Population and Three Metropolitan Populations with Ratio
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The Japanese population increased by 2.3 times in 80 years. In the three metropolitan areas, it increased by 3.6 times, which made the supply of housing a big social issue.
[Source: National Census, compiled by the Ministry of Internal Affairs and Communications]

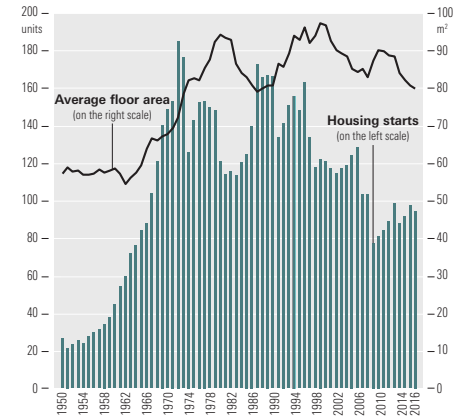

Fig. 3–Change in Housing Starts and Floor Area of Housing Unit
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Housing starts surged from the latter half of the 1960s, and the average housing floor area reached 80m².
[Source: Housing Starts Statistics, compiled by the Ministry of Land, Infrastructure, Transport and Tourism]

Economic Growth and Demand for Offices

During the period of rapid economic growth, expansion of tertiary industries was remarkable, especially in large cities, where the number of office employees was increasing drastically. Numerous office buildings were constructed, which led to the development of skyscrapers.

In line with the advanced IT technologies that emerged later, a new type of office building, referred to as "an intelligent building", was developed. The latest IT technologies were adopted for the building functions.

Improvement of Living Standard along with Expanded Consumption

As income levels rose, the demand for more comfortable and a convenient lifestyle grew, which included modern housing facilities, such as Western-style toilets and gas water heaters, as well as modern housing that could accommodate such amenities.

The prolonged housing shortage abated in 1973, when the total number of existing housing units exceeded the number of households, which meant that Japan was at the turning point "from quantity to quality" of housing. In that period, people's requirements for housing became diversified, with new needs created in accordance with social change. New systems of housing supply and residence types were introduced, such as a "*Cooperative House*" (building co-operatives).

As incomes increased, so did consumption, which facilitated construction of commercial and recreational buildings in various forms, such as shopping malls and theme parks. New styles of urban space were created under urban redevelopment projects, which incorporated mixed-use buildings of offices and residences, and spacious public areas.

Furthermore, an innovative technology that allows for large roofs that were unsupported by interior columns was developed and put to practical use, which resulted in construction of large-scale domes, arenas and exposition facilities to be used for large events.

Buildings as Symbols of Hope

Before the World War II, newly constructed modern buildings were regarded as symbols of the progress and prosperity of Japan, as well as the dreams of its people. They were dignified government buildings, magnificent office buildings, splendid department stores and theaters, which formed a spectacular urban scape in the city center.

After the war, however, while values of the Japanese society drastically changed to the equality principle in society, open-design modern architecture that eliminated decorative designs became the dominant style for government and office buildings. On the other hand, buildings used for national events, such as Olympic games and World Expositions, were built with the contemporary design that represented the era of each event. At that time, peace memorial facilities and towers were also built as monuments of memories and hopes that are widely shared by people.

Japan, which had achieved an unprecedented economic growth rate, also pursued advancement in architectural design. Modern Japanese architecture started with learning about, and then introducing, Western style architecture. After that, it went through a unique development process, and a number of structures have been built that are highly evaluated around the world for their design.

Building Technology Contributing to Economic Growth (Growing Investment for Buildings and Building Technologies)

In line with economic growth, investment in building construction increased sharply. In 1960, the area of building construction starts totaled 66 million square meters, which increased to 267 million square meters in 1973, four times what it was in 1960. Investment in tertiary industries, i.e., commercial and service industries, as well as the housing industry, showed outstanding increases. [**Fig. 4**]

As investment in buildings played an important part in the national economy, more efficient, faster and safer building construction was required, and thus the development of new technologies was strongly required to rationalize construction processes. At the same time, safety measures for construction workers also made considerable progress. As a result of these technical advances, the increase in construction laborers (for both building and civil engineering) was only about 1.5 times during this period, in spite of the remarkable growth of construction projects.

Under these circumstances, a shortage of skilled workers became a serious problem, especially in the housing sector, such as carpenters who had long supported the Japanese wooden-housing industry with their superb techniques for constructing traditional wooden structures. Therefore, more efficient housing supply mechanisms and technologies were required, together with the urgent need for a large supply of housing as previously mentioned. This was achieved by transferring some of the conventional on-site building works to in-factory production processes, where the prefabricated house system and the two-by-four housing system were adopted. This, at the same time, evolved into the establishment of a housing industry that became one of the modern Japanese industries, which developed innovative building systems, including factories for large-scale housing components. This movement further evolved into a new phase of technological progress.

Besides building up a large number of housing, securing the quality of housing became an urgent matter. For this issue, the specifications of housing published by the then Government Housing Loan Corporation played a great role. On the other hand, however, a significant number of defective houses were found at that time, which became a serious social problem. To cope with this issue, new housing-policy measures were formulated from the viewpoint of consumer protection, one of which was the Housing Performance Indication System.

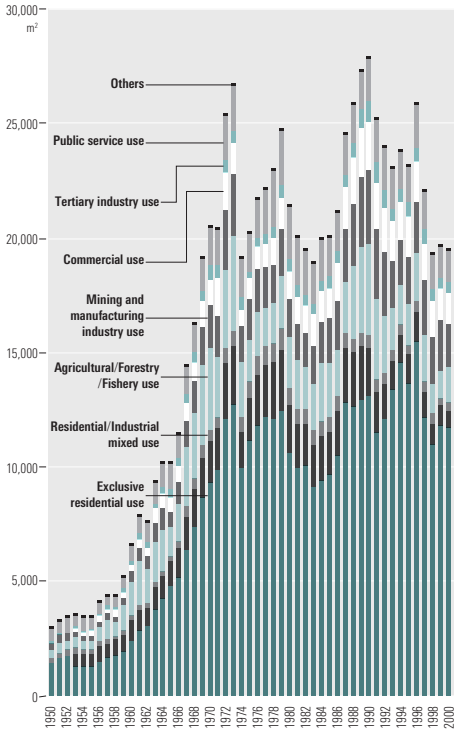

Fig. 4–Change in Total Area of Building Starts (classified according to use)

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In accordance with economic growth, the investment for buildings increased rapidly, especially for those of residential use, commercial use and the tertiary industry use.

[Source: Building Starts Statistics, compiled by the Ministry of Land, Infrastructure, Transport and Tourism]

Building Technologies to Cope with Frequent Natural Disasters

While the national economy showed incredible growth, a great number of congested quarters of wooden housing that were built before the World War II and in the post-war period still re-

mained in many cities. Until 1960s, fires often occurred in these areas, creating large urban conflagrations, These disasters gradually decreased as rebuilding of old wooden buildings were undertaken, to which new fireproof technologies were applied. Since the 1970s, the number of large fires has significantly decreased due to the improvement of firefighting capabilities. However, the risk of extensive fires occurring in urban areas still remains, especially in the event of large earthquakes. Thus, the issue of the congested urban areas of wooden buildings still exists as a challenging issue.

The "Shirokiya Department Store Fire", in 1932, was the incentive for the formulation of fire prevention measures for large-scale buildings, and all others that are open to the public. After that, openining fireprotective assembly was greatly improved, based on the experience of many fires and the knowledge gained as a result of them. Remarkable progress was seen in the research of fire safety of modern buildings, which allowed for the construction of new building-design methods that helped prevent the spread of fire, and for evacuation during fires. These technical developments eventually led to the introduction of the performance-based building regulations/standards and further progress in building technology.

Japan has been hit by a number of catastrophic earthquakes since the Great Kanto Earthquake. Every time a large quake occurs, considerable research is done regarding damage to buildings. Based on the improvement of structural techniques, the building standards were revised. Furthermore, great advancements have been made in seismic design technology, and the use of computers for structural design became common. All of this technical progress enabled the construction of skyscrapers and buildings with large spaces without support columns, both of which had previously been "the buildings of dreams". The result of the progress that the building standard reached became the New Seismic Standard.

More recently, innovative technologies such as a seismic isolation system and a response control system were introduced, with the aim of establishing more advanced safety measures. As seismic technology improves, it has become a challenge to secure the safety of existing buildings that were constructed according to the previous standard, which led to the development and diffusion of seismic retrofit building technologies.

Part 4
1990–

Growth to Maturity: Building Technology Supporting the Future

After the period of high economic growth, Japan experienced a bubble economy, followed by its collapse, which caused drastic changes in society and to people's sense of values. While the rapidly aging population and the global environment have become challenging social issues, the building sector was expected to support the coming society by development of new technologies.

Evolution to Diversified Society and Revitalization of Regional Resources

It has been necessary to create spaces where everybody, including the aged and persons with disabilities, can lead active lives. This requires housing for the elderly and building technologies such as barrier-free and universal designs.

Regional characteristics should also be an important factor. During the period of high economic growth, it was encouraged to develop every region in a uniform manner, in order to remain impartial. Recently, however, unique regional characteristics that were formed as a result of the local climate and history have caught on with many people. Accordingly, new building techniques are currently being explored to support, for example, the renovation and reuse of existing cultural resources, such as traditional buildings and streetscapes.

Transformation to Sustainable and Stock-based Society

In the high economic growth period, abundant resources were allotted for the construction of numerous buildings. This, at the same time, entailed demolishing the buildings that they replaced, thus creating a vast amount of waste. As social awareness of the global environment grew, however, the building sector was required to make efforts to realize a sustainable society through technological progress.

It was during the oil crisis in 1973 when measures of promoting techniques for proper insulation and building energy saving were implemented as resource conservation measures in the building sector. Since then, building technology has made steady progress, and now, more

advanced innovation is expected, such as development of sustainable buildings. Furthermore, recent research has proved that improvement of the indoor thermal environment greatly contributes to the promotion of people's health. When looking back on the history of Japan, it is not difficult to imagine that the remarkable advancement of indoor climate of housing that was made in post-war Japan has contributed to the longevity of the Japanese people today. The improved indoor environment is now anticipated to help reduce the cost to the government for national health care. As such, the roles and responsibilities expected of building technology have become further diversified in society.

However, the introduction of new building technologies has brought about some health hazards, such as asbestos health damage and the sick-building syndrome, for which proper technical measures were taken for these problems.

Annual industrial waste in Japan totals about 400 million tons, of which 80 million tons (20% of the total) is from the construction industry, with one-third of that being related to buildings. As effective use of resources and a reduction of waste have been serious issues in all sectors, including the domestic and industrial areas, it is required to improve technologies for the re-use and recycling of goods. In the building sector as well, technologies for building renovation and conversion are expected to be further improved, in order to continue using the stock of buildings that has accumulated over the years.

One of the most notable building materials that is expected to contribute to the creation of a sustainable society is wood. In post-war Japan, the use of wood was highly restricted, due to the devastation of forests, for which restoration has recently been completed. Currently, the use of wood is rather encouraged, as it is a recyclable material. Innovative technologies to compensate for the disadvantages of wooden structures have been developed, such as fire-resistivet wooden buildings and large-scale timber buildings. Along with these technologies, new structural evaluation methods have also been formulated, such as structural analysis for traditional wooden buildings, which are expected to further expand the potential of the usage of wood. It is expected to continue the efforts to make further progress in the field of wooden construction.

Although a variety of new technologies were introduced for housing construction during the mass-production era, 40% of newly built housing and 70% of total detached houses have been built with the conventional Japanese post-and-beam structure. About half of them were built by local contractors and carpenters as custom-built detached houses. Historically, conventional post-and-beam building techniques have contributed greatly to the remarkable progress of the building sector, as well as to the socio-economic development of Japan. These days, however, a serious problem has emerged in the wooden housing sector, which is the reduction in the number of skilled workers and the rapid aging of those currently in the field.

Contribution to International Society

The various building technologies introduced in this booklet were developed in response to the social needs of each time, which have supported the social progress of the modern/contemporary era of Japan. Some of them were developed in other countries and modified in Japan to suit the situations here, and some were invented in Japan and developed here.

Making use of these accumulated building technologies, Japan has continued to disseminate building information overseas to maintain communication with the global society. Japan also has provided technical assistance to a number of developing nations around the world.

In the field of seismic engineering, Japan's cooperation with the US and other nations has generated considerable mutual benefits to all parties. A Japanese technology for earthquake preparedness, which is the world leader of such technology, has made a notable contribution to safety in other countries.

Japan has also made great efforts to facilitate the formation of international measures toward the global environment issue by, for example, organizing Sustainable Building 2005 (SB05). These efforts are ongoing, by means of the provision of information and technical assistance to various countries around the world.

It is expected that Japan will further contribute to the world community based on experience accumulated in the field of building technology in Japan.

As described above, Japanese buildings and building technology have made progress in line with the development of Japanese society over the last 100 years. The progress of building technology has made great contributions to various aspects of society, such as the improvement of housing, which is fundamental to people's lives, the creation of spaces for various social activities, better safety and security in the event of disasters, the enhancement of the level of culture, along with improving people's sense of value. Additionally, the rationalization of the building production system has played an important role in the growth of the economy. Still now, efforts are being made to realize a sustainable and mature society. The progress of building technology will continue to support society by responding to the issues and requirements of each era.

Chapter

I HOUSING

Industrial Development and Population Concentration in Urban Areas

After the Meiji Restoration, Japan achieved a remarkable level of industrial modernization through the First Sino-Japanese War and then the Russo-Japanese War, which brought about dramatic growth of urban populations. For those who migrated to urban areas, apartments first became available as high-end, multi-unit residential buildings in the early 20th century. In the new industrial cities and the surroundings of large factories in rural areas, high-density apartment complexes were constructed for the workers, which was best represented by coal miners' housing [003]. Around the same time, renovations of slums and substandard houses were undertaken in urban areas as a government measure to improve deteriorated urban environments. During this period, railway companies developed residential areas outside of inner cities, which are called residential suburbs [001], modeled after developments in Western countries. After the Great Kanto Earthquake, an association named "Dojun-kai" was established as a national restoration program. They constructed *Dojun-kai apartments* [002], which were designed with ingenious layout plans, and were equipped with modern facilities and common spaces. The *Dojun-kai* was also engaged in housing supply, with the objective of improving the quality of housing in Japan.

Post-War Housing Shortage and Standardization/Industrialization

One of the most serious social issues in Japan after the World War II was a shortage of housing units, which totaled about 4.2 million units. In order to provide an enormous number of housing units with limited materials and human resources within a short period, standardization and industrialization of housing production and supply were vigorously promoted. A new housing policy was established, which was called "three pillars of the post-war housing policy", i.e., the Government Housing Loan Corporation (GHLC), Publicly Operated Housing Corporations and Japan Housing Corporation (JHC). The latter two mainly supplied multi-unit residential buildings, namely, publicly operated housing and JHC housing [004], for which standardized designs and housing components were utilized, as well as industrialized building techniques and materials, such as a pre-cast concrete. Large developments of JHC apartment complexes were widely referred to as *Danchi* [005], and an extensive number of new towns [006] were planned and constructed in the suburbs of metropolitan areas. Most of the publicly operated and JHC housings were initially multi-units for rent, however, beginning in the 1950s, supply of condominiums [007] began in urban areas, along with those supplied by the private sector, which is currently the predominant type of housing in Japan. In 1962, the Act of Unit Ownership of Condominiums was enacted, which legally established the rights of unit owners of condominiums.

The other pillar of the post-war housing policy was the establishment of the GHLC, whose function was to provide housing loans, mainly for construction of conventional post-and-beam wooden houses. It also contributed to the improvement of housing quality through the GHLC Specification [014], which was used as the technical criteria required to qualify for housing loans. The industrialization of detached houses was first attempted shortly after the end of the war, when some architects designed prefabricated housing [018], which had consequently led to the construction of minimal houses [013], with an aim to pursue modern living spaces, in spite of the limited availability of resources. In this period, many non-housing related industries, such as munitions manufacturers, entered the housing industry with the intention of a peaceful output of their industries. In the 1960s, the prototypes of large prefabricated housing manufacturers appeared in the industry, which thrives today. The government also facilitated the industrialization of housing production by utilizing the GHLC loan system, which was further promoted in the 1970s by some pilot projects [019], such as a design competition for the Ashiyahama High-rise Residential Project and other pilot housing projects.

On the other hand, the concentration of populations in urban areas that occurred in the era of high economic growth brought about unplanned residential developments, as previously seen before the war, which eventually led to the congested districts of small wooden multi-unit housing operated by private sector [008] in the peripheries of urban areas, that were called "wooden rent-house belt zones". There was an overall trend towards housing standardization, which however did not conform to the conventional existing local houses, in regard to the respective regional characteristics. One of the typical examples of such local-based housing was cold-region housing [015], which was developed in Hokkaido prefecture.

Resolution of Housing Shortage and the Following Trend

In 1968, the total number of existing houses exceeded the number of households in Japan. As the housing shortage problem was statistically resolved, the housing issues shifted drastically from standardization and industrialization to how to address the diverse housing demands of the people. In the 1970s, some attempts at providing "open buildings" were made in order to respond to the needs of residents, which allowed for flexible designs, through the "infill" method, by assembling generally distributed housing components. However, in Japan, the technical aspect of separating interior finishing from structural members was so emphasized that such housing units were established as skeleton-infill house (base building and fit-out for housing) [020], which mainly aims to provide long-life housing. Other attempts to explore new systems of housing supply and new lifestyles attracted people's attention, such as *cooperative house* (building co-operatives) [009]; whose residents, in the initial stage, organize a co-operative that is to be involved in the planning, design and operation of the building, and collective housing [010], which provides some common spaces, such as a dining room, so that the residents can share some time together every day. At the same time, the average household that was established in the post-war period, consisting of a couple with two children, and which had previously been the premise for housing design, now occupies a lower position, both socially and statistically. Currently, therefore, it is required to supply housing to meet the diversified needs of residents, of which one example is housing for the elderly [016].

As for the materials and building systems, while prefabricated housing starts remained at a level of a little more than 10% of the total number of newly built detached houses in around 1980, the majority of existing houses were built by the conventional wooden post-and-beam method, thus the quality and rationalization of conventional wooden houses emerged as an important issue of the housing policy. Under such circumstances, a pre-cut technique [021] developed in the 1970s gradually spread throughout the wooden housing industry. It encouraged rationalization techniques for conventional post-and-beam houses, such as factory-fabrication of structural members. With regard to multi-unit residential buildings, construction of skyscraper condominiums [011] started around 1990, which was technically supported by the development of high-strength concrete. Their construction was accelerated by the trend of people returning to city centers, as well as amendment of the regulation to allow the construction. Regardless of detached or multi-unit housing, people's awareness of housing quality has continued to be heightened, due to successive earthquake disasters, the problem of defective housing, the oil crisis, and the energy saving consciousness that followed. In response to the demand of the people, the Housing Performance Indication System [017] was put enacted in the year 2000. After experiencing recent natural disasters, including the Great East Japan Earthquake, it is urgently required to review production system of emergency temporary-housing and restoration housing [012] to allow for flexibility, in order to suit the actual situation of each affected area, such as aging and declining population.

001 Residential Suburbs

Adoption of Howard's "Garden City" idea and the Japanization of it

The "garden city" concept proposed by Ebenezer Howard 120 years ago was introduced to Japan at the end of the Meiji era. It has been materialized as residential suburbs ever since the 10's of the Taisho era. The business model of the Japanized "garden city" was to develop residential suburbs in conjunction with railroad construction, in order to generate revenue from train fares in addition to that from the housing project, which would be used to cover the enormous initial investment of the residential developments. By providing new styles of daily life facilities and adding new functions to the area, such as inviting educational institutions to locate there, these residential suburbs were then developed under the names of "healthy city", "cultural city" and "college city". In some of these suburbs, the landowners jointly implemented extensive land-adjustment projects, which still exist as high-end residential suburbs.

002 *Dojun-kai* Apartments

A multi-dwelling building complex as a town, created as part of earthquake recovery effort

Dojun-kai, an incorporated foundation established by the Japanese government for the reconstruction of houses that were destroyed by the Great Kanto Earthquake, built multi-dwelling buildings of reinforced-concrete (RC) structures in various places in Tokyo, which were called *Dojun-kai* apartments.
Dojun-kai apartments were designed to harmonize with the surrounding environment, and thus create scenic street landscapes so that they would be favorably accepted by the masses.
Dojun-kai provided various types of units to accommodate multiple types of households including single-family dwellings and were provided with community spaces for the residents. Around the *Dojun-kai* apartments, facilities, such as restaurants, public bathhouses, barber shops, clinics, and houses with small shops, were provided to support the residents, which would allow for the area to function as a town.

003 Coal Miners' Housing

Housing complexes built by companies as a part of production plan

Housing for coal miners was constructed in direct connection with coal production. It was a part of the necessary facilities for coal production from the viewpoint of the employers. Along with housing, various other living facilities were provided in large-scale collieries, which made them nearly self-sufficient towns like colonies. During the World War II, these collieries were actively constructed as one of the national programs, which then contributed to the economic recovery after the war. Shortly after, however, their economic role ended with the revolutionary change of energy resources. It may be said that coal miners' housing was a sort of flow-type housing, which continually wavered as the fortunes of the coal mining industry fluctuated.

004 Publicly Operated Housing and Japan Housing Corporation (JHC) Housing

A standard design, which contributed to the modernization of lifestyles

Publicly operated housing and JHC housing contributed to the rationalization and modernization of people's lives through the development of a standard housing-design. This design also served as a showcase for housing development in the private sector. As a result of a survey of people's lifestyles, the basic requirements for housing units were identified as "separation of the dining room from rooms for sleeping" and "separate bedrooms for parents and children". Based on these people's wishes, a standard design for publicly operated housing, called the "51C Type", was established in 1951. This became a prototype of a floor plan called a "2DK" (two rooms combined with a dining room & kitchen). Depending on the floor plan, a notational system, which included "nK" and "nDK", was used for housing supplied by JHC that was established in 1955. As the standard housing design became widespread, standardization of housing design came to be seen as restriction in the 1970s. Since then, flexible housing-systems have been developed to meet the diversified needs of people.

005 *Danchi*

The fruit of architectural planning study that supported the living standard of post-war period

After the World War II, one of the serious issues in the building sector was the provision of housing. There were numerous families who urgently needed housing, due to the destruction from the war as well as the post-war baby-boom. To cope with this issue, the Japan Housing Corporation (JHC) was established in 1955, which then constructed a number of *Danchi*. ("*Danchi*" is a large-scale housing complex consisting of multi-unit residential buildings, which were mainly supplied by the public sector in Japan.) For the purposes of fire-resistant housing construction, hygiene and the diffusion of a modern urban lifestyle, *danchi* were initially built of RC structures, with a floor plan that provided a dining room and bedrooms separately. These units were equipped with a stainless-steel sink and a western-style toilet. This was done in an attempt to create a desirable housing style in the future through the cooperation of industry, academia and government agencies.

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006
New Towns

Integrally planned and constructed large-scale residential cities

In post-war Japan, housing construction and urban development were urgently required to cope with the loss of housing during the war and also to deal with the rapid expansion of urban areas occurred afterwards.
To address these issues, large-scale, planned residential developments were carried out, which were called New Town developments.
After the development of *Senri New Town*, the first of this type of development which was begun in 1960, a number of New Towns were constructed throughout the country, following the Senri model of development. These included self-sufficient emerging urban areas surrounding existing large cities, and also new developments located in rural areas, which were developed aiming at promotion of regional industries.

007
Condominiums

From housing for high income people to that for the masses after booms

Condominiums are supplied and managed under an institution concerning ownership of multi-unit residential buildings. They appeared in Japan in the 1950s and were increasingly constructed after the Act of Unit Ownership of Condominiums went into effect in 1962. There were several booms of condominium construction: the first one in 1963 and 1964, the second one in 1968 and 1969, and the third one in 1972 and 1973. Through these construction booms, condominiums were eventually established as a typical residential building in urban areas. Condominiums in Japan have played an important role in the diffusion and the improvement of mid-high-rise multi-unit residential buildings of RC structure.

008
Multi-Unit Housing Operated by Private Sector

Wooden rental housing to accommodate a rapid migration to urban areas

Just after the war, the rental housing market was sluggish due to the war damage and also the continuing government control of rent. In the 1960s, the private sector became active in the supply of rental housing.
In the same period, population migration from rural to urban areas increased, which pushed up the demand for rental housing in large cities. It was wooden, multi-unit rental housing that satisfied the acute demand.
There were quite a few wooden multi-units rental housing in unfavorable conditions, which had shared toilets, shared kitchens and shared entrances. These housing units were phased out after their peak construction period in 1968.
At that time, the structures of multi-unit rental housing were gradually changed from wooden to non-wooden. However, the average floor area of each unit remained at the same level, about 40m^2.

009
Cooperative House (Building co-operatives)

A system to avoid the stereotyped housing design of multi-unit residential buildings

Cooperative house is a multi-unit housing system by which a union of residents purchases a plot, places orders for a building design and construction, and then arranges for maintenance and management activities to be carried out after occupancy. This type of housing was introduced to Japan in the 1970s, mainly in metropolitan areas. The advantages to the residents of a *cooperative house* are that they can purchase the land and the building at the actual price, eliminating an agent fee, and individuals can design their own units. Shortly after the introduction of *cooperative house*, residents themselves usually undertook the hiring of a contractor. This, however, has gradually changed; nowadays it is common for a private coordinator to find people to buy into *cooperative house* projects. Large-scale *cooperative house*, called "co-op-towns", have been developed by the public sector, such as local housing-supply corporations.

010
Collective Housing

A new style of co-living proposed for swaying family model

Collective housing is a multi-unit building whose residents cooperate on some of their daily life activities in a shared space, while still having some privacy.
This type of housing emphasizes the importance of dining together, and thus has a common dining room and kitchen, in addition to individual ones in each housing unit, which is one of the key characteristics of the spatial design of collective housing.
The pioneer project of collective housing in Japan was one that was supplied as disaster-recovery public housing for the Hanshin-Awaji Great Earthquake.
In 2003, the most advanced collective-housing project to date, called *Kankan Mori*, was opened by the private sector, where residents are sharing the housework, childcare and so forth.

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the Edo era: 1603–1868 / the Meiji era: 1868–1912 / the Taisho era: 1912–1926 / the Showa era: 1926–1989 / the Heisei era: 1989–2019 / the Reiwa era: 2019–

011 Skyscraper Condominiums

Technical development that realized construction of tower condominiums

Until the early 1970s, multi-unit housing that were built on the outskirts of cities, such as *danchi*, were all mid-rise buildings of around five stories.
The era of high-rise condominiums, such as skyscraper condominiums, began in 1974, which was marked by the construction of an 18-story RC condominium called the Shiina-machi Apartment.
Since the late 1980s, construction of skyscraper condominiums was further accelerated and in the 2000s, the scenery of skyscraper condominiums became a familiar part of the urban landscape.
The construction of these skyscrapers was enabled by an accumulation of technical development in various fields, including structural technologies, construction site works, and designs for buildings and interior of housing units.

012 Emergency Temporary Housing and Restoration Housing

From post-war public housing construction to an extensive support for housing

Construction of emergency temporary housing and restoration housing by the public sector have been the core of housing support for people affected by disasters, which was in line with the post-war government housing policy.
Through the experiences of the 1994 Hanshin-Awaji Great Earthquake and the following several large disasters, new, extensive housing development measures have been created, in addition to the conventional procedure of constructing individual buildings. These include a linkage with various other land development projects, an adoption of various systems for ordering construction works and building materials, and a re-use of the existing housing stock.
These attempts may lead to the new housing support system for the future, which will be established based on the mature housing market mechanism and be designed to best suit each regional circumstance.

013 Minimal Houses

Aiming at equal rights for habitancy

After the World War I, the possibility of providing "minimal houses" was studied in Europe as a measure to accommodate the vast number of immigrants who flowed into urban areas.
Most of those European minimal houses were multi-unit residential buildings, but those developed in Japan were detached houses.
To the question "How much affluent living can you provide with a limited floor area and budget?", many architects answered in various ways with their own design capabilities.
However, in the period of high-economic growth, the significance of "minimal houses" was diversified in accordance with changes of social circumstances.

014 GHLC Specification

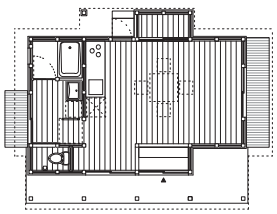
A design and construction manual that enhanced housing quality in post-war Japan

In 1950, the Government Housing Loan Corporation (GHLC) was established for the purpose of solving the severe shortage of housing. In order to provide housing with sufficient quality, the GHLC set technical criteria, which were slightly higher than the level of the Building Standard Law and required the housing to meet those criteria as a condition for approving loans for them. This program was implemented in conjunction with the building permit system.
The GHLC Specification is a manual that describes materials and building methods to be used in order to satisfy criteria so that home builders and craftsmen may properly proceed with building construction.
After a number of amendments, the GHLC Specification still plays an important role in improving the quality of Japanese wooden housing.

015 Cold-Region Housing

Technical development of housing that is suitable for cold regions with heavy snowfall

Historically, Japanese houses were built for summer weather. Thus, they were not suitable for cold climates with heavy snowfall, especially that of Hokkaido. After the World War II, therefore, "cold region housing" was developed for the specific purpose of improving the lives of the people of Hokkaido.
Cold-region housing is the fruits of the cooperative efforts in research and development made by a number of engineers, researchers and administrators in Hokkaido.
These R&D efforts continued after the development of the cold-region housing, which led to the development of the current energy-efficient housing and Housing for Northern Areas. Cold-region housing provided a basis of residences in areas of cold weather with heavy snowfall.



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019

016 Housing for the Elderly

Housing proposed to address the extreme population-aging in Japan

The housing for the elderly that is described in this section refers to a small room of a barrier free design for a single resident or a couple.
These units are, in most cases, in multi-unit buildings, which provide services such as monitoring, emergency treatment, daily life consultation, meals and nursing care.
It was in the latter half of the 1980s when the Japanese government began to take measures to provide adequate housing for the elderly, with the implementation of the Silver Housing Project.
Other government programs for senior housing include nursing homes for the elderly, established under the Act on Social Welfare for the Elderly in 1963, and housing for the elderly with home-care services, which was started in 2011.

017 Housing Performance Indication System

A system for properly evaluating housing technologies

The Housing Performance Indication System is a method of rating the level of performance of a housing unit, based on standardized criteria, which then indicates the evaluation results.
This system helps homebuyers to compare the quality of housing and also to settle housing-related disputes when such cases occur after the purchasing. Housing suppliers also find the method to be beneficial in receiving orders, based on their technical superiority.
With this system, fair assessments have been made on technologies developed by the housing industry, which contributed to the betterment of the housing market.
Now, this system is indispensable for providing communication between homebuyers and housing suppliers in addition to creating a quality stock of housing.

018 Prefabricated Housing

Houses produced and supplied in a similar way that automobiles are

Beginning in the 1960s, the Japanese housing market grew dramatically, which encouraged other industries to enter this attractive market, such as those of iron, steel, chemical, and electric appliances. These industries were seeking more productive manufacturing and supply systems for housing through industrialization, instead of continuing with the conventional wooden-house building system that relied on traditional carpentry methods. They had an eye on light-gauge steel material, which had just been put into practical use at that time, and developed housing structural systems utilizing this material. In the same period, other housing manufacturers entered this market who used concrete for the structural material and wooden components for the same. All of these new housing systems, called "prefabricated houses", were flexibly changed and created new styles of houses to meet consumer demands, which were gradually accepted into the Japanese housing market.

019 Pilot Projects

Linked with changing issues of housing administration of each period

Nowadays, the word "pilot" is commonly used to mean "a person who operates an aircraft", but it originally meant "a guide in waters, or a specialist who assists a captain of a ship in guiding it over rough seas". In the field of architecture, "a pilot project" means a building project carried out as a test of some unestablished technology to determine whether it is worthwhile to further develop it for a practical application.
In the housing sector, especially, a number of notable pilot projects have been conducted over the years to address issues of government housing-administration.

020 Skelton-Infill House (Base building and fit-out for housing)

Durable housing with diverse functions and flexibility

For planning of multi-unit residential buildings, a method to separate structural members (the frame/skeleton) from the interior/equipment (infill) has been employed to meet the diversified needs of residents and to allow flexibility for changes in residents' member and lifestyles. As a result of many technical developments and the related regulation changes, multi-unit skeleton-infill housing (base buildings and fit-out for housing) has gained popularity, as it ensures that residents can continue living in the unit for a longtime.
As the environment and natural resources issues have become increasingly serious, the use of durable frames/skeletons and flexible infill systems are the ideal responses to the current social requirements.

021 Precutting

A technique of processing wood that supported Japanese housing construction

The majority of newly built detached houses in Japan are built with conventional post and beam construction. Traditionally, those wooden members were made by carpenters using hand tools, but nowadays they are made with machinery.
Previously, machines were only used for simple processes which has recently become capable of more complicated processes and their abilities are continuously being improved. Thanks to the wide use of precutting techniques, the time and cost required for building houses have drastically been reduced, and the on-site work has become safer and more efficient.
Precutting is an indispensable building technique, which has supported the Japanese culture of wooden detached houses. It is a building technique unique to Japan, which was developed based on the Japanese building module.

011–021

the Edo era: 1603–1868 / the Meiji era: 1868–1912 / the Taisho era: 1912–1926 / the Showa era: 1926–1989 / the Heisei era: 1989–2019 / the Reiwa era: 2019–

Chapter

II

BUILDINGS

Public Buildings

From the late Meiji period through the Taisho era, Japan became a modernized nation, which was brought about in part by the construction of various public facilities. Major styles of public buildings that are currently existing already appeared in that period, including government buildings, schools, train stations, hospitals, city halls, museums and so forth.

As for school buildings [022], the use of a government standard-designs formulated at the end of the Meiji era gradually expanded after the war, quickly addressing the growing demand for construction of schools. After 1970, however, some very ambitious schools started to adopt new building designs for their buildings. Before the World War II, public cultural facilities [023], such as museums, art galleries, theaters and concert halls, were built in large major cities, which were, in the post-war period, constructed in each prefecture, and then after 1990, many of these were built in cities, towns and villages around Japan. A standard design for government buildings [024] was established before the war, which was applied to the majority of prefectural government buildings. After the war, a number of city/town office buildings were built in a modern architectural design. These were considered to be symbols of municipalities, not simply as offices for local administrators.

Architecture as a Symbol

A building is expected to serve as a symbol, besides having practical functions. Religious buildings and memorials [027] are typical examples, which are built with the most effective function as symbol. A tower [028] is constructed for broadcasting purpose and is familiar to people as an icon of a city, and also as a monument that marks time, as people recall when it was constructed. At international events, such as the 1964 Tokyo Olympics [029] and the Japan World Exposition, Osaka [030] in 1970, buildings and facilities designed by notable architects of the time appealed to the world as profiles of what Japan was, and what it strived to be. It can be said that modern architecture [025], which totally eliminated decorative features from buildings, was at one time an attempt to reject the idea of buildings serving as symbols, which, however, eventually became a symbolic style of architecture that represented the modern era. Post-modern architecture, which arose from criticism of modern architecture, was trying to incorporate regional features into buildings. Okinawan architecture [026] is typical of buildings that represent this movement in Japan.

Urban Environment

Urban populations have increased dramatically over the last 100 years. Various new problems have occurred due to sudden urban growth. New technical proposals were made to solve these problems. One proposition to create safe and comfortable shopping spaces for people gathering in city core areas was the arcade [032], which is a pedestrian street with a roof, and the underground mall [033], with the intention of transferring an entire aboveground-shopping town underground. Another example is the station building with shopping centers [031], combining facilities for shopping as well as for transportation, which is a type of commercial building developed solely in Japan. In order to secure open spaces in congested urban areas, a new plan was introduced to provide public open spaces [035] with an integral design program. Many pedestrian decks [034] were constructed to provide safe and comfortable walking spaces by allowing people to avoid automobile traffic intersections.

Urban Renewal

Since 1980s, urban redevelopment [036] project schemes have been undertaken in major cities in Japan, integrating offices, commercial buildings, hotels and cultural and multi-dwelling functions into one building complex by greatly increasing the floor-area ratio. Many new urban centers have been created through this type of projects. Urban waterfront development [037] projects were implemented in many cities to renew deserted port areas, which previously had warehouses and factories, into lively places, which attracted people from outside the area. The shopping mall [038], a new type of large-scale commercial facility, became popular as an alternative to department stores and traditional shopping centers.

Lively Spaces

Historically, buildings have created vitality in urban areas. Immediately after the World War II, it was black market districts that firstly recovered the vigor in burnt-out cities. Later on, these areas were further developed and transformed to the currently existing downtowns [039]. Later on, in accordance with people's growing desire for leisure time, various theme parks [041] were developed, where people can experience special entertainment in an extensive facility, designed to express a specific theme. Many convention centers [040] were also built as a new type of urban facility, where people came from far away for various purposes, e.g., commercial activities, exhibitions, cultural exchanges, tourism, etc., which contributed to forming new lively spaces.

1 Public Buildings

022
School Buildings

Rising above a uniform design building to become characteristic regional centers

Construction of school buildings in modern times began in line with the inauguration of a new educational institution in the Meiji era, which was greatly revised after the World War II, and has been further modified from time to time in accordance with the social environment of the time. For the one-hundred years from the beginning of Meiji era, efforts were made to standardize school-building design in order to urgently meet a demand for constructing a number of school buildings. During the fifty years after early 1970s, it has been explored to find the ways how school buildings may comply with a diversified educational system, may contribute to the fulfillment of people's lives, and may cooperate with each regional community. Currently, school systems are expected to meet the demands of issues related to the IT society, combined elementary-junior high school systems, the global environment, promotion of the use of wood in the construction of their buildings and a safe and secure environment. Japanese school administrations are also required to cope with the current problems of the deterioration of old buildings and a declining birthrate, together with the aging population. To address these issues, it is expected that school buildings be suited for multiple functions, including that of being the center of the regional community.

023
Public Cultural Facilities

From a place for appreciating others' performances to a space for expressing your creativity

Part of the modernization of Japan included the modernization of cultural facilities, which brought about the construction of public theaters/halls and museums/art museums. Theater/hall buildings initially served as public halls for meetings and assemblies, and then their use was expanded to include various other purposes, such as music performances and plays. Then, there appeared new facilities that are specialized in certain types of performances, and, on the other hand, multi-function facilities and their accompanying technologies were also developed. In the area of art museums, exhibition rooms called "white cubes", which were made in order to appreciate modern artwork, have been gradually changed to the places where people may have various spatial experiences that are created by the contemporary art. Public cultural facilities as well have been changed, from being places where people appreciate others' artworks and performances to spaces for people to create things and to express themselves.

024
Government Buildings

From symbolic design to post-war modernism

Construction of government buildings in the Meiji era started with the adoption of Western designs and building technologies, and with symmetrical floor plans and façades that emphasized symbolic characteristics. At the end of the Taisho era, most government buildings had a box-type external appearance, similar to office buildings, and were equipped with a tower that exhibited a strong symbolic feature. After the World War II, the idea of democracy influenced government building construction. Traditional designs that might recall feudalism were totally renounced, and instead, clear and bright modern designs were sought as an ideal style for government buildings. At the end of the 1950s, a government building-construction boom occurred as a result of the enactment of the Law for Promoting Consolidation of Municipalities, when fifty government buildings were newly constructed nationwide within three years.

2 Architecture as a Symbol

025
Modern Architecture

Modernism in Japan coinciding with the European movement

Modern architecture is characterized by the utilization of industrial materials, which were generated by the industrial revolution, for the structure and design of buildings, rejecting conventional architecture.
During the 1920s in Japan, "the secession school of architecture" was founded as a pioneer of modern architecture. During this period, the disciples of F. L. Wright grew out of their mentor's style, trying to pursue modernism. This movement in Japan coincided with the growth of modern architecture in Europe.
In the 1930s, Japanese architects who studied in Europe came back to Japan and established the era of modern architecture in Japan.

026
Okinawan Architecture

One of the practices of post-modernism

The Nago city office, completed in 1981, turned out to be a monumental building, deeply rooted in the history and climate of the region. For the exterior, concrete blocks were utilized, which were commonly used in Okinawa under the occupation by the U.S. It was equipped with statues of "Shisa", an Okinawan talisman that wards against evil; and had a terrace on each floor to provide shade.
Since then, a number of buildings have been built with strong references to Okinawa, its climate and its history. Okinawan architecture and its steady and persistent improvement have attracted the attention of the world as one of the greatest achievements of post-modern architecture in Japan.

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022–026

the Edo era: 1603–1868 / the Meiji era: 1868–1912 / the Taisho era: 1912–1926 / the Showa era: 1926–1989 / the Heisei era: 1989–2019 / the Reiwa era: 2019–

027
Religious Buildings and Memorials

A merger of modernism and symbolism

Religious buildings and memorials that represent spirituality had long played the leading part in Japanese architecture.
Since the modern era of architecture, the importance of architecture associated with spirituality has diminished, but the substance of these buildings still remains in the consciousness of architects.
For example, Tange Kenzo successfully achieved a high-level of integration of modernism and symbolism in his designs of a Christian cathedral and a war memorial museum.
New religions that emerged in Japan after the World War II constructed a number of huge-scale buildings that adopted advanced structural technologies to enable free and innovative building designs.

028
Tower

Repeatedly been destroyed by monsters in movies and advertisements

During the 1950s, many shared broadcast-transmission towers were constructed in major cities in Japan, including Tokyo, Osaka, Nagano and Sapporo.
For each tower, an observation platform was provided on one of the upper floors, where many people visited and enjoyed the views.
Tokyo Tower, which was once the most famous of all the Japanese towers, was said to be a symbol of post-war restoration and the high economic growth that followed in Japan, which gave hope to Japanese people for a prosperous future.
It was repeatedly featured in movies and advertisements in Japan.

029
The Tokyo Olympics

Showcasing post-war restoration with the fruits of engineering knowledge

In 1964, The Olympic Games were held in Tokyo, which was the first time they were held in Asia.
New transportation systems were developed for the Olympic Game, they were: the Tokaido Shinkansen railway and the Tokyo Metropolitan Expressway together with the Inner Circular Route.
Also, Olympic stadiums and many other facilities were constructed, such as Yoyogi Gymnasium and Komazawa Olympic Park, whose excellent architectural designs were highly evaluated throughout the world.
It was a great opportunity to showcase, both within and outside of the country, Japan's post-war restoration and the globalization of Tokyo, which were realized by achievements in national land-planning, city planning and planning of buildings.

030
Japan World Exposition, Osaka 1970

An opportunity to experiment with new building-technologies

In 1970, a world exposition was held for the first time in Asia, in Senri Hill, Suita city in Osaka prefecture. At the site, the organizer and a number of the participating nations and companies exhibited eye-catching facilities and pavilions and competed for the best building design and uniqueness.
Furthermore, many innovative technologies for structures and site works were introduced, such as space-frame- and lift-up construction methods, a capsule structure, a membrane structure and an air-beam structure, all of which had considerable impact on the further progress of building technologies in Japan.

3 Urban Environment

031
Station Buildings with Shopping Centers

Super intensively used urban building complexes unique around the world

Hankyu-Umeda station built in 1920 was the first Japanese-style station building that had a department store as a tenant. Since then this type of station buildings spread throughout Japan. In the post-war recovery period, the National Railway Corporation constructed many station buildings that comprised commercial functions with public-private joint financing, which were called "people's railroad stations". After the breakup and the privatization of the National Railway Corporation, the new railway companies actively took up development of such station buildings, which produced huge projects such as the Kyoto Station Building and Osaka Station City. The Japanese station building, best represented by Shibuya station, is a multi-use urban building complex that provides networks connecting the station and the surrounding facilities. It is still changing to make a type of building that is rarely seen in the world.

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100 Key Terms

032
Arcade

A buffer space created by a collaboration of shops along the street

The word "arcade" originally meant a corridor or gallery covered with a series of arches. Nowadays, arcades serve as avenues and shopping streets that are covered by roofs.
The origin of the Japanese-style arcade goes back to the sunshade used in the Edo and Meiji eras. The current style of arcade appeared in the early 1950s, and was constructed until early in the Heisei era, during which the design changed every ten to twenty years, influenced by the fashion of the respective period. Now they are often found in large cities and in regional urban centers.
An arcade, with the colored walkways and the streetlights, is a commonly shared facility which works as an important element for creating the urban image. It can be said that an arcade is a unique space that connects private properties with public areas.

033
Underground Mall

A distinctive Japanese-style development in densely populated urban areas

Underground malls typify overpopulated cities in Japan. They are all-weather pedestrian spaces that connect railway stations and the surrounding buildings, which are still making progress distinctive of Japan.
It was before the World War II when the first Japanese underground mall was constructed, as what was called "a Subway Store". These were then constructed throughout the country during the period of rapid economic growth. Their construction was halted when a large fire, the Osaka Sen-nichi Department Store Fire, occurred in 1972, but the construction resumed in the late 1980s.
There are now many large-scale underground shopping malls in Japan. There is no other country in the world that has developed so many underground malls of such enormous scale.

034
Pedestrian Decks

From a pedestrians-vehicle separation system to three-dimensional-space use in urban areas

In the 1960s, an increasing number of accidents involving pedestrians became a serious social problem, which brought about the provision of pedestrian lanes above existing roads to separate pedestrians from automobile traffic. In Kashiwa city, such pedestrian lanes were merged into an urban renewal project, the Kashiwa Station East Project, which was completed in 1973. In this project, an entrance of the elevated station building, and the surrounding buildings were linked by an artificial ground, which was the first pedestrian deck in Japan to provide an overhead walking network for people.
Since then, this procedure has been adopted for many large-scale urban renewal projects nationwide. It is an effective urban-infrastructure system that is unique to Japan.

035
Public Open Spaces

A measure to integrate urban environment contribution and building code deregulation

Public open space is a public space provided on a building site in various forms, such as a sidewalk, a through passage, an atrium, a waterside open space, a square open space, etc.
When a building owner agrees to provide a public open space that contributes to the improvement of an urban environment, some concessions are made by the government to the developer, in proportion to the level of the contribution. These can be in the form of relaxation of the regulations for floor-area ratio, building height limit, and others. This system is stipulated in the provision for "specific blocks" in the City Planning Act, and in the Building Standard Law for a "integral design system".
Since the 1970s, it has become common to provide public open spaces in skyscraper construction and large-scale redevelopment projects.

4 Urban Renewal

036
Urban Redevelopment

Creating an urban core for revitalization of cities

In 1969, the Urban Renewal Act was enacted, with a view to facilitating the efficient use of urban land and improving functions of cities.
Initially, this act was mainly applied to projects of consolidating small, dispersed building lots in order to create urban cores for modernized commercial activities, as well as to improve disaster prevention capability. After the late 1980s, there was a social trend towards deregulation and inducement of private-sectors to be involved in public works, which facilitated the execution of huge redevelopment projects, such as those on the sites of demolished factories, water treatment plants and former freight stations, turning them into multi-function building complexes that comprised offices, hotels, commercial facilities, cultural facilities and housing.

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the Edo era: 1603–1868 / the Meiji era: 1868–1912 / the Taisho era: 1912–1926 / the Showa era: 1926–1989 / the Heisei era: 1989–2019 / the Reiwa era: 2019–

037
Urban Waterfront Development

Taking attractive environment around harbors back to urban areas

Urban waterfront development: The renovation of port areas previously occupied by warehouses and factories into charming shopping streets and parks where people can enjoy themselves.
This urban development method, which reminds us of the beauty of waterfront area, came into fashion in Japan 10 years later than that when it occurred in the US. It began in Japan with the opening of Kushiro Fisherman's Wharf in 1989, which was followed by various developments in major port cities, such as Tokyo, Yokohama, Nagoya, Osaka, Kobe and Fukuoka.
In the 21st century, constructions of skyscraper condominiums and offices on waterfront property have been booming, which made the area draw people's attention again.

038
Shopping Mall

Safe and comfortable commercial districts developed in suburbs

In the late 1990s, many shopping malls designed by an American architect, Jon Jerde, were built one after another in Japan.
The technique of creating safe and comfortable shopping spaces, combined with pleasant pathways, was a completely new approach from the one for conventional shopping centers which had spread across Japan, accelerated by the trend of mass consumption in the period of high economic growth.
Since then, Japanese developers have rapidly caught up and have constructed a number of shopping malls in the suburbs. However, it is now a challenging time for them, considering the continuously decreasing population.

039
Downtown

Lively commercial and entertainment centers

In the early-modern times, there were places of amusement for people to gather, which were located in the peripheries of cities.
In the modern age, those amusement functions were drawn into the center of cities, which were further developed and formed downtown areas. In these areas, streets were lined with shops of various exterior designs, which were pleasing to passersby.
During the period before and after the World War II, the government attempted to develop planned downtowns, such as the Shinsekai district in Osaka and Kabuki-cho in Tokyo.
Immediately after the war, there emerged many black markets around railway stations, which gradually grew and eventually formed downtowns.

040
Convention Center

Multi-function facilities that accommodate various groups of people

There are several types of assembly halls; those for conferences organized by international organizations and academic institutions, for product exhibitions held by enterprises, for sports and entertainment events, and so forth. It used to be that a different type of building was constructed for each type of event, e.g., those for conference hall, exhibition hall, sports arena, etc. However, at the beginning of the 1980s, new types of convention facilities were constructed, which integrated multiple functions into one facility in order to correspond to the needs that arose from the increasing scale and diversification of events.
As convention centers are efficient tools to attract numerous people from an extensive area, they are expected to play an important role to vitalize the city who competes with other cities.

041
Theme Parks

The world separated from daily life

Theme Park: a different sphere, apart from daily life, created based on a specific theme, such as an exotic atmosphere, or the history of some country or region.
The name "theme park" originated in 1983 in Japan, when Tokyo Disneyland opened.
Looking back at history, there were similar facilities opened during the 1960s in Japan, such as Nara Dreamland and Meiji Village Museum.
Going further back to seek the origin of theme parks, it was found that some entertainment facilities and those for simulated pilgrimage (visiting one large temple where model buildings of many other temples are constructed in the precinct, so that the visitor may have simulated experience of visiting all the temples) in the Edo era were operated in a similar way to present-day theme parks.

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the Edo era: 1603–1868 / the Meiji era: 1868–1912 / the Taisho era: 1912–1926 / the Showa era: 1926–1989 / the Heisei era: 1989–2019 / the Reiwa era: 2019–

Chapter

III

STRUCTURAL METHODS

Introduction of Modern Structures and Japanization

Historically, wood was the only material used for building structures in Japan. However, since the modernization of Japan, a variety of structural materials and methods have been introduced, beginning with brick construction, which evolved the current building technologies. Then, the first adopted as a modern building material was a steel structure [043] which was first used in the latter half of the 19th century but to a limited extent, and then its use gradually increased in accordance with the introduction of American construction methods. Soon after that, in the early 20th century, a reinforced concrete structure [045] was introduced, which was valued as an effective seismic structure suitable for Japan, a quake-prone country. Therefore, a great amount of theoretical and practical researches was made on this structure. As there were many concrete-form carpenters, cast-in place was commonly practiced for concrete works in Japan. However, while searching for easier, more economical and efficient construction procedures, a concrete block structure [042] also came into use, mainly for housing construction. The latest invention that was made following these structural developments is a steel encased reinforced concrete structure [044]. This was a unique seismic structural method, which became an indispensable technology for construction of high-rise buildings in Japan.

Establishment of Seismic Design and Technology

The structural technologies introduced from overseas have gradually been improved their seismic performances in response to the requirements of this earthquake country. A seismic design provisions [046] were established before the World War II, which is to secure required seismic strength by length of bearing walls. These design provisions were developed based on the concept of seismic intensity proposed by Toshikata Sano. After the war, the seismic standard was drastically advanced through a number of earthquake disaster experiences, which was followed by amendments to the seismic legislation. Finally, the New Seismic Design Provisions were created in 1981, which has formed the basis of the current seismic design. Furthermore, a seismic isolation system [047] was introduced, which is an innovative system to separate buildings from seismic forces; a completely different system from the anti-seismic structure, which allows buildings to resist seismic forces through their rigidity. As another technology to reduce seismic vibration transmitted to buildings, a response-control [048] technology was developed, which has increasingly been used for a number of buildings. It is especially effective as a countermeasure for long-period earthquake motion of skyscrapers. These new technologies are applied not only to newly constructed buildings, but also for the preservation of traditional/cultural buildings and the continued use of existing buildings as well. They are called seismic retrofit [049] building technologies including seismic isolation retrofit, which allows for the preservation of a building's design features yet providing protection against seismic activity. Various other designs and technologies are currently being developed for seismic retrofit to correspond to the need of the individual building.

Development of Higher/Larger Buildings

While the basic styles of the Japanese building structure were established, and, on the other hand, ongoing overseas building information was continuously flowing into Japan, the possibility for constructing much larger-scale buildings had been raised. This technology made remarkable progress during the post-war growth period, with the representative example being the Kasumigaseki Building, completed in 1968. This was Japan's first skyscraper [050] realized through a thorough utilization of prefabrication techniques that were applied to pursue a safe and efficient construction process. This consequently promoted industrialization of construction projects in Japan. In accordance with the growing social needs for large-span buildings, such as exposition and sports facilities, together with the progress of structural technologies and new materials, new structural methods were developed, which includes the tubular structure [051], the shell-and-spatial structure [052] and the membrane structure [053]. Later, a retractable-roof dome [054] was built that is suitable for seasonal changes, which is now in common use as sports facilities.

Evolution of Wooden Structures

Since the era of the modernization of Japan, a variety of structural types have been adopted. At the same time, considerable technological progress was made to the original Japanese wooden building. Steady advances were made to seismic technology for wooden housing [055], based on accumulated research data obtained as a result of a number of earthquakes. This accelerated the spread of the application of braces and bearing walls. Also, wooden fire-preventive construction [058] came into wide use, which was facilitated by the extensive conflagrations that destroyed wooden buildings during World War II. A mortar-coated external wall, one of the approved fireproof specifications in Japan, was a typical building element that characterized Japanese post-war houses. The two-by-four building [057] system was introduced to Japan, mainly from North America, as a new structural method, which was quite different from the Japanese conventional wooden structure. This structural method was standardized and incorporated into the Japanese building standards in 1974, which became available without any special approval. The system was mainly used for detached houses, and gradually became recognized in Japan due to the simple construction process that is involved and its strong seismic properties, which is realized through the large quantity of bearing walls used in this system.

After the war, on the other hand, non-wooden buildings were dominant in urban areas, except for small structures such as houses, in order to ensure fire safety in modern cities. From the beginning of the Heisei era, however, various advanced research efforts and the following deregulations made it possible to construct large-scale timber buildings [060] and fire-resistive wooden buildings [059], which were being erected more and more. Since enactment of the revised Building Standard Law in 2000, various attempts have been made to enable construction of large-scale fire-resistive wooden buildings. Among the huge technical and institutional progress made towards the establishment of new wooden buildings, a study of the structural analysis of traditional wooden buildings [056] has made notable progress, which now is a world-leading technology, being utilized for the renovation and restoration of buildings of cultural importance.

1 Structural Method

042
Concrete Block Structures

Structure that supported post-war recovery housing through their fire resistance, seismic stability and affordability

In line with Japan's modernization, "fire resistance" and "seismic resistance" have been ongoing issues for building construction and urban development in Japan.
After the war, there was an urgent need to construct buildings as fast as possible, and at a low cost.
The concrete block structure was widely used to satisfy this housing demand for a certain period after the war because of its simple construction method that was similar to that of a brick (masonry) structure, applicability of seismic technology already developed for brick structure, fire resistance property and the reasonable construction cost.

043
Steel Structures

Steel structure prevailed due to improved connection techniques and the use of shaped steel

A steel structure in Japan was first used at the end of the 19th century, and its use spread rapidly through the period of high economic growth in the 1960s.
During this period, tremendous progress was made regarding the assembly method, from conventional riveted joint assembly to the use of H-section steel and high-strength bolted friction-joints, as well as in welding techniques. With this structure, a wide range of buildings were constructed, from low- and middle-rise buildings to skyscrapers which was best represented by the Kasumigaseki building.
After that, the use of square-steel pipe became common, which was followed by CFT (concrete-filled steel tube).

044
Steel Encased Reinforced Concrete Structures

A unique technology, developed in earthquake-prone Japan

A steel encased reinforced concrete structure was developed in Japan by combining a steel structure with a reinforced concrete structure. The Marunouchi building, which was built at the end of the Taisho era, was constructed with a steel structure and then reinforced after the Great Kanto Earthquake. This was done by covering the existing steel columns with reinforced concrete to make each of them an integrated structural member. The head office of the Industrial Bank of Japan was built with a steel encased reinforced concrete structure. Half a year after its completion, the Great Kanto Earthquake occurred, however, it did not suffer any damage as a result of the quake, which drew much attention of engineers. The design method of the steel encased reinforced concrete structure was fully established in the 1950s and has been used for high-rise buildings of around twenty stories, and for the lower floors of skyscrapers.

045
Reinforced Concrete Structures

Structure that allows for the design of various building forms

Due to its excellent seismic- and fire-resistive properties, together with the reasonable construction cost, the reinforced concrete structure has been widely used by architects and engineers in modern Japan.
Using this structure, buildings with innovative structural methods were constructed before the World War II, such as domes and other large-span roofs with vaults.
In principle, it is possible to form any shape of building with reinforced concrete. This has inspired the creativeness of many architects, resulting in various attempts to create novel building forms.
The fair-faced concrete finish, which has nothing applied to it after the forms are stripped, has been preferred and adopted by many architects for their masterpieces.

2 Seismic Technology

046
Seismic Design Provisions

Changed by earthquake disaster experiences and technological developments

The seismic design provisions are structural standards that were established to prevent buildings from collapsing as a result of earthquakes. Different from ordinary structural designs, this design does not exclude the possibility of buildings being damaged in quakes.
In 1923, the Great Kanto Earthquake hit, and in the following year, the Urban Building Law was revised to incorporate seismic design provisions, which was the first such building legislation in Japan.
In the 1960s, construction of skyscrapers began in Japan, for which dynamic seismic-response analysis was adopted by utilizing advanced computer technologies.
In 1968, the Tokachi-Oki Earthquake caused serious damage to many middle-rise reinforced concrete buildings, which lead to the formulation of the New Seismic Design Provisions enacted in 1981.

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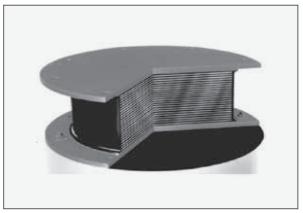


047
source: The Japan Society of Seismic Isolation

100 Key Terms

047 Seismic Isolation Systems

The Great Hanshin-Awaji Earthquake verified the effectiveness

A seismic isolation system is a system that significantly reduces the amount of damage to buildings as a result of earthquakes. The system equipment is installed between the foundation and the building, allowing it to absorb earthquake energy. It was 1983 when the first seismic isolation system with laminated rubber bearing, which is still in widespread use at present, was applied to a two-story residential unit with a reinforced concrete structure. After that, the system was applied on an experimental basis to, for example, facilities of construction companies who were interested in this technology. Its effectiveness was finally verified by the experience of the Great Hanshin-Awaji Earthquake, and since then, the use of the seismic isolation system has been widespread, being applied to all types of buildings. Currently, the system is used mainly for high-rise residential buildings, large hospitals and the like. Just recently, its application to detached houses has been increasing.

048 Response Control

A combination of an elastic frame and quake-energy absorbing walls and braces

Even if a building does not collapse as the result of an earthquake, if its columns and beams have undergone plastic deformation, the building can no longer be occupied and will eventually be demolished.
Response control was an attempt to prevent plastic deformation of structural members by installing deformable walls and beams.
To realize this idea, many technologies have been developed, such as a steel-plate shear wall, a viscous dumping wall, a buckling restrained brace, an oil damper and a damper that uses non-oil viscous material.
Another system of this kind is a tuned-mass damper response control device, installed at the top of a skyscraper, which is effective in securing stability of the building and allowing continuous occupancy, even in strong winds.

049 Seismic Retrofit

Prevalent since the Great Hanshin-Awaji Earthquake

As a quake-prone country, Japan has developed seismic retrofit technologies in parallel with the accumulated experience resulting from earthquake disasters.
In the Great Hanshin-Awaji Earthquake in 1995, buildings constructed according to the old seismic standard, which was effective until 1981, were significantly affected.
From this experience, the Act for the Promotion of Seismic Retrofit of Buildings was formulated to facilitate the implementation of seismic retrofit, which led to the retrofit of many schools and other buildings throughout the nation.
There are two procedures of seismic retrofit: one is a conventional method by which the strength and toughness of the building itself are enhanced; the other is to install a seismic isolation system or a response control system to existing buildings.

3 Large-scale Buildings

050 Skyscrapers

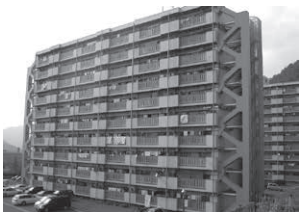
The world's first super-high-rise building constructed in earthquake-prone area

In 1963, the Building Standard Law was revised to abandon the 31-meter building-height restriction. After that, high-rise buildings of 60 to70 meters in height were constructed one after another, such as the Hotel New Otani building. However, the first skyscraper in Japan which exceeded 100 meters in height was the Kasumigaseki Building, which was completed in 1968. This was also the first skyscraper in the world to be constructed in an earthquake-prone area as well as in a region frequently hit by typhoons.
To realize the construction of this building, various technical developments were made in many fields including city planning, structural design, facilities, materials and site work.
Based on these developments and other technical innovations that followed, the record for the height of a Japanese building has been broken every several years since then.

051 Tubular Structures

Structural method that forms towers and other space structures

Steel-tube is suitable as an axial tension member, as it is light in weight and has high resistance to buckling. When its production technology was established, it was applied to large-scale towers and buildings with long spans.
In the beginning, branch joints were used to connect steel-tubes by welding. In the 1970s, a system truss using spherical nodes was developed, which has been widely used since then for roofs of gymnasiums, stadiums, shopping malls, exhibition halls and airport facilities.
Since the late 1990s, steel-tube welded trusses have again been favored by designers for application to airport- and convention-facilities, which realized affluent structural designs utilizing various curved shapes.



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052
Shell/Spatial Structures

Technical challenge of human beings for centuries

From the ancient Roman era, it had been a dream of human beings, as well as a technological challenge for generations, to create a large astylar space where people could gather and meet.
The most important technical subject to achieve this end was how to reduce the weight of the structure in order to realize a reasonable, and at the same time, esthetically pleasing structure, which enabled to create light, transparent and fluid space.
This basic concept is reflected in a "spatial structure", which is represented by "shell structure" that utilizes form resistance.
When overviewing the period from post-war, when shell/spatial structure appeared in Japan, through today, episodes which marked each time in the history come into our minds.

053
Membrane Structures

Realization of huge-space buildings, allowing for the use of natural daylight

In response to the increasing needs for large-space buildings, membrane was adopted as a lightweight material used for tensile structures, which then became the membrane structure.
From the late economic growth period through to the economic bubble time, membrane structure made a remarkable development and a number of characteristic membrane-structure buildings were constructed in Japan.
For the Osaka Expo held in 1970, an air-supported membrane structure, which uses air as a structural material, was introduced in the US pavilion and the Fuji-group pavilion as temporary buildings.
Since then, many membrane-structure buildings have been constructed throughout the country, mainly for sports facilities, which can provide huge bright spaces utilizing natural light.

054
Retractable-Roof Domes

Competing ideas for roof open/close technologies

In accordance with the commercialization of sporting events which requires accommodation of large audiences, such as baseball and American football, construction of large-scale sports facilities with retractable roofing was begun.
Japan's first retractable-roof sports facility was the Ariake Colosseum constructed in 1991, followed by the Fukuoka Dome which opened in 1993.
There are several types of mechanical systems to retract roofs, namely, the rigid-panel type, the frame-mechanism type and the membrane folding-type, with each type having its own different variations.
Unlike ordinary building structures, those with retractable roofs require many moving parts, which create various technical challenges that must be solved in the design stage, such as techniques for waterproofing and restrictions on the amount of allowable deformation of structural members.

4 Wooden Structure

055
Seismic Technology for Wooden Housing

Seismic properties of conventional P&B houses improved through many earthquake experiences

The basic idea of the current seismic design for conventional wooden housing in Japan, namely, the wooden post and beam structure, is to resist earthquake forces by using load bearing walls installed with diagonal bracing.
In order for the braces to work effectively, it is essential to connect the column head/bottom and edges of the braces firmly with the appropriate hardware. To secure sufficient level of seismic stability of a building as a whole, it is necessary to provide a required length of bearing walls that are to be placed in good balance throughout the building.
These seismic design techniques were established over time, owing to the accumulated knowledge from earthquake experiences from the Meiji era. As a result, an increasing number of wooden houses are now seismic resistant.

056
Structural Analysis of Traditional Wooden Buildings

Extract elements of seismic property and change them into engineering model

It is extremely difficult to determine the seismic performance of traditional wooden buildings from an engineering perspective, as they were developed over time by the accumulated experience of carpenters and craftsmen.
In order to conduct structural analysis on them, it was necessary to firstly study the mechanism of resisting earthquake forces; secondly, to quantify the aseismic property; and finally, to replace them with an engineering model for each type of building structure.
In the 1980s, it became possible to calculate the seismic property elements of structures, such as rotational resistance of joints, column rocking resistance and effects of isolated column with spandrel walls.
It also became possible to conduct collapse analysis, using 3-dimensional frame models, for which validity can be confirmed by comparison with vibration-test data.


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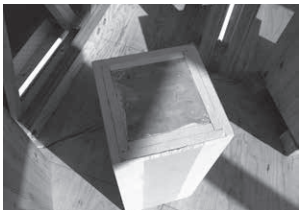
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100 Key Terms

057
Two-by-Four Buildings

Construction method served as an effective social service system

For housing construction, there are various wooden-frame structural methods that have been developed overseas, whereas in Japan, a unique post and beam method has been used for many years.
However, after 1974, when the two-by-four structure was stipulated in a technical standard for wood frame construction in the Building Standard Law, this structural method became widespread throughout Japan.
The two-by-four structural method was introduced to Japan not simply as a technique and a building product, but also as an effective system for providing social services that was common in North American countries. Nowadays, more than 100,000 two-by-four houses have constantly been constructed in Japan.

058
Fire Preventive Construction

A basic factor that characterizes the view of low-rise built-up urban areas

The idea of fire preventive construction was initiated before the World War II as a measure to prevent buildings from catching fire as a result of air-raids, by using either lath-mortar, plaster, mud, etc. as external wall coverings. Still after the war, this technique was succeeded and was incorporated in the Building Standard Law as a measure to prevent fire from spreading in urban areas, which had dense concentrations of wooden buildings. Thus, external walls finished with mortar and non-combustible siding materials were commonly seen in cities, which became an important element that characterizes townscapes of low-rise urban areas.
Fire preventive construction was developed in Japan as performance-based criteria, by which the safety of buildings was verified by conducting tests. Japan was the first country to take this approach, which later became a model for fire research in the world.

059
Fire-Resistive Wooden Buildings

Expanded the potential of wooden buildings

After the World War II, construction of wooden buildings was interrupted due to a stringent fire regulation imposed under the government policy of developing cities of non-combustible construction. Being subjected to external pressure, the regulation was gradually relaxed in the late 1980s, beginning with approval of three-story and multi-unit wooden housing construction. In this century, an increasing number of MLIT (Ministry of Land, Infrastructure, Transport and Tourism) approvals have been issued for wooden fire-resistive construction permits since the enforcement of the revised Building Standard Law (BSL) in the year 2000. Furthermore, a standard specification of walls for fire-resistive construction was provided in BSL Notification 2014, and in Notification 2018, those of other principle building parts for the same were provided, which includes floors, roofs and stairs. As a result, construction of wooden fire-resistive buildings has become realized, which will further expand the potential of wooden buildings.

060
Large-Scale Timber Buildings

Creating novel structures/spaces using traditional building materials

From ancient times, wooden structures had been a conventional building method in Japan, which was changed and utilized in various forms to fit the needs of each era. Throughout the history, the possibility of constructing large-scale timber buildings has been explored for various reasons, notably due to a shortage of building materials during and after the World War II, and later during the economic growth period, with the aim of developing innovative technologies and the consequent expansion of economic zones. Recently, large-scale timber buildings have been expected to play an important role in the promotion of the use of wood, aiming at better forest management, the circular economy and fixation of carbon dioxide. The possibility of creating new architectural designs by using large wooden buildings has also been explored. Nowadays in Japan, it is not unusual to find large buildings of wooden structures. To realize these building designs, it was essential to develop large-dimension/high-strength engineered lumber and metal joints, to formulate design standards related to fire safety, and to develop advanced structural-analysis technology.

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Chapter

IV

BUILDING PRODUCTION/ FACILITIES

RC Structures and Production Technology

Historically, the wooden structure was the sole construction method in Japan. In the beginning of Meiji era, Western-style building structures were introduced to Japan. First introduced was brick structure and brick buildings were deliberately constructed with an aim to develop a fireproof city, but they suffered serious damage in earthquakes. Thus, at the end of the Meiji era, the reinforced concrete structure was introduced as an alternative fire-resistive building structure. The first full-scale reinforced concrete building built in Japan was the Yokohama branch office of Mitsui & Co. Ltd., which was covered with exterior tiles [069] as cladding, which was the first such application in Japan, and asphalt roofing waterproof [075] was utilized for its flat roof, which had also just been introduced to Japan. As the reinforced concrete structure came into common use, foundation- and ground-improvement [065] technologies were also introduced, such as the concrete pile.

Cast-in place concrete [061] was, and still is, a common method of concrete work in Japan. After the World War II, production capacity of concrete was remarkably enhanced, due to new production facilities, such as Japanese designed concrete batch-plants and concrete pumps, which supported the construction boom that occurred during the period of high economic growth. On the other hand, pre-cast concrete products were developed to replace the time-consuming on-site formwork. These products were reinforced block, which was developed from the Taisho era to the beginning of the Showa era, and a precast (PCa) concrete [064] that was manufactured after the war. To respond to the massive demand for housing construction in the thriving economy, especially in the public sector, PCa was adopted to the standard specifications of JHC and publicly operated housing, which unfortunately led to stereotypical design houses that looked nearly identical. Also, a pre-stressed concrete (PC) [064], especially PCa crimping structure pre-stressed by post-tensioning, came into wide use in the 1970s for buildings of large spans, such as warehouses, stadiums and bowling alleys.

ALC [073], a type of foam concrete, was developed in Japan as a lightweight and effective fire-resistive material for small- mid-size steel structures and is now widely used for exterior cladding of skyscraper condominiums and also for fire-resistive partition walls in all types of steel structures.

Instead of steel-reinforced concrete, bamboo-reinforced concrete [062] was used as an alternative material [062] during the war, due to a shortage of iron. Still today, research is being done to develop a new type of concrete, which would be reinforced with an alternative material to steel, such as carbon fiber, in order to prevent the reinforcement from rusting due to neutralization and salinity.

For the exterior finish of concrete structures, tile, stone, brick and mortar were commonly used before the World War II. After the introduction of an exposed concrete-finish [063] to the world by Antonin Raymond, his Japanese disciple, Kunio Maekawa used the same concrete finish for his building designs after the war, which was in turn used by Tadao Ando, who has designed many world-renowned exposed-concrete buildings.

Modernization of Housing Equipment/ Materials

From the post-war restoration through the period of high economic growth, remarkable progress was made in the design of Japanese housing. First, concerning hygiene conditions; vault toilet, which used to be a common type of toilet, was gradually replaced with a flush toilet. However, the sewage system was not designed for flush toilets, thus *Johkasou* systems (domestic wastewater treatment facilities) [081] was commonly installed, which secured the minimum level of required hygiene. At the same time, the Japanese-type toilet (squat type) began to be replaced by the Western-style toilet [080], which had recently been equipped with a warm-water rear-wash function. Thus, the lavatory has been changed from an "unclean room" to a "comfortable room".

Innovative changes have also been made to the kitchen as well, through the introduction of the dining-kitchen room, which considerably reduced the housework assumed by women. This new kitchen was technically enabled by the introduction of the stainless-steel sinks [078], which is mass produced by integral press-molding, which later led to the development of the built-in kitchen unit. Back in the day, the houses of common people in urban areas did not have bathtubs, thus the people ordinarily used public bath facilities. This changed with the introduction of the gas water heaters [076] and the prefabricated bathroom unit [079]. An FRP (fiber-reinforced plastic) unit bathtub, which was combined with a washing space, is widely used, due to the high waterproof quality of fiberglass and its workability. It was initially made for hotels and multi-unit housing, but it later became common for use in detached houses. This was supported by the development of small, but high-performance water heaters. It should be noted that the ventilation fan [077] greatly contributed to the innovations of the commode, the kitchen and the bathroom.

Regarding detached houses, new structural types appeared after the war, in addition to the conventional post-and-beam structure, i.e., the prefabricated structure and the two-by-four structure. For all of these structural methods, various new building materials [074] were increasingly being used as substrate materials, such as plywood [074], gypsum board, PVC sheet, and so forth. In recent years, however, the use of these new materials has made it difficult to disassemble and sort out materials for re-use and recycling from those to be discarded, which is currently posing a question regarding their use from the viewpoint of the re-use and recycling of building materials [066].

Technologies that Support Building Construction

In the early stages of building construction, a steel window-sash was commonly installed, which was replaced by an aluminum sashes [070] after the war, and at the same time, factory-made sashes became popular. Use of these sashes extended to the housing sector, which eventually made an important contribution to the demand for insulation/energy efficiency [087] that was raised as a result of the oil crisis. With the abolition of the building height restriction in the building standards, increasing number of high-rise buildings and skyscrapers began to appear, which brought about a boom in the installation of curtain walls [071] as non-load-bearing cladding. Accordingly, the progress that was made for glass used for openings was outstanding, and in the 1990s, glass buildings [072], employing a high-performance heat-reflective glass and a Low-E glass, took the architectural world by storm.

The progress of electric equipment/lighting appliances [082] has made an enormous contribution to large-scale office/commercial buildings, as well as to other types of buildings. In the 1980s, as the use of computers became very common, intelligent buildings [086] emerged, installed with LAN and other information circuits, which are now standard specifications for large office buildings.

Elevator [084] technology, which is now indispensable for every tall building, was introduced from the US, and later, when skyscrapers became common, a high-speed elevator was developed in Japan, which is now a renowned Japanese technology. Since 1970, the district heating/cooling system [085] has commonly been employed for skyscrapers and other office buildings.

While buildings became larger and larger, and with the non-combustible properties of wooden buildings having been improved, the concern regarding large fires shifted from the spread of fire in urban areas to fires in large-scale buildings. To prevent such building fires, legal requirements for opening protective assembly [083] were strengthened, which led to the improvement and diffusion of fire doors/shutters.

Workers who historically supported all of the building construction had been suffering in awful working conditions and in a premodern labor environment. The labor environment improved though, due to the measures to ensure safety of workers [067], which was implemented by GHQ (General Headquarters). The Industrial Safety and Health Act was created in the 1970s, to which a number of amendments have since been made. As a result, the number of fatal accidents involving construction workers has decreased to one-seventh of the number of a half a century ago.

Production Technologies in Future

In the last 100 years, tremendous progress has been made in building production technologies. Currently, addressing global warming is an issue, along with the aging population and a declining birth rate. As a countermeasure to global warming, every building constructed from now will be required to be, to a greater or lesser extent, a sustainable building [088]. Also, under the chronic labor shortage and demands for workplace reform, it is imperative that production efficiency in the construction sector be improved further. The key issue for improved production is automation technology, such as construction robots, for which wide use of BIM [068] (an advanced technology of CAD [068]) is indispensable.

1 Production

061
Cast-in-Place Concrete

Dramatically advanced by concrete batch plants and pressure pumps in the economic growth period

Reinforced concrete structures of cast-in-place concrete were introduced at the end of the Meiji era. This method was dramatically improved after the World War II, through the introduction of concrete batch-plants and the advancement of concrete pressure-pumps and chemical admixtures.
In recent years, high-strength concrete of more than 100N/mm^2 compressive strength has become widespread and is currently used for construction of skyscrapers.
Various other technical developments have been made, such as a self-compacting concrete, which does not require a vibration compaction process. This evolution has contributed to the creation of architectural masterpieces based on the free ideas of architects.

062
Alternative Materials, e.g. Bamboo-Reinforced Concrete

Materials that symbolize hardship in wartime

In the period from the Sino-Japanese War through the Pacific War, all Japanese industries and laborers were under the control of the government, and in the building sector as well, the use of steel, a major building material, was greatly restricted.
As an alternative to steel, building-product manufacturers turned to wood, cement, pottery, synthetic resin and bamboo to manufacture various building products, such as hinges, sash rollers, structural plywood, etc.
Much research was done on bamboo regarding its replacement for steel as reinforcement of concrete structures. It was said that bamboo-reinforced concrete was used for construction of bridges, bunkers and some buildings, which, however, is not known whether it is true or not.

063
Exposed Concrete Finish

A concrete finish developed in Japan that led the way

The world's first building of exposed concrete is said to be Église Notre-Dame du Raincy (The Church of Notre Dame du Raincy), completed in 1922, which was designed by Auguste Perret.
Several years later in Japan, Antonin Raymond designed many buildings of exposed concrete, and became recognized as a world-leading expert in this field.
After the World War II, Tange Kenzo and some other Japanese architects adopted the exposed concrete finish for the restorations of many public buildings.
Inspired by this trend in Japan, many American architects began using this finish. In this way, the Japanese exposed-concrete finish had considerable influence on architecture around the world.

061

062

061–063

the Edo era: 1603–1868 / the Meiji era: 1868–1912 / the Taisho era: 1912–1926 / the Showa era: 1926–1989 / the Heisei era: 1989–2019 / the Reiwa era: 2019–

064
PCa Concrete/PC

Structural method that rationalized construction process leading to realization of large-span buildings

The precast (PCa) concrete method is a construction method by which pre-manufactured concrete members are taken to the building site and to be assembled there.
Through this method, mid-rise multi-unit residential buildings were mass produced by using large factory-made, concrete panels. Factory-made columns and beams also came into widespread use, especially for high-rise buildings.
The pre-stressed concrete (PC) method is a construction method that applies stress to concrete by using high-strength steel.
As it is a method to simplify the construction process of large-span buildings, the PC method has been used for the construction of gymnasiums, stadiums, distribution warehouses, factories and so forth.

065
Foundation/Ground Improvement

An "unsung hero" that has supported buildings for centuries

Wooden piles are traditional foundation components, and a part of the technique is seen in the pile dwellings in Switzerland that were constructed before 3000 BC to provide protection from floods.
Up until the 1950s, wooden piles were major components to support buildings from underground. In Japan as well, pine piles were found in perfect condition when the Old Marunouchi Building was demolished, which dumbfounded many building engineers.
Since the beginning of the Meiji era, concrete-pile techniques were introduced from France and the U.S. in accordance with the diffusion of reinforced concrete structures in Japan. Concrete piles actually supported buildings in Japan from deep underground as a sort of "an unsung hero".

066
Reuse/Recycling of Building Materials

Resource utilization technology to realize a recycling society

Technologies to enable the efficient re-use and recycling of limited resources are indispensable for creating a recycling society.
In the building sector, the reuse of materials is the process of removing some of the building components from dismantled buildings and use them for other buildings without any processing. In recycling process, on the other hand, materials such as concrete and wood collected at dismantling sites are transported to intermediate treatment facilities for recycling.
For recycling of building materials, technologies are required for three processes: collection and transport of materials, intermediate treatment to render the materials usable again, and the manufacturing of the final products.

067
Measures to Ensure Safety of Workers

To prevent fall accidents at construction sites

Until the late 1990s, more than 1,000 workers were killed annually in construction accidents in Japan, which accounted for 40% of the total number of labor accidental deaths.
The most frequent types of accidents in this industry are the result of workers falling from buildings under construction. To prevent such accidents, enforcement orders and guidelines concerning scaffolds and safety belts were enacted.
Regarding scaffolds, a prefabricated type was developed and has been widely used in Japan, which is to assemble a building constructing scaffolding using ladder frame and cross brace.
As for safety belts, a conventional body-belt type was used for many years, however, a harness type has become obligatory in order to secure a higher level of safety of construction workers.

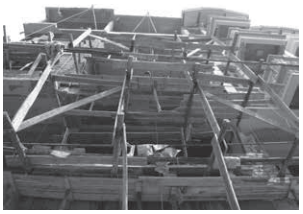
068
CAD/BIM

Drawing system was fundamentally changed in accordance with progress of computers

In the late 1970s, drawings made by CAD, instead of traditional manual drawings, gained popularity among designers, but there also was a strong objection to this trend.
However, in accordance with progress made in computer technology, the use of CAD drawings became so dominant that it was almost like a prerequisite condition for the design and building construction works. The method of drawing was overturned with the changes of a concept of "layer" and "content library".
In the late 1980s, 3-dimensional CAD was introduced, but its use was stagnated due to the collapse of the bubble economy. In the first decade of this century, however, it was reintroduced in a different form, called BIM, and is now about to once again drastically change the system of architectural drawing.


064


066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069

069
Exterior Tiles

A typical exterior finish that was developed in Japan

Buildings with exterior tiles are very popular and commonly seen in Japan. They give Japanese people an image of a modern design and the Western style, even though it is not common in Western countries to tile an entire exterior wall of a building.
Exterior tiles were introduced to Japan along with the modernization of the country. These were favorably accepted by Japanese people, developed through an ingenious idea and became widespread in Japan, later spreading to other Asian countries.
Peeling has been the crucial problem regarding the use of exterior tiles since they were introduced. Overcoming such difficulty, buildings with exterior tiles are still popular and being constructed today.

070
Aluminum Sashes

A component that drastically improved the performance of building openings

Currently, aluminum is an indispensable material as a component of building openings.
Before aluminum was introduced by the building industry, steel sashes were used extensively, however, it was quite natural to shift to aluminum, considering its high performances of manufacturing, processing and durability.
When aluminum was initially used to manufacture sashes, they were made by simply switching the material from steel to aluminum using the same production system. It was after the development of the closed section aluminum profiles that aluminum sash became dominant and the age of the aluminum sash industry began.
As the demand for high quality housing increased, the performance of sashes was also improved, and various types of high-quality, durable aluminum sashes were manufactured, which are now indispensable components for openings of every type of building.

071
Curtain Walls

External wall system developed concurrently with skyscrapers

"Curtain wall" is normally used as a general term of "non-load bearing wall", however in Japan, it refers to systematized exterior walls, often installed in skyscrapers.
After the war, they were adopted for ordinary office buildings. When construction of skyscrapers began, their use gradually increased, as technologies were developed to secure high seismic strength and durability of various finishing materials.
Metal curtain walls are prevalent in other countries because of its light weight, but in Japan, the majority of curtain walls are of precast concrete with an outer surface of tile or stone.
Recently, new types of composite curtain wall are often used, which are made by combining metal and precast concrete curtain walls.

072
Glass Buildings

Transparent buildings realized by technique making supporting members inconspicuous

In the 1920s, Ludwig Mies van der Rohe proposed a plan for a building whose entire exterior would be covered with glass, which was, unfortunately, too difficult to be realized.
In Japan, the introduction of a float-glass manufacturing technique in the 1960s enabled the mass production of transparent-flat glass.
In order for the support members of glass to be less conspicuous, several techniques, such as the SSG (structural silicone glazing) method, the glass rib method and the DPG (dot point glazing) method, were developed in the late 1960s, which paved the way for the design of transparent-glass buildings. Combined with eco-friendly technologies such as double-skin glass, a variety of attractive glass-buildings are being constructed.

073
ALC

High strength concrete light enough to float on water

Prefabricated building components were indispensable for the modernization and industrialization of the building production system during the period of high economic growth in Japan.
ALC (autoclaved lightweight aerated concrete) was developed in Scandinavia, one of the coldest areas in the world with a long wintertime, as concrete with a high thermal-insulation property. After being introduced to Japan, it was developed to satisfy the specific needs of each era in Japan.
ALC is a mass-produced lightweight precast component that has incredible properties, which have contributed to the improvement of fire safety in urban areas, as well as the overall habitability of residences.

071

064–073

the Edo era: 1603–1868 / the Meiji era: 1868–1912 / the Taisho era: 1912–1926 / the Showa era: 1926–1989 / the Heisei era: 1989–2019 / the Reiwa era: 2019–

074 Plywood/New Building Materials

Products in widespread use, due to their excellent performance, workability and cost effectiveness

A wide variety of new building materials have been developed and used for many common wooden houses in Japan. Among them, plywood is representative of wooden building-materials, which are used as finishing material, substrate material, structural panel and also as concrete form-board.
Gypsum, an inorganic material that is used to make gypsum board, has superior fireproof and sound-insulation properties, excellent workability and is cost effective, which made it widely used as interior materials for ceilings and walls.
Furthermore, "wooden boards", a generic term for OSB, particle board, MDF and the like, are also used as materials for structural substrates and furniture/woodcrafts.

075 Waterproofing for Roofs

Material for flat roofing that allowed for flexibility of building planar plans

As Japan experiences a high amount of rainfall, housing traditionally had only pitched roofs, which is effective for drainage. An asphalt roofing technique that was introduced to Japan in the Meiji era enabled construction of flat-roof buildings. Asphalt roofs were welcomed by many building designers who wanted to freely design floor plan without being restricted by the roof shape.
After the World War II, a new type of high-polymer material was developed, which was used for membrane waterproofing. This was widely accepted in the industry, due to its light weight and the quick installation process.
For pitched roofing as well, a variety of materials were developed and diffused, such as cement-based corrugated sheet, roofing slate, and metal-based materials such as zinc-coated steel sheet and galvalume steel sheet.

076 Gas Water Heaters

Hot-water supply system developed to respond to the needs of the times

When RC multi-unit residential buildings began to be constructed, the bathtubs installed in each housing unit had a problem with the flu gas exhaust, which was solved by the development of the BF type (closed and balanced flue type) bath boiler. This new equipment helped secure the safety and comfort of urban workers, who supported the sharp growth of the post-war economy in Japan.
Further efforts of seeking a more convenient, comfortable and safer lifestyle led to the development of the RF type (rooftop flue-type) water heater, which is unique to Japan.
Necessitated by the oil crisis and the global trend toward environment protection that began in the late 20th century, more efficient water heaters, like Eco-Jaws and Ene-Farm, were introduced in Japan.

077 Ventilation Fan

Equipped first in kitchens, then for toilets and in bathrooms, and finally all around the house

Ventilation fans became common in Japanese housing since Japan Housing Corporation (JHC) adopted them for the rental housing units, which were first constructed in the 1950s. They were provided for the purpose of preventing condensation and mold.
During the 1960s, ceiling embedded ventilation fans were developed, which exhausted the air through a duct system. This ventilation system enabled to make floor plans that locate damp rooms, such as kitchens and bathrooms, in the center of the housing unit, which does not face outside.
In the late 1960s and thereafter, Japanese housing became more and more airtight. To correspond to this, a continuous (24-hour) ventilation system was developed, and more recently, higher-quality ventilations systems combined with heat exchangers have appeared on the market.

078 Stainless-Steel Sinks

A leading product for kitchen innovation that changed the image of home life

The lifestyle innovation that occurred in post-war Japan might be symbolized by the change to the kitchen design, with a stainless-steel sink placed in the center. Until the 1950s, most sinks were made of materials such as some metals that easily became rust stained, artificial stones or concrete. Production of stainless-steel sinks had already begun at that time, however, they were still high-end products, thus not affordable for most people. It was Japan Housing Corporation (JHC) that disseminated stainless steel sinks. Their first application was in the Harumi Danchi project that was completed in 1958, in which Hamaguchi Miho, the first female architect in Japan, was deeply involved in its design. In the background of this innovation, there was an important contribution made by a company that achieved mass production of stainless-steel sinks through extrusion molding press.

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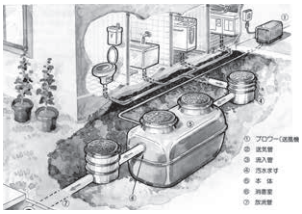

081

source: Ministry of the Environment Government of Japan

source: Panasonic Ecology Systems Co., Ltd.

079

Prefabricated Bathroom Unit

Revolutionary component that solved water leaks from bathrooms

It is required for bathrooms to have properties of waterproofing, damp proofing, water resistance and fireproofing, except of course for the water supply and drainage systems. Traditionally in Japan, people in highly populated areas went to public bathhouses, and in the case of houses with bathtubs, bathrooms were normally located outside the house or in the corner of the house unit. Gradually, it was required to equip every housing unit with an individual bathroom, which led the development of prefabricated bathroom unit. This bathroom units were increasingly adopted to high-rise buildings, including hotels and multi-unit residential buildings. Because of the Japanese custom of washing themselves outside of the bathtub, prevention of water leaks was a critical issue in constructing bathrooms. Development of the prefabricated bathroom unit was the ideal solution to the problem, and it is now indispensable for Japanese housing.

080

Western-Style Toilet

Is the Japanese-style toilet now an endangered species in Japanese housing?

It was about 100 years ago when the first Western style flush-water toilet was manufactured in Japan.
At that time, this type of toilet was not widely accepted by people, however, it suddenly became popular since the Japan Housing Corporation (JHC: established in 1955) adopted this toilet as its standard specification.
Currently, almost 100% of toilets delivered by Japanese manufacturers are Western style ones.
It is characteristic of Japan that almost 80% of housing are currently equipped with a warm water washing toilet, called "Washlet".

081

Johkasou Systems (Domestic wastewater treatment facilities)

Environmental equipment that contributed to living standard improvement and aqueous environment preservation

Development of *Johkasou* system (domestic wastewater treatment facility) enabled to install flush toilets even in areas where sewage systems are not available, which played an important role in improving people's lives. At first, a single-sewage treatment *Johkasou* was used, which treated only wastewater from commodes. This has been replaced by a multi-sewage treatment *Johkasou* system, which is a tank that treats sewage from commodes, as well as general household wastewater, including those from kitchen, washing, bathing, etc. It may be said that the role of *Johkasou* system changed from sanitary equipment to an environmental protection system, as it has greatly contributed to the preservation of the aqueous environment. The Japanese term, *Johkasou*, is now used overseas in reference to this unique equipment that was developed in Japan for wastewater treatment of individual households.

082

Electrical Equipment/ Lighting Appliances

From the incandescent light and the fluorescent light to energy efficient LED

In the trend of Westernization in the Meiji era in Japan called "civilization and enlightenment", a new age of electricity began with the introduction of the incandescent lamp. Improvement of lighting appliances has been made over the years, together with advancements in creative interior designs of commercial facilities.
In recent years, energy efficient LED has been used as a light source, replacing conventional incandescent and fluorescent lights.
Electrical equipment in buildings is supported by electrical substations, which are equipped with multiple electrical lines and emergency power sources in preparation for power failures.
Electric equipment of the next era will be an innovative integration of hardware, software and human ware with the aim to achieve an ideal "fusion" of building engineering and electrical engineering.

083

Opening Protective Assembly

New techniques employed by learning from experiences of conflagrations

In the Urban Building Law formulated in 1919, installation of fire doors/windows was stipulated for parts of exterior walls that are liable to catch fire in buildings that are constructed in Fire Prevention Zones.
After the Great Kanto Earthquake, it was found that the amount of damage by fire was larger than that by building collapse as a result of the quake, which accelerated the diffusion of fire doors/windows and fire shutters.
After the Shirokiya Department Store Fire in 1932, the installation of fire shutters inside of buildings was begun in order to divide large spaces into multiple fire compartments.
Following two successive fires at large commercial buildings in the 1970s, a smoke/fire preventive shutter was developed, which is highly airtight and automatically closes when smoke is sensed.

083

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084
Elevators

Technological progress of lifts to improve vertical movement of people

As buildings became higher, elevators, which vertically transport passengers in cages, were becoming popular. During this process, various innovative elevator-technologies have been invented.
These include: an elevator with no machine room developed by minimizing the sizes of winches and control equipment; a variable double-deck elevator with an improved transportation capacity, which enables operation in buildings with floor heights that are not uniform; and an elevator that can be operated in buildings with a seismic isolation system installed in the middle floors; and an ultra-high speed elevator, exceeding 1000m/min.
There are further efforts taking place now to improve the safety and security of elevators, which are: setting a mandatory requirement for each elevator to be equipped with a device to prevent people from being trapped inside; and improving strength and durability of cables.

085
District Heating and Cooling System

Born as an anti-pollution measure and now dispersed as an environmental conditioning facility

The district heating & cooling system is an intensive heat-source system, which mass produces cold and heat within a region and delivers cold water, hot water and steam to multiple users. The pioneering example in Japan was in the Tokyo Imperial University Hospital, where a district heating and cooling system was installed in 1895. With this system, steam was delivered to seven wards from a central boiler room, which was called "school-building type district heating". "Business-type district heating/cooling", by which heat is supplied by corporations or individuals other than the user, began in 1966 in Japan with Enzan-Kitamchi Jutaku *Danchi* in Sapporo city. The district heating/cooling system was incorporated in the City Planning Act in 1968 as part of the urban infrastructure, and consequently, was approved as part of the public works under the Heat Supply Business Act, 1972. Since then, it has gradually been diffused throughout Japan.

086
Intelligent Buildings

Introduced in accordance with advancements in information and communication technology

In the 1980s, an increasing number of office buildings were equipped with an abundance of electronic appliances, due to the rapidly spreading information and communication technologies, which required upgrades of the electrical, ventilation and wiring capacities of buildings, as well as consideration for the health of building occupants. Also, the use of computers for digitalized telecommunications together with an advanced sensor technology brought about huge improvements in energy efficiency and optimization of building equipment as well as in the comprehensive safety of the building as a whole. Liberalization and deregulation of the telecommunication industry also had a considerable impact on the planning of buildings. In 1984, the first building to be called an "intelligent building" opened in the US, the excitement of which quickly spread to the Japanese building sector.

087
Insulation & Energy Efficiency

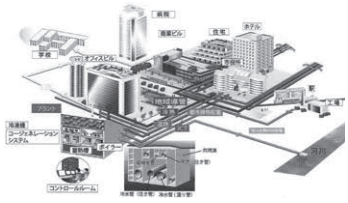
Essential elements for a sustainable society

Japanese building-insulation techniques spread from Hokkaido, the coldest region, to most other areas in Japan. In 1969, a standard for building insulation was established for the purpose of reducing costs for heating, as well as preventing surface condensation on buildings. After the first oil crisis in 1973, energy conservation became a serious social issue, and in 1980, an enforcement order under the BSL was enacted that provided insulation standards for housing together with their design and construction guidelines in order to facilitate energy savings of housing. Since then, installation of insulation has been promoted nationwide and its regulations/standards have been amended and strengthened many times to the present day. There are various kinds of insulation materials, which are mainly grouped into two types, fiber-type and formed plastic type. In terms of insulation of windows, double-glazed windows became popular in the 21st century in Japan, which has considerably improved the insulation performance of Japanese housing.

088
Sustainable Buildings

Buildings that contribute to the creation of a sustainable society

At the end of the 20th century, many environmentalists started warning of global environment problems, with a prediction that if the world population and economy continued to grow, global warming and destruction of the ecology would further proceed, and thus damaged the basis of human society to the point of no return.
Buildings in the modern era have been developed with a sort of 'artificial environmental technologies' which allow consumption of vast amounts of energy as a necessary antecedent. New approaches for reducing ecological footprints have been explored; from the stage of production of materials, through the period of product use, to the stage of product demolition.



085
source: Japan Heat Supply Business Association

088

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Chapter

V

POLICY/ REGIONAL PLANNING

Disaster Prevention

Japan deals with many natural disasters. It has experienced many such disasters in modern times, and the first of those to occur after the establishment of the Urban Building Law in 1919, was the Great Kanto Earthquake in 1923. In Tokyo, the most seriously damaged area, the reinforced concrete structure, a new structural method at that time, was used for the rebuilding of primary schools considering its superior seismic and fire-resistive performances. These were later called "*Fukko Shogakko* (Restoration primary schools) [089]". For wooden school buildings built before the introduction of the reinforced concrete structure, improvement was also made for their structure after the Muroto typhoon hit in 1934.

During the World War II, Japanese buildings that were made with wood and paper were completely destroyed in great numbers by incendiary bombs. Reflecting this experience, Japan vigorously promoted the creation of cities where large conflagrations could be prevented. One of the measures that was proposed was the construction of fire-preventive building zones [090], which were "belts" of fireproof buildings to function as firewalls for the city. These were eventually constructed in nearly 100 cities throughout the country. This idea was succeeded by the concept of fire preventive zone under the Disaster Prevention Block Development Law which was the basis of the current urban-space planning.

Going back to the Taisho era, there had been many residential districts in urban areas that were deteriorated, thus, slum-clearance measures [091] were taken in some districts. It was not until after the war, however, that extensive measures were taken to address this issue, when it was acknowledged that the existence of such huge areas of slums seriously impeded the development of urban areas. Among various countermeasures, one notable project was "Sakaide Artificial Ground", developed in 1968, which was an attempt to create a comfortable residential environment in collaboration with a challenging type of architecture.

Under the economic prosperity afterwards, concentrations of people in urban areas became conspicuous, and cities were fully built-up with housing. When the Great Hanshin-Awaji Earthquake occurred, in 1995, this congestive-city problem was suddenly recognized as a serious social issue. Through this experience, measures for densely populated urban areas [092] were established to address the problems related to over-developed cities, and to improve living environments by, for example, providing a sufficient number of open spaces in urban areas.

Culture

In the process of social restoration, problems arising in line with the economic growth were demolition of historically significant buildings, together with the surrounding traditional streetscapes. Various policy measures have been proposed to address this issue which, however, do not seem to be sufficient. Concepts of preservation/conservation of historic architecture [093] and conservation of townscape [094] still remain as challenging issues.

On the other hand, when a massive housing supply was urgently required, houses were built in a stereotyped style; all of the same design and with the same materials. When the housing shortage problem was resolved, promotion began for the construction of regional houses [095], i.e., houses that incorporated regional characteristics, which was represented by the HOPE (Housing with Proper Environment) Plan.

Later on, the renovation and conversion [096] of buildings have emerged as new issues with the mature society and sluggish economic growth as a background. These are vitally important subjects, as it is now strongly required to re-utilize existing buildings as social assets.

It is particularly interesting to know that measures taken to address these key issues have been created by grass-roots activities, rather than by bureaucrats and authorities.

A type of building that is rather peculiar in this booklet, and also in Japan in general, is colonial architecture [097]. Before the current national boundary was delineated, Japanese boundaries used to be extensive, and many cities and buildings were developed by the Japanese people in the areas not within present-day Japanese territory.

Legal Framework

When considering how to control construction of buildings that constitute urban spaces, it gradually came to be realized that the existing simple restriction of building height limit, which was provided in the Urban Building Law, was not sufficient to respond to the social demands for higher-density accommodation in urban areas and for construction of taller buildings that has been enabled by advancements in technology. Thus, the concept of floor-area-ratio restriction [098] was thought out.

Later on, demand for building quantity was satisfied and the quality became an important requirement, which included barrier-free designs in special consideration for people with disabilities and for the growing number of aged people. Then its scope was extended to include every single person, not only people in need, which is known as universal design [099].

It is said that generally, formation/revision of legislation tends to follow social movements. Under such a tendency, the most important change of the Japanese building legislation in the 20th century must have been the introduction of performance-based building regulations/standards [100] from the conventional specification-based standards. This revision was made with the aim to ensure that building standards may swiftly reflect technical developments of the time. The revision has had some positive effects so far and is expected to generate more significant results in the future.

1 Disaster Prevention

089 *Fukko Shogakko* (Restoration primary schools)

A new type of school building, born of the rebuilding after the Great Kanto Earthquake

Fukko Shogakko (Restoration primary schools) are a group of primary schools that were constructed during the course of rebuilding around Japan after the Great Kanto Earthquake.
By applying a design code specifically developed for the schools, these reinforced-concrete school buildings enabled sufficient fireproof and seismic performances in a short period of time.
Some of the objectives of *Fukko Shogakko* were implementing the New Education proposed in the Taisho era in Japan and serving as cores of the social education of each region. To this end, these schools were planned to have multiple functions, which later formed a basic concept of the current "open schools".

090 Fire Preventive Building Zones

Building shields to prevent fires in urban areas

There are several ways to make a city fireproof; however, in existing urban areas, it is difficult to implement such measures as they would require drastic renovation of the structures of cities. To solve this difficulty, an innovative plan was thought out from the viewpoint of "turning a war disaster into an advantage", which was development of fire preventive building zones; belts of nonflammable buildings that could prevent the spread of fire, much like shields to protect the city. Fire preventive building zones were usually constructed along main streets. In some cities, these zones gradually formed shopping streets with stores like row-house, which attracted people to move there, and they eventually became lively city-centers. Fire preventive building zones contributed not simply to creating fireproof cities, but also to keeping the quality of people's living and to forming the townscape as well.

091 Slum Clearance

Improve deteriorated residential areas to create new living environment

It was 1920 in Japan when measures were taken to address the problem of slums as there was a sudden increase of deteriorated residential areas, which was caused by the rapid urbanization and industrialization of large cities. In accordance with the Act for the Improvement of Deteriorated Residential Areas formulated in 1927, scrap-and-build style residential redevelopments were implemented, that was; within a district designated for residential improvement, demolished old houses and constructed a sufficient number of new houses so that the existing residents could continue to live in that district. In the economic growth period after the war, deteriorated residential areas were considered to be a hindrance to the development of the city as a whole. Succeeding the previous act, the Act for the Improvement of Residential Areas was formulated in 1960. Based on this new act, the Sakaide Artificial Ground in Kagawa prefecture and Motomachi/Chojuen housing complexes in Hiroshima city were constructed.

092 Measures for Densely Populated Urban Areas

From improvement of the living environment to strengthening disaster prevention

Densely populated urban areas have long been a serious problem in the history of city planning in Japan, and many measures were taken to cope with this issue, including slum clearance.
When the World War II ended, new housing supply programs were carried out in the Kyojima district in Tokyo and some other areas, by which new public housing was provided for existing residents of the area, while rebuilding the deteriorated houses.
After the Hanshin-Awaji Great Earthquake, the function of disaster prevention was considered to be more important than the improvement of the residential environment in densely populated urban areas.
Current measures taken to address the issue include; providing more area for public open-spaces, increasing floor area in fire-resistive buildings, and providing streets that could function as firebreaks.

2 Culture

093 Preservation/ Conservation of Historic Architecture

Formulating legislation for utilizing stock in urban areas

In the period of high economic growth, it was difficult to preserve/conserve historic architecture, as the efficient use of land had a top priority.
In recent years, however, it has become important to efficiently utilize stock (existing architectural resources), while carrying out urban renewal projects. Accordingly, various legislation has been formulated to allow for development, and at the same time, the preservation/conservation of existing resources as well.
While the need for preservation/conservation of valuable buildings is growing, new approaches have recently been taken, such as commissioning local governments to legislate their own regulations to preserve/conserve historic resources in their jurisdictions.

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100 Key Terms

094 Conservation of Townscapes

"Favorable townscape", identified by each region

Measures for townscape conservation have been implemented under joint enforcement of the Law for the Protection of Cultural Properties, the City Planning Act and the Building Standard Law.
From the 1960s to the 1970s, a movement to conserve townscapes occurred across the country, which led to the current activities of re-evaluating and maintaining old and modern architecture that form townscapes unique to each region, although they are not as valuable as national cultural resources.
Various measures are now being developed to create beautiful townscapes for the future, which will remain as one of the scenes of the history, while respecting the characteristics of each region.

095 Regional Houses

Measures to provide houses suited to each local climate and culture

Beginning in the Meiji era, Japan adopted Western style housing with both the exterior look and designs of the living space. After the World War II, there was no room to consider the regional climate or culture when constructing houses, due to a severe shortage of building materials and labor for the huge housing demand. Under the sharp economic growth afterwards, a nationwide housing provision plan was carried out, facilitated by the development of new building materials/components and production technologies, as well as the trends towards the nuclear family and urbanization. However, houses had traditionally been built with floor plans, forms and materials that reflected each regional characteristic. Those houses actually created the townscape and scenic beauty that is unique to the region, which eventually generated a specific local attractiveness. Based on such view, the "HOPE (Housing with Proper Environment) Plan" started in 1983 as a government program for promoting housing that is suitable for each regional climate and culture.

096 Renovation/ Conversion

Towards new value of architecture created by growing imagination for building usage

From the late 1990s through the first decade of the 2000s, there was a fundamental shift in the Japanese building industry; from the period when newly built construction was dominant, to the era of repair/renovation/usage conversion of existing buildings.
Housing starts, which once reached almost two million units a year, steadily declined and have been fewer than one million units a year since 2009. Currently, the housing stock surplus is a serious problem that reflects the shrinking population. In order to utilize the value of the housing stock, renovation/conversion is inevitable to keep them as social assets. This idea is now a major trend in the building industry and in the cultural sector as well.

097 Colonial Architecture

Facilities/style/structure/regulations that demonstrates governing power

Japan constructed a variety of buildings in colonies that Japan governed from the end of the 19th century through the early 20th century.
The priorities were facilities required for colonial governance, which were government buildings and hospitals.
Brick construction was used for the structures of these buildings for the purpose of making the cities safe from fires, while maintaining their aesthetic value.
Initially, those buildings were modeled after the architecture of powerful Western countries, such as Queen Anne style- and Neo-Baroque style buildings. However, in 1931, when the Manchurian incident occurred, Japan began to adopt Asian-style architectural designs.

098 Restriction of Floor Area Ratio

A means to regulate density in urban areas

As the total floor area of buildings grows, the active population of the area increases, which imposes a bigger load on the infrastructure, such as roads and water/sewage systems.
The restriction of the floor-area ratio is a measure to balance the total building floor area of a city and the capacity of the city's infrastructure by restricting the ratio of the total floor area of each building to the building lot.
In the old days, the density of a city was controlled indirectly by restrictions on the maximum building height and the building coverage ratio. To comply with the boom of higher and larger-scale building construction during the period of high economic growth, the density control method was changed in favor of the restriction of floor-area ratio.

096

097
photo: NISHIZAWA Yasuhiko

089–098

the Edo era: 1603–1868 / the Meiji era: 1868–1912 / the Taisho era: 1912–1926 / the Showa era: 1926–1989 / the Heisei era: 1989–2019 / the Reiwa era: 2019–

099

Universal Design

From barrier-free for the disabled, to a subject common to all human beings

The barrier-free design, which was established during the 1980s in Japan, was based on the premise of excluding all existing barriers in the physical environment, people's consciousness, information and social systems. Beginning in the 21st century, on the other hand, a universal design spread, which aims to allow access to as many people as possible to spaces, the environment, products, and the provision of services.
A point common to both barrier-free and universal design is their objectives, which is to establish cities and a society where diversity is accepted and no discrimination exists, in order to eliminate existing barriers and to prevent the creation of new barriers in the future.

100

Introduction of Performance-Based Building Regulations/ Standards

Changed to legislation that enhances design flexibility and introduction of new technologies

Specification-based regulations/standards require buildings to conform to specifications of size, shape, used materials, etc. that are stipulated in the regulations, whereas performance-based regulations/standards simply require buildings to have a certain level of performance. Under performance-based regulations/standards, it is possible to use various materials, equipment and structural methods if they satisfy the required performance, which heighten the flexibility of building designs, and also streamline the process of introducing new technologies and products from overseas. The Building Standard Law was initially established as specification-based regulations/standards. For products/technologies not specified in the Law, it was required to obtain approvals under Article 38 of the Law. In 2000, the Building Standard Law was drastically revised in order to incorporate performance-based regulations/standards into it.

099–100

100th Anniversary of Enactment of City Planning Act and Building Standard Law

Architecture that Supported Modernization of Japan — 100 selected building technologies

Table of Contents

- Preface
- Contents
- Chronology
- Overview: Modern and Contemporary Japan Supported by Architecture
- 100 Selected Building Technologies
  - Chapter 1 Housing
  - Chapter 2 Buildings
  - Chapter 3 Structural Methods
  - Chapter 4 Building Production/Facilities
  - Chapter 5 Policy/Regional Planning
- Roundtable Talk:
- Index
- Writers Profiles

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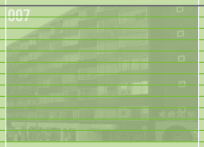
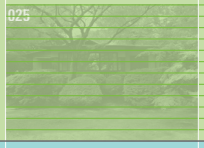
003 Coal Miners' Housing	KIKUCHI Shigetomo
004 Publicly-Operated Housing and Japan Housing Corporation (JHC) Housing	TAKADA Mitsuo
005 *Danchi*	UEDA Makoto
006 New Towns	NARUMI Kunihiro
007 Condominiums	KOBAYASHI Hideki
008 Multi-Unit Housing Operated by Private Sector	MORIMOTO Nobuaki
009 *Cooperative House* (Building co-operatives)	NAKABAYASHI Yoshiyuki
010 Collective Housing	HINOKIDANI Mieko
011 Skyscraper Condominiums	ANDO Masao
012 Emergency Temporary Housing and Restoration Housing	WATANABE Shiro
013 Minimal Houses	TSUKAMOTO Yoshiharu
014 GHLC Specification	MIZUTANI Tatsuro
015 Cold-Region Housing	TANIGUCHI Naohiro
016 Housing for the Elderly	SONODA Mariko
017 Housing Performance Indication System	SUMIKURA Hideaki
018 Prefabricated Housing	MATSUMURA Shuichi
019 Pilot Projects	YOSHIDA Takuro
020 Skelton-Infill House (Base building and fit-out for housing)	MINAMI Kazunobu
021 Precutting	GONDO Tomoyuki
022 School Buildings	NAGASAWA Satoru
023 Public Cultural Facilities	SATOH Shinya
024 Government Buildings	ISHIDA Junichiro
025 Modern Architecture	YAMANA Yoshiyuki
026 Okinawan Architecture	MATSUBA Kazukiyo
027 Religious Buildings and Memorials	IGARASHI Taro
028 Tower	YOSHIMI Shunya
029 The Tokyo Olympics	TOYOKAWA Saikaku
030 Japan World Exposition, Osaka 1970	HASHIZUME Shinya
031 Station Buildings with Shoppping Centers	FUJIMURA Ryuji
032 Arcade	TSUJIHARA Makihiko
033 Underground Mall	HATSUDA Kosei
034 Pedestrian Decks	FUJIMURA Ryuji
035 Public Open Spaces	ASAMI Yasushi
036 Urban Redevelopment	ASAMI Yasushi
037 Urban Waterfront Development	YOKOUCHI Norihisa
038 Shopping Mall	MATSUBA Kazukiyo
039 Downtown	ISHIGURE Masakazu
040 Convention Center	ISO Tatsuo
041 Theme Parks	INOUE Shouichi
042 Concrete Block Structures	KUMAGAI Ryohei
043 Steel Structures	YAMADA Satoshi
044 Steel Encased Reinforced Concrete Structures	KUMAGAI Ryohei
045 Reinforced Concrete Structures	FUJIOKA Hiroyasu
046 Seismic Design Provisions	SHIOHARA Hitoshi
047 Seismic Isolation Systems	NISHIKAWA Takao
048 Response Control	WADA Akira
049 Seismic Retrofit	NAKANO Yoshiaki
050 Skyscrapers	GONDO Tomoyuki
051 Tubular Structures	TAKEUCHI Toru
052 Shell/Spatial Structures	SAITOH Masao
053 Membrane Structures	KAWAGUCHI Ken' ichi
054 Retractable-Roof Domes	KAWAGUCHI Ken' ichi
055 Seismic Technology for Wooden Housing	SAKAMOTO Isao
056 Structural Analysis of Traditional Wooden Buildings	KAWAI Naohito
057 Two-by-Four Buildings	ABE Ichiroh
058 Fire Preventive Construction	HASEMI Yuji
059 Fire-Resistive Wooden Buildings	YASUI Noboru
060 Large-Scale Timber Buildings	KOSHIHARA Mikio
061 Cast-in-Place Concrete	NOGUCHI Takafumi
062 Alternative Materials e.g. Bamboo-Reinforced Concrete	HAYAMI Kiyotaka
063 Exposed Concrete Finish	FUJIMORI Terunobu
064 PCa Concrete/PC	OKAMOTO Shin
065 Foundation/Ground Improvement	FUJII Mamoru
066 Reuse/Recycling of Building Materials	TSUNODA Makoto
067 Measures to Ensure Safety of Workers	KANISAWA Hirotake
068 CAD/BIM	KANO Naruo
069 Exterior Tiles	OMI Yasuo
070 Aluminum Sashes	MANABE Tsunehiro
071 Curtain Walls	SEIKE Tsuyoshi
072 Glass Buildings	INOUE Tomo
073 ALC	KITSUTAKA Yoshinori
074 Plywood/New Building Materials	ANDO Naoto
075 Waterproofing for Roofs	TANAKA Kyoji
076 Gas Water Heaters	KURABUCHI Takashi
077 Ventilation Fan	KOMINE Hiromi
078 Stainless Steel Sinks	WADA Nahoko
079 Prefabricated Bathroom Unit	MANABE Tsunehiro
080 Western-Style Toilet	KAMATA Motoyasu
081 *Johkasou* Systems (Domestic wastewater treatment facilities)	IWAHORI Keisuke
082 Electrical Equipment/Lighting Appliances	GOTO Masahiro
083 Opening Protective Assembly	HAGIWARA Ichiro
084 Elevators	FUJITA Satoshi
085 District Heating and Cooling System	IBAMOTO Tadahiko
086 Intelligent Buildings	OKISHIO Soichiro
087 Insulation & Energy Efficiency	SAKAMOTO Yuzo
088 Sustainable Buildings	KODAMA Yuichiro
089 *Fukko Shogakko* (Restoration primary schools)	KANAYAMA Mahito
090 Fire Preventive Building Zones	HAYAMI Kiyotaka
091 Slum Clearance	ISHIGURE Masakazu
092 Measures for Densely Populated Urban Areas	YAMAMOTO Toshiya
093 Preservation/Conservation of Historic Architecture	GOTO Osamu
094 Conservation of Townscapes	EBARA Sumiko
095 Regional Houses	MIISHO Kiyonori
096 Renovation/Conversion	SYNBORI Manabu
097 Colonial Architecture	NISHIZAWA Yasuhiko
098 Restriction of Floor Area Ratio	OSAWA Akihiko
099 Universal Design	TAKAHASHI Gihei
100 Introduction of Performance-Based Building Regulations/Standards	GOJO Wataru

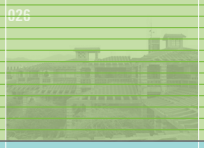
Architecture That Supported Modernization of Japan

100 selected building technologies

An English Summary







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