

and nearshore currents, acting on coastal sediment. However, various artificial causes, such as construction of dams for flood control, water resources and electric power generation, mining of sand from riverbeds, and construction of coastal structures including harbor breakwaters, have impacted strongly on the natural coast, inducing severe beach erosion as a result of a sediment budget imbalance. Considering the present strong demand and shortage of sandy beaches for recreation, it is presently recognized that beach erosion is one of the most serious environmental problems in Japan.

In addition to the beach preservation requirement, water quality in the nearshore area has been a matter of serious concern since the 1970s. The reason is that the coastal water was once badly contaminated by sewage discharged from urban areas as well as industrial plants. In Minamata Bay (Kyushu) the organic mercury discharged from a plant deposited on the sea bed inside the bay, dissolving gradually into water. Through the food chain, a certain number of dwellers near the bay suffered severely from the poisonous substance. The efforts of government officials as well as inhabitants including fishermen over fifteen years, have resulted in a slightly improved situation at present.

In recent years, the Japanese people have realized the importance of human dignity in their daily life. Hence, the concept of seeking a healthy lifestyle has been introduced gradually into the utilization of the coastal zone. The main target of the above approach is to establish a comfortable environment in the coastal zone.

3. Chronological Review of Coastal Engineering Activities in Japan

From the previous section, it is clear that coastal engineering in Japan started substantially in 1953. However, in the following discussion, a chronological review of coastal engineering activities in Japan will be made in each decade starting from 1950 to the present.

3.1. *First decade (1950–1960)*

The main concern of coastal engineers in this decade was coastal disaster prevention as described below. In this decade, Japan was anxious to recover as a nation from the miserable destruction caused by World War II.

As stated previously, in September 1953, Typhoon No. 13 induced a big storm surge inside Ise Bay facing the Pacific Ocean, and thus caused

tremendous disaster, along the bay shore. Due to this natural disaster, the importance of coastal preservation became a matter of serious concern for Japanese people.

Just after the end of the war, serious beach erosion at Niigata, Kaike and Toyama coasts, all facing the Sea of Japan, was recognized from the view point of national land conservation. Thus, government agencies organized an investigation committee for each locality in cooperation with researchers in the fields of oceanography and civil engineering in order to determine the causes of beach erosion and to establish suitable prevention measures.

Under such circumstances, the Sea Coast Act of 1956 was issued by the Japanese government as mentioned previously. In parallel with this event, the Committee on Coastal Engineering JSCE was founded by Masashi Hom-ma with the aim of promoting research activities in coastal engineering in Japan. Since that time, an annual conference on coastal engineering has been organized by that committee up to the present day. The Proceedings of the Japanese Coastal Engineering Conference, written in Japanese, and an English journal, Coastal Engineering in Japan (presently Coastal Engineering Journal), have been issued under the editorship of the Committee on Coastal Engineering since 1955 and 1958, respectively.

In September, 1954, the Tohyamaru Typhoon headed along the Sea of Japan and generated heavy waves near Hokkaido causing chaos. The Tohyamaru, a ferry boat traveling between Hakodate in Hokkaido and Aomori in Honshu, sank with all her passengers and crew. This unfortunate accident was a motivation for the underwater tunnel construction mentioned previously. This huge Seikan Underwater Tunnel construction project was completed in 1988 after overcoming numerous technological difficulties.

Following the above typhoon disasters, the Ise Bay storm surge damage caused by Typhoon No. 15 in 1959, and the Chilean Tsunami damage in 1960 raised again a strong interest in coastal preservation among the Japanese coastal engineers for maintaining the coastal land area as a basis for social and economical development in Japan.

3.2. *Second decade (1960–1970)*

This decade corresponds to the period of recovery of the nation from the war and for development of the national economy. However, natural disasters still occurred. For example, the Niigata Earthquake in 1964 caused heavy earthquake damage to port facilities at Niigata Harbor, and a tsunami hazard in

the Niigata City area. Another serious problem in Niigata was land subsidence induced by pumping up ground water from which subsoil natural gas was separated for production at plants.

In the meantime, coastal development works such as land reclamation for industrial sites were very active as seen in the 27738 ha of reclaimed land within this decade. Hence, coastal disaster prevention was still kept as a top priority in coastal works. The popular areas in coastal engineering research were, for example: (1) Characteristics of ocean waves in the nearshore zone as well as in deeper water, (2) Wave action on coastal structures, (3) Storm surge behavior by numerical simulation, (4) Tsunami deformation inside a bay and tsunami run-up on beaches, and (5) Mechanism of beach erosion. Reflecting these activities, this period was highlighted by active coastal development. In addition to the above, environmental problems in the nearshore area existed in the shadow of coastal development.

Here it should be mentioned that the Tenth International Conference on Coastal Engineering (ICCE) in 1966 was held in Tokyo, in which Masashi Homma took the leading role as a Chairman of the Local Organizing Committee. The Conference was the first ICCE held in Asia and gave young researchers not only in Japan but also in other Asian countries strong motivation to actively promote coastal engineering research.

Prior to this Conference, a US–Japan Seminar on Coastal Engineering was organized in 1965 by the joint efforts of J. W. Johnson (University of California) and M. Homma (The University of Tokyo) under the financial support of the National Science Foundation (NSF) and the Japan Society for Promotion of Science (JSPS) in Japan. The members visited typical sites of coastal engineering works in Japan and gave seminars at various locations on different topics. It was a kind of Pre-ICCE in Tokyo and offered a very good opportunity to exchange views on common interests among the members and Japanese observers.

3.3. *Third decade (1970–1980)*

In the previous period, the Japanese people focused on economic development at a high rate with little consideration of the natural environment, including ecological aspects. The people could not afford any time or money to take coastal environmental change into consideration. As a result, contaminated areas spread from rivers to bays, to nearshore areas and finally to the ocean. Thus, we are seriously concerned about marine pollution from not only

domestic but also international viewpoints. Based on the stated circumstances, numerous environment protection acts were successively issued in 1967. Therefore, field measurements of pollutant concentration in sea water were made very regularly in various locations to determine its real state, and then numerical model studies were carried out by coastal engineers to predict the behavior of contaminated sea surface areas.

On the other hand, a number of power plants have been constructed along the coast in Japan since the 1960s. As the capacity of each unit of the power stations increased significantly, the discharge volume of heated water also increased rapidly. At the initial stage of power development, the main concern of engineers was how to take cooling water effectively for a power plant from the sea without interfering with the heated water discharged from the plant. However, due to environmental concerns, the concern of engineers has shifted from the above to the prediction of the rise in sea surface temperature caused by the heated water discharged from the plant. However, it was unfortunate that basic investigations on the negative or positive effects of heated water on marine growth were almost ignored in order to expedite agreement between electric companies and the related Fishermen Associations.

Hence, research subjects related to water pollution, sea bed material pollution, and chain reactions, and effects on marine growth have become an additional field in coastal engineering. The coastal sediment subject also has been treated as one of the coastal environmental preservation problems.

Here it should be noted that the first oil crisis happened in 1973, owing to the Fourth Middle East War, resulting in a high rise in oil prices and a severe cut in oil production. Due to this unpredictable event, people have recognized the limits of natural resources as well as economical development, as was pointed out in the report issued by the Club of Rome in 1972. On the other hand, due to rapid advances in space technologies, it has become a daily experience for us to look at global images from satellites. These satellite images assist people in realizing that the size of the planet is not infinite, but limited. Hence, the people can now understand various environmental phenomena on a global scale.

3.4. Fourth decade (1980–1990)

In the meantime, the third United Nations Conference on the Law of the Sea was held and a UN treaty related to that subject was compiled in 1982. Based on this treaty, the Japanese government enacted a law, in which the territorial

seas were defined by the line drawn at a distance of 12 nautical miles seaward from the shoreline. Reflecting the above worldwide trend, resources including not only natural ones such as petroleum but also fishery resources have been a great interest of the Japanese people. Thus, the research subject related to fishery resources has become one of keen interest among researchers. Hence, exchange of information between coastal engineers and fishery scientists has become more active these days.

The third decade can be characterized as a time when the marine and coastal environment recovered from the contamination. As a result of painstaking efforts, the quality of sea water improved and reached an acceptable level. On the other hand, due to rapid economic development, people are wealthy enough to enjoy their leisure time. Thus, the demand for recreational facilities has become strong. Even though seashore industrial development has slowed down, development of coastal areas has still been active owing to increasing demand of urban development in the coastal zone. Adequate adjustment between conservation and development in the coastal zone has again become one of the important research subjects.

It should be noted that the Japanese government initiated a new project entitled "Coasted Environment Improvement Work" in 1984 with the aim of establishing a better coastal environment. Even though the initiation of the above work seems to be too late, the important role of natural beaches in absorbing or reducing the impact of wave energy has been publicly and officially recognized by government engineers.

It was in May, 1983, that tsunamis generated by an earthquake with its epicenter in the middle part of the Sea of Japan killed a number of people including school children who were taking their lunch on the beach. Different from the previous major tsunamis in Japan, this tsunami happened nearly at noon; hence many local people recorded the event using their video camera. These tapes have been invaluable for looking at the actual behavior of tsunami waves in the nearshore area. Up to that time scientists had tried to perform numerical simulations of past tsunamis by using fault models, and had improved its technique for practical use. The numerical simulation of the 1983 tsunami was displayed on TV showing successively the generation and deformation of tsunamis in the whole region of the Sea of Japan. Video recordings and tsunami simulations were televised frequently, and they were quite instructive to the people in understanding clearly the importance of evacuation from low-lying land to higher areas and of engineering technology advancement.

3.5. Fifth decade (1990–present)

During the last four decades, coastal protection works have been carried out intensively by the Japanese government, and the frequency and magnitude of coastal disasters have been reduced greatly. At the same time, the Japanese people are gradually losing their appreciation of these efforts. Looking at this tendency and considering factors such as magnification of earthquake activity, extraordinary meteorological phenomena including typhoon behavior, and global mean sea level rise due to global warming, we have to always recall prevention against coastal disasters as an underlying theme of our research. These subjects have been treated and clarified by specialists in each field. However, the people have very little knowledge of the facts which are common knowledge among specialists. Therefore, it should be the duty of specialists to provide a campaign of disaster-prevention education for the benefit of the people.

Global warming was one of the topics at the UN Human Environment Conference held in Stockholm in 1972. This kind of topic, particularly mean sea level rise due to global warming, has been a matter of serious concern of government agencies worldwide. It is needless to say that the mean sea level rise should impact strongly on human activities in the low-lying land. For countries occupying coral reefs and atolls, mean sea level rise is becoming a matter of life or death. According to a report issued in 1990 by the Intergovernmental Panel on Climate Change (IPCC), the mean sea level will rise by 30–110 cm in 2100 (Warrick *et al.*, 1990). Accuracy of this prediction should be checked by future investigations. As a remarkable response to the above prediction, two workshops were successively held in 1993 in the United States and in Japan for the western and eastern hemispheres, respectively. These workshops were in preparation for the World Coast Conference held in the Netherlands in 1993 with the aim of preparing input to the IPCC Second Assessment Report (Mimura *et al.*, 1993). Such effort might be valuable to form habitable and stabilized coastal environment in the world.

In 1994, the twenty-fourth ICCE was held at the Port-Island in Kobe as the second ICCE in Japan. This conference was successfully organized by the great efforts of T. Sawaragi (Osaka University) and Y. Tsuchiya (Meijyo University, formally Kyoto University) who took the role of Co-Chairmen of the Executive Committee of the Local Organizing Committee. None of the participants expected that the conference site, Kobe, would suffer tremendous earthquake damage on January 17, 1995, as reported all over the world.