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Construction Plan of Osaka Municipal Subway Line No. 8

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Abstract

With a view to enhancing its urban infrastructure by establishing a comprehensive transportation system and developing urban functions, and in light of global environmental preservation, the City of Osaka has been working to improve its subway network. To expand the subway network further as part of such efforts, a plan is being developed for the construction of a new subway, Line No. 8, which will link existing lines running radially in the eastern part of the City. Linear Induction Motor-driven Mid-capacity Subway will be introduced on Line No. 8 to meet specific transportation demand in the region.

Due to its smaller size, the Linear Induction Motor-driven Mid-capacity Subway offers the advantages of reduced construction cost for its smaller tunnel cross-section area, and smooth travel on lines with sharp curves and steep gradients, enabling flexible route layout.

The construction plan formulation involves environmental impact assessment, to ensure adequate environmental preservation measures.

1. History of Osaka Municipal Subway Network Development

The City of Osaka has been working to improve its urban functions so as to meet the requirements for the central city of western Japan in the 21st century. As part of its urban infrastructure, a public transportation system has been developed, which is primarily based on the subway, with which New Tram and bus networks are systematically linked. At present, seven subway lines, 115.6 km in total, are in operation. These lines form a network, laid out in a grid pattern in the central part of the City, and radially in peripheral areas. Serving approximately 2.62 million passengers daily (about a billion annually), the subway network plays a leading role as a primary means of transportation in the city.

The Osaka Municipal subway commenced service in 1933, on a section between Umeda and Shinsaibashi (3.1 km), as the first municipal subway in Japan. During the more than 67 years since, the City of Osaka has steadily expanded the network operation length. Particularly in the 1960s and onward, the subway network was improved rapidly. To cope with massive population concentration in the urban center during the high economic growth period, the City of Osaka promptly enhanced its subway system in the urban area. In 1970, when EXPO '70 was held in Osaka, six subway lines were established, approximately 64 km in total, running in a grid pattern in the central part of the City, an area surrounded by JR Osaka Loop Line.

After such a period, there were significant changes in the urban structure, partly due to the "doughnut phenomenon" (population shift from the central area to the suburbs), and consequent changes in transportation demand. To cope with these changes, the City of Osaka extended the subway lines to the peripheral areas of the City and adjacent cities, and started reciprocal through operation with private railways. In 1981, a new form of the Intermediate Capacity Transportation System, New Tram, was introduced for the first time in Japan, to provide a means of transportation in a newly developed residential district (New Town) in Osaka's Nanko (South Port) area, a reclaimed island of 1,100 ha. With transportation capacity between that of bus and subway, this transportation system with elevated structures serves 6.6 km.

Meanwhile, extensive research on the Mid-capacity Subway as an underground Intermediate Capacity Transportation System suitable for existing urban areas led to the development of a Linear Induction Motor-driven Subway. Use of a Linear Induction Motor enabled a car size slightly smaller than conventional subway, thereby reducing tunnel cross section area. (See Fig. 1.) In 1990,

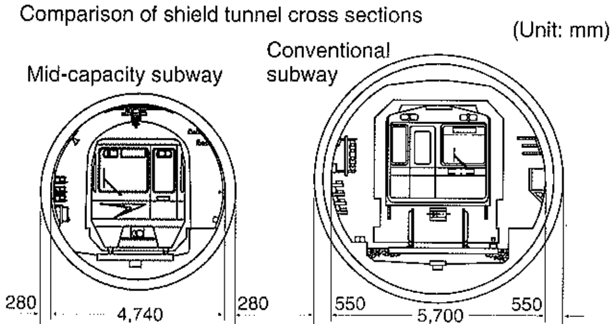


Fig. 1 Comparison of Shield Cross Sections between Mid-capacity Subway and Conventional Subway Line

the Linear Induction Motor-driven Subway was introduced on Line No. 7 to serve commuters and other passengers in the eastern part of the City, thereby improving the subway network and enhancing transportation service quality. Line No. 7 also served as an important means of transportation for visitors to the International Garden and Greenery Exposition held in Tsurumi-ryokuchi Park.

Line No. 7, between Kyobashi and Tsurumi-ryokuchi, was located separately from existing subway networks. In December 1996, with opening of a section between Shinsaibashi and Kyobashi (5.7 km), the line was extended toward the central part of the City and connected with existing lines. With this, the name of Line No. 7 was changed to Nagahori-Tsurumi-ryokuchi Line. In August 1997, line extension work was completed both between Taisho and Shinsaibashi (2.8 km) and between Tsurumi-ryokuchi and Kadoma-minami (1.3 km). As a result, the line was connected to all existing subway lines: Sennichimae Line (Line No. 5), Yotsubashi Line (Line No. 3), Midosuji Line (Line No. 1), Sakaisuji Line (Line No. 6), Tanimachi Line (Line No. 2) and Chuo Line (Line No. 4), for more convenient subway networks.

2. Decision to Construct Subway Line No. 8

Under its transport policy, the City of Osaka seeks to improve public transportation service not only by developing the railway, bus and road networks separately, but by working to create a comprehensive transportation system interlinking these modes of transportation.

Among these traffic systems, the subway network is considered indispensable to a comprehensive transportation system. The subway is also important as part of the urban infrastructure that will support the creation of urban functions of the city for the 21st century. In addition, it is necessary to continue to improve the subway network steadily in the future, since this will promote a shift from automobiles toward the public transportation system, mitigating air pollution and global warming. In this context, improvement of the subway network is a measure to help improve the global environment.

Until construction of Subway Line No. 7 between Kyobashi and Tsurumi-ryokuchi, the railway network in the Osaka urban area had been developed in accordance with the 13th Recommendation submitted in 1971 by the Urban Transportation Committee, an advisory organization to the Minister of Transport. With subsequent changes in environment represented by the construction of large-scale projects such as Kansai International Airport and Kansai Science City, it became necessary to revise the master plan of the railway network in the Osaka Metropolitan Area. In May 1988, when 18 years had elapsed since presentation of the 13th Recommendation, the Council for Transport Policy came up with the 10th Recommendation, which sets forth the target year of 2005; the development of railway networks is currently under way nationwide, based on this recommendation.

Of the lines specified in the 10th Recommendation, four listed below relate to Osaka City. In November 1989, the City of Osaka decided to develop these four as subway lines, and revised the Ordinance for Installation of Transportation Facilities to change the target of the City's railway network from 8 lines covering 120 km to 9 lines covering 150 km. (See Fig. 2.)

A. Itakano - Yuzato 6-chome (Morishoji-Yamatogawa Line)

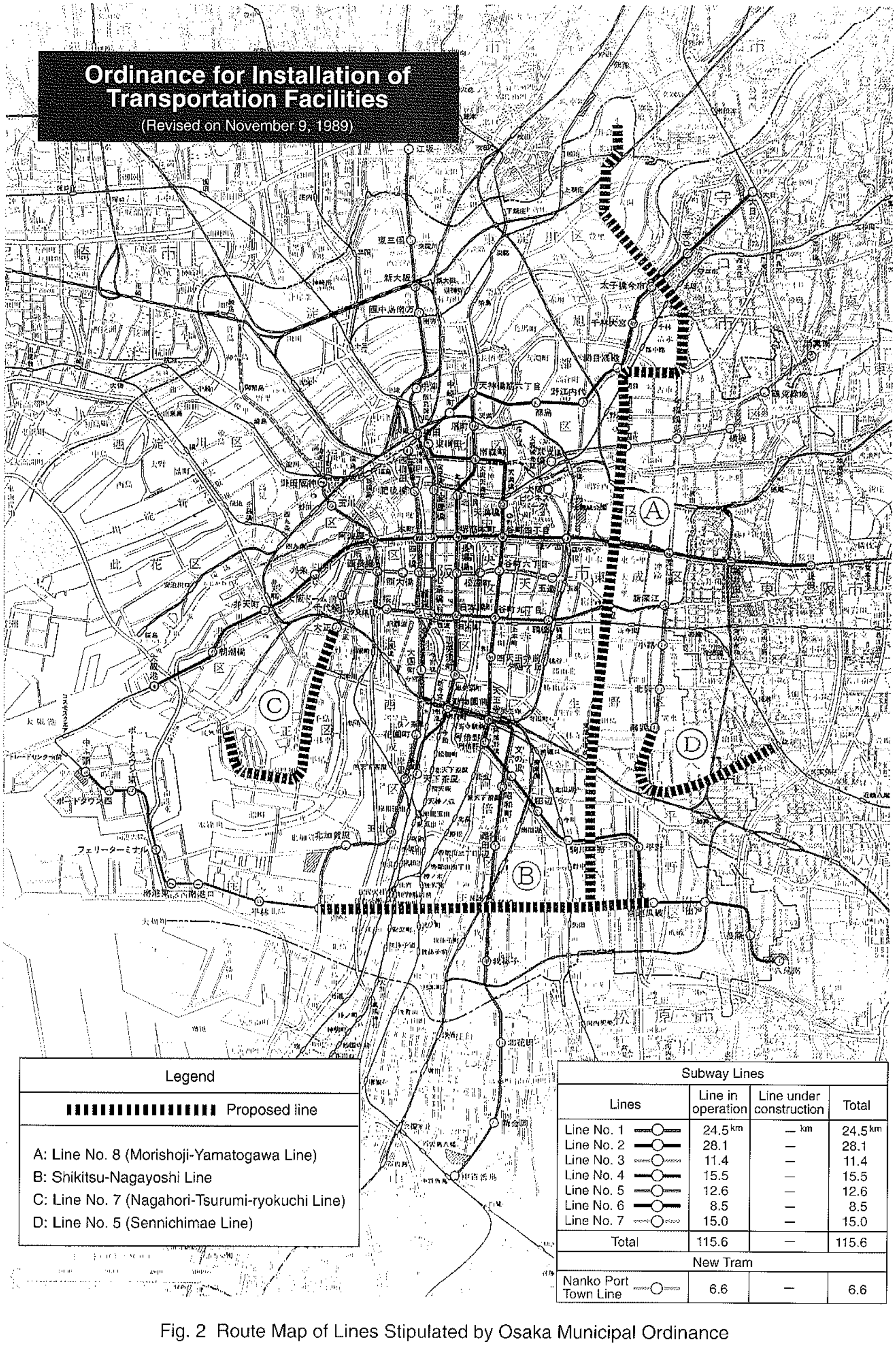
B. Suminoekoen - Kire-Uriwari (Shikitsu-Nagayoshi Line)

C. Extension of Line No. 7 to Tsurumachi (Nagahori-Tsurumi-ryokuchi Line)

D. Extension of Line No. 5 to Mito (Sennichimae Line)

To improve its subway network, the City of Osaka must develop the lines stipulated in the ordinance. Surveys were carried out regarding the situations along the four lines, such as regional development and traffic conditions, potential transportation demand and line layout plan, to examine the necessity of developing these lines and approaches toward development. It was found that development of the Morishoji-Yamatogawa Line should take first priority. The establishment of a comprehensive transportation system is designed to cope with increasing transportation demand arising from recently progressing large-scale residential development projects, as well as existing concentration of housing, and to settle traffic problems in areas where it is inconvenient to use railways and where road traffic is congested. From this viewpoint, Morishoji-Yamatogawa Line must be developed. Moreover, it is possible to form a railway network by conveniently connecting this line with existing subway and private lines. As part of the urban infrastructure that will help create well-balanced urban functions of Osaka City as a whole, the proposed line will play an important role. In December 1996, based on the conclusion that it was very important to develop this line, the Transportation and Water Works Committee of the Osaka City Council decided to treat Morishoji-Yamatogawa Line as the subway line to be constructed next, Line No. 8.

Since early commencement of Line No. 8 construction is necessary for development of the City's urban infrastructure for the 21st century, the City of Osaka continually holds discussions with the Ministry of Transport and other related organizations to obtain subsidies for construction of the new subway line. As a result, it was decided that a section between Itakano and Imazato (all station names are tentative) would be covered by the subsidy for fiscal 1999. Currently, procedures were completed and construction works have been commenced at the end of fiscal 1999.



Subway Lines

Lines	Line in operation	Line under construction	Total
Line No. 1	24.5 km	— km	24.5 km
Line No. 2	28.1	—	28.1
Line No. 3	11.4	—	11.4
Line No. 4	15.5	—	15.5
Line No. 5	12.6	—	12.6
Line No. 6	8.5	—	8.5
Line No. 7	15.0	—	15.0
Total	115.6	—	115.6
New Tram			
Nanko Port Town Line	6.6	—	6.6

Fig. 2 Route Map of Lines Stipulated by Osaka Municipal Ordinance

3. Predicted Effects of Subway Line No. 8 Development

Subway Line No. 8 will run north-to-south in the eastern part of the City, and be connected with existing lines running radially to form a part of a loop line. The development is expected to have following effects:

- The eastern region includes urban districts with the highest population density in Osaka City. In addition, residential development has been promoted (in Itakano, Furuichi, and other districts) actively in recent years. The new line is expected to meet growing transportation demand along the line. (See Photo 1.)

Photo 1 Furuichi Area, a Residential Development Site

- In the eastern region, there are many areas requiring development of a railway system, such as the eastern part of Higashi Yodogawa Ward. Line No. 8 will provide these areas with direct access to the central part of the City, thereby resolving transportation problems.
- In the eastern region, trunk roads running north-to-south are congested and in bad traffic condition. As a result, bus punctuality cannot be ensured. Development of Line No. 8 is expected to resolve such chronic traffic problems.
- The existing subway lines in the central part of the City are still heavily congested. Line No. 8, which will run north-to-south in the eastern region, will provide an alternative to existing lines running north-to-south, thereby alleviating congestion of these lines.
- Line No. 8 will cope with growing transportation demand that will arise from promotion of large-scale regional development projects in the future, such as the land readjustment project in the eastern part of Higashi Yodogawa Ward, enabling integrated development with other urban development projects.

4. Outline of Subway Line No. 8 Project

Subway Line No. 8 (between Itakano and Imazato) starts from Itakano (where the population increase rate is among the highest even in Higashi Yodogawa Ward), goes southward along National Road 479 (urban planning road "Shinjo-Yamatogawa Route"), a trunk road running north and south in the ward, passes across National Road 163 (urban planning road "Furuichi-Shimizu Route"), and crosses National Road 1 and urban planning road "Morishoji-Yamatogawa Route" to reach Imazato. (See Photos 2 and 3, Fig. 3, and Table 1.)

Photo 2 Itakano Area

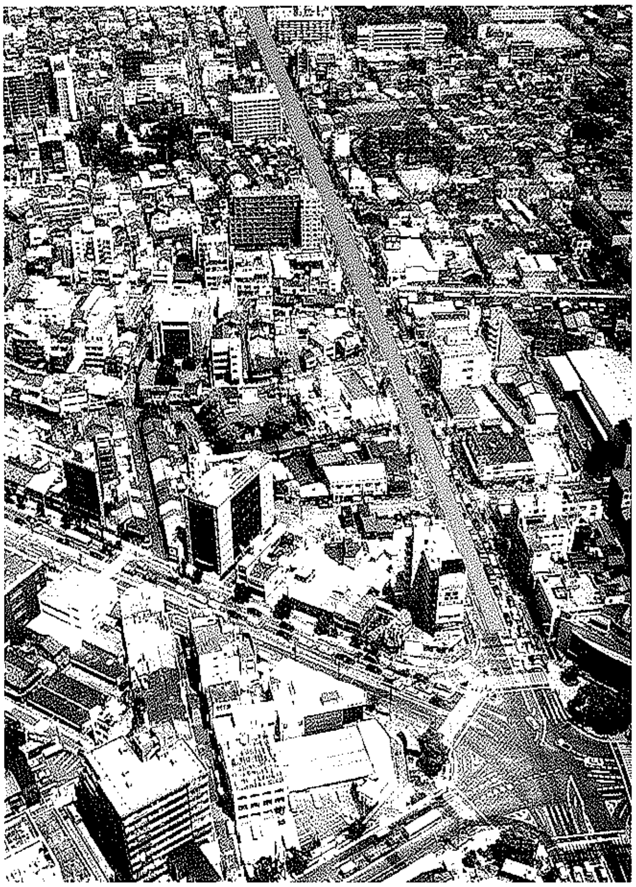
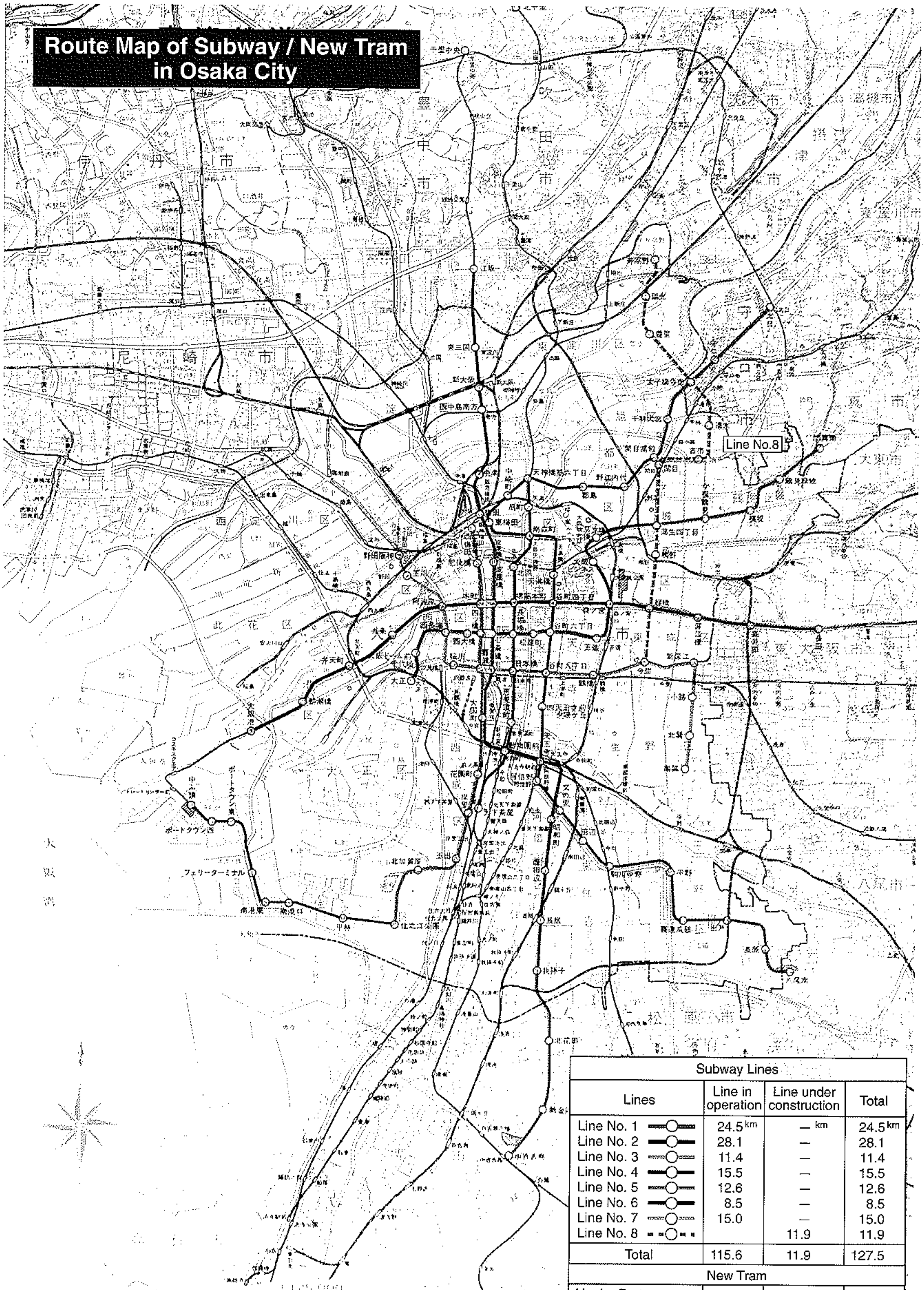


Photo 3 Imazato Area



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Line No. 5	12.6	—	12.6
Line No. 6	8.5	—	8.5
Line No. 7	15.0	—	15.0
Line No. 8		11.9	11.9
Total	115.6	11.9	127.5
New Tram			
Nanko Port Town Line	6.6	—	6.6

Fig. 3 Route Map of Subway Lines in Osaka City

Table 1 Outline of Subway Line No. 8 Project

Section covered		Kita-Eguchi 4-chome, Higashi Yodogawa Ward, Osaka City (Itakano) ≀ Oimazato 3-chome, Higashinari Ward, Osaka City (Imazato)
Operation length Construction length		Double track 11.9 km Double track 12.1 km
Specifications	Gauge	1,435 mm
	Rail	50 kgN
	Electric Power Supply	DC 1,500 V (Overhead rigid conductor system)
	Block system	Cab signal system
	Car	Linear Induction Motor-driven system (Non-floating type) Rated capacity Lead car: 90 Middle car: 100
Operation system		One-man operation
Train depot		Under Tsurumi-ryokuchi Park (Works such as overhaul and car repair will be carried out at the existing Tsurumi Car Inspection Workshop in the depot of Line No. 7.)
Construction method		Underground structure for entire line (Cut-and-cover method and shield method)
Construction period		From fiscal 1999 (Scheduled to open in fiscal 2006)
Construction cost		Approx. 315.6 billion yen

Subway Line No. 8 (between Itakano and Imazato) will have an operating length of 11.9 km and a construction length of 12.1 km, with its entirety underground. As for construction method, the cut-and-cover method will be used for stations, and the shield method for tunnels. (See Fig. 4)

The new line will be connected with the following existing railway lines: Subway Tanimachi Line (Line No. 2) at Taishibashi-Imaichi Station, Keihan Main Line and Subway Tanimachi Line (Line No. 2) at Sekime Station, Subway Nagahori-Tsurumi-ryokuchi Line (Line No. 7) at

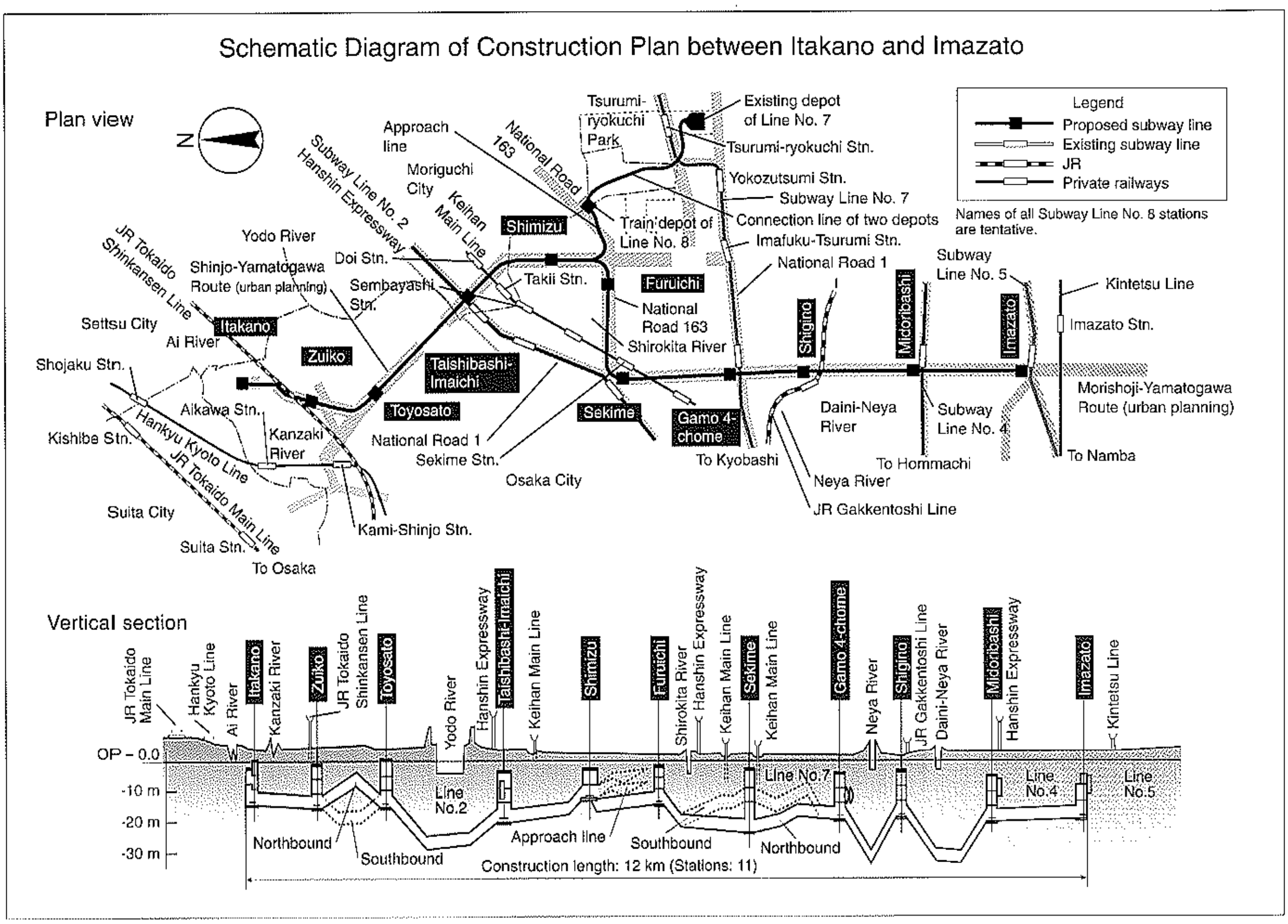


Fig. 4 Schematic Diagram of Line No. 8

Gamo 4-chome Station, JR Gakkentoshi and Osaka Outer Loop Lines at Shigino Station, Subway Chuo Line (Line No. 4) at Midoribashi Station, and Subway Sennichimae Line (Line No. 5) at Imazato Station. Two stations, Zuiko and Toyosato, will be established between Itakano and Taishibashi-Imaichi; an additional two stations, Shimizu and Furuichi, between Taishibashi-Imaichi and Sekime. Between the terminuses, Itakano and Imazato, Line No. 8 will have 11 stations in total.

From the viewpoint of a vertical section, the new line will pass under the five rivers Kanzaki River, Yodo River, Shirokita River, Neya river, and Daini-Neya River, and the four existing subway lines Tanimachi Line (Line No. 2), Nagahori-Tsurumi-ryokuchi Line (Line No. 7), Chuo Line (Line No. 4), and Sennichimae Line (Line No. 5).

5. Outline of Subway Line No. 8 Facilities

Based on assessments of future transportation demand for the new line, it has been decided that Line No. 8 will be designed and operated in a cost-efficient manner so as to achieve profitability. In terms of facilities such as stations; and cars of the Linear Induction Motor-driven Mid-capacity Subway using cars of the same type as those for Line No. 7 (Nagahori-Tsurumi-ryokuchi Line), will be introduced on the new line to enable smaller cross section areas for tunnels and stations, thereby reducing construction cost. One-man operation will be adopted to save operating costs. The gauge will be the same as that for the Nagahori-Tsurumi-ryokuchi Line (Line No. 7).

To help passenger vertical movement at stations, and based on the concepts of normalization and removing barriers for all passengers, elevators and/or escalators will be installed in all stations of Line No. 8 to secure one route from platform to the ground surface. To achieve this, problems must be solved regarding land purchase and structural plans of stations.

Bicycles parked illegally near subway stations constitute a serious problem, partly in terms of environmental preservation. Recently underground bicycle parking lots have been established adjacent to existing subway stations on the same floor as the wickets, where this is structurally feasible, with the cooperation of the administrator of roads. For the stations of Line No. 8, discussions have been held regarding establishment of bicycle parking lots on the ground surface or in the underground, in consultation with the administrator of roads and other parties concerned.

A fully underground train depot of Line No. 8 will be constructed under a parking lot in the northeastern part of Tsurumi-ryokuchi Park. To reduce Line No. 8 train depot size and construction cost, works such as overhaul and repair of cars will be carried out at the existing Tsurumi Car Inspection Workshop in the depot of Line No. 7. For connection of the two depots, a single-track shield tunnel will be constructed under Tsurumi-ryokuchi Park.

Linear Induction Motor-driven Mid-capacity Subway to be introduced on Line No. 8 have the following advantages:

① By employing a flat Linear Induction Motor, floor height can be lowered to enable a more compact car, while securing a comfortable interior ceiling height. As a result, the Linear Induction Motor-driven Mid-capacity Subway enables tunnel cross-section area reduction to as little as 60% that of conventional subways, and construction cost to 80% that of conventional subways.

② Non-adhesive drive method (not using friction between wheels and rails) enables the car to run along steep slopes. For Line No. 8, the maximum gradient is set at 50/1000 (while 35/1000 for conventional lines). As a result, stations can be constructed underground as close as possible to the ground surface, though the line passes under rivers and existing subway lines.

③ By employing a truck that has a self-steering function, the car travels smoothly on lines with sharp curves. For this Line No. 8, the minimum curve radius is set at 80 m. (See Fig. 5.)

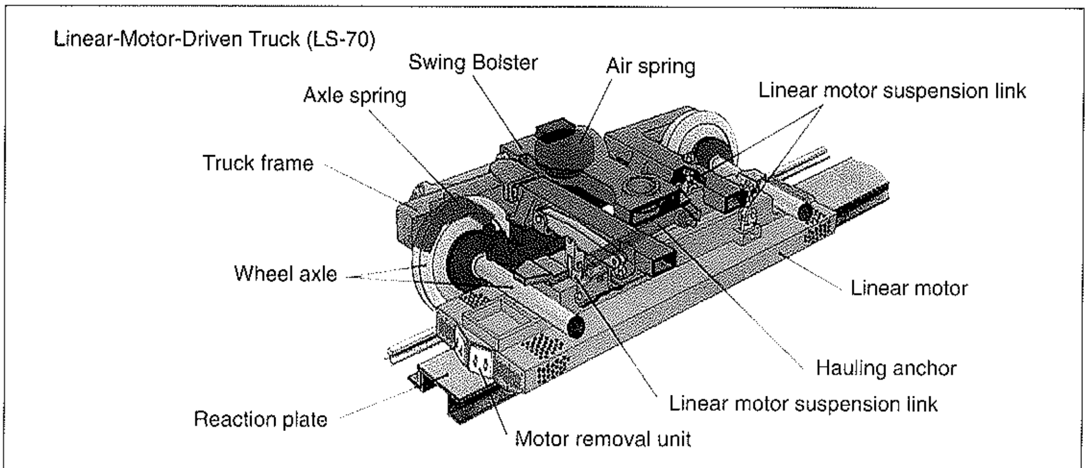


Fig. 5 Linear-Motor-Driven Truck

6. Environmental Impact Assessment

Since Line No. 8 is a project (construction of tracks under the Railways and Tramways Law) covered by the provisions of Article 2 of the Environmental Impact Assessment Law (enacted in June 13, 1997: Legislation No. 81), environmental impact assessment is under way.

In environmental impact assessment, current living and natural environments are examined to predict the environmental impact of the proposed project, or to assess the degree of impact or whether there will be any impact, and measures are discussed to minimize the impact and preserve the environment.

Although development of Line No. 8 is expected to have little impact on surrounding areas since almost all subway facilities, such as stations and tracks, will be constructed underground, a list was prepared of items to be assessed or predicted regarding their impact on the environment, taking the characteristics of surrounding areas into consideration. (See Table 2.) Needless to say, it is important to take adequate environmental preservation measures in the process of construction and during service, so as to meet environmental standards and achieve the goals of environmental preservation. It is also necessary to fulfill as early as possible the inherent functions of the subway as it is benign to the environment.

7. A Plan for the Future

Subways are expected to play an increasingly important role as a central key portion of the transportation system in the City. Therefore, efforts will be continued toward improving the subway network as a safe, convenient and comfortable public transportation system. For subway Line No. 8, procedures are currently under way in accordance with the Railways and Tramways Law and the Urban Planning Law. These procedures were completed by the end of 1999; construction works have been commenced at the end of fiscal 1999, with the goal of inaugural operation in fiscal 2006.

Table 2 Items to Be Examined in Environmental Impact Assessment

Items Related to Facility Operation	Description
Noise	Noise caused by operation of ventilation facilities
Vibration	Ground Surface vibration caused by train runnings
Low frequency vibration of air	Low frequency vibration of air caused by operation of ventilation facilities
Waste	Treatment and disposal of waste at stations

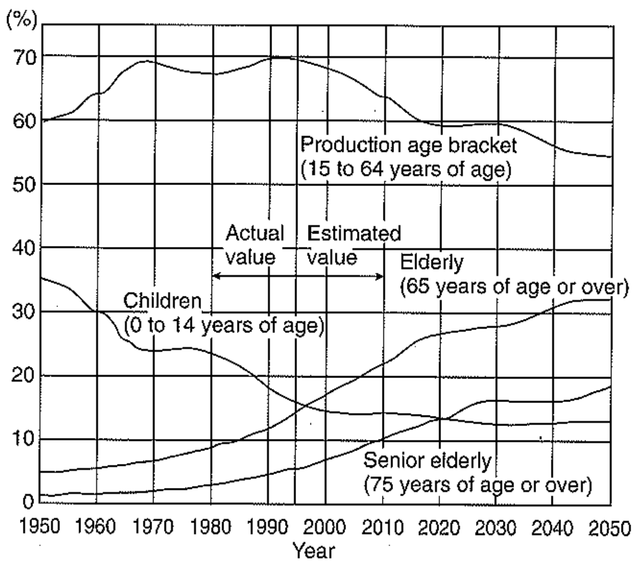
Items Related to Construction Work	Description
Air pollution	Impact of construction work
Noise	Impact of construction work
Vibration	Impact of construction work
Ground subsidence	Impact of construction work
Waste	Impact of construction work
Cultural properties	Impact of construction work

Pursuit of People-Friendly Public Transportation Service
—Installation of Elevators and Escalators under the "Second EEMACHI Plan"—

Koji Kamishinbara
Transportation Bureau

1. Introduction

Japan is a rapidly aging society. According to a survey conducted by the Management and Coordination Agency Statistics Bureau, Japan's population 65 years of age or over reached 20 million in 1998. It is predicted that with the longer average life expectancy and falling birthrate, one out of four Japanese will be part of the elderly population around 2015. (Fig. 1) Meanwhile, the number of physically handicapped is currently estimated at about 3 million, according to a survey by the Ministry of Health and Welfare. (Fig. 2)

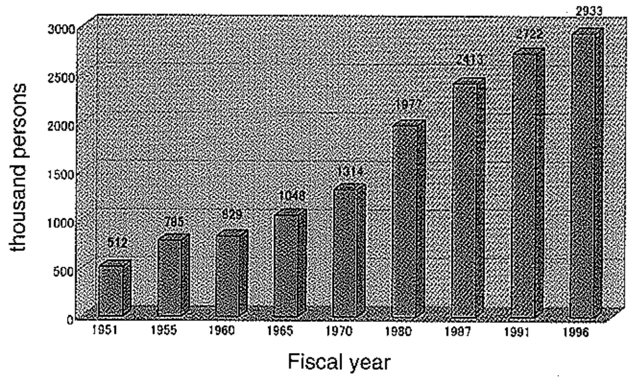


Source: National Institute for Social Security and Population Problem, Statistics Bureau, Management and Coordination Agency (Jan. 1997, Estimate)

Fig. 1 Changes in Population by Age Bracket

Continuing advances in medical technology and social welfare systems are likely to result in increasing numbers of elderly and handicapped living at home. It has therefore become an important task to develop social infrastructure that will encourage elderly and handicapped living at home to live in a self-supported manner, and to participate in social activities.

Under such circumstances, it is an urgent task to improve facilities used by the general public. In the area of public transportation as well, improvement should be addressed positively. Recent years, however, have seen a steady increase in platform-to-surface distance in urban railway facilities as a result of subway network improvement and multilevel railway crossings. This has imposed a greater burden of vertical movement not only on the elderly and handicapped, but on passengers with baby carriages and other impediments. Even in conventional station facilities, passengers experience various difficulties in movement.



Source: Ministry of Health and Welfare

Fig. 2 Timely Changes in Population of the Physically Handicapped (18 years of age or over living at home)

To improve this situation, the Transportation Bureau has implemented various improvement measures, such as installing of elevators and escalators, in subway, New Tram, and bus systems to make the public transportation service user friendly.

This paper describes various measures the Transportation Bureau is carrying out to improve the facilities of its transportation network, with the focus on elevator and escalator installation.

2. Osaka City Improvement Measures for the Elderly and Handicapped

The United Nations designated 1981 as the International Year of Disabled Persons, setting forth the goals of "Full Participation and Equality." It also declared the period 1983 - 1992 the U.N. Decade of Disabled Persons.

In Japan, a long-term plan focusing on improvement measures for the handicapped was formulated in 1982. Under this plan, such measures have been promoted systematically and effectively. The Ministries of Health and Welfare, Construction, and Transport, and other related ministries and agencies have also developed various guidelines for such improvement, and have implemented appropriate measures accordingly.

In 1983, Osaka City formulated its long-term plan regarding improvement measures for the handicapped, to effectively promote its projects based on the International Year of Disabled Persons. The plan set forth basic goals regarding improvement measures for the handicapped in the City, and clarified the basic policy and key measures for the decade.

In 1990, the "Iki-iki Aging Miotsukushi Plan" was established to create a city that meets the needs of an aging society. In 1993, measures for "Developing a People-friendly City" were formulated so as to realize a welfare society by improving public facilities for all citizens to use safely and comfortably in daily life and for social activities. Osaka City has been doing its utmost to achieve these goals.

3. Problems of the Elderly and Handicapped in Using Public Transportation, and Countermeasures

(1) Major problems in use of public transportation sevice, and countermeasures therefor

Problems arising from use of public transportation service differ depending on whether the passenger is aged or handicapped, or how the individual is handicapped. It is therefore important to understand specific problems and take appropriate measures to meet them.

Table 1 shows typical problems of the elderly and people with limb impairment, visual impairment and other types of handicap when using public transportation, and countermeasures therefor.

Table 1 Problems for Elderly and Handicapped in Using Public Transportation Service, and Countermeasures

	Problem	Countermeasure
Elderly people	• They have difficulty walking up and down stairs or to different levels, and walking long distances without rest. • It is hard for them to understand how to use new equipment. • Due to failing eyesight and hearing, their ability to handle information is diminished.	• Installation of elevators/escalators • Replacing step with ramp • Installation of handrail • Installation of easy-to-understand signs (display system for information provision: LED etc.) • Installation of platform door • New type ticket vending machine • Pictograph (symbols)
People with limb impairment (wheelchaired)	• They have difficulty going up and down to different levels, and cannot go up steep slopes. • It is difficult for them to move along narrow spaces. • They have limited reach.	• Installation of elevators/escalators • Replacing step with ramp • Installation of passage and handrail • Expansion of passage width • Installation of easy-to-understand signs (display system for information provision) • Installation of platform door • New type rest room • New type ticket vending machine
People with limb impairment (not wheelchaired)	• They have difficulty walking up and down to different levels or on slopes. They may fall. • Those who walk on crutches have difficulty moving along narrow spaces. They may slip. • They have difficulty performing delicate actions.	
People with visual impairment	• They walk relying on their own stride, cane, sound, etc. • It is difficult for them to accurately understand facilities, shapes of equipment, location, etc. • They have difficulty with or cannot read written information and signs.	• Guide/warning tiles • Braille information plates • Braille fare list plates • Braille information dispensers • Installation of platform door • Installation of handrail
People with hearing/speech impairment	• Since they cannot hear sound, they rely on sight and senses other than hearing. • They can hardly hear alarms or buzzers. • They have difficulty talking with other people.	• Installation of easy-to-understand signs (display system for information provision) • Telephone machine with facsimile function • Installation of elevators/escalators • Touch recognition map information plate • Pictograph (symbols)
People with internal impairment	• It is difficult for them to stand for long. • It is difficult for them to walk long distances without rest.	• Installation of handrail at passage and stairs • Non-slip stairs
Pregnant women and passengers with infants	• It is difficult to walk long distances without rest. • They have difficulty walking up and down to different levels or on stairs.	• Installation of elevators/escalators • Replacing step with ramp • Installation of handrail • Installation of platform door • Installation of baby bed

Notes) Source: Guidelines for Improvement of Facilities for the Aged, Physically Handicapped, etc. in Public Transportation Terminals (The Ministry of Transport, March 1994)
This table does not cover all problems and countermeasures; some items are redundant.

(2) Concrete measures taken by the Transportation Bureau

The Transportation Bureau has implemented the above countermeasures in creating subway, New Tram, and bus systems that not only the elderly and physically handicapped, but everyone can use with ease and comfort.

Below are a few examples of facility and car improvements:

1) Improvement of subway system

Improvement measures include: installation of elevators, escalators, and ramps (Photo 1); equipping of rest rooms with Western style toilet designed for the wheelchaired (Photo 2); installation of Braille information dispensers (Photo 3) and Braille fare list plates. At the time of rest room renovation, baby beds or baby chairs are installed so that passengers with infants can use the rest rooms comfortably. Continuous handrails at stairs (Photo 4) and Braille guide tiles have been installed in all subway stations. In addition, the method of displaying train destination and present train location has been changed to the plasma system or LED (Light Emitting Diode) system. Compared with the conventional system, these systems enable the display of more information on one screen, as well as displays with motion. (Photo 5) As for improvement of the cars themselves, space for a wheelchair is secured in each car built or remodeled into air-conditioned type since 1992. (Photo 6)

2) Improvement of bus system

Bus stops are equipped with Braille plates and voice guide to provide aural information regarding approaching buses and their destinations. As for vehicles, Osaka City has introduced: the lift bus, which enables wheelchaired passengers to board and alight easily; the leveling bus,

Photo 1 Installation of Ramp

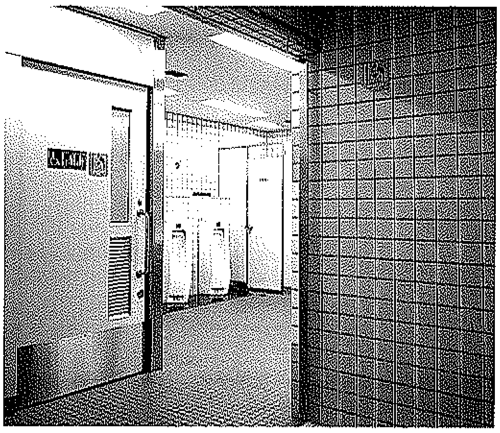


Photo 2 Rest Room Designed Especially for Wheelchaired Passengers

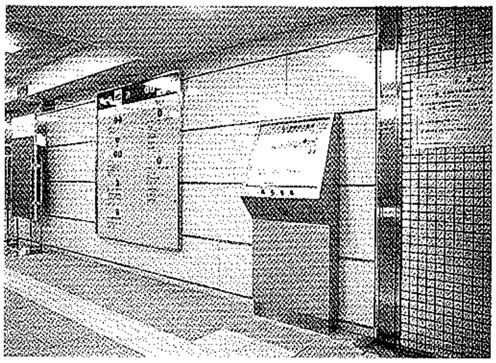


Photo 3 Braille Information Dispenser

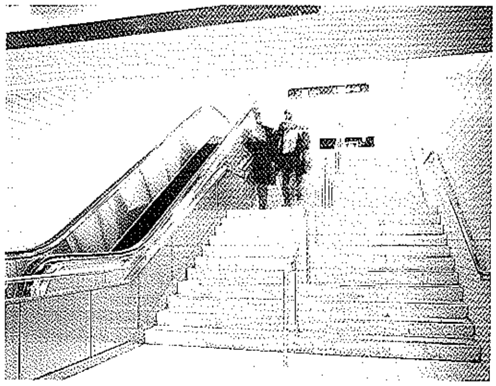


Photo 4 Installation of Handrail

Photo 5 Destination and Present Train Location Display by LED System

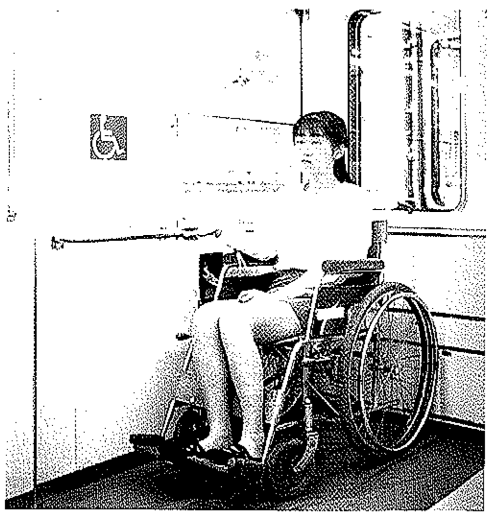


Photo 6 Wheelchair Space in Subway Car

which lowers its level 5 cm by releasing air from the pneumatic spring at bus stops; and the non-step bus, which has no step between boarding/alighting area and floor.

• Lift bus (introduced in 1991)

When the driver presses a button, the steps at the front door become a lift, and the passenger is lifted into the bus. Moreover, space can be secured for fixing the wheelchair by raising the bench-type seats installed behind both front wheels. (Photos 7 and 8)

• Non-step bus (introduced in 1997)

The height between the ground and the floor of the non-step bus is 34 cm, approximately 50 cm less than the conventional bus. Passengers board the bus at the middle door and alight at the front door. To facilitate easy boarding and alighting for the wheelchaired, an electric ramp plate is provided at the middle door. (Photos 9 and 10)

4. Elevator and Escalator Installation Policy

Between 1933 and 1938, escalators were installed at Umeda, Yodoyabashi, Shinsaibashi, Namba, and Tennoji Stations of Line No. 1 (Midosuji Line) at the time of line construction. During the war, however, they were removed to provide metal materials to the government. Among existing escalators, those installed since 1964 at Shin-Osaka Station of Line No. 1 are the oldest ones.

Elevator installation began more recently. In 1980, the first two elevators were installed at Kire-Uriwari Station of Line No. 2 (Tanimachi Line).

Since then, installation had been promoted under the policy: at newly constructed stations, one escalator will be installed between the platform and concourse floors; existing stations will be equipped with two to three additional escalators each year; while at stations where elevators are considered to be particularly necessary, elevators will be installed whether the stations are new or not.

However, it became necessary to take more positive measures to meet the needs of the rapidly aging society and encourage handicapped people to participate in social activities. In 1991, the Transportation Bureau formulated a 5-year plan for escalator and elevator installation; the plan serves as the Bureau's first guidelines for installation.

Further, as a measure for "Developing a People-friendly City" mentioned earlier, the "First EEMACHI Plan" was developed in fiscal 1993. Under the plan, with a total project expense of 31 billion yen, elevators and/or escalators

Photo 7 Lift Bus whose Steps Become Lift

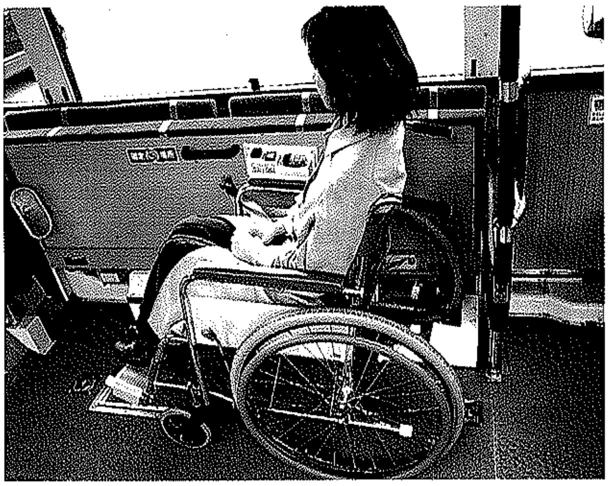


Photo 8 Fixed Wheelchair

Photo 9 Non-step Bus for Easy Boarding and Alighting

Photo 10 Electric Ramp Plate

were installed at almost all stations during the five years between fiscal 1993 and 1997.

At present the "Second EEMACHI Plan," successor to the "First EEMACHI Plan," is under way with a total project expense of 35 billion yen and a period of five years between fiscal 1997 and 2001. The plan aims to secure one route for passenger movement between platform and surface via elevator and/or escalator, without using the stairs, at all stations. (Table 2)

The basic concept common to these installation policies is to secure one route by which passengers can move between platform and surface without using the stairs. This is because subway users must move between platform and surface. To make a station truly barrier-free, it is important to ensure the continuity of installed elevators/escalators.

As stipulated by the Transport Ministry's elevator installation policy and other guidelines, elevators should be the primary equipment installed, since they can be used by a wider range of passengers restrained in movement. In line with this, Osaka City has gradually changed its installation policy to place greater importance on elevators. When elevator installation is not feasible for structural or other reasons, an escalator for use by wheelchaired passengers is installed. Fig. 3 shows an example of stations where one route consisting of elevators is secured between platform and surface.

For reference, the EEMACHI (Kind Town) Project was named using the first letters of "Escalators and Elevators for Kind (Magokorono-aru) Subway (Chikatetsu)."

Table 2 Outline of the "Second EEMACHI Plan"

Second EEMACHI Plan	
Project scale	
Project period Total project expense Number of units to be installed	Fiscal 1997 to 2001 35 billion yen Elevators: 110 units Escalators: 30 units
Installation goals	
1) To secure one route by which passengers can move between surface and platform to different floors via elevator and/or escalator without using the stairs, at all stations 2) With focus on installation of elevators, approximately 80% of all stations will provide one route of elevators. 3) To install additional escalators at transfer and terminal stations with large passenger use	

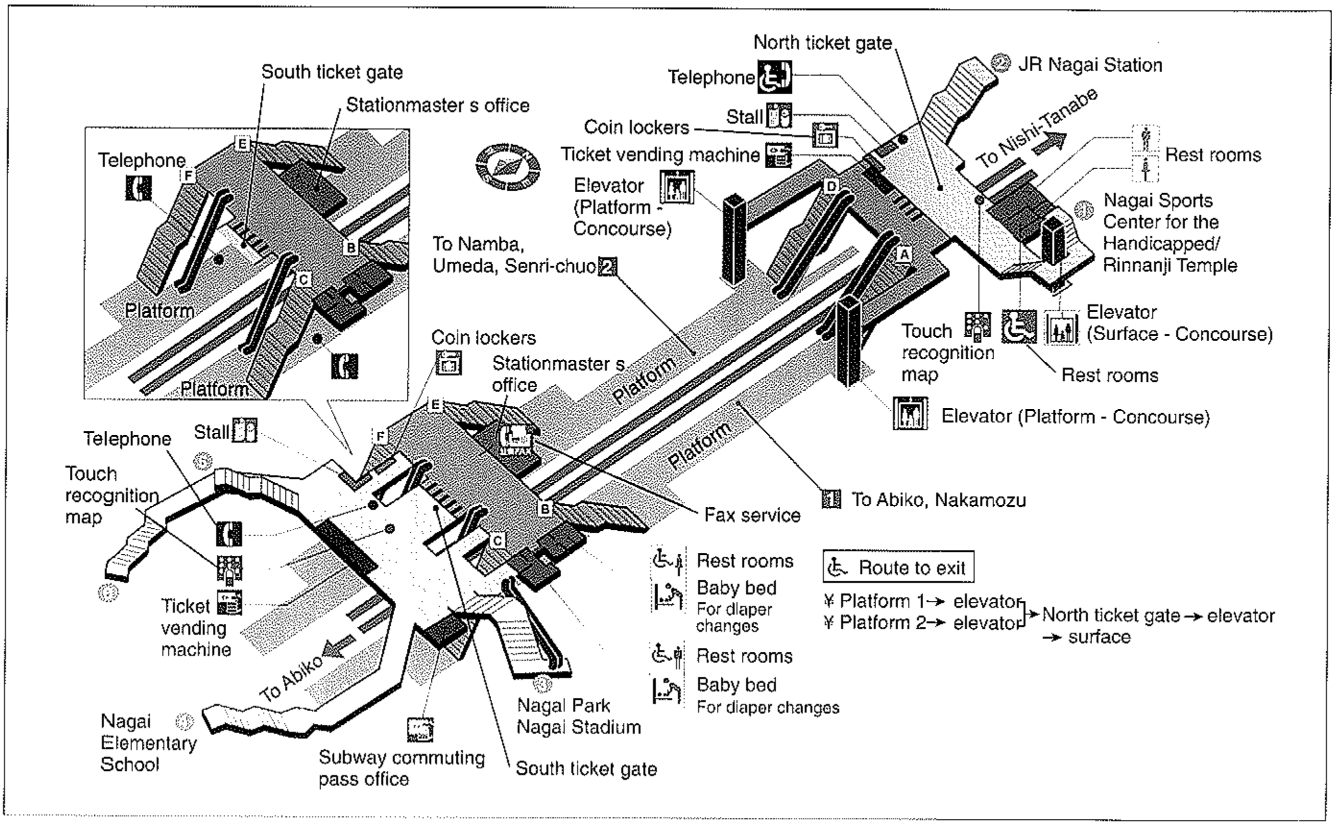


Fig. 3 Nagai Station of Midosuji Line, where Route of Elevators Was Completed

5. Current Status of Elevator and Escalator Installation

As a result of installation efforts in accordance with the policies described above, and construction of new lines, 272 escalators have been installed at 114 of 119 stations in total, and 131 elevators at 80 stations, as of September 1, 1999. (Table 3 and Fig. 4)

As for stations with one route via elevators and/or escalators between platform and surface, 83 stations, or 69.7% of the total, provide one such route of elevators and/or escalators; and 63 stations, or 52.9%, with one route consisting of elevators only. These numbers include elevators and/or escalators installed in buildings connected to stations.

Under the ongoing Second EEMACHI Plan, the target percentage of stations with one route using elevators and/or escalators is 100%, and that of stations with one route using elevators is 80%.

6. Example Elevator/Escalator Installations

(1) Considerations for installation

For elevator or escalator installation in an existing subway station, the situation should be examined from various aspects, since the equipment will be installed in limited space underground, unlike in a newly constructed station. The Transportation Bureau considers installation, with attention to the following points:

1) Convenience

- Location as close as possible to ticket gate
- Facility in easy-to-find location
- Platform-concourse and concourse-surface elevating facilities close to each other
- Location close to exit to hospital, welfare facility or other facility visited by elderly and handicapped persons

Table 3 Current Status of Installation of Elevators/Escalators by Line

(As of September 1, 1999)

Line		No. of Stations	Elevator	Escalator
Subway (111 stations)				
	Midosuji Line (R1)	20	14 stations 23 units	20 stations 54 units
	Tanimachi Line (R2)	26	19 stations 33 units	25 stations 47 units
	Yotsubashi Line (R3)	11	6 stations 7 units	11 stations 21 units
	Chuo Line (R4)	13	7 stations 10 units	12 stations 24 units
	Sennichimae Line (R5)	14	5 stations 10 units	13 stations 26 units
	Sakaisuji Line (R6)	10	8 stations 13 units	8 stations 23 units
	Nagahori-Tsurumi-ryokuchi Line (R7)	17	17 stations 31 units	17 stations 66 units
New Tram (8 stations)		8	4 stations 4 units	8 stations 11 units
Total		119	80 stations 131 units	114 stations 272 units

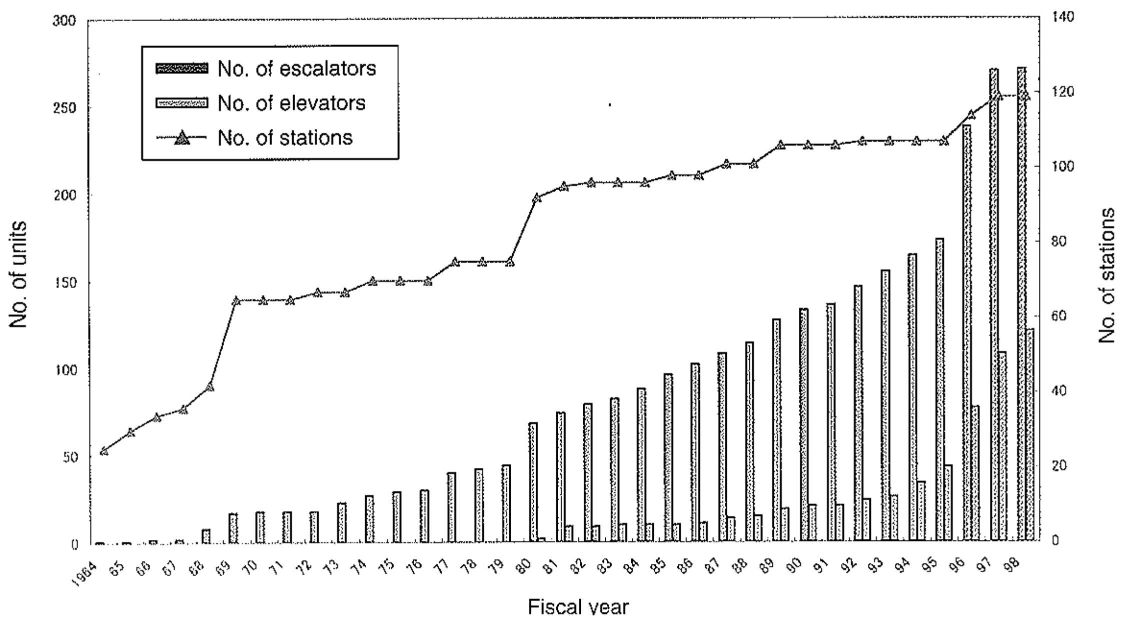


Fig. 4 Cumulative Number of Installed Elevators/Escalators by Fiscal Year

2) Impact on flow

- Avoid installation where many passengers gather, such as top and bottom of stairs and vicinity of ticket vending machines.
- Install where facility will not disturb major flow of passengers.

3) Cost efficiency

- Avoid construction under important structures, such as platforms, to reduce construction cost.
- When excavation is necessary, avoid relocating large-scale buried structures, to minimize excavation.
- Reduce construction period.

4) Structural aspects

- Locate facility so as not to affect overall structural system.
- Avoid complex structure.

5) Construction aspects

- Secure adequate remaining width of platform or stairs under construction, and take appropriate countermeasures against noise.
- Ensure work efficiency by, for example, providing sufficient latitude in execution.

These points, however, are not mutually compatible in some cases. It is very difficult to satisfy all the requirements.

For example, even though it would be highly convenient for passengers if a concourse-platform linking elevator or escalator were installed in a location close to the ticket gate, a huge amount of money would be needed to relocate some station facilities. It would be difficult to replace part of the stairs used by many passengers with an escalator, since the stair width during and after construction would be too narrow for the large number of users.

When an elevator or escalator is installed between concourse and surface, the most important issue is to secure the site on the surface.

Since most existing lines run in urbanized areas, buildings and commercial facilities are constructed along the lines. This makes it extremely difficult to secure such sites.

The Transportation Bureau conducts examinations first on the Bureau's lot (available space at sites of existing exit or entry, and of inlet), followed by lots for public use (such as ward office, school, and park), private property, and sidewalks. The installation of an elevator or escalator on the sidewalk is not accepted by the administrator of roads, as a rule. It is approved only when there is no feasibility under the first three options (Bureau lot, public use lot, and private property) and it is considered that there will be little impact on the road.

Even though the various issues addressed above are involved in elevator/escalator installation, the Transportation Bureau continues to consult with related organizations, asking their understanding and cooperation.

(2) Various innovative ideas

To cope with these issues, various innovative ideas were devised to enable installation.

In the case of conventional elevators, a passenger taking the elevator from the platform to the concourse floor enters and exits the elevator from the same side (door). Technological innovations now enable entry and egress from different sides. In the new type of elevator, passengers can move forward in the elevator, in the exit direction; in another type of elevator, passengers can exit from the right or left. Thanks to such elevators, wheelchaired passengers do not have to turn around before exiting. Also, the new types of elevators can be installed where there are structural restrictions regarding exit direction on the upper and lower floors. (Photo 11 and Fig. 5)

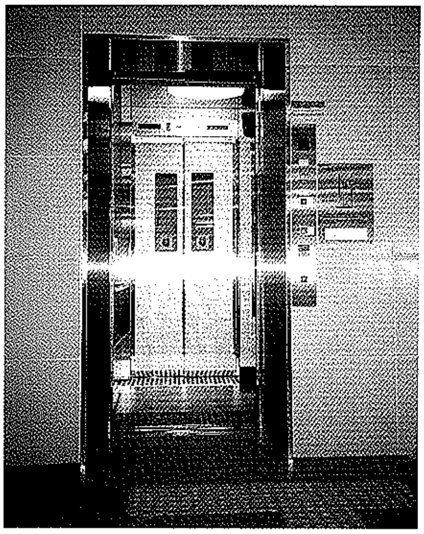


Photo 11 Thoroughfare-type Elevator
(Exit elevator from back door on destination floor.)

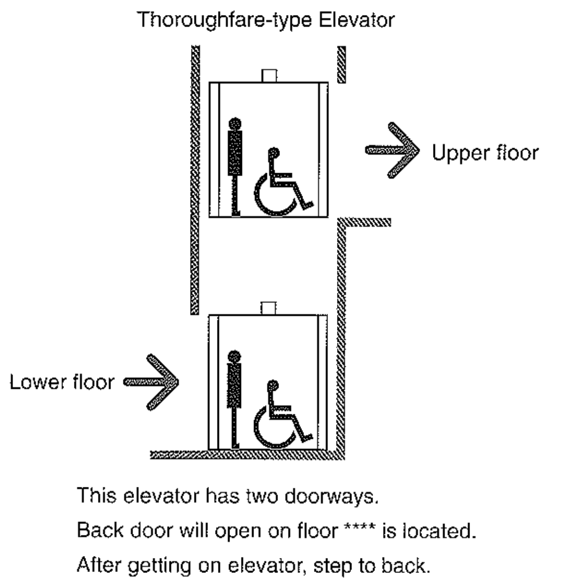


Fig. 5 Explanation Plate for Thoroughfare-type Elevator

Another breakthrough is the development of an elevator that does not require an elevator machine room. The Bureau is planning to install this new type of elevator in stations except where passengers walk under the elevator. The new elevator will offer significant advantages. For example, machine room space savings can obviate structural relocation, or reduce construction cost in excavation.

(3) Example installations

Examples of elevators/escalators already installed are shown in Photos 12, 13 and 14.

7. Conclusion

In line with the "Second EEMACHI Plan," efforts are under way to secure one route consisting of elevators and/or escalators at all stations. Various issues are involved in such installation efforts. The Transportation Bureau is determined to work harder to make its subway and New Tram systems more user-friendly.

In the future it will be necessary to promote barrier-free facilities for transfer between subway lines and between subway and bus systems. The subway network should be improved in keeping with the barrier-free policy, hopefully enabling smooth transfer not only between municipal subway lines, but between all means of transportation.

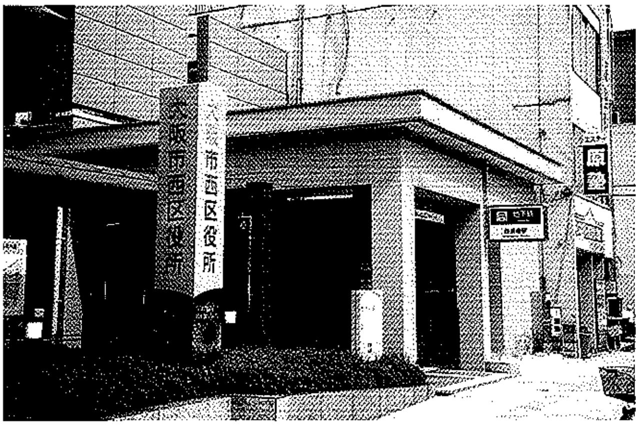


Photo 12 Elevator in Ward Office (Nishi-Nagahori Station of Nagahori-Tsurumi-ryokuchi Line)

Photo 13 Elevator in Station Square (Nodahanshin Station of Sennichimae Line)

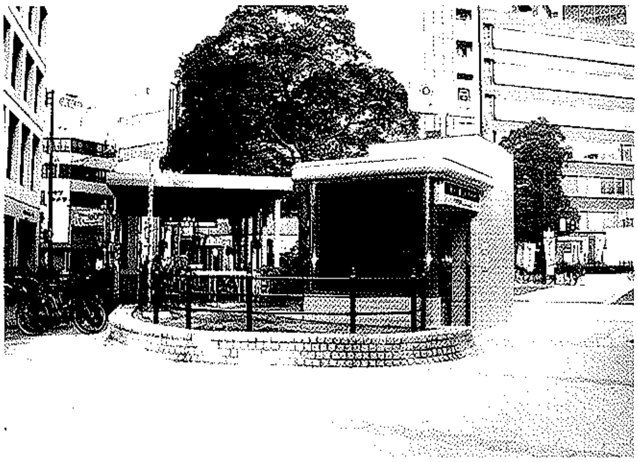


Photo 14 Elevator Installed on Sidewalk Green Section (Nippombashi Station of Sakaisuji Line)

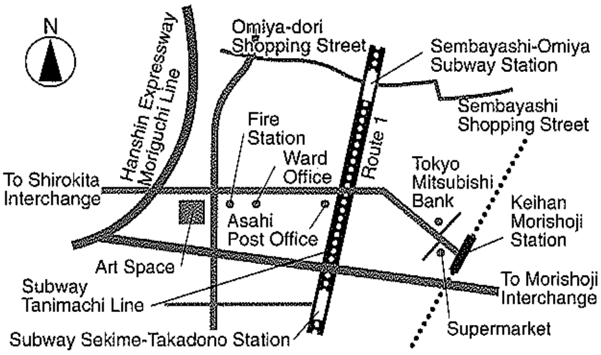
Outline of Osaka Municipal Art Space

Citizen's Affairs Bureau
Citizen's and Cultural Affairs Division

Osaka Municipal Art Space, recently completed in Asahi Ward, Osaka City, is the first facility in Osaka dedicated to drama and music rehearsals and related activities. In this facility, young artists desiring to become professionals are allowed to use rooms and equipment for drama production and rehearsal, as well as music composition, rehearsal, recording, and editing, especially rock and popular music. Opened on January 15, 2000, Art Space is located in a complex containing Asahi Civic Center, Asahi Library, and Asahi Storage. Construction of the complex commenced in October 1997 and was completed at the end of October 1999.

The facility (11-14, Nakamiya 1-chome, Asahi Ward) is on Yanagi Street, together with the ward office, tax office, post office, and police station. The nearest bus stop is Asahi-kuyakusho-mae. From the Sembayashi-Omiya subway station (Tanimachi Line), walk 10 minutes southwest; from Keihan Morishoji Station, walk 10 minutes northwest.

From Higashi-Umeda, take subway Tanimachi line to Sembayashi-Omiya, and walk 10 minutes.
From Kyobashi, take Keihan line to Morishoji, and walk 10 minutes.



Address: 11-14, Nakamiya 1-chome, Asahi-ku, Osaka-shi, 535-0003
Tel : 06-6955-1066
Fax : 06-6955-7901

● Outline of the Complex Facility

Building structure: steel-framed reinforced concrete structure with steel-structure section
4 floors above ground and 1 basement floor (parking lots)
Area of premises : approximately 5,800 m²
Area of building : approximately 4,100 m²

Total floor area : approximately 12,400 m²
Breakdown :
Art Space : approximately 4,300 m²
Asahi Civic Center: approximately 5,430 m²
Asahi Library : approximately 1,480 m²
Storage : approximately 1,190 m²

● Features of the Building

The building features a modern design matching the surrounding environment, and emphasizes "friendliness" and "cleanliness." The hall ceiling employs a building material that suppresses sunray reflection. The hall also features pop-art-like decoration, with rhythmic patterns in blue representing the sky and water, and red, symbolic color of the sun. The building is in the shape of an ark, symbolizing its embarkation for the sea of culture with young artists onboard.

To the south of the complex facility runs the Shirokita River; to the west spreads a park of approximately 1,000 m². With three fountains on the premises of the complex, this waterfront area serves as an amenity-rich park.

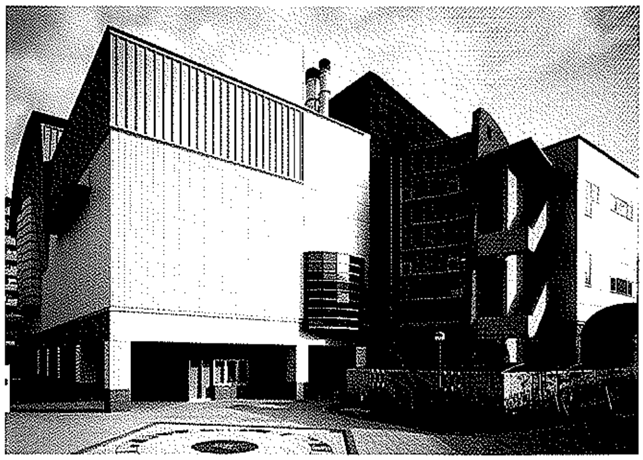
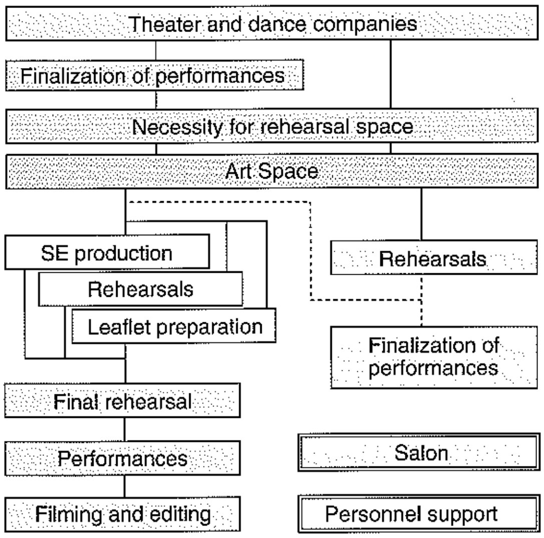
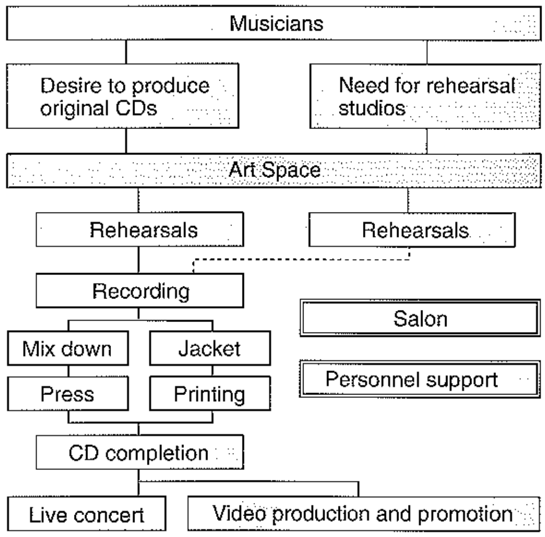


Photo 1 Art Space

● Features of Art Space

Art Space grants access to artists who need space to rehearse modern theatrical plays and music (rock, popular music, etc.). Artists can reserve desired rooms at specific times and days of the week (regular use), or consecutive use of desired rooms for about 4 weeks prior to performance (long-term use).





To benefit artists who have day-time occupations, the Art Space is open until 10:30 p.m., unlike many other municipal facilities that close much earlier.

In addition to providing rehearsal rooms, Art Space serves as a meeting place for artists and citizens, where they can share the deep emotions induced by excellent arts. By opening rehearsals to the public, artists can stimulate citizens' interests in and enhance their eye for art. The citizens, on the other hand, can inspire artists to further develop their potential and polish up their techniques.

By providing artists with personnel support, as well as cutting-edge equipment, Art Space supports artists' creative activities, from rehearsals to performances, recording, and video production.

● Outline of Art Space Facility

• Large Rehearsal Room: 1

Lighting equipment is available for performances, final rehearsals, and full-scale practice. In addition, the room can be used for workshops, experimental productions, and live concerts.

• Drama Rehearsal Rooms: 5 (1 large, 2 medium, and 2 small rooms)

For drama and dance rehearsals. The large room and medium room A have mirrors and bars. Users can select the room in accordance with type of performance, number of performers, and so on.

• Music Rehearsal Room (Recording Studio: Large)

Japan's highest quality recording studio, equipped with STUDER digital mixing console D 950. Digital recording is available from basic rhythm sound recording to mix down. In addition to cutting-edge equipment, experienced staff support artists in their creative activities.

Photo 2 Drama Rehearsal Room

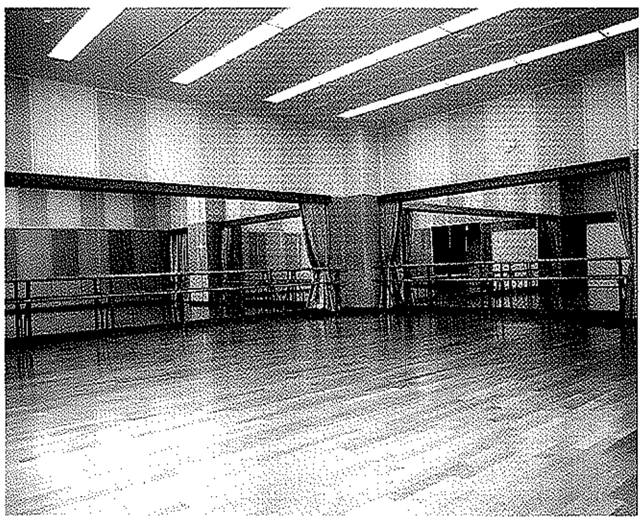


Photo 3 Music Rehearsal Room
(Large recording studio)

• Music Rehearsal Room (Recording Studio: Medium A)

This room, with an attached mixing room, functions as a recording studio, in addition to a rehearsal room. Equipped with MIDI sequencer system and PRO-TOOLS24MIX, the room permits users to input, digitally record, and edit music, allowing them to create a wide variety of musical sounds. Moreover, the room is ideal for preproduction and demonstrative recording, since artists can record music in a relaxed atmosphere.

• Music Rehearsal Rooms (2 medium and 2 small rooms)

Ideal for music rehearsals. Equipped with a variety of musical instruments, these rooms can serve a wide variety of musical groups.

• The salon on the first floor can be used for discussions and information exchange among artists. The media room on the second floor can be used for designing and producing leaflets, as well as for producing sound effects.

Photo 4 Music Rehearsal Room (2 medium-size and 2 small rooms)

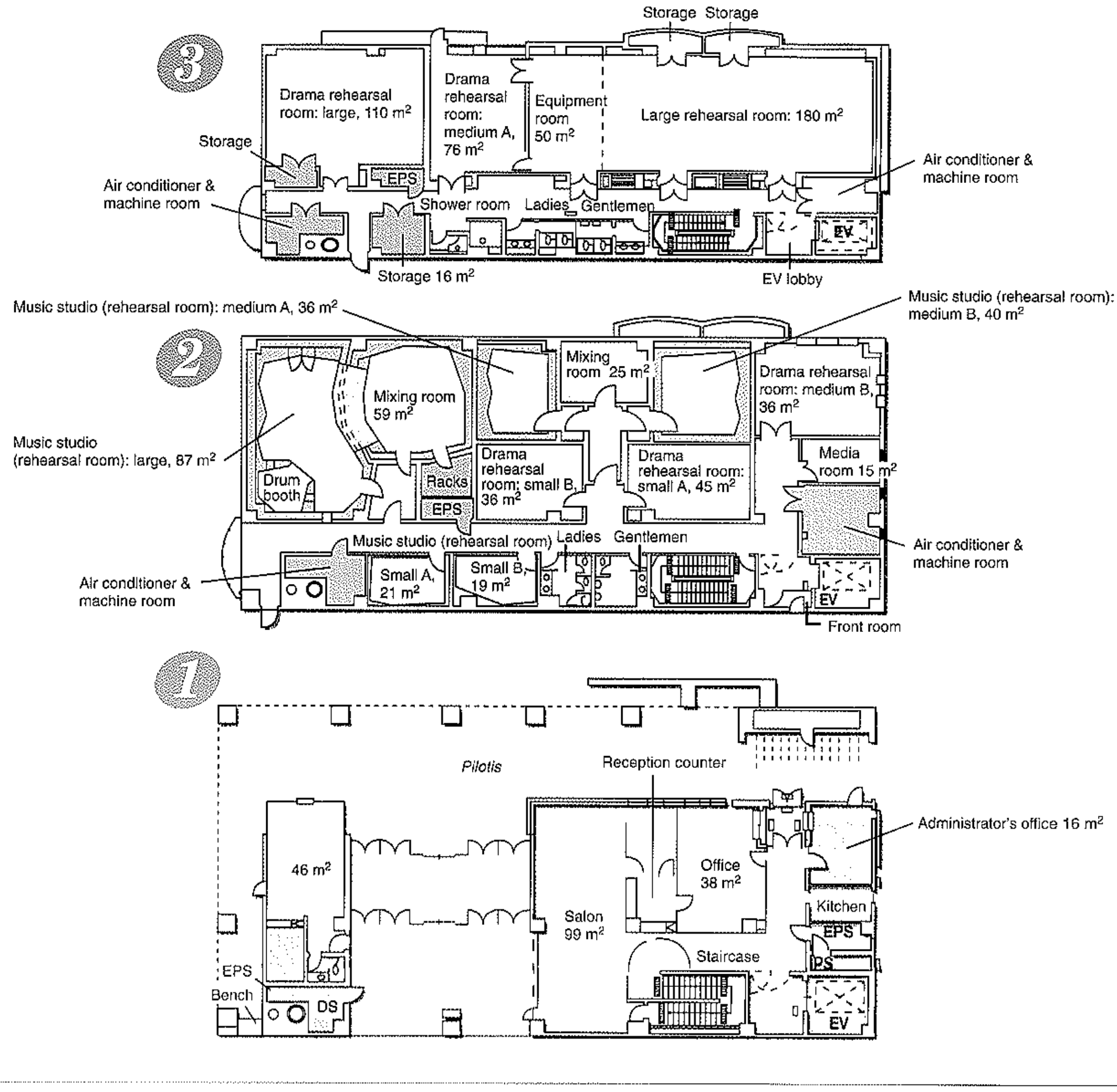


Fig. 1 Floor Map

● Art Space Facility Fees

■ Drama Rehearsal Room Basic Fee

(unit: yen)

Room	Fee				
	Morning 10:00 - 12:30	Early afternoon 13:00 - 15:30	Late afternoon 16:00 - 18:30	Evening 19:00 - 22:30	All-day 10:00 - 22:30
Large room	4,500	4,500	4,500	6,300	19,800
Partial use A: 100 m^2	2,500	2,500	2,500	3,500	11,100
Partial use B: 80.2 m^2	2,000	2,000	2,000	2,800	8,800
Drama rehearsal room: large	2,700	2,700	2,700	3,800	11,900
Drama rehearsal room: medium A	1,900	1,900	1,900	2,600	8,300
Drama rehearsal room: medium B	1,200	1,200	1,200	1,600	5,200
Drama rehearsal room: small A	1,100	1,100	1,100	1,500	4,800
Drama rehearsal room: small B	900	900	900	1,200	3,900

◆ The basic room fee for the large rehearsal room does not include the following equipment fees:
▲ Large rehearsal room equipment fees (per use)
❍ Audio equipment A: ¥5,000 ❍ Lighting equipment A: ¥8,000; B: ¥5,000 ❍ Balance beam set: ¥2,000
❍ Seat set: ¥2,000 ❍ Pipe seat set: ¥1,000 ❍ Video camcorder set: ¥500 ❍ Video projector set: ¥800
▲ Drama rehearsal room equipment fee (per use)
❍ Movable acoustic wagon: ¥5,000 ❍ MD radio cassette recorder: ¥400
◆ Users who collect admission fee from audience shall pay 1.5 times the basic room fee.

■ Music Rehearsal Room Basic Fee

(unit: yen)

Room	Within 2 Hours	Additional Fee per Hour	All-day
Music rehearsal room: large (recording studio: large)	4,000	2,000	24,000
Music rehearsal room: medium A (recording studio: medium A)	1,200	600	7,200
Music rehearsal room: medium B	1,200	600	7,200
Music rehearsal room: small A	600	300	3,600
Music rehearsal room: small B	600	300	3,600

▲ Musical instruments and equipment fee (per use)
❍ Music rehearsal room: large (recording studio: large): piano: ¥6,000 (excludes tuning fee); synthesizer: ¥3,000; drums: ¥3,000
❍ Music rehearsal room: medium A (recording studio: medium A) and medium B: A set: ¥2,000; B set: ¥600
❍ Music rehearsal room: small A, B: A set: ¥1,400; B set: ¥600
* A set: drum set, keyboard, 2 G amps, B amp, basic PA set /B set: 2 G amps, B amp, basic PA set
❍ Music rehearsal room: medium A (recording studio: medium A): basic equipment fee: ¥3,000 (for recording alone)
◆ Basic room fees do not include musical instrument fees.
◆ Users of recording studios shall also pay personnel fee and production fee (including miscellaneous fee).
◆ Before using recording studios, prior discussions are necessary.
◆ Users who collect admission fee from audience shall pay 1.5 times the basic room fee.

■ Media Room Basic Fee

(unit: yen)

Room	Fee				
	Morning 10:00 - 12:30	Early afternoon 13:00 - 15:30	Late afternoon 16:00 - 18:30	Evening 19:00 - 22:30	All-day 10:00 - 22:30
Media room	1,400	1,400	1,400	1,900	6,100

◆ Users of media room shall also pay personnel fee and production fee (including miscellaneous fee).
◆ Users who collect admission fee from audience shall pay 1.5 times the basic room fee.

● Events in Osaka City

To support young artists in their music activities, Osaka City holds Youth Music Festival "Osaka GIG" every summer at Sunset Plaza, Tempozan Harbor Village. With the backdrop of Osaka Port and the summer sun, young artists present music enthusiastically, continuing after sunset, even until late at night. Since fiscal 1998, the City has also annually organized the Osaka Drama Festival, with the aims of promoting the production of new dramas and the development of theatrical talent. This year, to celebrate the opening of Art Space, various events were held at Art Space from January 15 to the end of March, including joint performances of numerous theatrical companies, seminars on drama, and student drama contests.

The City is currently planning to construct in Shin-Osaka Youth Cultural Creation Center (tentative name), a facility to support young people's creative activities. Together with Art Space, the new facility will develop professionals who will carry on Osaka's future culture. As a culmination of these facilities' activities, the City plans to establish Theatrical Art Center (tentative name), to provide artists with venues for presenting performances.

Construction of the Maishima Incineration Plant (provisional name)

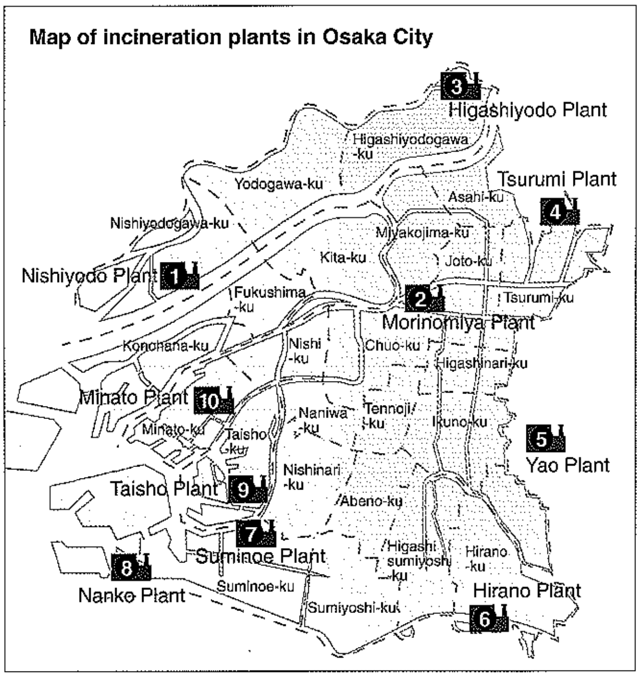
Environmental Management Bureau

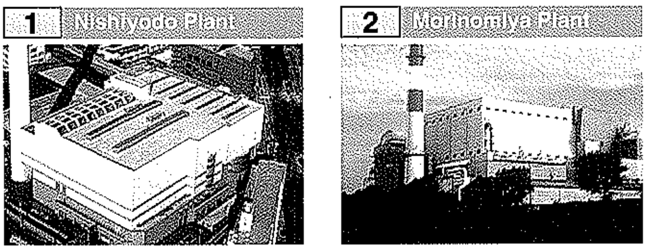
Introduction

The Maishima Incineration Plant of the Environmental Management Bureau (provisional name; hereinafter referred to as "Maishima Plant"), is an incineration plant currently under construction by the Environmental Management Bureau, on Maishima, a sports and recreation island. In the construction of this plant, particular attention has been paid to a variety of aspects relating to the location, and the most innovative pollution prevention devices have been adopted. Notably, this facility will have unique features in its exterior design and in its facility for visitors, unusual for an incineration plant. These features are outlined below.

1. Construction of the Maishima Plant

Osaka City currently has ten incineration plants (see Figure 1), where combustible waste is incinerated. Of these plants, some are reaching the age where re-building is required. However, due to reasons such as limited available land, it is becoming difficult to build a new plant within the same premises while continuing to operate the current plant. This is the reasoning behind the decision to build a completely new plant in Maishima.





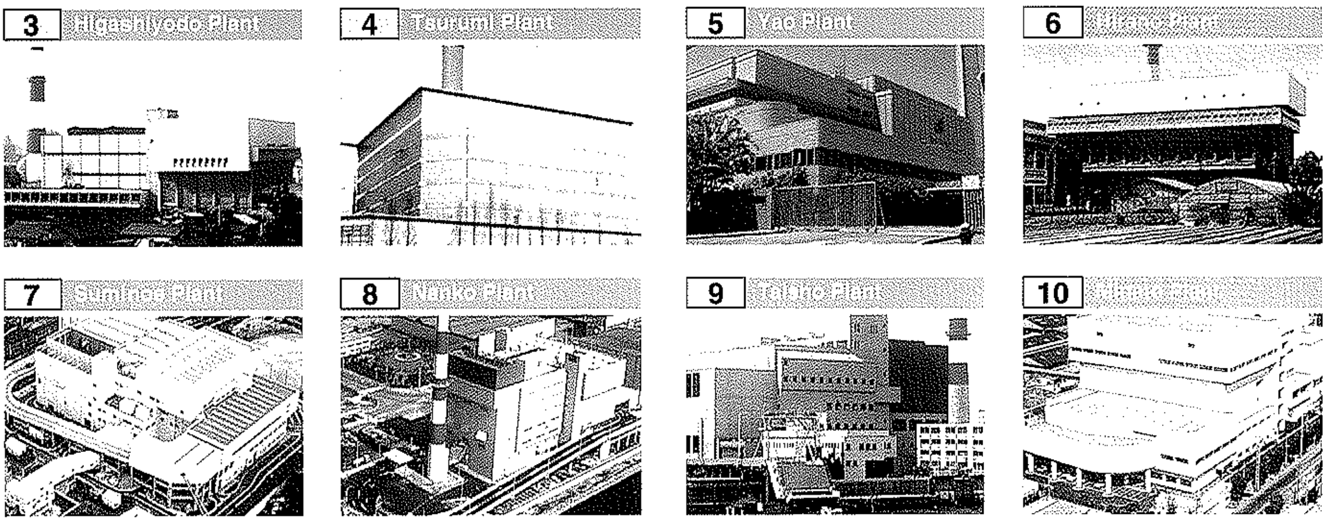


Fig. 1 Incineration Plants in Osaka City

2. Outline of Construction of the Maishima Plant

The outline of the Maishima Plant is shown below.

Outline of construction:

- Location : 1-chome, Hokko Shiratsu, Konohana-ku, Osaka City
- Land area : Approximately 33,000 m^2
- Building area : Approximately 16,500 m^2
- Floor area : Approximately 55,800 m^2
- Construction period: March, 1997 to April, 2001 (estimated)
- Building : Steel-encased reinforced concrete (partial steel structure) Seven stories above ground and two partial stories below ground

Outline of facility:

Processing capacity:

- Incinerator : 900 t/day (450 t/day per furnace × 2 furnaces) Fully continuous combustion type (Stoker furnace)

Bulky waste processing facility:

- Non-combustible waste: 120 t/day (rotary crusher)
- Combustible waste : 50 t/day (low-speed rotary shear crusher)
- Re-usable materials collected : Iron and aluminum

At the Maishima Plant, the latest technologies are used to minimize pollution (Plant model and processing equipment flow chart are shown in Figure 2 and Figure 4, respectively). In particular, for dioxin and similar matter contained in exhaust gases, lately a major focus of attention, the concentration will be kept at 0.1 ng/m^3 maximum.

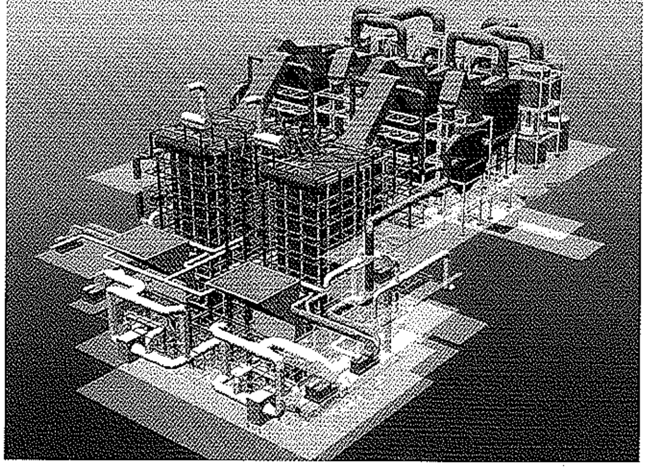


Fig. 2 Plant Model for the Maishima Plant

In addition, the plan is to decompose dioxin contained in fly ash (ashes captured during the exhaust gas treatment process) before the ashes are discharged. For high efficiency, the waste heat generated by incineration will be put to use through a 32,000 KW steam turbine power generator to be installed, the largest in Osaka City; a plan to supply steam to outside parties is also under consideration.

3. Exterior Design

One of the outstanding features of the Maishima Plant is its exterior design. Maishima, the location for this plant, continues to develop as a sports and recreation island, with the focus on ecology. As the Maishima Plant will be built at the front gateway to the island, its design has been carefully selected with an eye for the landscape (Figure 3).

In the initial planning stage, some thought was given to

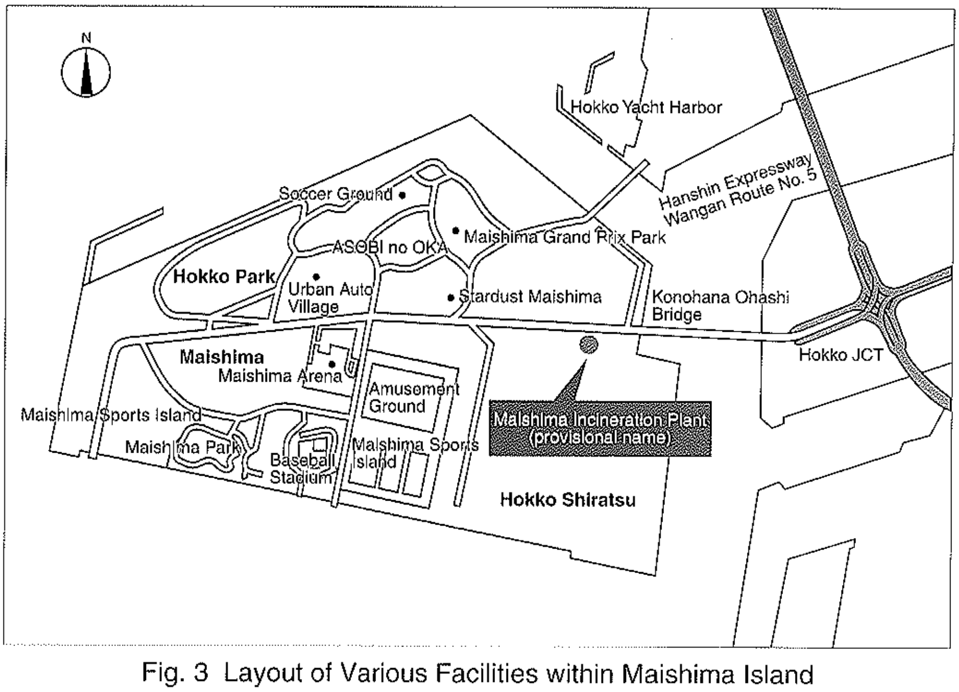


Fig. 3 Layout of Various Facilities within Maishima Island

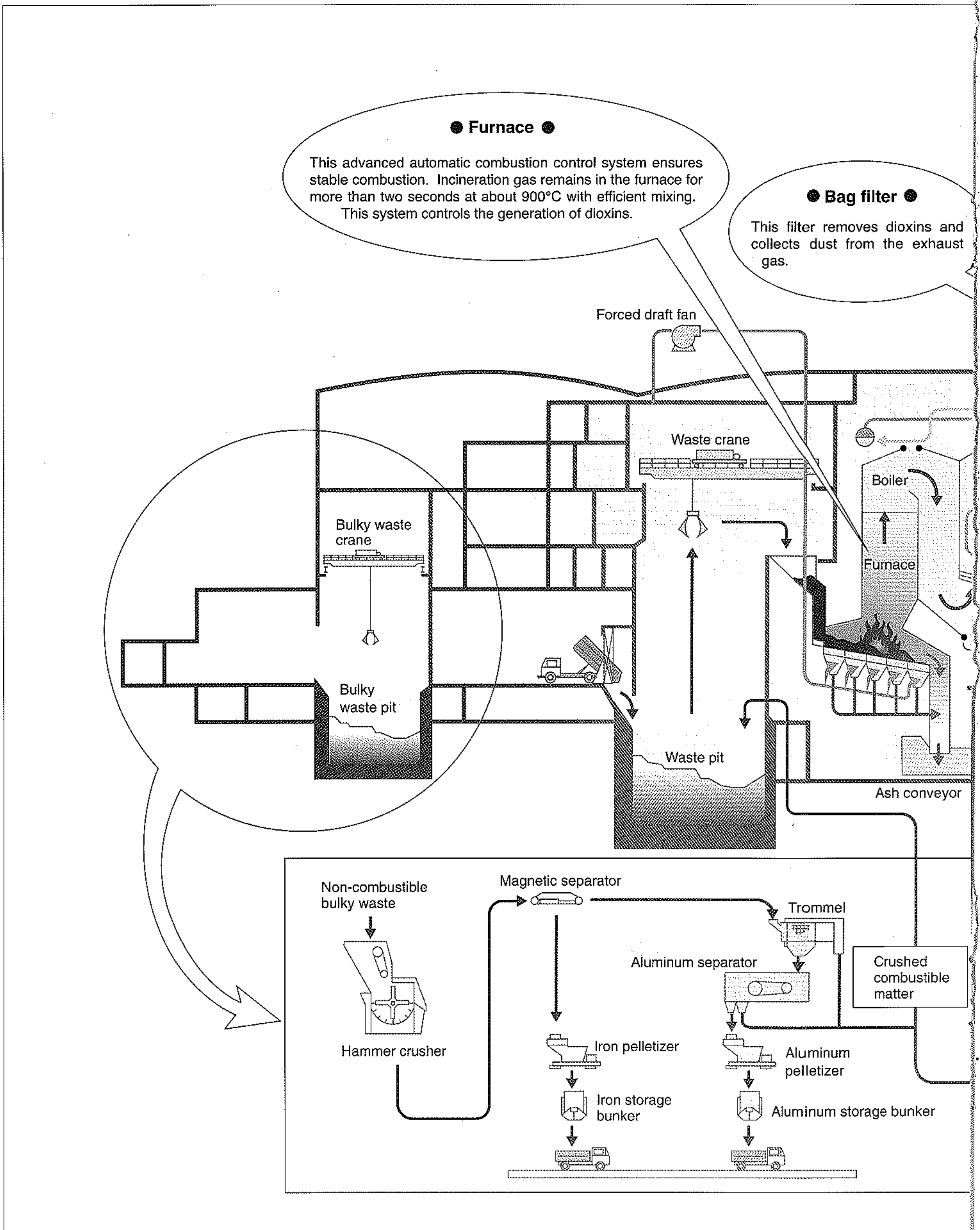
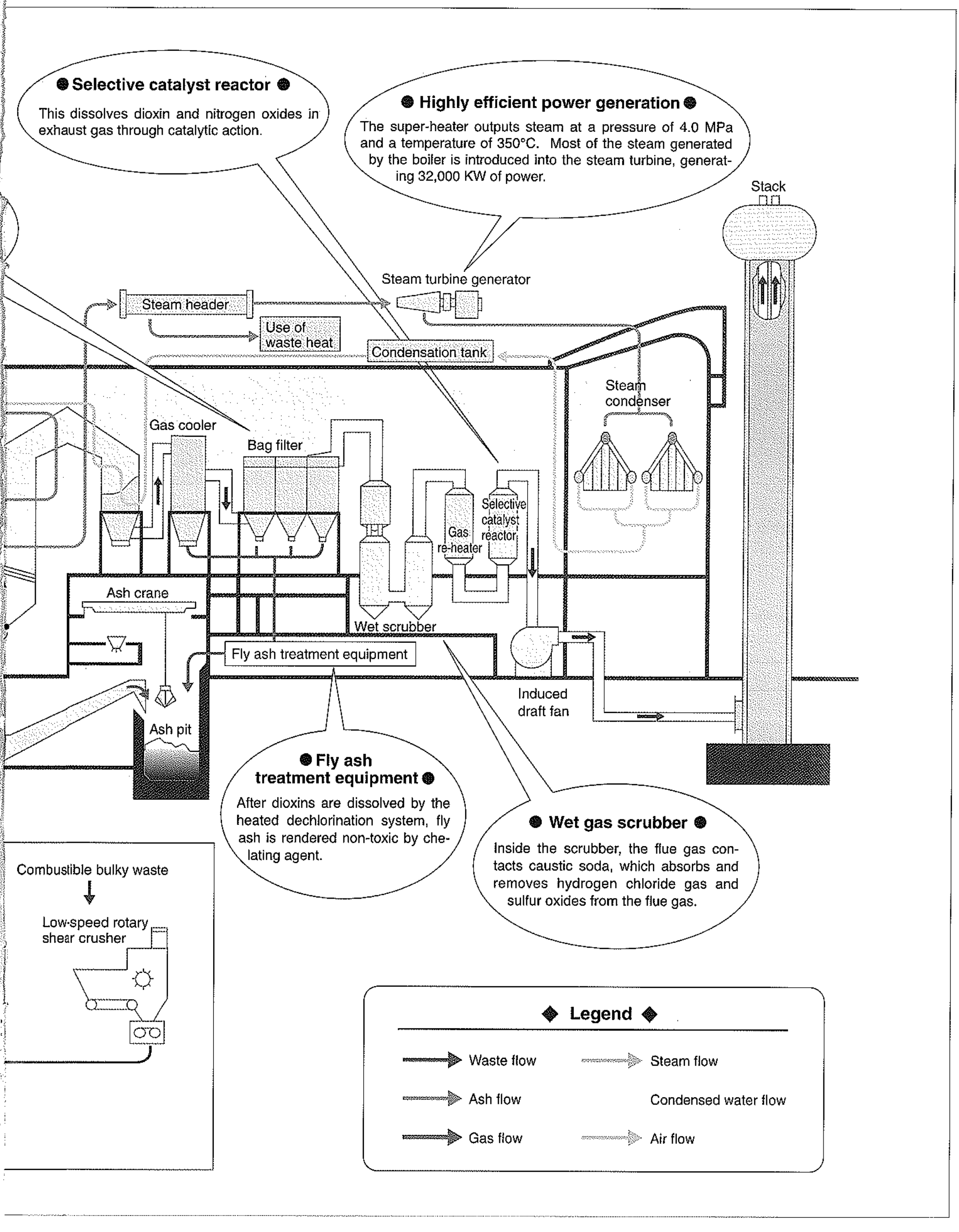


Fig. 4 Processing Equipment Flow Chart


● Selective catalyst reactor ●
This dissolves dioxin and nitrogen oxides in exhaust gas through catalytic action.
● Highly efficient power generation ●
The super-heater outputs steam at a pressure of 4.0 MPa and a temperature of 350°C. Most of the steam generated by the boiler is introduced into the steam turbine, generating 32,000 KW of power.
Stack
Steam turbine generator
Steam header
Use of waste heat
Condensation tank
Steam condenser
Gas cooler
Bag filter
Selective catalyst reactor
Gas re-heater
Ash crane
Wet scrubber
Fly ash treatment equipment
Induced draft fan
Ash pit
● Fly ash treatment equipment ●
After dioxins are dissolved by the heated dechlorination system, fly ash is rendered non-toxic by chelating agent.
● Wet gas scrubber ●
Inside the scrubber, the flue gas contacts caustic soda, which absorbs and removes hydrogen chloride gas and sulfur oxides from the flue gas.
Combustible bulky waste
Low-speed rotary shear crusher
◆ Legend ◆
Waste flow
Steam flow
Ash flow
Condensed water flow
Gas flow
Air flow

moving the stack, a typical symbol of an incineration plant, or to building an observatory on the stack to alleviate the negative association with an incineration plant. However, those ideas were not adopted due to the inordinate construction cost involved. Instead, it was decided to adopt a design unlike any conventional plant, so that the viewers would not immediately be aware of the negative associations of an incineration plant (Figure 5).

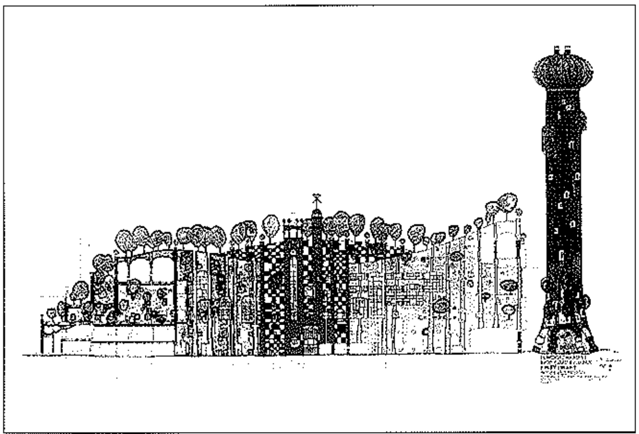


Fig. 5 Design Sketch for the Maishima Plant by Master Hundertwasser

The design of the Maishima Plant was undertaken by the Austrian artist Master Friedensreich Hundertwasser (hereafter referred to as Master Hundertwasser). Besides being a well-known painter, he is an artist with unique ideas for environmental protection, and has led architectural projects for environmental protection. Master Hundertwasser has designed numerous buildings with designs highly reputed as creating "harmony of technology, ecology, and art." In fact, in 1992 he was responsible for the exterior design of a waste incineration plant, Spittelau Heating Plant, in Vienna, Austria. Because of its unique design, this incineration plant is now so well known as to be included in sightseeing tours, though incineration plants were conventionally always considered a necessary evil. His design for buildings starts with the idea that "there is neither a single straight line nor two identical beings in the natural world"; he therefore intentionally avoids using straight lines or repeating the same shape, which means that windows, for example, are of curved lines and different sizes. Furthermore, as the Maishima Plant is an incineration plant, red and yellow stripes, taken from the image of "combustion," are used on the walls. Also, to compensate for the destruction of nature necessitated by the act of construction, vegetation will be placed in the buildings; even in the plant building itself, numerous tall trees and shrub trees are planned for various locations within the building. The Maishima Plant, with this design, will bring a new edge to the landscape of the Osaka Bay area. At the same time, the intention is to bring back nature by introducing plenty of greenery into the plant's site, at different locations within the building, and to make this plant a facility that induces comfort and a sense of familiarity in the numerous people who visit the surrounding areas, including Maishima.

There are further plans in progress that are rooted in the same concept, including one to re-use rainwater in this facility, so that the building will be ecologically sound in practical terms as well (Photo 1).

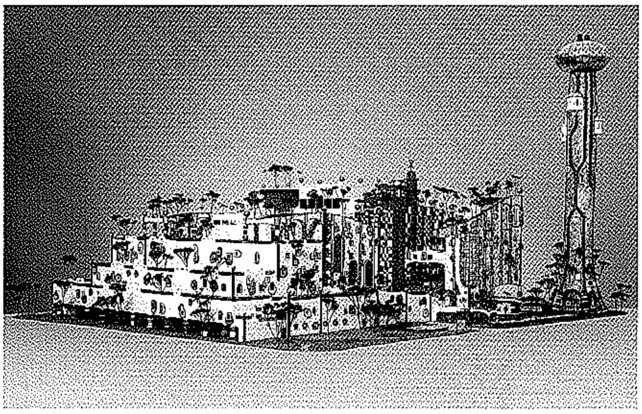


Photo 1 Conceptual Drawing of the Maishima Plant

4. Stack

The 120 m-high stack, with its conspicuous height, can be a major landmark of the island. Therefore, similar considerations have been given to stack design as to the plant building. The stack's design was also commissioned to Master Hundertwasser; the stack is topped off with a golden ball, a particular feature used by the artist, closely followed below by small rooms styled as bay windows. The flue leading from the plant building is located underground, to de-emphasize the stack function.

5. Greenery

For the Maishima Plant, a commitment was made at the environmental assessment stage to secure at least 30% of the site as greenery area, and plans are in place to provide greenery within the plant site, to the maximum extent possible. Furthermore, in line with Master Hundertwasser's concept, greenery will also be located on the rooftop of the plant building. The plan is to grant free access to the general public to the greenery on the outer periphery of the plant area.

6. Facility for Visitors

Osaka City is currently providing education on waste treatment to 4th graders. Therefore, many elementary schools request waste treatment facility visits, and adequate considerations are necessary at the visitor facility in preparation for such visits. The Maishima Plant is expected to attract many more visitors, due to its exterior design and its location in Maishima. Therefore, the facilities inside the Maishima Plant will accommodate display presentation to the visitors. In conventional incineration plants, major pieces of equipment except for garbage cranes are covered by casing, and a verbal explanation provided on-site fails to instill a good visual understanding of the facility in the visitors' minds. This new display type of presentation facility will be designed so that details of waste processing equipment at the incineration plant can be understood easily by children through visual images (Figure 6).

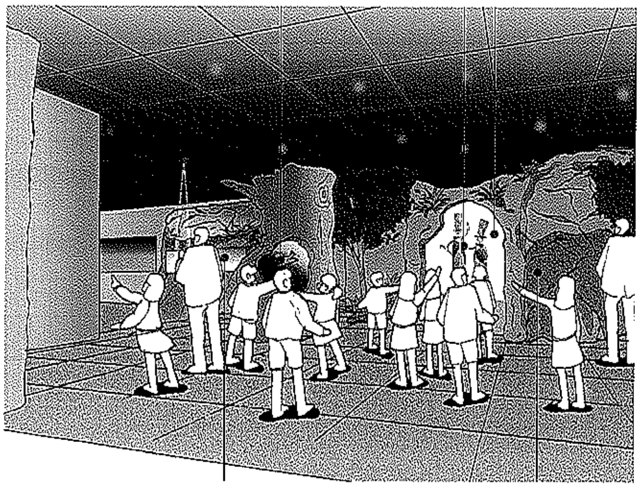


Fig. 6 Conceptual Sketch of Maishima Plant Visitor Facility

In Closing

Currently, the public attitude toward incineration plants has always been negative, no matter how much care has been taken in pollution preventive measures or waste heat use facilities; for this reason, it has never been easy to obtain consent from residents for plant construction. Under such circumstances, it is the responsibility of the planners to change the image associated with incineration plants, and to build facilities that will be accepted by the community. As described herein, Maishima Island, where the plant will be built, is an artificial island built to attract people for its sports and recreational facilities; its coastal area has already been developed to a great extent, including the construction of Universal Studios Japan. When a plan is made to build an incineration plant in such surroundings, due care must be taken not only with regard to the environment and the landscape, but also to public acceptance of the facility. In this regard, the planners hope that many people will feel this incineration facility to be a part of their community, and that it will help to widen public acceptance of incineration plants in general.

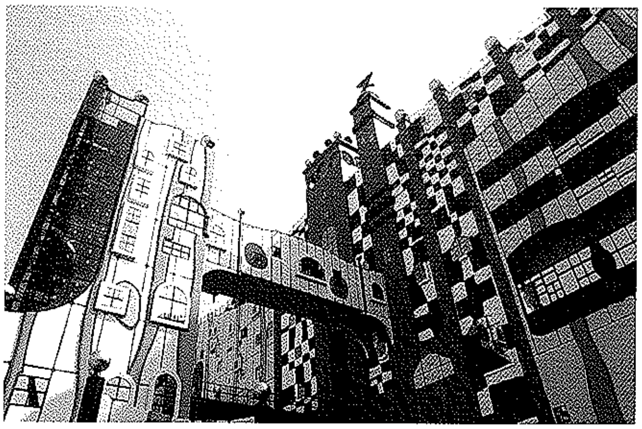


Photo 2 Maishima Plant Site Photograph, March 2000

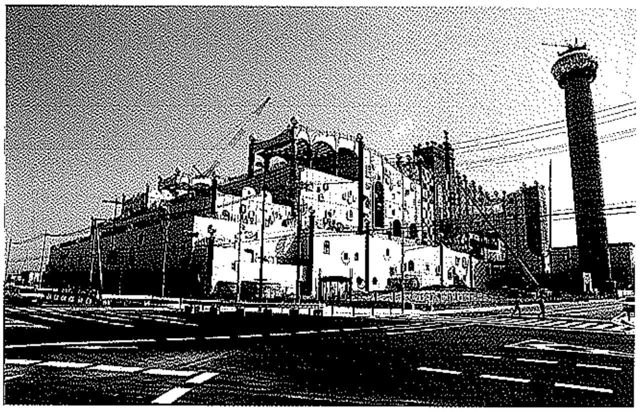


Photo 3 Maishima Plant Site Photograph (full view), March 2000

Construction of a Floating Swing Bridge—Yumemai Bridge

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Osaka City Road Corporation

Yukio Kawamura
Public Works Bureau

1. Introduction

The City of Osaka has been undertaking the "Techno-port Osaka" project to develop in its waterfront area a new metropolitan center with advanced features for the 21st century. This project covers the construction of three reclaimed islands, Maishima, Yumeshima and Sakishima, in the waterfront area (Fig. 1). As a candidate for the host city of the 2008 summer Olympic Games, Osaka has decided to use Maishima as the main venue for the Games. Yumeshima, which is still under reclamation, is planned for residential, commercial and various amenity facilities. Under these circumstances the City of Osaka planned the construction of the Yumemai Bridge, which is expected not only to contribute to accelerated development and improvement of these reclaimed islands, but also to play an important role in transportation access to the waterfront area.

The channel between Yumeshima and Maishima, called "North Waterway," as a subsidiary to the main waterway located to the south of it, provides passage mainly for small craft. These two waterways are the only routes via which ships and boats can access major facilities in the Port of Osaka. If the main waterway becomes unusable due to an accident or for other unforeseeable reason, the North Waterway needs capacity as an international passage through which even large vessels can navigate. To ensure marine passage in emergency, it was decided to construct a movable bridge over this North Waterway. Compared with a tunnel and an ordinary fixed bridge with large clearance under the girder, a movable bridge is far advantageous in terms of costs, construction time, and land use.

The Yumemai Bridge was constructed as a floating swing bridge, the world's first type of movable bridge (Fig. 2). It comprises a floating bridge over the waterway, transitional girder bridges on both ends of the floating bridge,

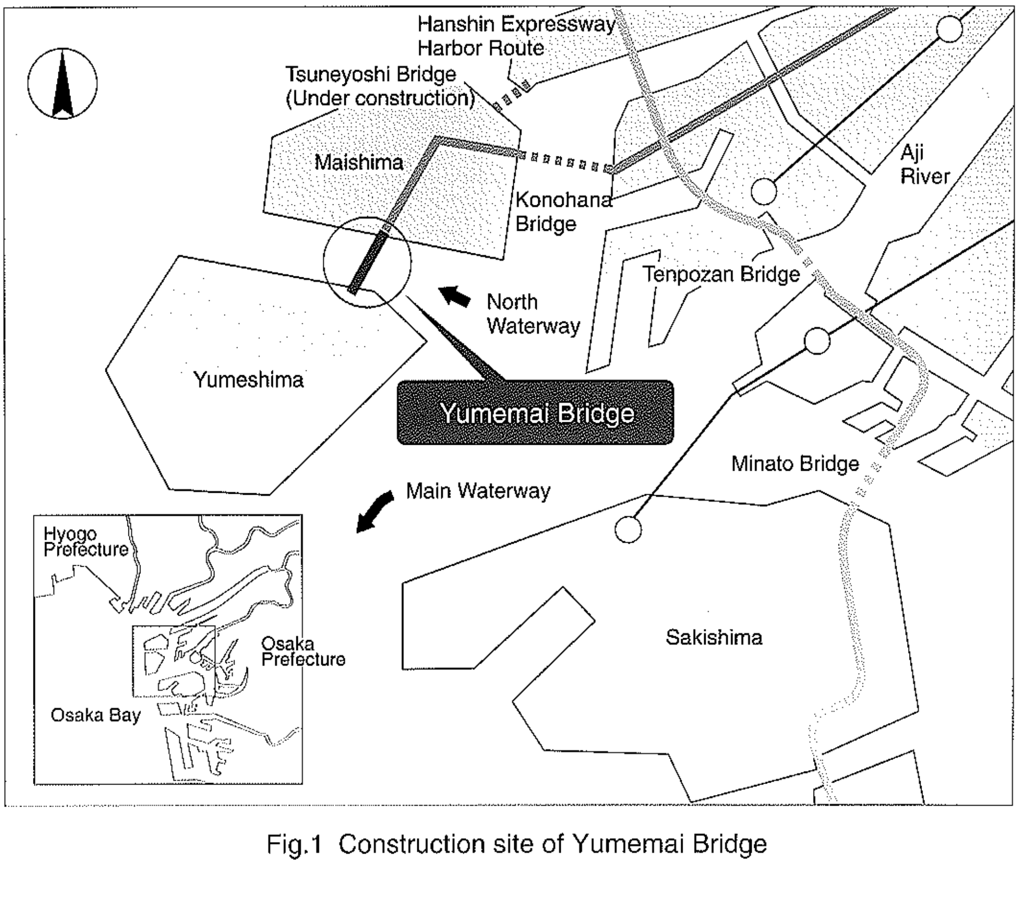


Fig.1 Construction site of Yumemai Bridge

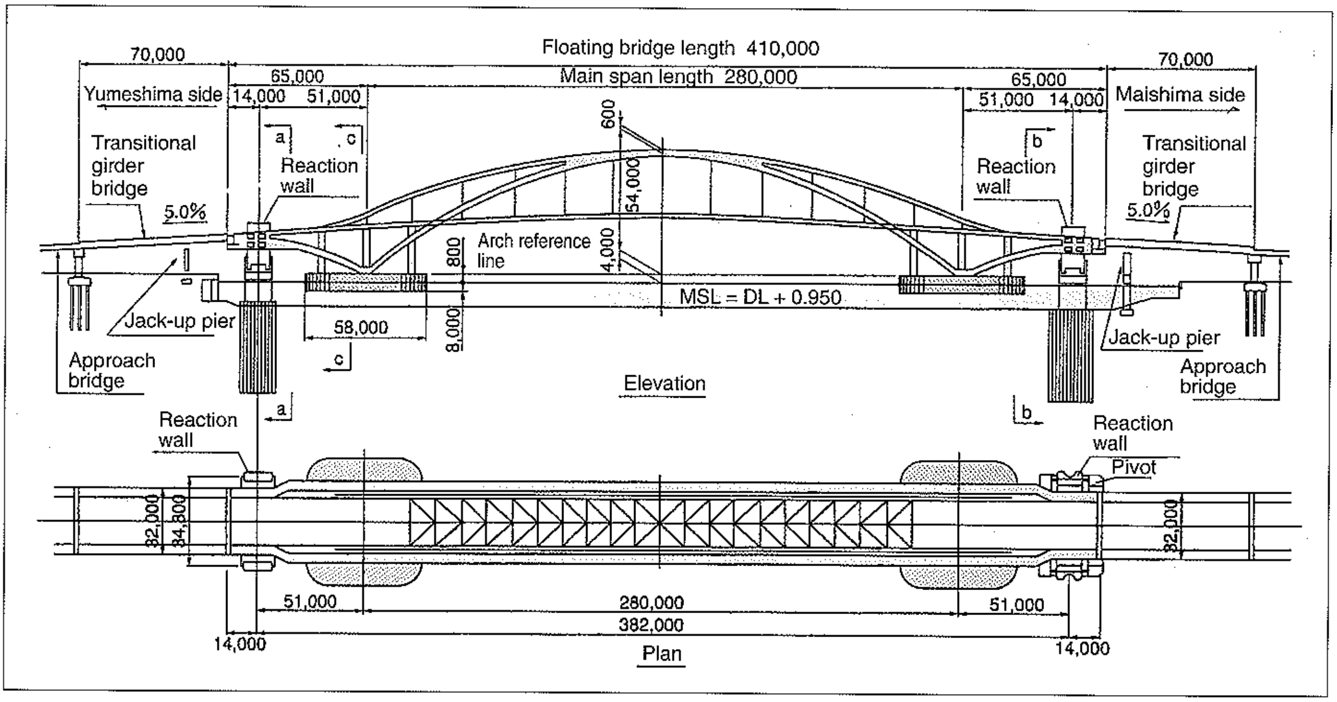


Fig. 2 Superstructure

and approach bridges on the grounds of Yumeshima and Maishima, respectively. This floating bridge, a large arch bridge structure floating on two steel pontoons (58 m × 58 m × 8 m), is horizontally supported by two mooring dolphins with rubber fenders. When positioned for normal service, the floating bridge accommodates a navigation passage width of 135 m (see Photo 1). In emergency, when the main waterway is out of service, the entire floating bridge is swung by tugboats to widen the passage width (200 m or more), enabling the passage of large vessels.[1,2]

2. Selection of Bridge Type

Normally, the lift bridge, swing bridge, retractable bridge, and bascule bridge are candidates for a movable bridge. These candidates, excluding the bascule bridge, were compared and investigated for suitability to the Yumemai Bridge, which must provide a relatively wide (200 m) navigation passage in emergency. During the preliminary investigation stage, a floating swing type was studied in particular detail from various aspects, including

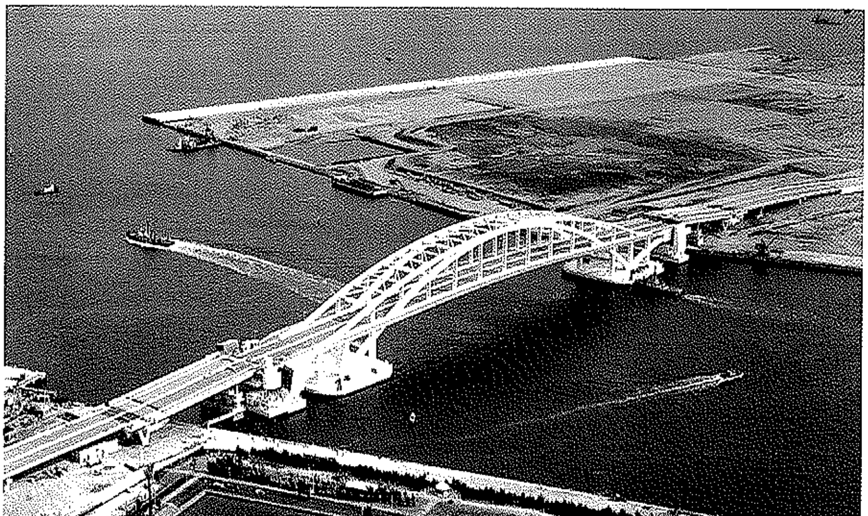


Photo 1 Panoramic View of the Yumemai Bridge

mooring method. Table 1 summarizes the result of the comparison. A floating swing bridge and a cable-stayed swing bridge were found to have economic advantage over the other types. Closer investigation of these two candidates led us to choose the floating swing type, for the following reasons:

(1) The bridge over the North Waterway will rarely need to be opened. When it becomes necessary to open it, the floating bridge can be swung by tugboats, requiring very little power and minimum drive equipment. In addition, opening by towing is accurate.

(2) Yumeshima is still in the process of reclamation, and ground displacement and subsidence by consolidation are inevitable. With a floating bridge, the influence of ground displacement and subsidence on the bridge and bridge driving system can be minimized.

(3) The bridge is erected at a large dockyard and towed to the installation site. Since the superstructure and substructure can be erected simultaneously, a floating bridge can substantially save on construction time.

For the superstructure of the floating bridge, single-rib arch, double-rib arch, and truss designs were proposed. As the result of comparison, the double-rib arch design was selected because of its superior overall rigidity, and the potential for minimizing wave influence and local distortion by uniformizing the flexural and torsional rigidity along the bridge axis. The aesthetic effect was also taken into account.[3)]

3. Technical Challenges

Various design standards, including the "Highway Bridge Specifications" are conventionally used in bridge design in Japan. In designing this floating bridge, however, these standards alone were not sufficient. It was necessary to establish new design techniques and a new concept of design safety factors. Floating structures have been the focus of investigation in various occasions, e.g., at the time of planning the Kansai International Airport, and in the "Mega-Float Project" led by the Ministry of Transport. Among large floating structures now in service in Japan are oil reservoir terminals at Kamigoto (Nagasaki Pref.) and Shiroshima (Kita-kyushu City). With reference to the data and experience thus accumulated, various technical challenges had to be dealt with in the process of designing the Yumemai Bridge. Fig. 3 is the flow chart showing this process. The major technical challenges[4,5,6)] are listed below:

(1) Since a floating bridge is more vulnerable to meteorological and oceanographic conditions than a conventional fixed bridge, proper environmental conditions, suitable to the characteristics of the installation site, must be set in designing the bridge.

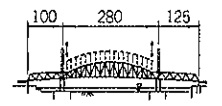
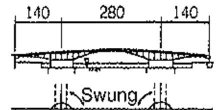
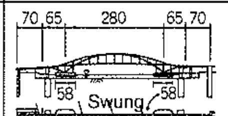
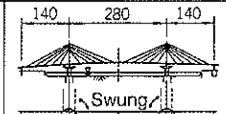
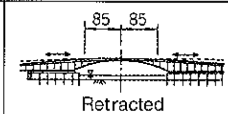
(2) The motion of a floating bridge in winds and waves must be studied in detail, so that the result can be incorporated in the design.

(3) The driving safety and riding comfort of vehicles on the bridge must be maintained against bridge deck geometric line form change caused by tidal flux and bridge motion.

(4) The characteristics of rubber fenders used as mooring shock absorbers must be identified and taken into consideration in the design.

(5) The effect of ground displacement on the bridge structure must be evaluated and taken into consideration in the design.

Table 1 Comparison of Various Movable Bridges

	Lift bridge (Curved chord truss through bridge)	Floating bridge (Pool-type upper side supported bridge)	Floating bridge (Swing type bridge)	Swing bridge (Cable-stayed bridge)	Retractable bridge (Abacus bridge with lifts)
Schematic (Unit: m)					
Economy	×	×	○	○	×
Structural rigidity	○	△	△	○	×
Construction ease	△	△	○	△	△
Movable performance	○	△	△	△	△
Ground displacement	×	○	○	△	△
Serviceability	○	△	△	○	×
Maintenance ease	△	△	○	△	△
Overall rating	△	×	◎	○	×

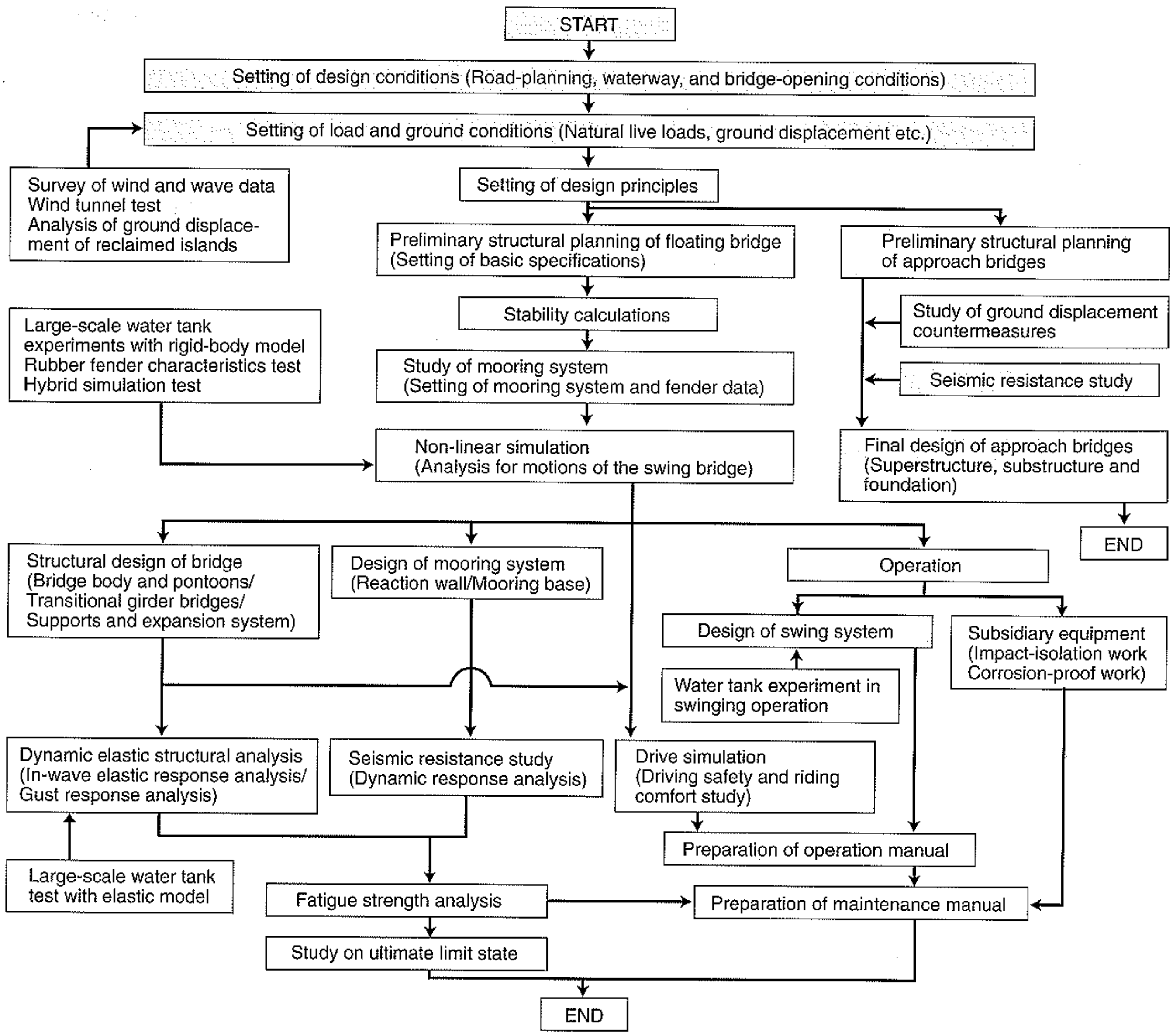


Fig. 3 Flow Chart for Design of Yumemai Bridge

(6) Floating bridges are generally said isolated bridge type. This general notion must be validated to confirm seismic safety; seismic displacement must also be determined and incorporated in the design.

(7) Since this bridge is of the swing type, manuals must be prepared for opening/closing and for maintenance.

4. Design Conditions

4.1 Meteorological and Oceanographic Conditions

The basic design wind velocity (V_{10}: wind velocity at height of 10 m) was set at 42 m/s with a 100-year return period, based on wind velocity data obtained near the installation site and the observation record (1931 to 1995) supplied by the Osaka District Meteorological Observatory. For bridges near the installation site, the regulation sets the traffic safety wind velocity limit at $V_{10} = 20$ m/s. This value was adopted as the design condition. The wind velocity limit for safe bridge opening/closing was set at $V_{10} = 15$ m/s, on the basis of the marine operation standard for the Port of Osaka.

As for design tide level, a tidal fluctuation between DL + 4.8 m (design high tide) and DL - 0.52 (ultra-low tide) was assumed, the design datum level (construction datum level) being CDL + 0 m. The design wave was set at H1/3 = 1.4 m, based on typhoon and gale data for the past 40 years (1956 to 1995), the result of wave diffraction calculations for the waterway, and the result of large-scale water tank experiments. Based on wave spectrum observation at the wave observation tower in Osaka Bay, simulation of bridge drift in winds and waves employed the Bretschneider-Mitsuyasu type wave spectrum.

The design tidal current velocity under ordinary conditions was set at 0.2 m/s on the basis of existing data; that under storm condition, for which there was no data, was set at 0.5 m/s by estimation taking bridging site topography into account. As for tsunami, the design tidal fluctuation at the site was set at 2.62 m, and the flow velocity (including tidal current) at 2.6 m/s, on the basis of values set for the regional disaster prevention program of Osaka City.

4.2 Earthquake

"Expected earthquake," taking into account the influences of the active faults, topography, geology and ground condition of the bridging site, was used to determine the bridge's seismic requirements. Specifically, the design considered the two types of expected earthquake waves: one based on the Tohnankaido-Nankaido Seismic Fault Line model, which corresponds to a level II type I earthquake (Plate boundary earthquake) as provided in the "Highway Bridge Specifications," and the other based on the Uemachi Active Fault Line model, which corresponds to a type II earthquake (Inland earthquake).

4.3 Combined Loads, Allowable Stress Increment Factors, and Safety Factors

The design of the Yumemai Bridge is essentially based on existing design standards. However, for combined loads, which are not covered by any of existing design standards, allowable stress increment factors were set using the safety evaluation techniques proposed by the Japan Society of Civil Engineers. Table 2 lists the allowable stress increment factor for each load combination on the floating structure and the mooring dolphins. For each major component, the margin to ultimate collapse was determined and incorporated in the safety factor.

5. Study for Stability

For the Yumemai Bridge, a long-span floating bridge supported on two pontoons, floating stability is a very important concern. Since this bridge must secure a large navigation clearance of 26 m under the bridge girders, the bridge's center of gravity and the wind loading point are necessarily positioned high. To ensure its stability, therefore required careful attention.

For the initial righting moment to secure a satisfactory static stability of the floating structure, it is essential that the vertical distance between the center of gravity and the transverse metacenter (i.e., TGM), shown in Fig. 4, are positive. The greater the TGM value, the greater the stability of the floating structure. Using the basic design dimensions of pontoons, static stability calculations were carried out for three cases: without live load (S1), with

Table 2 Combined Loads and Allowable Stress Increment Factors

(a) Floating structure (Superstructure, pontoon and pivot pin)

Loading status	Combination of loads	Allowable stress increment factor
Standard	D + U + L + I	1.00
Temperature	D + U + L + I + T	1.15
Storm	D + U + W + WP	1.20
Earthquake	D + U + EQ	1.50
Swinging	D + U + W + WP + DR	1.25
Construction and towing	D + U + W + WP + ER	1.25

(b) Mooring dolphin (including reaction wall, reaction wall supporting beam, reaction wall anchor frame, RC dolphin, steel pipe sheet pile well foundation, and floating structure fender installing section)

Loading status	Combination of loads	Allowable stress increment factor
Standard	D + U + GD	1.00
Temperature	D + U + T + GD	1.15
Storm	D + U + W + WP + GD	1.50
Earthquake	D + U + EQ + α • GD(α: coefficient)	1.50
Swinging	D + U + W + WP + DR + GD	1.25

D: Dead load
L: Live load
I: Impact
U: Uplift of buoyancy
E: Earth pressure
W: Wind load
T: Effect of temperature fluctuation
EQ: Effect of earthquake
WP: Wave pressure
PD: Tidal force
GD: Effect of ground displacement
SD: Effect of supporting point displacement
DR: Bridge driving load
ER: Load during erection
CO: Ship collision load
TU: Effect of tsunami

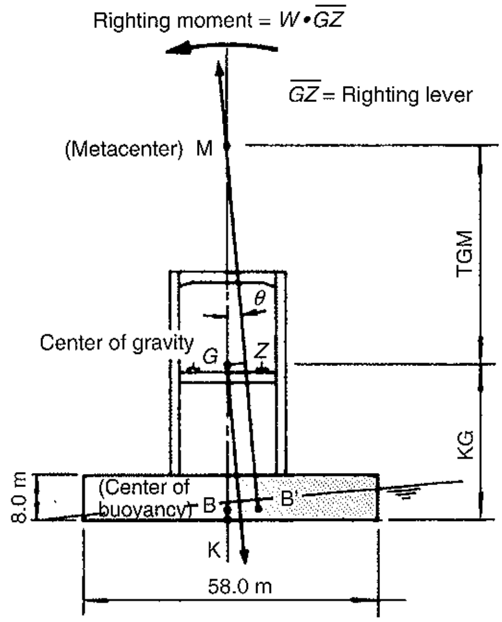


Fig. 4 Centers of Buoyancy and Gravity, and Metacenter

biased live load (S2), and with full live load (S3). Table 3 shows the results. For all three cases, the calculated values are larger than those for conventional marine structures and ships, verifying that this floating bridge is extremely stable.

Dynamic stability was evaluated using the following formula:

Area $(A + B) \geq 1.4 \times$ Area $(B + C)$

in which areas A, B and C are as schematically shown in Fig. 5. To satisfy this formula, the righting moment must be at least 1.4 times the inclining moment. The required righting moment inclining moment ratio for securing satisfactory dynamic stability, determined using the pontoon dimensions as parameters, was incorporated in the basic design. Table 3 also shows the ratio for a 58 m × 58 m × 8 m pontoon, for each of the above-mentioned three cases.

6. Mooring Method

The floating bridge is supported vertically by the buoyancy of seawater. It must also be supported horizontally to resist such lateral forces as wind, wave and earthquake. Horizontal support is achieved by mooring. The following three different mooring methods were compared and assessed for applicability to this floating bridge:

- Anchor chain mooring
- Submersible mooring

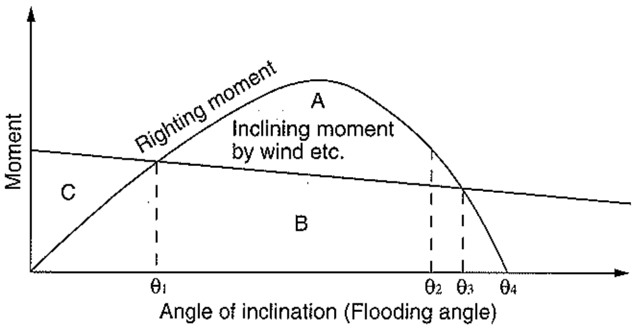


Fig. 5 Dynamic Stability Study

Table 3 Static and Dynamic Stability Calculation Results

	Case S1 & D1	Case S2 & D2	Case S3 & D3	Condition
Mean draft d (m)	4.80	5.08	5.30	
Displacement Δ (t)	31 445	32 287	34 700	
Height of center of gravity KG (m)	26.38	26.58	26.72	
Transverse metacenter TGM (m)	30.09	27.03	24.92	TGM > 0
Lateral inclination θ (deg)	0.00	1.14	0.25	
DSR = $(A+B)/(B+C)$	1.44	4.97	4.50	DSR ≥ 1.4

(Specific gravity of seawater: 1.025)

- Rubber fender mooring

Comparison revealed that the rubber fender mooring most effectively restricted the bridge motion, yet was the most economical. Therefore, the focus of our attention was on the two rubber fender mooring methods: reaction wall and link damper. Fig. 6 schematically shows the two mooring methods, and Table 4 compares their characteristics. The wall reaction method has been adopted, due to its superior bridge motion prevention characteristic, and con-

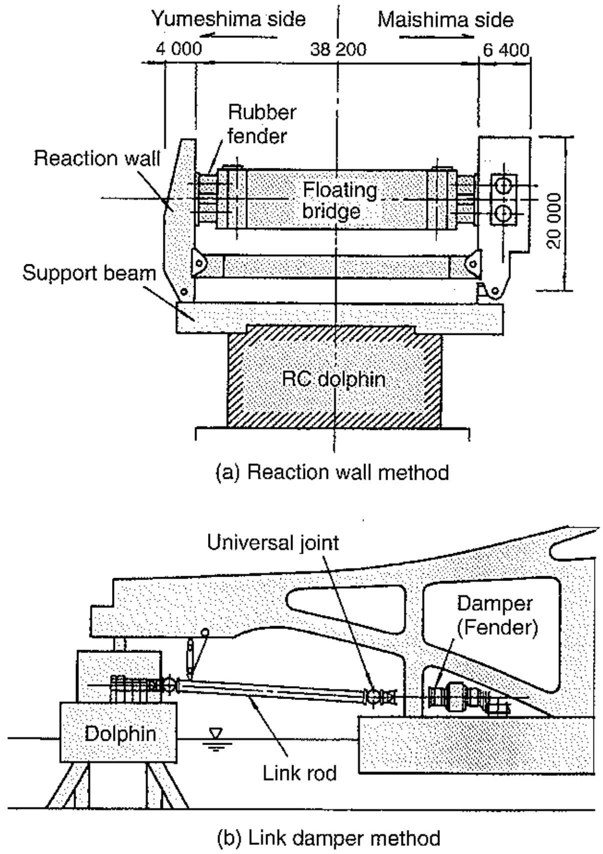


Fig. 6 Schematic of Mooring Systems

Table 4 Comparison of Mooring Methods

Item \ Type	Reaction wall method	Link damper method
Motion of bridge body	Motion in wind and waves is relatively small, since mooring point is at the same level as the center of gravity.	Motion in wind and waves is relatively large, since mooring point is at the same level as the pontoon.
Opening/closing operation	Release from the mooring system and positioning of the bridge are relatively easy, since they involve only moving the reaction walls.	Rod connection/disconnection requires labor and involves operation of bridge position retaining mechanism.
Technical problem	Steel 20 m high movable reaction wall. Reaction wall operating mechanism, and fixing pin insertion/removal mechanism	Link mechanism Rod connection/disconnection mechanism
Dolphin (Foundation)	Load-acting point is high, resulting in a large moment.	Load-acting point is low, resulting in a small moment.

venience in bridge swinging operation. The constant-reaction rubber fenders used for mooring this bridge have the reaction characteristics shown in Fig. 7.

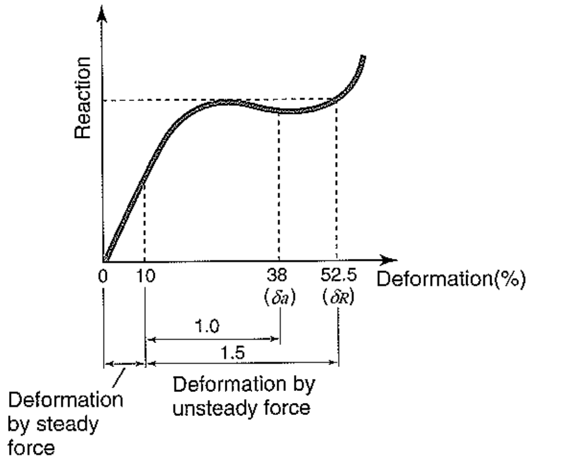


Fig. 7 Relation between Reaction Force and Deformation of Rubber Fender

7. Wind Tunnel Test

In determining the design of each component of a floating bridge, storm wind and wave loads are more influential factors than in the case of a fixed bridge. Therefore, proper evaluation of wind load is necessary. If wind load can be reduced by a relatively simple measure, cost can be saved. In view of this, the static wind load characteristics (mainly drag coefficient) of this floating bridge were investigated by wind tunnel test[7] using a rigid 3D model, and effective wind load reduction measures were sought. (See Photo 2.)

The test revealed that the following measures are effective in reducing wind load:

(1) A corner cut is formed in each side face of the upper and lower arch ribs, so that the aspect angle becomes approximately 30 degrees.

(2) A fairing is provided on both ends of the stiffening girder, and the bottom face of the girder is closed to streamline the girder vertical section.

These measures reduce the drag force by about 20%. The measures shown in Fig. 8 were therefore applied to the basic section of this bridge. For the stiffening girder, a box girder was adopted in lieu of facing plates.

8. Large-scale Water Tank Experiments & Non-linear Computer Simulation

In designing a floating bridge, it is essential to clarify the bridge's drift characteristics in wind and waves, and to obtain accurate drift characteristic values. Since the Yumemai Bridge would be moored by rubber fenders, a

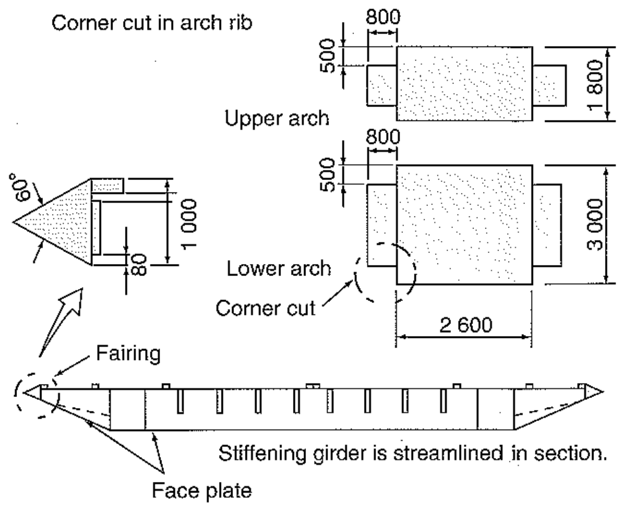


Fig. 8 Wind Load Reduction Measures

new analytical technique had to be developed that takes into account the non-linear characteristic of the rubber fenders. It was also necessary to determine the effect of the relatively flexible bridge structure's elasticity and to investigate opening/closing safety of the mechanical system.

For designing the floating bridge, a structural analysis program was developed, and large-scale water tank experiments were conducted to verify the appropriateness of simulation-based calculations. Hybrid simulation testing was also carried out to clarify the actual behavior of constant reaction rubber fenders with high nonlinearity. Three different large-scale water tank experiments were conducted, and drift simulation results were validated using three different programs which contain the same basic formulas but improved for consistency with respective experiments. Table 5 outlines the large-scale water tank experiments and the hybrid simulation test.

Table 5 Large-scale Water Tank Experiments and Hybrid Test

	Model	Scale	Water tank size (Length × Width × Depth)	Site of experiment
Experiment I	Topographic model, Rigid model	1/80	50m×40m×*	Tsuchiura, Ibaraki pref.
Experiment II	Elastic model	1/40	190m×30m×*	Nagasaki, Nagasaki pref.
Experiment III	Rigid model, Bearing model	1/80	100m×5m×*	Akishima, Tokyo
Experiment IV	Rubber fender model	1/12.5	—	Totsuka, Yokohama, Kanagawa pref.

*: Depth conforms to water depth at site.
For experiment II, height was varied.

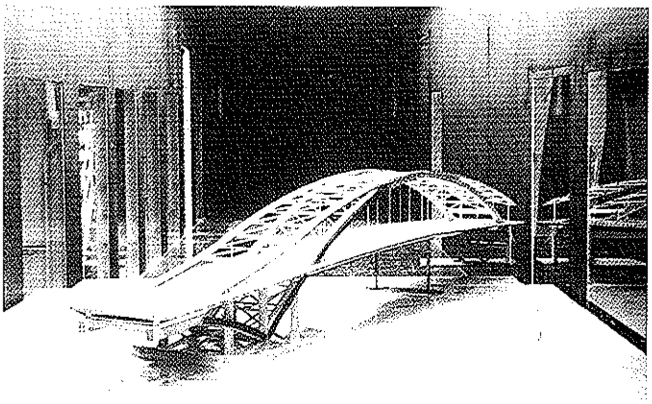


Photo 2 Wind Tunnel Test

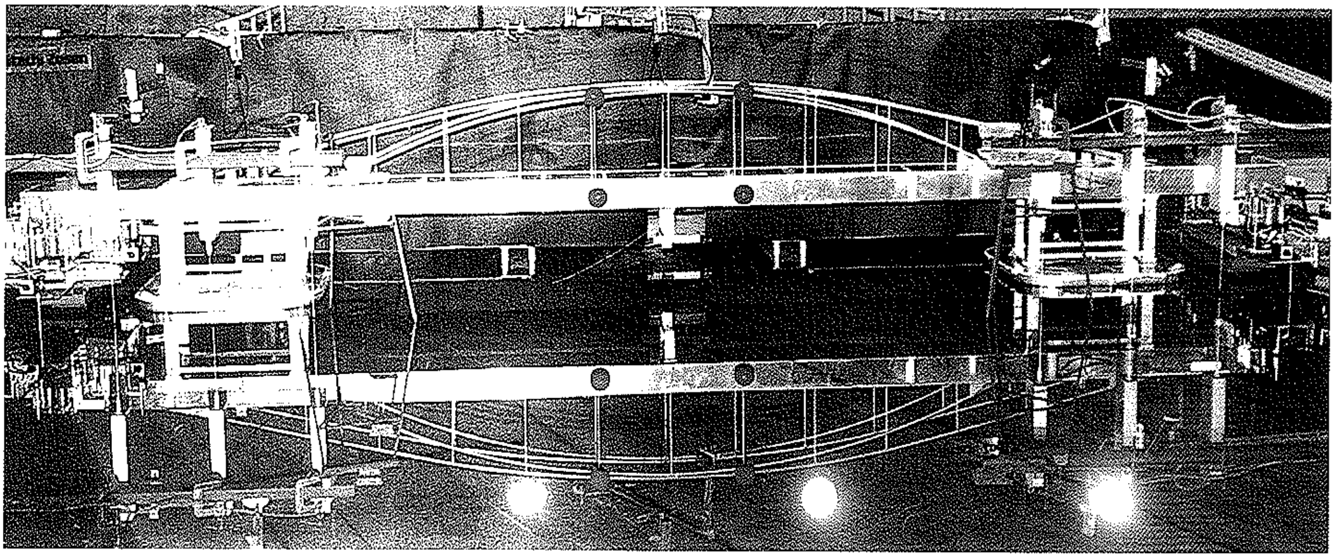


Photo 3 Rigid Model Experiment on In-wave Motion of Moored Floating Structure

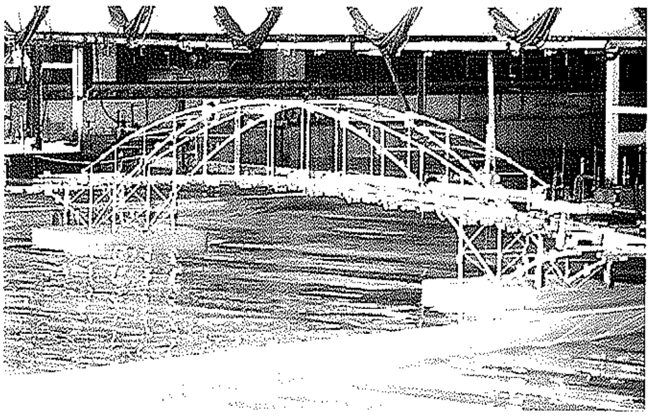


Photo 4 Elastic Model Experiment on In-wave Elastic Response

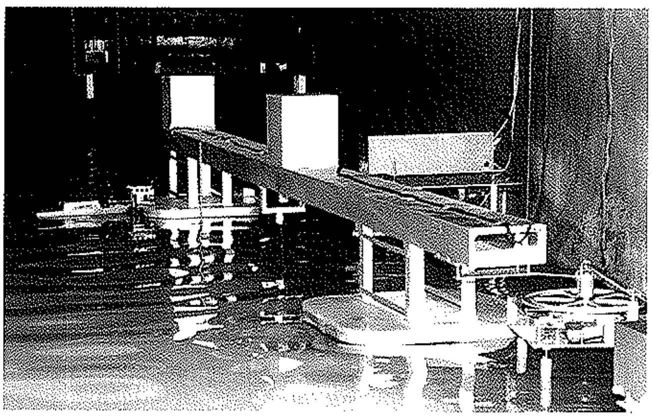


Photo 5 Experiment in Swinging and Temporary Mooring Operations

- Experiment I[8] (Rigid model experiment in a topographic model) (Photo 3)

  The objectives of the experiment were:

  (1) To clarify the oceanographic conditions at the bridging site, taking into account the influence of wave diffraction and interference, by accurately reproducing the waterway between Yumeshima and Maishima and the seawall structures

  (2) To obtain data regarding the motion of the entire floating bridge, deformation of rubber fenders, etc., and develop simulation techniques and data that could represent such motion and deformation

- Experiment II[9] (In-wave elastic model experiment) (Photo 4)

  Objectives of the experiment were:

  (1) To experimentally investigate the elastic response of the floating bridge in waves

  (2) To experimentally verify in-wave elastic response simulation's applicability to the structural design

- Experiment III[10] (Swinging operation experiment) (Photo 5)

  The objectives of the experiment were:

  (1) To confirm bridge swinging performance, and check loads imposed on the swing mechanism during swinging operation

  (2) To obtain data on swinging operation, such as the tug thrust of a tugboat

  (3) To confirm the temporary mooring force

  (4) To validate the analytical program by comparing the analytical results with numerical analysis results

- Experiment IV[11] (Hybrid experiment)

This floating bridge is horizontally supported by mooring with rubber fenders. Various experiments and simulation analyses were carried out to clarify the motion of the floating bridge in wind and waves. It is known that the reaction characteristic of rubber changes when the rubber is subjected simultaneously to different deformations other than compression. The hysteresis of deformation also changes with loading repetition. Therefore, it was necessary to study how rubber fender characteristics change with deformation, and to verify the appropriateness of the formula for simulation calculations. To these ends, hybrid experimentation was carried out using a scale model of the rubber fender.

9. Driving Comfort Simulation

The vertical load of this floating bridge is supported by the buoyancy of seawater, and the horizontal load by the mooring system. Therefore, in addition to deflection, which is a general problem with ordinary fixed bridges, each of the following changes had to be studied from the viewpoint of vehicle driving safety and serviceability:

(1) Change in longitudinal gradient of the transitional girder bridge decks due to tidal change

(2) Change in longitudinal and transverse gradients of the floating bridge deck due to wind and waves

(3) Change in draft of each pontoon due to live loading

It was necessary to confirm that these changes would cause no problem in regard to driving safety and riding comfort.

At present, there is no regulation or standard specifying the requirements regarding the riding comfort of vehicles on bridges. Therefore, driving on this floating bridge was simulated, and a questionnaire survey was conducted as to the vibration feeling and riding comfort on existing bridges in Osaka. The relations between the simulation and the questionnaire survey results were used as data for relative evaluation of floating bridge riding comfort.[12]

To evaluate driving safety, vehicular lateral and vertical accelerations were calculated by simulation. The result showed that these accelerations would cause no problem in driving safety, considering the long oscillation period of the bridge.

A large bus carrying 36 passengers was run at a speed of 30 to 60 km/h on existing long-span bridges, viaducts in the urban area and ordinary roads in Osaka. Vibration acceleration was measured in the bus, and the 36 passengers were asked to fill in a questionnaire on riding comfort, to obtain the correlation between vibration acceleration and riding comfort. Riding comfort was rated in five grades as

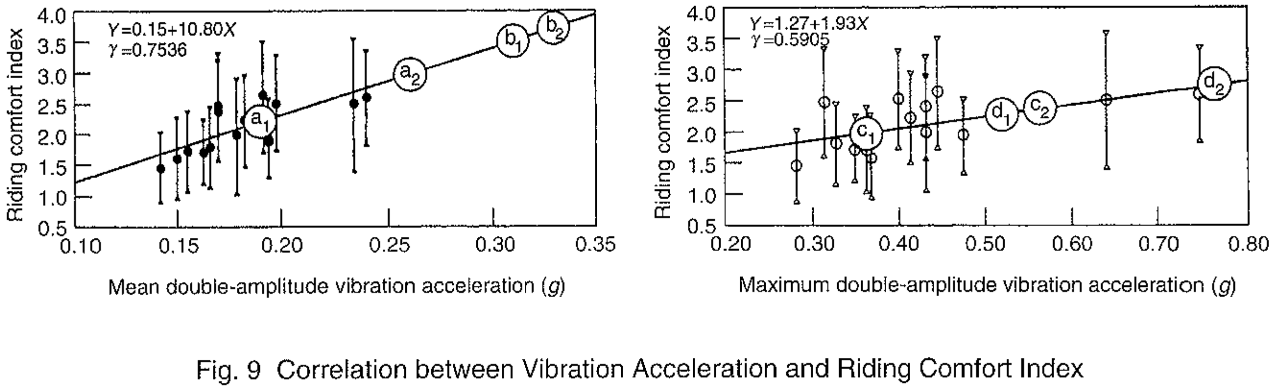


Fig. 9 Correlation between Vibration Acceleration and Riding Comfort Index

shown in Table 6.

As an example evaluation result, Fig. 9 shows the correlation between riding comfort index and mean or maximum vertical vibration acceleration as measured on the bus floor over the front wheels. The correlation shows that only in the worst case passengers may feel peculiar but not annoying vibration. It is reasonable to conclude, therefore, that vehicles can run safely on the floating bridge.

Table 6 Riding Comfort Rating

1: No peculiar vibration is felt.
2: Some vibration is felt which causes no problem.
3: Obviously peculiar vibration is felt.
4: Vibration is considerably large and uncomfortable.
5: Vibration is extremely large, uncomfortable and uneasy.

10. Superstructure Design

In designing the superstructure of this bridge, the sectional force was calculated based on the results of static and dynamic analyses. Fig. 10 shows the models used for static analysis. The buoyancy working on each pontoon was evaluated at the vertical spring set at each node of the pontoon. A floating bridge is subjected simultaneously to wind and wave loads. To study the influence by the elastic response of the floating structure in wind and waves, dynamic gust response in wird and in-wave elastic response analyses were carried out to obtain the sectional force.

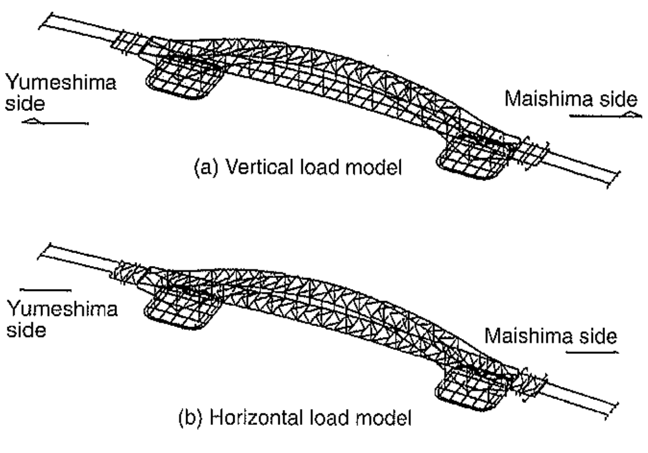


Fig. 10 Static Analysis Models

The sectional forces due to dead load, drift force of waves, tidal force, and lateral inclination caused by winds and waves, thus obtained based on the static and dynamic analyses, were evaluated superposed over each other, to design the superstructure.

The intersection between each support and inside arch forms a corner and generates complex stress. The design section was therefore studied by 3D FEM analysis, to confirm structural safety.

Each arch rib has been designed as a beam-pillar member that receives axial force and in-plane and out-of-plane bending moments. The ultimate load resistance of the design arch rib was estimated in order to confirm that the arch rib collapse load is sufficiently high compared with the load working on the rib, leaving a sufficient safety margin.

11. Design of Pontoons

Considering the shallow waterway at the bridging site and the long span of the floating bridge, pontoons of PC structure would become huge in size, making it difficult for the bridge to allow safe passage of boats. In addition, large thin-wall PC structures are difficult to construct. In view of these aspects, steel pontoons were adopted for this floating bridge.

Fig. 11 shows the pontoon internal structure. The outermost frame of the pontoon is of double-hull structure comprising outer wall and water-tight inner wall, as a failsafe measure against possible water leakage in the event of damage to the outer wall. The water-tight inner wall is installed 3 m inside the outer wall. For safety in case of ship collision, the outermost construction limit was set at 6 m inside from the outer wall. Superstructure supports are positioned within this limit. The stress generated at the base of each pontoon support is too complex to be determined by skeleton analysis only. Stress flow was therefore clarified by analyzing the FEM model of the entire pontoon shown in Fig. 12.

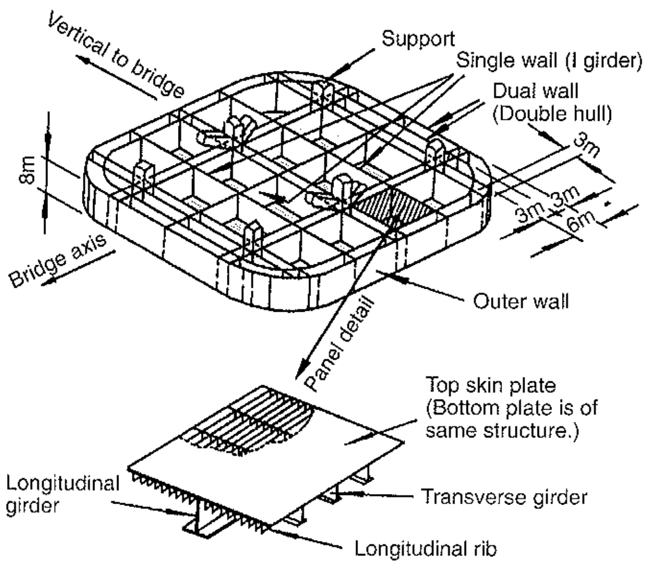


Fig. 11 Structure of Pontoon

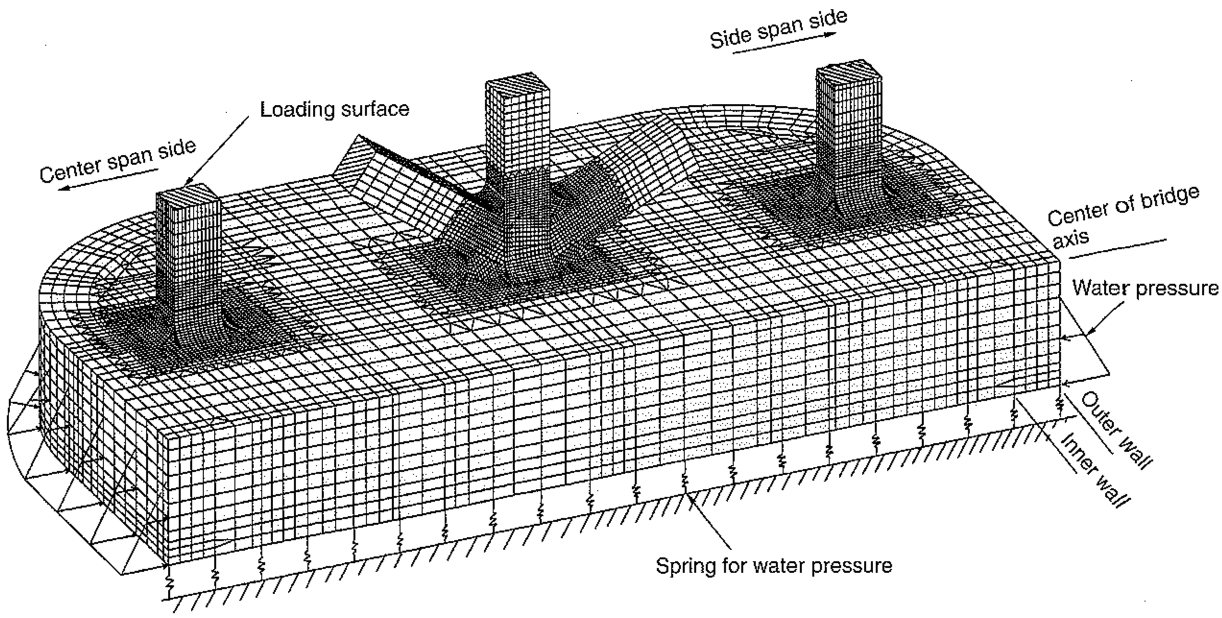


Fig. 12 FEM Model of Pontoon

12. Safety against Ship Collision

Ship collision with a floating pontoon was simulated to confirm safety. Dynamic 3D FEM model analysis (LS-DYNA3D) was used. Fig. 13 shows the FEM model used for this analysis[13].

Fig. 14 shows the analysis results. The maximum outer wall deformation was approximately 1.7 m, and the deformed outer wall did not reach the water-tight inner wall 3 m inward. This proves that even if the outer wall is partly damaged, water will not enter the inner wall, so traffic on the bridge will not be affected.

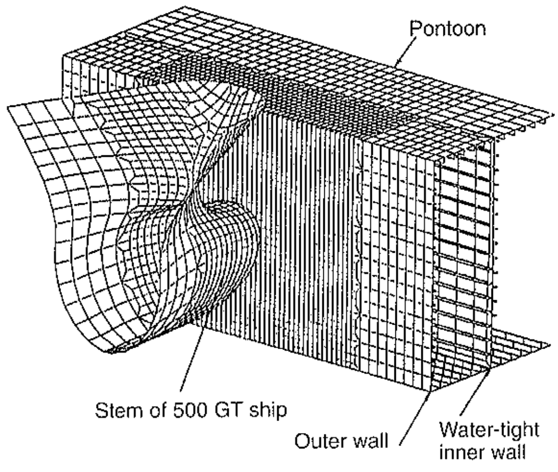


Fig. 13 Ship Collision FEM Model

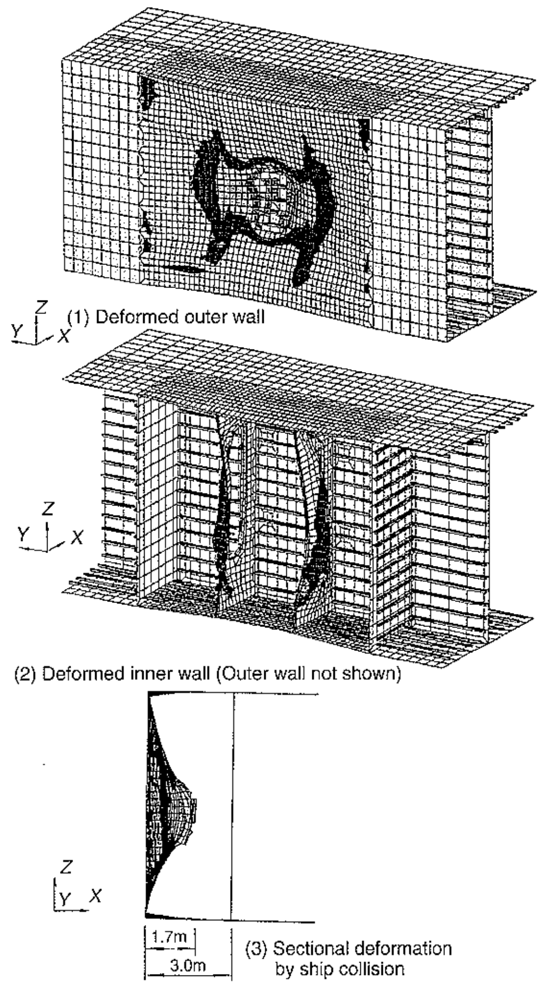


Fig. 14 Results of Ship Collision FEM Analysis

13. Construction Outline & Procedures

The superstructure of the floating bridge with two pontoons was constructed at a dockyard about 10 km away from the bridge installation site. Construction began in March 1998 and was completed in July of 2000. The dock, which measures 62 m wide by 408.3 m long by 12 m deep, could precisely accommodate the two pontoons, with the superstructure girder end protruding by about 5 m outside the dock.

Each superstructure block (average weight: 60 t, maximum weight: approx. 110 t) was mounted by the temporary support method, using two 120 t suspension jib cranes installed on both sides of the dock. Fig. 15 shows the construction procedure (see Photos 6 through 9).

The temporary bents used in constructing the superstructure can be grouped into three types: the center- and side-span stiffening girder supporting bents, which are set on the foundation installed at the dock bottom; center arch supporting bents, which are set on the main stiffening girder structure; and bents for supporting arch members and stiffening girder blocks on the pontoon. The tallest bent used was 36 m tall. The total weight of all temporary bents used was about 4,500 t.

While center-span stiffening girders and structural members were constructed over each pontoon, the pontoons are exposed to sunlight and can warp excessively due to the temperature differential between the upper and lower sides. Before construction, therefore, dimensional measurements were taken during day and night, and adjustments were determined, to secure construction accuracy. Upon installation at the site, the center-span stiffening girders between the two pontoons are also affected by temperature fluctuation. Therefore, the two pontoons were set about 150 mm further apart from each other than the design distance, and center-span stiffening girder blocks were arranged from each end toward the center. After the final block was installed, the Yumeshima-side pontoon was set forward by about 200 mm (150 mm + 50 mm for contraction during winter) to join the stiffening girders.

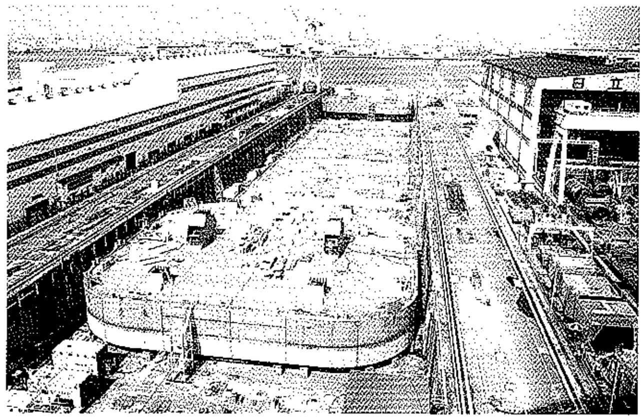


Photo 6 Pontoons Installed

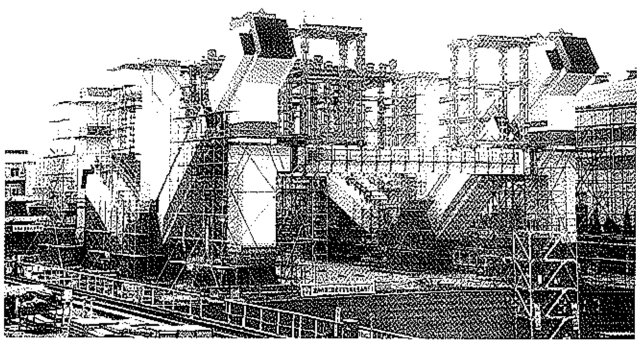


Photo 7 Superstructure Construction Started

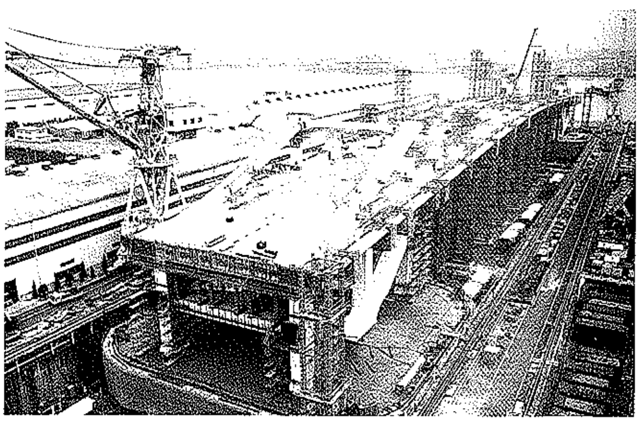


Photo 8 Stiffening Girder Assembled

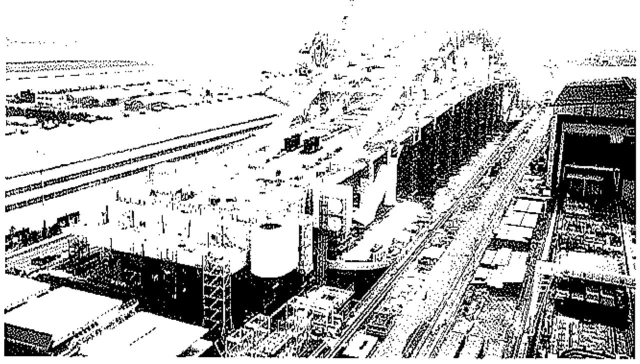


Photo 9 Full View of the Completed Superstructure

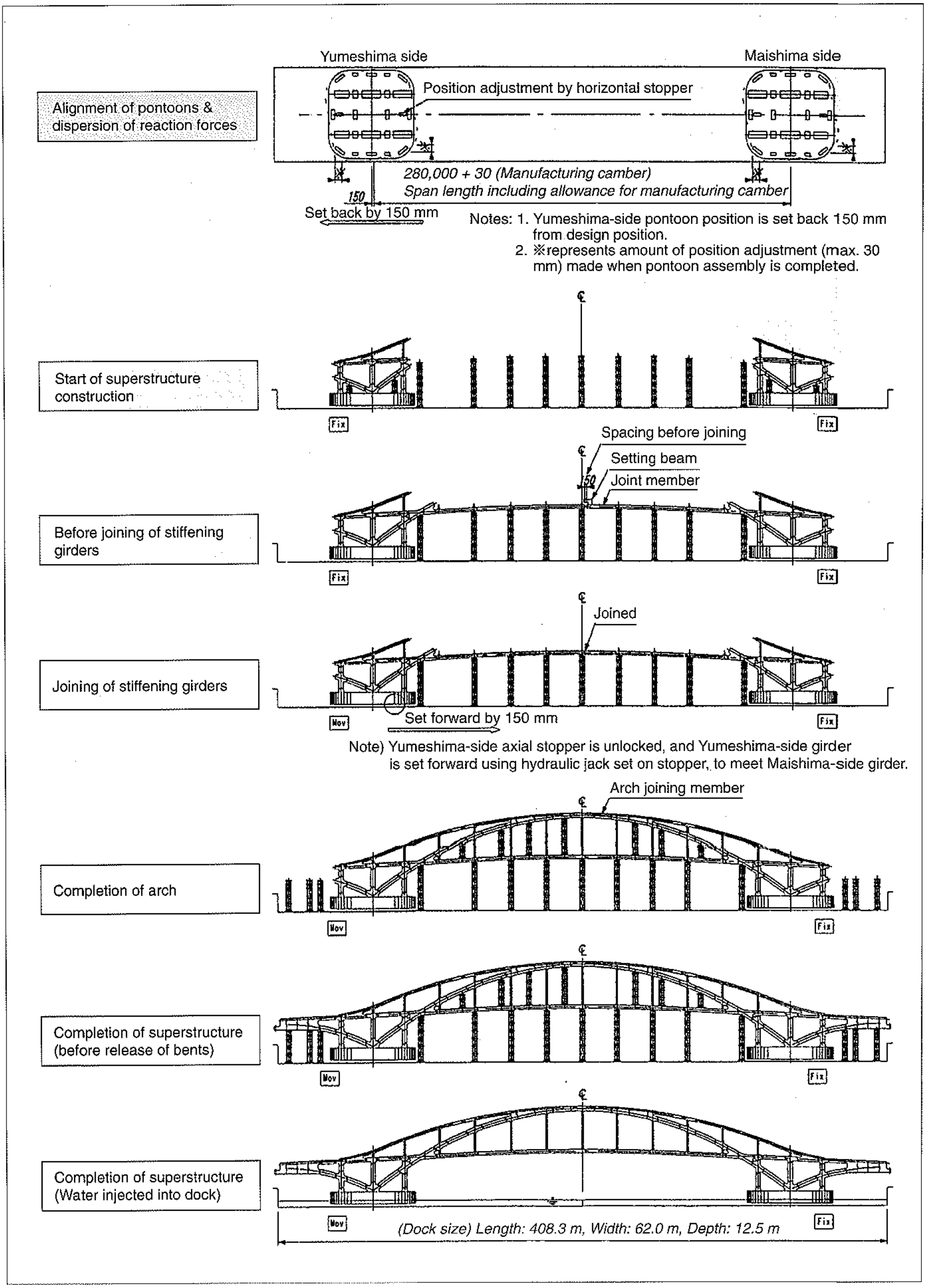


Fig. 15 Procedure for Construction of Pontoons and Superstructure at Dockyard

14. Pulling out of Dock, Towing & Installation

Upon completion, the floating bridge was pulled out of the dock and towed by tugboats to the installation site, where it was successfully installed in mid July 2000. Fig. 16 outlines these operations (see Photos 10 through 12).

(1) Pulling out of the Dock

The floating bridge has two pontoons spaced 280 m apart. After either of the pontoons came out of the dock, the most demanding task was to control the positions of the two pontoons. The position of the trailing pontoon was controlled by operating the dockyard winches and carriages connected to the winch on the pontoon. The position of the leading pontoon was controlled by operating tugboats on both sides of the floating bridge.

(2) Towing

The floating bridge, thus pulled out of the dock, was towed at a speed of about 3 knots by a formation of eight 3,600 HP tugboats, over the 9 miles to the installation site. The towing took about 3.5 hours.

(3) Installation on the Site

At the installation site, the floating bridge was wired to anchors previously installed in the water and on the grounds of Yumeshima and Maishima, by operating the pontoon winch used at the time of pulling the floating bridge out of the dock. The bridge end on the Maishima side was drawn to the mooring system, and a pivot pin was inserted in the same way as in opening/closing the bridge. The other end of the bridge was then rotated by tugboats and connected to the mooring system on the Yumeshima side. Finally, reaction walls were raised to complete the installation. The entire operation, from pulling the floating bridge out of the dock to the on-site installation, was completed in one day.

Closing

The Yumemai Bridge is the world first floating swing bridge. In designing this bridge, therefore, it was necessary not only to meet various existing design standards, such as the "Highway Bridge Specifications," but also to solve many technical problems. The bridge has successfully been installed on the site, thanks to cooperation from the academic sector, and from various industrial fields, including the shipbuilding, machinery and electric industries. The Yumemai Bridge is scheduled to be fully completed by the late fall of 2000.

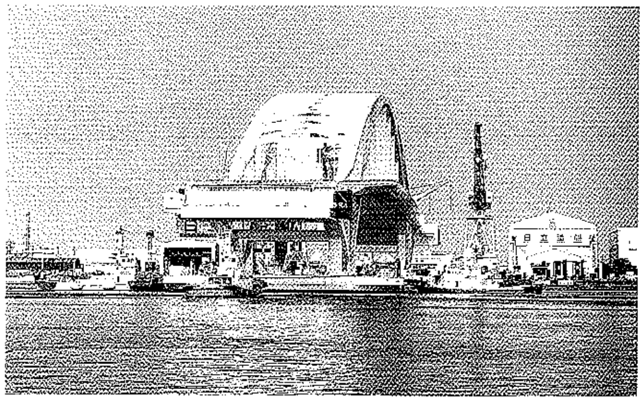


Photo 10 Floating Bridge Is Being Pulled out of the Dock

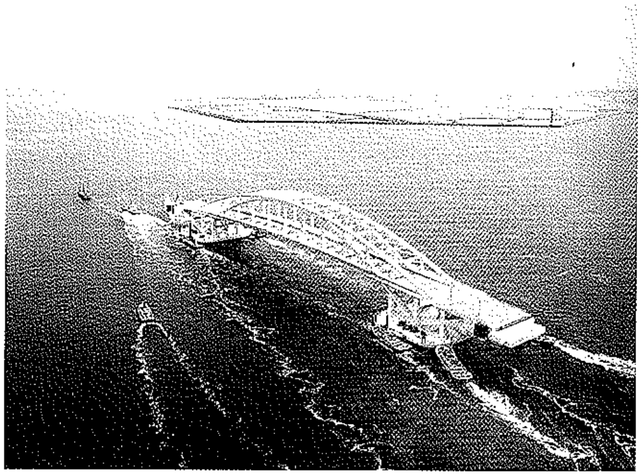


Photo 11 Floating Bridge Is Being Towed

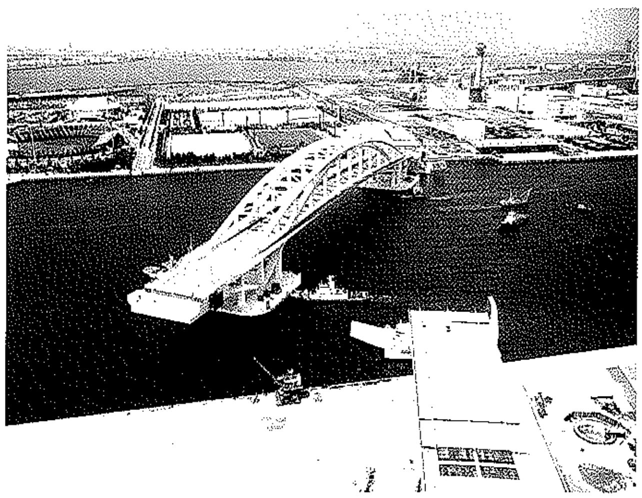


Photo 12 Floating Bridge Is Being Installed at the Site

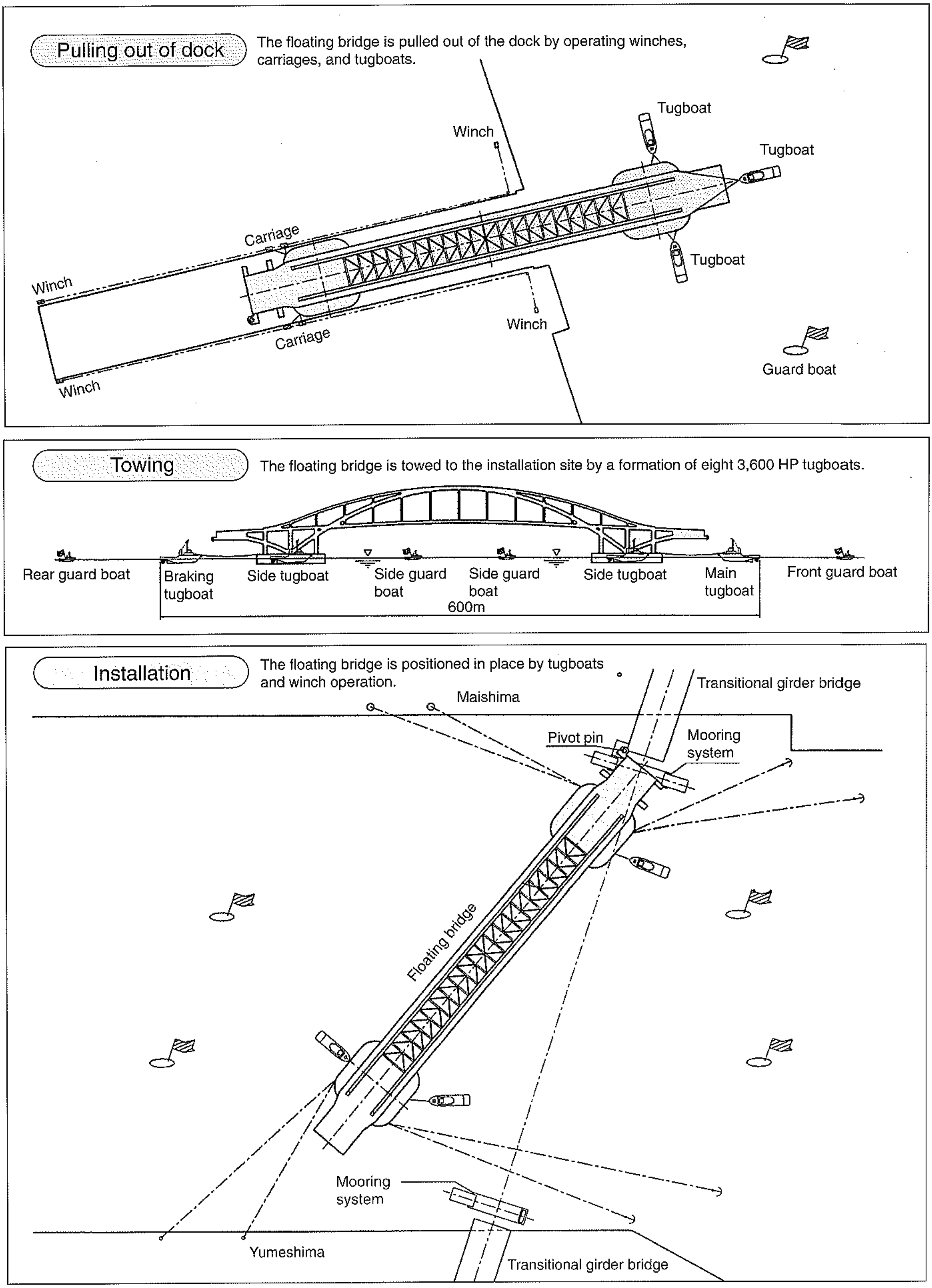


Fig. 16 Pulling out of Dock, Towing & Installation

(References)

1) Maruyama, T., Watanabe, E., Tanaka, H.: Floating Swing Bridge with a 280 m Span, Osaka, Structural Engineering International, 1998.3.

2) Watanabe, E., Maruyama, T., Kawamura, Y., Tanaka, H.: A New Movable Floating Bridge Project in Osaka City, Proc. of the IABSE Symposium Long-Span and High-Rise Structure, Kobe, pp.155-160, 1998.9.

3) Maruyama, T., Kawamura, Y., Tsuda, T., Kishimoto, T., Tanaka, H., Yasuda, Y.: Planned Design of Yumeshima-Maishima Bridge (1)–Movable Floating Bridge–, Bridge and Foundation, Vol.32, No.2, 1998 (in Japanese)

4) Maruyama, T., Kawamura, Y., Tsuda, T., Takeda, S., Nakaji, E., Oka, S., Tsuchiya, M.: Plan and Design of Yumeshima-Maishima Bridge (2)–Movable Floating Bridge–, Bridge and Foundation, Vol.32, No.3, 1998 (in Japanese)

5) Maruyama, T., Watanabe, E., Utsunomiya, T., Tanaka, H.: A new Movable Arch Bridge in Osaka Harbor, Proc. of the Sixth East Asia–Pacific Conference on Structural Engineering & Construction, EASEC6, Taipei, Taiwan, pp.429-434, 1998.1.

6) Watanabe, E., Maruyama, T., Tanaka, H.: Design & Construction of A Floating Swing Bridge in Osaka, Proc. of the Third International Workshop on Very Large Floating Structures, pp.888-897, Honolulu, Hawaii, USA, 1999.9.

7) Maruyama, T., Ogawa, K., Shimodoi, H.: Wind-tunnel Test for the Maishima–Yumeshima Bridge, Proc. of Wind Engineering of J.S.C.E., pp. 161-162, 1995.4.

8) Nagata, S., Miyake, S., Fujita, T., Yoshida, H., Tanaka, H., Maruyama, T., Ueda, S.: Motions of a Movable Floating Bridge in Waves, Proc. of VLFS'99, pp.358-366, Hawaii, USA, 1999.9.

9) Ueda, S., Maruyama, T., Ikegami, K., Seto, H., Kumamoto, N., Inoue, K.: Experimental Study on the Elastic Response of a Movable Floating Bridge in Waves, Proc. of VLFS'99 pp.766-775, Hawaii, USA, 1999.9.

10) Kobayashi, M., Hineno, M., Shimada, K., Hyodo, T., Kawamoto, A., Ueda, S., Maruyama, T.: Model Experiments on Swinging of a Movable Floating Bridge in Waves, Proc. of VLFS'99, pp.546-554, Hawaii, USA, 1999.9.

11) Oda, K., Maruyama, T., Tanaka, H., Nagata, S., Yamase, S.: Hybrid Simulation for a New Movable Floating Bridge, Proc. of the Sixth East Asia-Pacific Conference on Structural Engineering & Construction, EASEC6, Taipei, Taiwan, pp.435-440, 1998.1.

12) Kawatani, I., Maruyama, T., Kawamura, Y., Kishimoto, T.: Vibration Serviceability of Floating Bridge, Proc. of Structural Engineering J.S.C.E., Vol.43A., pp.757-764, 1997.3. (in Japanese)

13) Maruyama, T., Kawamura, Y., Mizukami, Y., Tsuchiya, M., Yoshikawa, T., Sano, J.: A Study on the Strength of Floating Bridge Pontoon in Small Ship Collision, Proc. of Structural Engineering J.S.C.E., Vol.46A., 2000.3. (in Japanese)

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