Construction information on recent concrete structures (2007 - 2009)

This article presents the construction information on recent concrete structures in Japan. Each article has been published in Japanese in the Concrete Jounal from October, 2007 to August, 2009.

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Development of Top-down Construction Using Precast Ultra-high Strength Concrete for Basement Columns and Application to High-rise Building

Keiki YAMAMOTO[*1], Tetsuji MIYATA[*2], Norishige MOTOOKA[*3] and Atsushi HATTORI[*4]

Keywords: top-down construction, basement column, precast, high-strength concrete, 100N/mm^2, shortening of construction period, reduction of environmental burdens

Since precast concrete basement columns for top-down construction method can be utilized as the permanent structural framing as they are, basement column erection and excavation for the underground structural framing can be completed simultaneously. However, in case of a high-rise building, the large sizes of conventional precast concrete columns required to bear the heavy axial loads pose problems in the erection of the columns. Ultra-high strength concrete provides a solution to this problem by allowing reductions in the member size, thereby enabling engineers to apply precast concrete basement columns to skyscrapers.

Compared with the conventional top-down construction method using temporary steel columns, this top-down method of using precast concrete basement columns further streamlines and improves the quality of basement construction, while reducing the construction period and saving labor. It is also an effective way to decrease the burden on the environment because of reductions in the amount of steel and concrete used.

This paper first describes the development of the top-down construction method using ultra-high strength precast concrete basement column (referred to as HSPC basement column) with design strength of 100 MPa, and its application to an actual high-rise building.

The paper then proceeds to report the effects of applying the method developed to high-rise building construction. The HSPC basement column requires no column construction under the ground floor after excavation (Photo 1), and is effective in shortening construction time compared with the conventional top-down method. Use of 100MPa ultra-high strength concrete also allows significant reductions in the amount of CO_2 emission from the component materials of the concrete used for the basement columns (Fig. 1).

Erection of HSPC basement column

Bottom floor after excavation

Photo 1 Construction of HSPC basement column

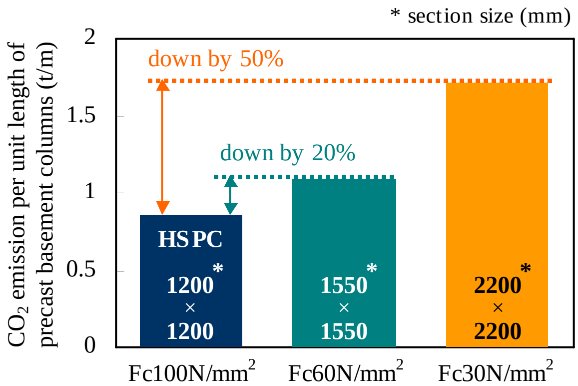

Fig.1 Comparison of CO_2 emissions from component materials used per unit length of precast basement columns

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Concrete Journal Vol.47, No.7, pp35-41, Jul. 2009/

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Design and construction of PC Box-Girder bridge using high-strength concrete

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Keywords: high-strength concrete, PC Box-Girder bridge, thermal stress analysis, placement ability, placing method

1. Introduction

Ryouisi Viaduct (Fig-1) is a three-span rigid frame PC box-girder bridge constructed as a part of Kamaishi Yamada motorway running across the Sanriku area. High-strength concrete was intentionally used to reduce the weight of superstructure and scale down the substructure. Consequently, countermeasure against possible thermal cracking in thick section and selection of proper placing method were required.

2. Design

This project is a design & build package that consists of both super and sub structures. The final design of superstructure is a three-span prestressed concrete box girder. The strength of designed concrete was as high as 60N/mm^2. By using high strength concrete, the thicknesses of members were largely reduced and, consequently, substructure was also scaled down compared with initial design. As a result, construction cost was largely diminished.

Furthermore, the super structure is considered very durable against salt attack over 100 years thank to densified matrix of high strength concrete. This means that the cost of maintenance is minimized because no special care other than regular inspection is required.

3. Construction Plan

Since this concrete has high cement content (567kg/m^3), there was great concern of harmful thermal cracks in the column capital that has large cross section, thermal stress analysis was carried out. Analytical results (Fig-2) showed that, by appropriately changing the height of placing lifts, the possibility of thermal cracking was largely reduced, and, consequently, the amount of crack-controlling reinforcement was also reduced.

Besides, due to high viscosity, the workability may be lowered during pumping. For this reason, pumping test on selected mix proportion was carried out to observe the workability change (Fig-3). The effect of formwork configuration at upper face of lower slab on the placability was also verified. It was confirmed that workability change during pumping is neglectable, and the solution of fully covering upper face by formwork was selected.

4. Construction

Concrete placing was performed as mentioned above. For confirming the status of placement, a portion of formwork was made transparent and some air vents were installed. Concrete was placed from high position of a web (for creating high gradient for concrete flow) and flowed to the opposite web through the slab section.

5. Conclusion

It is expected that this report may serve as a reference for construction of box girder using high-strength concrete. The construction work was completed at the end of February, 2009 and the bridge will be in service in fiscal year of 2010.

Fig-1 Ryoishi Viaduct

Fig-3 Pumping test

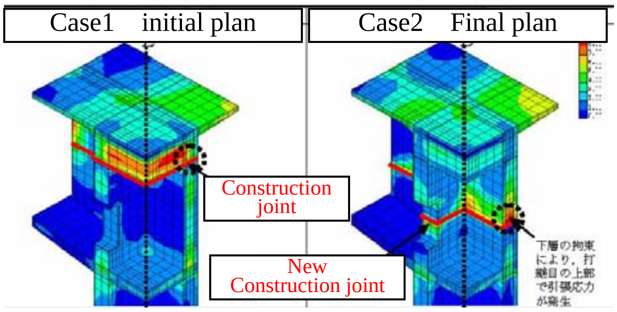

Fig-2 Result of thermal stress analysis

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Renovation of Hanshin Koshien Stadium
—Rehabilitated Concrete Structure of the Taisho Period—

Masaaki YASUI[*1], Hiroyuki ENOMOTO[*2], Ippei MORIYASU[*3] and Yoshihide NAKAMURA[*4]

Keywords: renovation, seismic retrofitting, durability improvement, chemical anchor, fireproof capacity

Hanshin Koshien Stadium is the historical reinforced concrete building, which was opened in 1924. Now, it has not been rebuilt but renovated to succeed its history and tradition. This paper reports about seismic retrofitting, durability improvement and fireproof test of chemical anchor, which were adopted in this project.

1. Outline of the project

This stadium consists of 6 buildings, which are connected with exp.j. Fig.1 shows the layout of the buildings.

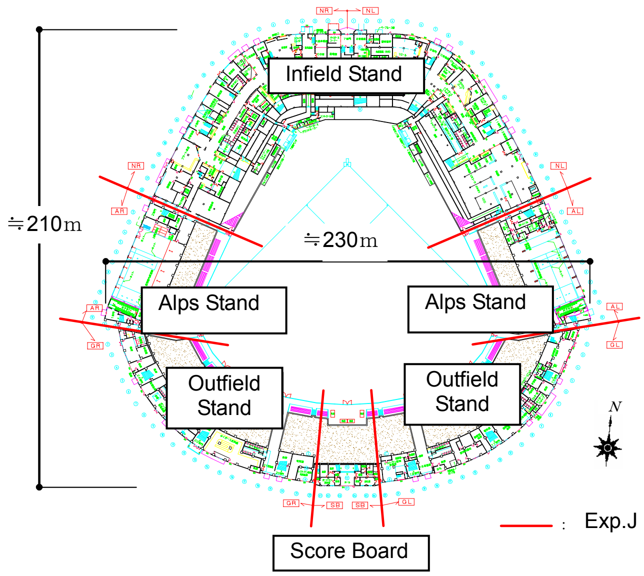

Fig.1 Layout of the buildings

Rehabilitations of this project are as follows.

①Seismic retrofitting of Existing Stand
②Replacement of Ginsan Roof (Steel Roof)
③Replacement of Stadium Lights
④Renewal of Stands and Facilities
⑤Renewal of Building Equipment

2. Seismic retrofitting

Main items of seismic retrofitting are to add shear walls to the outside and inside and to add new frame to the outside of the buildings. To reinforce the infield stand, we adopted the truss-type reinforcement using the triangle shape of the building. Fig.2 shows the image of the truss-type seismic retrofitting.

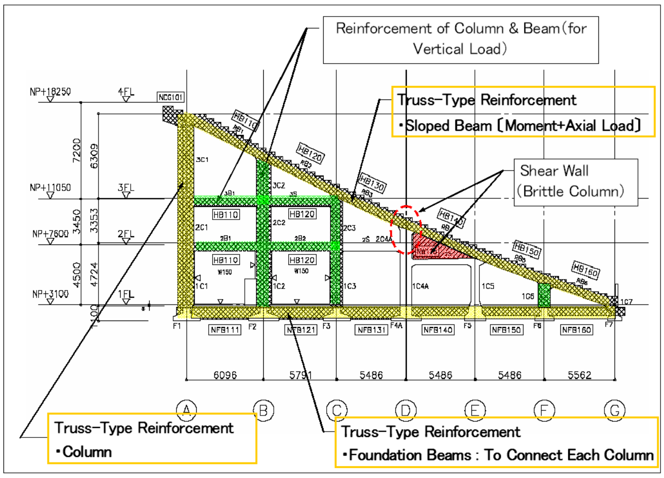

Fig.2 Truss-type Seismic Retrofitting

3. Durability and others

To secure the thickness of the cover concrete and to prevent neutralization of the existing concrete, we provided polymer-cement-mortar for the exposed surface of the existing concrete.

No one has inspected the fireproof capacity of the shear wall which is connected by the chemical anchors (organic compound) with the existing concrete structure. We carried out the fire proof test and verified it had the required fireproof capacity.

4. Conclusion

We could complete the renovation of the stadium in short period with a great cooperation of the owners, sight engineers and others.

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Construction of a Concrete Faced Rockfill Dam
—Ponre Ponre Dam in Indonesia—

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Keywords: CFRD, Face Slab, Cement Stabilized Zone 2B, Slip form, inclined chute

The Ponre Ponre Dam Irrigation Sub-project is one of sub-projects of DISIMP (Decentralized Irrigation System Improvement Project in Eastern Region of Indonesia) being executed by the Ministry of Public Works of Republic of Indonesia with assistance of a Japanese loan.

The Ponre Ponre Dam is designed as a concrete faced rockfill dam (CFRD), and constructed in Bone District in South Sulawesi Province having a height of 55 m, a volume of 510,000 m^3, and a reservoir capacity of 40 MCM to provide a reliable supply of water to a net command area of 4,400 ha. The main feature of the dam is shown in the following table.

Location	Bone, South Sulawesi, Republic of Indonesia
Executing Agency	Ministry of Public Works
Construction period	Jan. 2006 ~ Apr. 2009
Purpose	Irrigation
Catchment Areal	78 km^2
Mean Annual Inflow	53.6 MCM
Probable Max. Flood	1,590 m^3/s
Dam Type	Concrete Faced Rockfill Dam (CFRD)
Dam Height	55 m
Crest Length	236 m
Dam Volume	510,000 m3
Dam Slopes	US=1:1.4, DS=1:1.4
Face Slab	A=12800, t=30 cm
Effective Storage	40,400,000 m^3

The CFRD is not popular in Japan, while many CFRDs have been constructed in the world, and the CFRD has been the standard type of rockfill dam in the world in these two decades.

The CFRD is composed of rockfill embankment, concrete plinth, and concrete face slabs as shown in Figure 1 and 2. The plinth is a watertight seal, and the concrete face slabs are impermeable membrane.

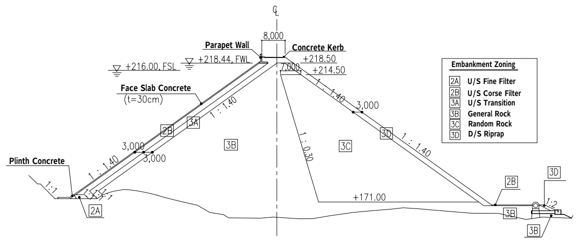

Figure 1 Typical Cross Section of Ponre Ponre Dam

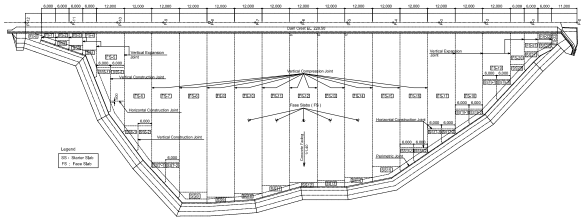

Figure 2 Face Slabs of Ponre Porne Dam

The face slab concrete was placed successfully by using a slipform that was locally manufactured (Photo 1). The slipform enabled continuous concreting on the upstream slope with an average rising speed of 2.7 m per hour.

Photo 1 Concrete Face Slab by Using a Slipform

Besides the details of the above concrete works, this paper also presents a newly developed method for compaction and protection of upstream slope, i.e. cement stabilized zone 2B (CS2B).

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Construction records

Rapid Construction of Underground Structure using PCaPC members

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Keywords: rapid construction, PCaPC, rigid connection, seepage control, seismic performance

This paper represents construction report of underground bike parking (Fig.1) at Kasai Metro Station in Edogawa Ward, Tokyo. There are lots of pedestrian and vehicle traffic in the area. Commercial buildings stand close to the site which is on the soft Kasai Stratum with high groundwater level. Because rapid construction was necessary to minimize impact on residential life in the neighborhood, instead of conventional cast-in-place concrete method using temporary earth retaining, we proposed a method using H-shaped Precast prestressed concrete (thereafter PCaPC) members, which were pressed into the ground after excavation one by one next to each other, forming continuous wall as a whole (Fig.2). One of the critical performances required to this method is seepage control between PCaPC members and between them and the bottom slab concrete. As for the former seepage control, concrete was filled in the voids between adjacent members. A new rigid connection was proposed for the later seepage control.

Fig.1 Kasai Station Underground Bike Parking

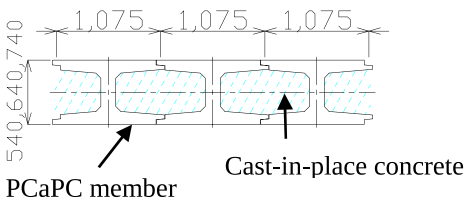

Fig.2 PCaPC Continuous wall

1. PCaPC members

The concrete design strength is 70N/mm^2. Section selection is based on crack resistance bending moment (maximum bending moment at crack width under 0.05mm).

2. Rigid connection between PCaPC and the bottom slab concrete.

Connection devises are embedded in PCa members. Rebar and PC bars are attached to them at site. After first stage concrete for the bottom slab, PC bars are stressed so that post-tension is applied to the joint,which is PRC structure. Performance of this joint structure was verified by life-size specimen loading test (Fig.3). Fig.4 shows crack width of the joint at tensile side at varying loads, which verifies its high waterproof and seismic performance.

The use of PCaPC and the rigid connection mentioned above shortened construction period significantly from six years to two and a half years. It also successfully provides high water proof performance to the structure.

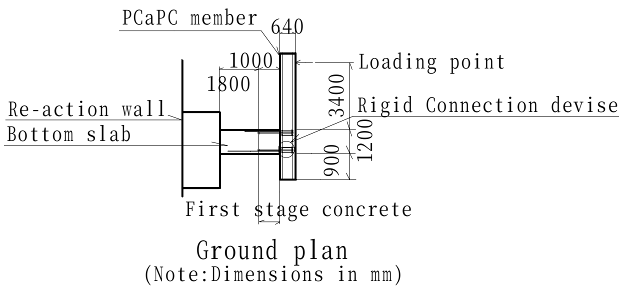

Fig.3 Life-size Specimen Loading Test

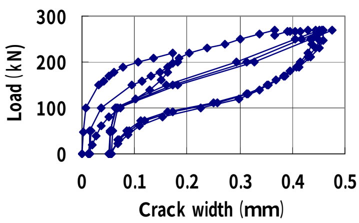

Fig.4 Crack Width of Joint at Loading Test

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Design and Construction of New Hybrid Structure with prestressing for Large Hospital

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Keywords: new construction method, hybrid structure, prestressed, large span structure, base-isolated structure

The hybrid structure consisting of reinforced concrete structure (hereinafter, RC) and steel structure (hereinafter, S structure) is effective to shorten construction periods and reduce costs in designing large span structures with high rigidity, by taking advantage of the characteristics of both structures. Particularly, the hybrid structures are now commonly used to reduce construction costs against the recent high rise of prices of steel materials.

Under this circumstance, Shimizu Corporation has developed a hybrid structure "SHIMIZU Hy-ECOS (Hybrid Economical & Ecological Structure) structure system (hereinafter, Hy-ECOS structure)". This is comprised of RC structure for columns and S structure for beams, which the ends of the steel beams are covered by RC. Shimizu then newly developed "SHIMIZU PS Hy-ECOS (Prestressed Concrete Hybrid Economical & Ecological Structure) structure system (hereinafter, PS Hy-ECOS structure)" for large-sized hospitals, which is to achieve larger spans than that of the Hy-ECOS structure by applying prestressed (hereinafter, PS) materials to the beam end RC.

Photo 1 shows the external view of the facility.

Photo 1 External view of the facility

This is one of the consolidation projects of the hospitals located nearby, under PFI (Private Finance Initiative) program, as the joint venture of Nikken Sekkei for design and construction management and Shimizu Corporation for construction. The construction period is planned from June 19, 2007 to September 30, 2009. The facility is designed to have one basement, eleven ground floors and two towers with the total floor area of 129,590.36m^2. With this seismic isolation RC structure, PS Hy-ECOS structure system is applied to the beam for the span of 14.2m to bear the large load of the rooftop garden. Hy-ECOS are used for other beams at the same span.

PS Hy-ECOS structure system (Fig.1) may be applied to the spans up to about 25m, using the PS to the reinforcing materials (Prestressing steel bar or Prestressing strand) to RC over the steel beam ends of Hy-ECOS structure system, in order to set off the shear force resulted from a long-term load of the large span structure.

For construction of the large-scale facility in a short construction period, 27 months, Shimizu Corporation strives to achieve a certain level of quality and shorten the construction period by actively using the hybrid industrial method combining rebar construction and site precast (hereinafter, PCa) works as well as framing, simultaneous works of column bars and frames, and exterior PCa works aiming the completion by September 2009.

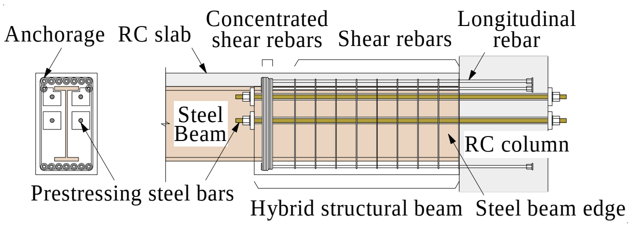

Fig.1 Details of PS Hy-ECOS structure system

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Development of an Environmentally Sound Demolition Method for High-rise Building

— Deconstruction by the "jack-down" Method —

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Keywords: jack, environmentally sound demolition, recycling rate

The Revolutionary New Demolition Method improves both safety and environmental impact

In November 2007, Kajima began demolition of its former head office buildings, which had served the company since 1968. Although major renovations had been carried out twice, Kajima finally decided to replace its head office buildings in order to upgrade to a more advanced office environment with cutting-edge IT and energy-saving features.

Buildings are usually demolished by placing heavy equipment and workers on the top floor, and then lowering the waste material down to ground level. Kajima, however, demolished its former head office buildings (75 meters / 20 stories, and 65 meters / 17 stories) using a world-first technique. Called the Kajima Cut & Take Down Method, it enables demolition work to be done on the ground floor. By starting at the bottom, gutting one floor, and then lowering the entire building down on jacks one floor at a time, all the work can be performed safely at ground level.

Reduced noise, dust and other neighborhood environmental impact

Construction noise tends to emanate widely from the upper floors of a building, But this method reduces both the number of noisy processes and the distance at which noise can be heard, since the large-scale demolition of beams, floors, and outer walls can be consistently carried out on the ground.

Of course, this also means less dust dispersion.

Operational safety is also greatly improved since there is little need to move heavy equipment and people to the top of the building.

Recycling rate : 99.4%

"Reducing" the amount of waste from the start is usually the most effective process among the "3Rs" of reduce, reuse, and recycle. However, since the amount of waste from a demolition site cannot be controlled, there is no other choice but to sort and recycle as much as possible to increase the recycling rate. Using Kajima Cut & Take Down Method, waste materials can be easily and reliably sorted, floor by floor. Being able to wait until a predetermined amount of sorted waste material can be dispatched also makes it easier for recycling facilities to plan ahead and be efficient. Using this method, Kajima was able to sort waste into 30 types of material for recycling, while the conventional method can only sort about 20. With a recycling rate of 92.2 percent for the interior portion of the building, Kajima far surpassed the average rate of 55 percent yielded by conventional demolition methods. When this is combined with the recycling rate for materials from the shell of the building---namely concrete debris and steel scrap, which are not affected by Kajima's new demolition method---the recycling rate climbs to 99.4 percent.

Demolition progress (March・April・May 2008)

Demolition work at the ground.

Jack

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Construction records

Construction of the south-side underpass of the second phase Kansai International Airport island

Akira SAKAI[*1] and Toru YAMAJI[*2]

Keywords: underpass, airplane load, PC girder, settlement, reclaimed ground

South-side underpass of Kansai International Airport, with the form of two-level crossing between taxiway and road for vehicle, can bear the large airplane load.

On the original plan, the structure of underpass was the tunnel type of RC box. Final plan is that PC girders are set on the only part of taxiway and road for vehicle. This plan is the first attempt at airports in Japan. This structure enabled to construct at the shallower depth than RC box type and shorten the total length, because the thickness of PC girder is thinner than that of RC box. The PC girder has very large section of 700×1000mm, in order to bear the airplane load (total load: 6,664kN).

On the original plan, this construction was planned after piling the water-shielding wall and excavating the soil (Fig.1). The site was reclaimed ground on the seabed with very thick clay layer. Therefore, it was estimated that the settlement from the beginning of construction to 50 years afterwards was about 7.5～9 m. We utilized this settlement under construction! That is, we planned that the underpass was constructed before finishing the reclamation works around underpass when the ground level was higher than water table (Fig.1). This enabled to eliminate temporary works such as water-shielding construction.

The construction procedure is below: First, the improvement of reclaimed ground as the foundation of underpass was carried out.

Second, the lower part of underpass was constructed. Concrete was placed from the bottom to the side wall.

Third, the soil was reclaimed at the part of side wall after concrete placing except the top of side wall where the bearings of PC girder were set.

Finally, PC girders were set after increasing the top level of side wall to the necessary level. The level was decided by measurement of ground settlement. This PC girder (Pre-tension type) has very large section. Therefore, the occurrence of thermal crack was concerned. In order to control the thermal crack, some experiments were carried out by using the specimen with real size, and a manufacturing control system in a factory was established before PC girder construction.

The construction with utilizing the settlement was expected very hard because the ground movement around the site was complex. However, we constructed the body of underpass with high accurate construction control and estimation of settlement. As a result of these works, total costs and construction period were reduced by eliminating the temporary works. On August 2, 2007, the use of south-side underpass was started with the opening of Second runway in Kansai International Airport.

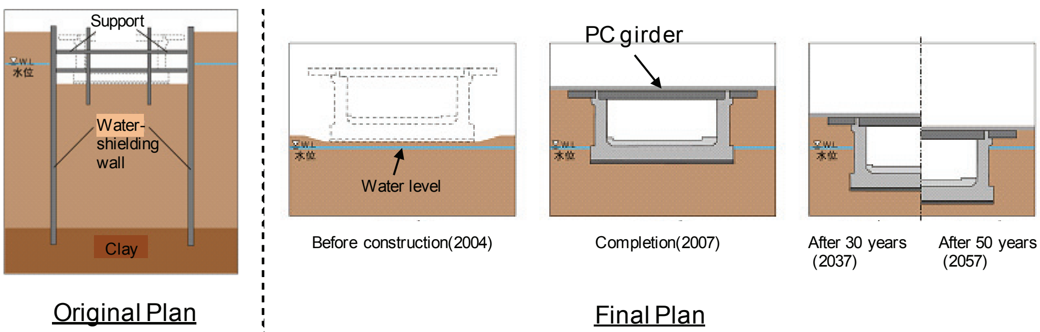

Fig.1 construction work of south-side underpass

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Construction records

Renewal Construction of Okubi River Bridge in the Okinawa Expressway using Ground Granulated Blast Furnace Slag

Yasuo FUKUNAGA [*1], Jun ISHIZUKA [*2], Masahiro TANAKA [*3] and Toru YOSHIMURA [*4]

Keywords: renewal construction, pretensioning system hollow slab bridge, girder connection system, ground granulated blast furnace slag

1. INTRODUCTION

The northern part of the Okinawa Expressway was opened in 1975 in association with Expo 75 Okinawa. At that time, Okinawa was a chronic shortage of water. Therefore, marine sand, that was not sufficiently processed to remove salt, was used as the fine aggregate for concrete in this part of the expressway. From 1989 onwards, surveys of the state of degradation, due to attack by salt initially contained, and partial repairs were carried out, but the degradation expanded further.

Therefore, following a study of the life cycle costs (LCC) based on the results of the cost effectiveness and the life of past repair methods, it was decided to carry out thorough renewal construction as a comprehensive measure.

2. OUTLINE OF THE PROJECT

(1) Construction period reduction and cost reduction

1) Reduction of the facing traffic control period was achieved by adopting a structure in which pretensioned hollow girders are joined using precast cross beams supported on bearings. Furthermore, cost reduction was achieved by a large reduction in the number of bearings used.

(2) Improvement in durability

1) The ingress of chloride ions and alkali aggregate reactions were reduced by replacement of 50% of the cement used in all the concrete by ground granulated blast furnace slag 6000.

2) The durability of the corrosion protection films was improved by using an Al-5%mass Mg alloy coating applied by thermal spraying as the corrosion prevention method for the metal parts of bearings and expansion joints.

(3) Reduction in environmental impact

1) By mixing in ground granulated blast furnace slag, which is a by-product of iron and steel making, the cement quantity was reduced, and the quantity of CO_2 emissions associated with the manufacture of concrete were reduced by 40% (about 260t CO_2).

2) By adopting Al-5%mass Mg alloy coating by thermal spraying, the use of volatile organic compounds and zinc, which cause environmental pollution, could be eliminated as much as possible.

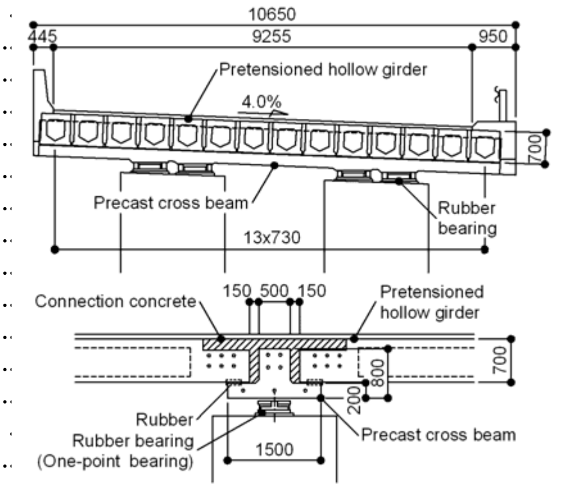

Fig.1 New connection system of pretensioned hollow girder

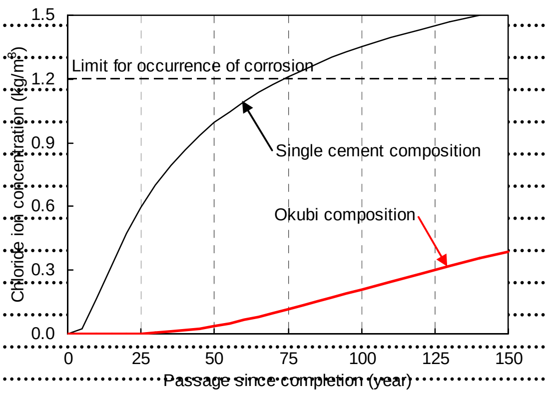

Fig.2 Variation of chloride ion concentration at the surface of the reinforcement(Hollow girder , Cross beam(Cover 35mm))

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Construction records

High-speed construction in high rise large-scale housing

Hidekazu HIRANO[*1], Keisuke MINAMI[*2], Yasuhito HARA[*3]

Keywords: high rise RC housings, Pre-cast-concrete, system construction method

This building is a large scale RC-housing complex where a vast site of about 20,000 ㎡ in the area has 1,085 households by 33 stories. As for the shape, the long side direction is 85.5m, and the short side direction is 68m, and the multistory parking of the steel frame building is arranged in the Boyd part in the center shape. The column and the beam touched the outside, were arranged, and adopted column-beam connection joint integration pre-cast concrete industrial method “SumitomoMitsui Quick RC Integration-system” in the part. Pre-cast members were multiuse to other structural sub assemblages and making to the high quality and the labor saving aimed at. And the DOC industrial method that was an original technology SumitomoMitsui Construction was adopted and one floor was constructed in three days.

The feature in the “SumitomoMitsui-Quick-RC-Integration-system” isn’t to generate the poured concrete in the joint part of the material as Fig-2. And, the workability is high and effective for shape that the column and the beam bound to the outside. And, making uniformly and the upgrade of the quality can be attempted by producing all of the column and the beam at the pre-cast factory. Moreover, the construction of the high-strength concrete on the site can avoid.

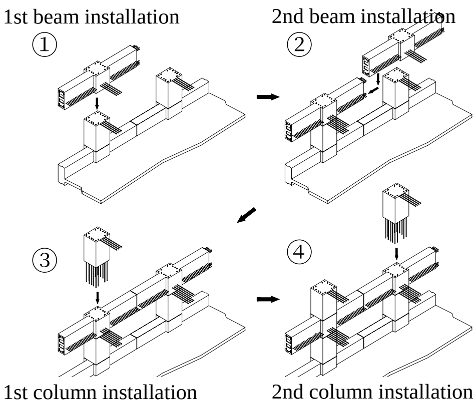

Fig.2 SumitomoMitsui Quick Rc Integration system

Fig.1 Completion drawing

The DOC industrial method is abbreviation of “one Day-One-Cycle”. It’s an industrial method of our original developed aiming at efficiency improvement and a short term of the term of works in the site mainly, and the housing complex is mainly developed. It’s system construction to which is skeleton worker thing is advanced like the assembly line operation of the factory production because the building is divided in the industrial sector, and each occupational category repeats the same work every day. So it’s an industrial method that it’s becomes easy to secure and to upgrade the quality.

The vehicle management used our original distribution system “Foreman.Net” that was able to share construction information by the Internet promptly. Materials are carried with vehicles of about 100 on a day only in upper structure frame construction. This system was developed, and newly for the purpose of the carrying vehicle to the destination smoothly, and to decrease efficiency improvement and to reduce a communication error.

The scheme of execution of the upper structure frame construction that uses the above-mentioned technology and executions are described in this report.

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Construction records

The Design and Construction of The Cut and Cover Tunnels by the Method of Replacement of Brace Reaction Using Side Wall

Atsushi SHIMURA[*1], Takashi NAKASHIMA[*2], Koutaro MIMURA[*3] and Keisuke KAWAMATA[*4]

Keywords: cut and cover tunnel, cofferdam, replacement of brace reaction using side wall, residual stress, creep, stress relaxation

The replacement of brace reaction using side wall is the one of constructing techniques of the cut and cover tunnel. This technique means that the concrete structure is built during removing of braces and replacing of brace reaction using side wall. In comparison with the replacement of brace reaction using inner strut which is popularized, our method can be expected for reducing cost, shortening work periods, and improving safety. However, the evaluating method for the structural stress under replacement of brace reaction is not established now. Therefore, we invent the reasonable design method of cofferdam in consideration of concrete stress relaxation by creep during replacement of brace reaction using side wall. In this paper, we report a design case which is applied at the construction site of cut and cover tunnel.

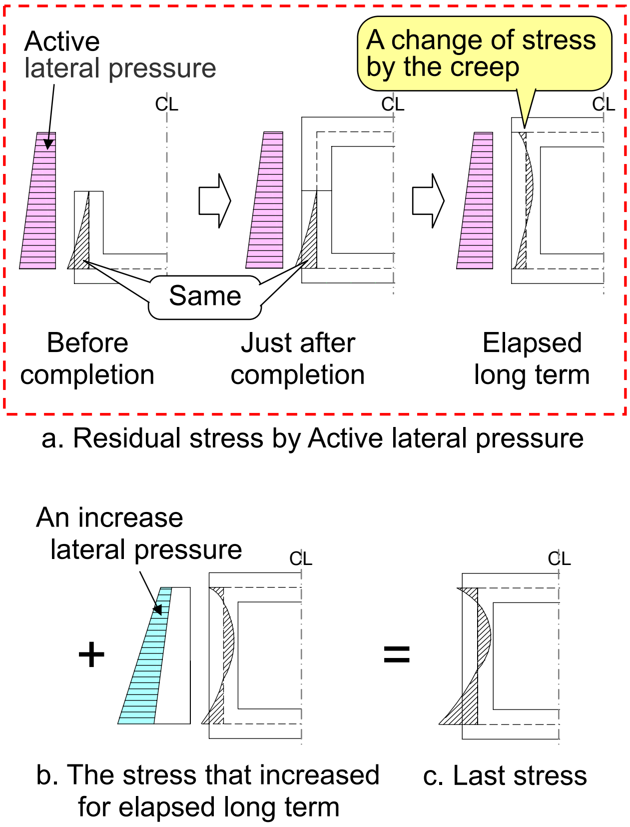

Figure-1 The stress evaluation method that considered creep stress-relaxation

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Construction records

Application of Self Compacting Concrete to Reinforced Backfill Concrete for Advanced Natural Gas Storage Project

Toru KAWAI [*1], Masanori IMAZU[*2], Toru KOMATSUBARA[*3]

Keywords: self compacting concrete, natural gas, high pressure storage, backfill concrete, air -tightness

1. Outline of ANGAS Project:

Construction technologies of an underground natural gas storage system, a Lined Rock Cavern (LRC) high pressure gas storage system called ANGAS (Advanced Natural Gas Storage) have been studied. An experimental LRC constructed at Kamioka mine in Gifu Prefecture was shown in Fig.1. The cavern of 6.0 m in diameter and 10.5 m in length was constructed at the depth of 400 m below the ground surface. It was about 1600 m far from the entrance of the mine through the access tunnel. The storage cavern was composed of steel liner of 6 mm in thickness covered with a buffer material. The backfilled reinforced concrete of 700 m in thickness was constructed between the storage cavern and the surrounding rock.

2. Placement of Backfilled Reinforced Concrete

Requirements for the concrete are as follows;

(1)An inner gas pressure can be transmitted to surrounding rocks.

(2)Maximum crack spacing was 500mm.

(3)Complete filling around the steel liner.

In order to meet the above requirements newly proportioned self-compacting concrete with non-bleeding property was applied to the project. Maximum size of aggregate was 15mm and the unit volume of coarse aggregate was reduced to 0.2 m^3/m^3 to enhance the filling capacity. Design strength was set up to 40N/mm^2. Reinforcing steel bars were assembled to grid with 150 mm spacing and the cover was designed to 50mm around the steel liner.

The concrete produced at the batching plant was transported to the entrance of the tunnel. After inspection, the concrete was loaded to the rotary type truck agitator on rail and transported to the site through an access tunnel and placed around the steel liner. The time from the start of mixing to the completion of placing was controlled within 2 hours. Photo 1 shows the placement of the concrete for the bottom lift through the pipe. The concrete was placed separately by 8 lifts according to conditions of jobsite.

3. Verification Test

The verification tests with maximum pressure 20MPa were conducted. These tests consists of a hydraulic pressure test, an air-tight test and a cyclic and long- term test. The resistance and air- tightness up to 20 MPa of cavern were confirmed from these test results.

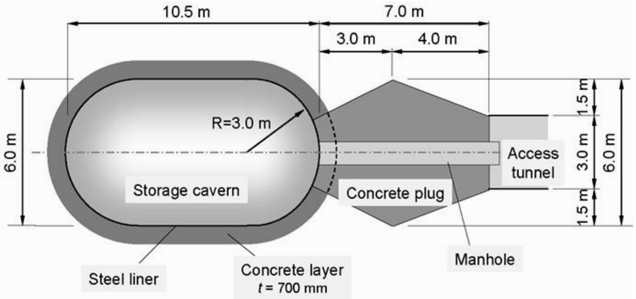

Fig. 1 Schematic view of small experimental LRC.

Photo 1 Placement of the concrete for the bottom lift.

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Construction records

Execution of Line-anode Cathodic Protection System using New Technique
—Repair Work for the Sourou-Bridge Suffered from Salt-damage—

Kimikazu IKEYA*1, Masaaki SATO*2, Kouji ISHII*3 and Hiroshi SEKI*4

Keywords: Prestressed Concrete Girder, Salt-Damage, Cathodic Protection, Line-anode, Way of Anode-setting, New Technique, Quality Control

The Seisyou Bypass Highway which extended for 14.5km is an overhead motorway and was built along the Sagami bay. The Sourou-bridge in the Bypass was constructed using prestressed concrete girders and located 30m to 50m apart from a sea shore as shown in phot.1.

Phot.1 Sourou Bridge

This bridge deteriorated due to the chloride-induced corrosion of the steel reinforcement in the concrete. The patch repair and the coating as a countermeasure had been so far performed. However, the cathodic protection method was recently used when the deterioration was detected again shown in phot.2.

Phot.2 Deterioration after repair

Though the method is well known as a most effective countermeasure, it has some problems such as durability and execution cost. The authors had conducted some research works to solve these problems. As a result of some works, the new technique on setting the line-anode into concrete was developed. This paper discusses experiments and shows the new anode-setting method applying to the Sourou-bridge.

The traditional ways and the new one of setting line-anode are shown in Fig.l. The latter one is characterized by shape of the slit on the concrete. All dimentions of the slit of the new technique are 5mm width and 25mm depth, and it is cut vertically or leaned 60 degrees against concrete surface.

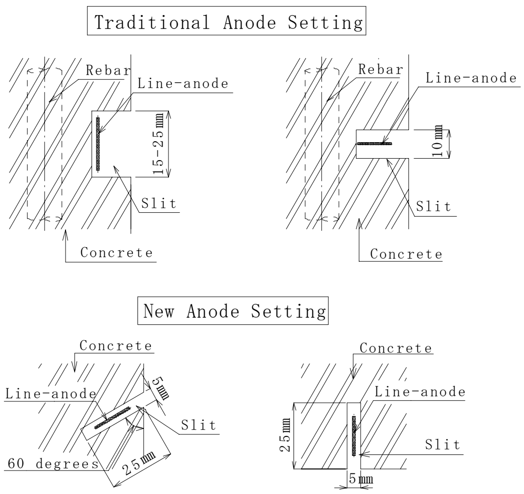

Fig.1 Ways of Anode-Setting

As a result of applying the new technique to Sourou-bridge, the new facts as follows have came to light.

1) The execution cost was reduced to 30% compared to that of traditional techniques.
2) The skillfull workers were not necessary because the setting work of line-anode into concrete was easily carried out.
3) The influence to structure was small due to the smaller slit.

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Construction records

The construction report of Super high-rise RC residential tower with Super Flex Wall System

Hiroaki Ohta[*1], Naoki Aso[*2], Taku Kawai[*2], Yuji Ishikawa[*3]

Keywords: Residential, super high-rise, response controlled structure, structural control beam, Low Yield Strength Steel, High-strength concrete

1. Outline of the building

Building (as shown in Fig.-1 and Photo-1)
Akasaka Tower Residence Top of the Hill
Location 17-50, Akasaka 2-chome, Minato-ku, Tokyo 107-0052
Client SunwoodCorporation , Tokyu Land Corporation, Takenaka Corporation, Mori Building
Use Residential
Design Takenaka Corporation, Nikken Housing Corporation
Construction Takenaka Corporation
Site area 6,939.30 m^2
Total floor area 73,122.18 m^2
Maximum height 162.00m
Eaves height 158.23m
Floor 3 floors below ground 45-story
Structure Reinforced concrete structure
Concrete Fc*80 (AFR* concrete)
(maximum specified concrete strength)
Steel bars SD*685, SD590, SD490,
Shear reinforcement SBPD*1275/1420 etc
*AFR concrete: Advanced fire resistance Concrete
*Fc : specified concrete strength
*SD : steel deformed bars
*SBPD : Small diameter steel bars
Number of SD and SBPD are express yield strength using N/mm^2.

2. Super Flex Wall system

Super Flex Wall System, as shown in Fig.-2, was developed to supply excellent view for inhabitants by TAKENAKA Corporation. The "Super Flex Wall" combines with a core wall (the earthquake-resistant reinforced concrete wall penetrating through the center of the building from the lower part to the top floor) and a structural control method using multi-story shear walls, energy dissipation beams and outrigger beams. Maximum width of the core wall is 750mm. Depth of the outrigger beams are from 1800 mm to 1650 mm. The energy dissipation beams of Super Flex Wall System performed damping effect by means of inelastic shear distortion due to multi-story shear walls' flexural deformation.

By supporting the building with the core wall installed in the center of the building, the columns and beams around the outer side can be made smaller, and even be done away with in parts. Residents are able to obtain large surface area can be used for the openings, maintaining maximum views.

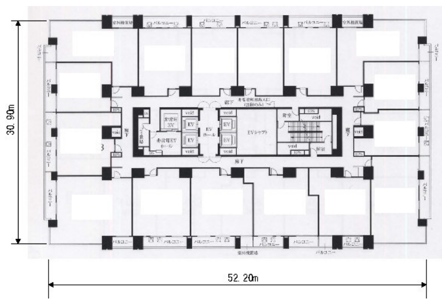

Fig-1 Plan

Photo-1 Complete view

Fig-2 Super Flex Wall System

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Construction records

Preventive Maintenance against Chloride Attack for the Superstructure of Oyashirazu Seaside Bridge on the Hokuriku Expressway

Masashi SAITO[*1], Kazuhiro ONOZUKA[*1], Hiromoto KOBAYASHI[*1] and Minobu AOYAMA[*2]

Keywords: chloride attack, coating, desalination, mortar containing corrosion inhibitor, preventive maintenance

Oyashirazu Seaside Bridge is an offshore prestressed concrete bridge constructed in a fierce chloride environment of the Japan Sea in 1987 Measures against chloride attack were applied to this viaduct including addition to cover concrete (70 mm)(Fig.1). As chloride penetration monitoring after the viaduct was put into service revealed significantly high concentrations of chlorides in the superstructure, it was expected that the threshold chloride ion concentration for corrosion (1.2 kg/m^3) would be exceeded. For this reason, preventive maintenance measures against chlorides were taken 19 years after completion. Four types of methods were adopted: coating; application of mortar containing a corrosion inhibitor + coating; surface patching with mortar containing a corrosion inhibitor + coating; and desalination + coating.

One of the methods with the lowest LCC was selected by chloride transfer prediction at the depth of rebars in steps shown in Fig. 2. Coating was selected where the amount of chloride penetration was small and the chloride content at the depth of rebars after coating would be less than 1.2 kg/m^3. Measures using mortar containing a corrosion inhibitor were methods whereby nitrite ions in the mortar containing a corrosion inhibitor are allowed to seep into the concrete to form a corrosion-resistant atmosphere. These were selected where the chloride content at the depth of rebars would exceed 1.2 kg/m^3 after coating. Desalination was selected where the amount of chloride penetration was greater and the measures using mortar containing a corrosion inhibitor were inapplicable. Coating was applied as finishing in all cases to block subsequent penetration of chlorides.

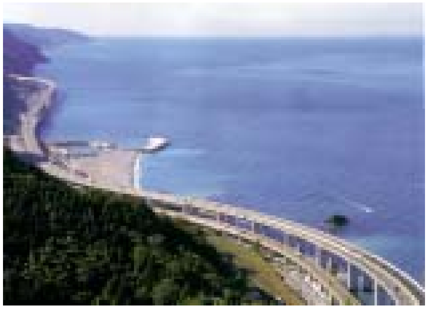

Fig.1 Oyashirazu Seaside Bridge

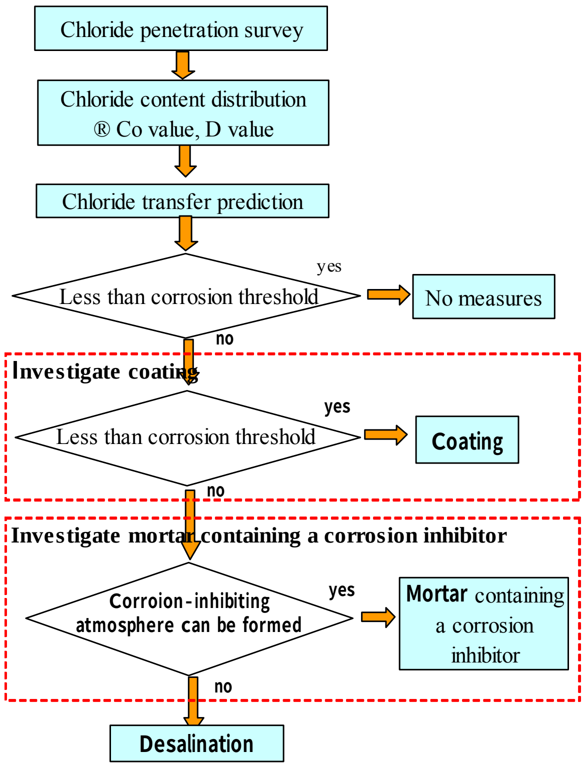

Fig. 2 Procedure for selecting measures against chlorides

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Construction records

Seismic Strengthening by Buttress for 3-story R/C school building

Shigeru MIYAZAWA*1, Fumio TAKEUCHI*2, Youji HOSOKAWA*3 and Minehiro NISHIYAMA*4

Keywords: Seismic Capacity Evaluation, Seismic Strengthening, Outframe Method, Buttress, High Performance Construction Anchor of Metal with Resin, Shape Index

Existing buildings which were designed and constructed according to the out-of-date old Building Standard Law and Enforcements need seismic capacity evaluation and strengthening if they do not have enough seismic capacity according to the current Building Standard Law and Enforcements. The strengthened buildings are expected to be renovated and used for another several decades. This is a report about strengthening and renovating an old school building in Kyoto, which was used to be part of a junior high school. The building was designed and constructed in 1930s when the Building Standard Law had not yet established. The building was expected to be strengthened and renovated by methods which could conserve the appearance and atmosphere reminding us of prewar days. The methods chosen were constructing an additional frame with shear walls at the end of the building, and dividing it into two buildings by an expansion joint. High-performance metal anchors with resin were used for connecting the existing building with the additional frame. Test results of anchors are also included in the report.

Pic-1 Buttress Shear Wall with frame

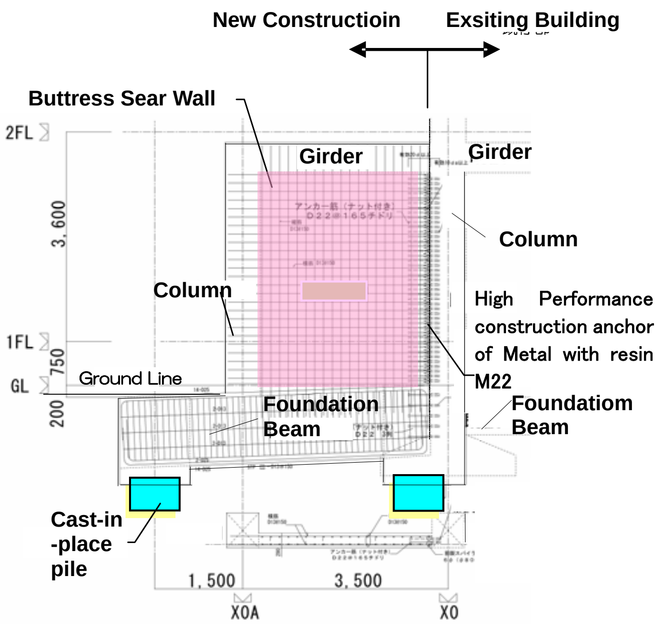

Fig-1 Buttress Shear Wall with frame

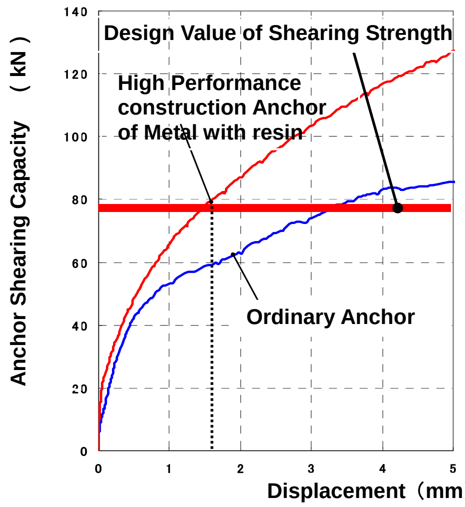

Fig-2 High Performance Construction Anchor

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*3 Engineering Researcher, Sanko techno Ltd., Dr.E., JCI Member
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Construction records

Seismic Performance and Retrofit of "the Tsutihashi River Floodway Tunnel (Tentative)"

Michinori KUDOU*1 Kazuaki NIREI*2 Xuesong YANG*3

Keywords: floodway tunnel ,high density slurry shield ,alluvium,local inland-earthquake distance attenuation relationship, beam～nonlinear spring model, ductile segment

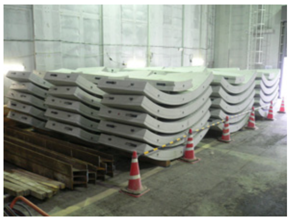
The 'Tsuchihasi' river floodway tunnel, which is a floodway tunnel where the flood prevention of the class A river 'Mabechigawa' river water system, was started constructing in the purpose in 2005 fiscal year.

The high density slurry shield was used for a construction work of the tunnel. Most in the proceeding to dig section is diluvial gravel bed of the overburden about 10m or more. However, a weak alluvium section of the overburden 5m or less that consisted of humus over about 100m existed(fig-1). Moreover, the construction ground in this tunnel is in the region where a lot of deep type earthquakes that cause big damage of the surrounding area occur. In addition, the active fault is confirmed to the west of the tunnel. Therefore, a verification of seismic safety of the tunnel for level 2 earthquake was done in consideration of the importance of the tunnel.

The inside diameter of the tunnel is 4.4m, and the segment in the diluvium section is RC segment(pho-1) of girder height 20cm. On the other hand, Ductility segment(pho-2) was adopted in the alluvium section because a big sectional force had been generated in the direction where the segment was crossed in the alluvium section. This depends on the boundary of the alluvium and the diluvium there in the center part in the tunnel. Moreover, to decrease power to absorb the displacement axially of the tunnel, and to act on the connecting bolt, the coupling between segments in the alluvium section was made an elasticity washer.

Fig-3 shows ground displacement in diluvium section by earthquake wave.

Fig-4 shows ground displacement in alluvium section by earthquake wave.



Pho-1 RC segment

Pho-2 Ductility segment

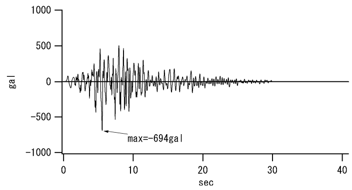


Fig-2 Earthquake wave of the active fault

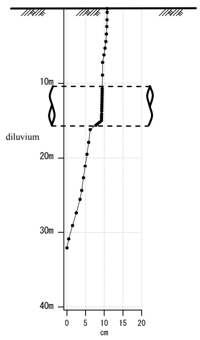


Fig-3
Ground displacement in diluvium section

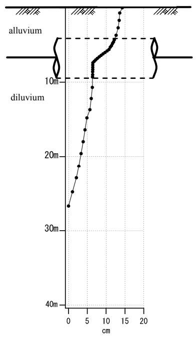


Fig-4
Ground displacement in alluvium section

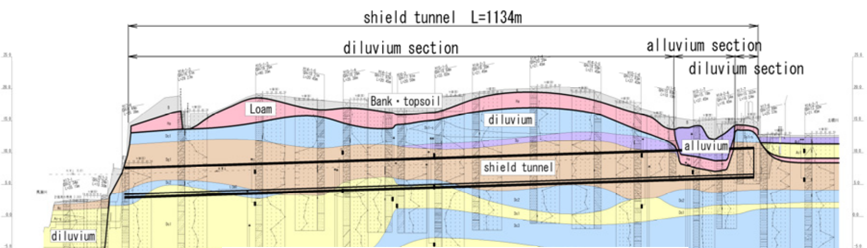


Fig-1 Geological features profile

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Construction records

Design and Construction of Longest Span SHINKANSEN Bridge
—Tohoku SHINKANSEN SANNAI-MARUYAMA Bridge—

Shinichi TAMAI[*1], Takeshi TANAKA[*2], Takashi SUZUKI[*3] and Takashi SAKAMOTO[*4]

Keywords: extradosed bridge, performance based design, stay cable saddle system

Sannai Maruyama Bridge is an extradosed prestressed concrete bridge built for Tohoku Shinkansen from Hachinohe to Shin-Aomori.

The bridge is 450m in total length with four spans 75m+150m+150m+75m. The main span length 150m is the longest span of railway bridges in Japan.

The bridge cross the Aomori ring road and the Okidategawa river continuously adjacent to Sannai-Maruyama site which is a special historic site of the Jomon period. For the location the extradosed bridge that a pylon height and a girder height had been suppressed was selected.

It is necessary to limit the deflection of the girder to the certain scope in Shinkansen bridge for the train safety and a comfortable travel. Even though the bridge has long spans, the deflection of the girder is controlled within very limited range applying performance based design method and several technologies.

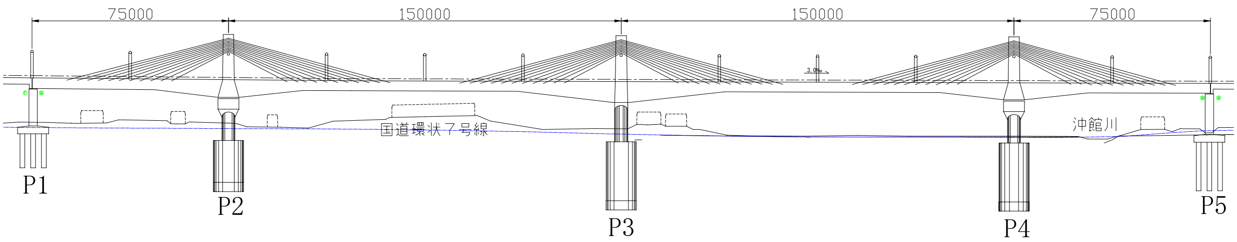
Seasonal temperature effect is eliminated by adopting sliding support system other than the center pier.

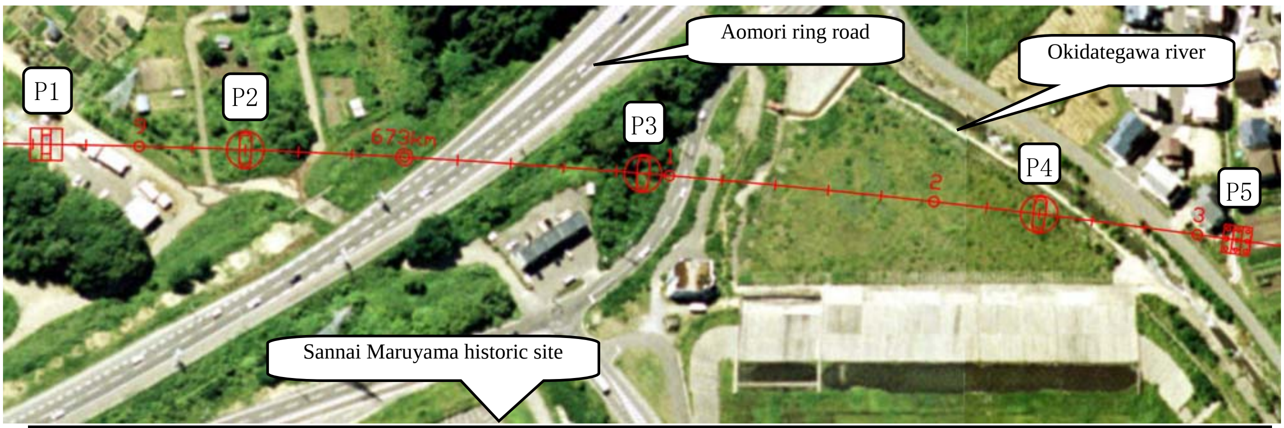
The influence from temperature change for the stay cable is minimized by limiting pylon height. Further the temperature change of the cable is reduced by encasing them into thick cement grouting.

The deflection by train loads is also reduced by employing 2-line bearing system.

Single duct system was applied to the stay cable saddle on the pylon substitute for double duct system.

Setting of three pneumatic caissons was started in October 2005. Cantilever election of the girder was started in November 2006, and was completed in June 2008.





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Concrete Journal Vol.46, No.6, pp25-30, Jun. 2008/

Construction records

The Execution of Toyota Pedestrian bridge

—Pedestrian bridge that ultra high strength fiber reinforced concrete—

Kunihiro OSHIMA [*1], Minoru NAKASHIMA[*2], Kouzi TANAKA [*3] and Hidehiko INAHARA [*4]

Keywords: ultra high strength fiber reinforced concrete, prestressed concrete bridge,precast segment, dry-joint, wet-joint, the method of short line mach-cast

The Toyota pedestrian bridge in Aichi Prefecture Toyota City is a prestressed concrete bridge that was constructed to connect the ground with the second floor of the gym. It was necessary to make the height of the main girder extremely lower, because of the relation between the construction gauge of the road and the second floor level of the gym. In order to clear that severe design condition, the ultra high strength fiber reinforcement concrete (Ductal) was applied to the main girder. By utilizing Ductal's ultra high strength, such as compressive strength of 200 N/mm^2, and its high ductility, the extremely lower girder height of 550 mm and the depth/span ratio of 1/41 was realized.

Up to then, the wet joint, which is a method of pouring Ductal between segments after setting up segments on the site, had been an ordinary method to connect the segments. Even though, this method has the tendency to make the construction period long, because this method needs a lot of work such as formwork, casting-work, and curing-work. However, this pedestrian bridge steps over on the road where a lot of traffic exists, therefore a traffic obstruction had to be made minimum during its construction period. To shorten the execution time, the dry joint (adhesive joint) method was adopted to this bridge, since the dry joint can connect the segments without the time consuming work of the wet joint method.

Because the dry joint is a method of directly connecting segments using adhesive, the smoothness and the size accuracy on the bonded surface of the segments are necessary. Segments for dry joint, therefore, are produced by the short line match-cast to ensure the accuracy. Match-cast is a method that use the edge side of the already produced segment as a substitute form to produce the next segment. However, the shrinkage of Ductal is relatively large such as 800μm within its production period, so it was very difficult to secure the smoothness and the size accuracy on the bonded surface of the segments. Then, developing new type forms, the accuracy has been obtained even if the shrinkage of concrete material is large.

This bridge has very low girder height, and two-cell box structure. It was considered that the production of the low height girder and the work of stripping out the inside forms from two-cell box were difficult. Then, the special inside form system and the method of the stripping form using the peculiar high temperature steam curing to Ductal were developed not only to solve those problems but also to produce segments effectively.

Due to these improvements and developments, the production of segments and the construction had progressed well, and the project was able to execute on schedule.

This paper is a construction record that reported the production and the construction of the mach-cast segments of Ductal, and low height girder.

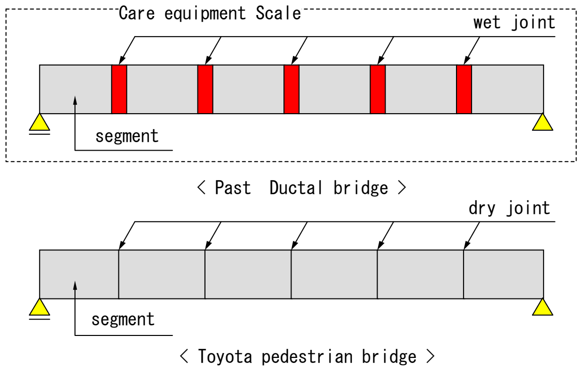

Fig.1 Comparison between dry joint and wet joint

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Concrete Journal Vol.46, No.4, pp42-48, Apr. 2008/

Construction records

Design and construction of a base isolated super high-rise RC building composed of three connected towers with vibration control system

Akira NISHIMURA[*1], Yousuke SHIRAISHI[*2], Takeshi SUZUKI[*3] and Hideki KIMURA[*4]

Keywords: high-rise RC Building, three connected towers, base isolation, vibration control, high-strength concrete, pre-cast, lift-up construction method

The Island Tower Sky Club is a forty-two-story, 145-meter-tall super high- rise RC condominium composed of three connected towers. It is located in the Island City (a reclaimed land, northeast of Hakata Bay) of Fukuoka-city, Kyushu, Japan. The building presents a variety of challenges related to structural design of tall buil dings and construction method.

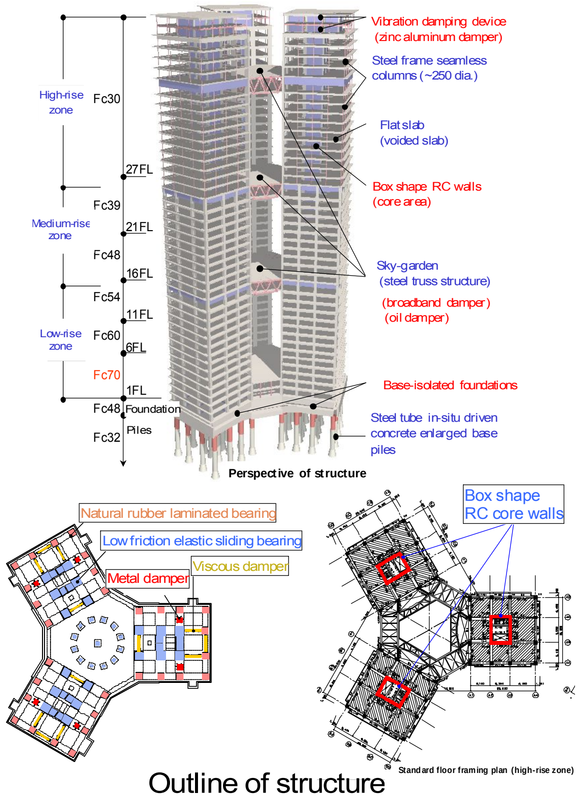
The superstructure is characterized by three towers which are connected at their 15th, 26th and 37th floors by steel frame trusses supporting aerial gardens (Sky-Garden). Two kinds of vibration control systems for wind and earthquake are used. Viscoelastic dampers and oil dampers are introduced at the main truss ends of the Sky-Garden to reduce wide-range wind-induced vibrations.

Zinc-aluminum (Zn-Al) alloy dampers of excellent ductility are employed on the top floor of the building for earthquakes. Each tower has a central RC core wall with a thickness varying from 900 to 300 mm along its height. The maximum concrete strength is 70 MPa. The building is isolated at its base. The isolation system is composed of two kinds of isolators (including low friction sliding bearing) and two kinds of dampers to reduce low to high level earthquake vibrations.

The latest advancements in construction techniques are applied to achieve high quality and short time construction work.

Precast concrete columns, beams and slabs are effectively used. The reinforcing cages are prefabricated on the ground. The core walls are formed using aluminum forms. The slabs are formed with steel forms. For assembling, the main steel bars of structural elements are connected using grout type mechanical sleeve joints.

The particularity of the construction is the method selected (lift-up method) to erect the Sky-Garden. This method allows each garden to be built upon a lower garden and then lift it up to its designated location. The lowest Sky-Garden is built first on the ground and lift up to the 15th floor. This system contributes a great deal to safe and short time construction work.



Outline of structure

a)Before Lift b) During Lift c) Finished

Lift up construction procedure

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Construction records

Tokai-Hokuriku Expressway, Hida Evacuation Tunnel
—Secondary Tunnel Lining Construction by Shotcrete—

Mamoru Moriyama[*1], Shinobu Kaise [*2], Isao Tsukiji[*3] and Akinobu Hirama[*4]

Keywords: shotcrete, dry-process shotcreting , slurry type set accelerator, secondary lining , fiber reinforced concrete

1. INTRODUCTION

Hida Tunnel is a mountain road tunnel with a total length of 10.7 km located between the Shirakawagou interchange and the Hidakiyomi interchange, a section of the Tokai Hokuriku. The tunnel is the second longest in Japan after the Kanetsu Tunnel, and the seventh longest in the world. Generally, the secondary lining of tunnel is constructed by stamping of concrete. In the case of evacuation tunnel for the Hida Tunnel, complicated geological condition requires installation of different types of formworks, which makes the conventional construction method uneconomical. Therefore, we resolved the problem by applying high strength fiber reinforced shotcrete to the whole construction line of the evacuation tunnel.

During construction, the suitability of different shotcreting methods was evaluated based on their respective quality and workability. Due to the fact that concrete mixed for the Shirakawa side could only be placed after a minimum of two hours, in addition to the need for installing invert blocks for secondary lining construction that complicated concrete placing, it was considered that a dry mix method should be used for the shorcreting. The dry mix method, however, produces a higher quantity of dust compared to the wet mix method. Beside, the quality of concrete produced by the dry mix method is less consistent. To solve this, we developed the slurry shot method, as well as a new method for measuring the water content of dry mix. These methods were applied in the construction and their effectiveness was verified.

2. CHOICE OF SHOTCRETING METHOD

The dry mix method basically produces a higher quantity of dust in comparison with the wet mix method. In addition, shotcreting for the Shirakawa side has to be carried out at its upstream in order not to affect the construction work at the Kawai side. With regard to these, a new dry mix method using slurry type set accelerator was developed and applied in the construction.

3. SHOTCRETING

In the shotcreting by dry mix method, procedures including correction for surface moisture content of aggregate were usually conducted by a same operator from the beginning. The quality of shotcrete was largely dependant on the skill of nozzle operator.

By setting up a boiler facility in the aggregate storage bin, fluctuation of surface moisture content of aggregate was reduced. Moreover, the surface moisture content was measured in a real-time manner at the exact construction location. The feasibility of using luminance meter for measuring water content of dry mix to determine correction amount for water was investigated and then applied in-sitully.

Photo.1 Situation of shotcrting

Photo.2 Completion Situation of Secondary Lining

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Construction records

Design and Construction of KIRIGATAKI Bridge (A-line) in Shin Meishin Expressway

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Keywords: pretension-web, strut, distribution ratio of shear force, mean shear stress, bond anchorage length of PC strand, camber control, practical measurement

KIRIGATAKI Bridge (A-line) is a newly constructed viaduct which has the 1,257m total length composed of three main rigid frame structures with PC box girder of West(5 spans), Central(4spans) and East(5spans) bridge. Pretension web construction method (PPW hereafter in short) was applied to the middle web of 2 cells box girder of Central and East bridge as the first practical application in Japan.(see fig-1) And also the cantilever slab supported by strut is also partially involved in it. On the occasion of adoption of this innovative method, rationalization of the design and device of construction were executed by through the analytical and experimental studies to solve subjects in addition to refer the concerning knowledge. PPW is one of the methods to construct a composite girder to replace the web casted in situ normally with a precast member fabricated by pretension method at a existing factory. The characteristics of this method are expressed that / construction cost is to be minimized by lightening the weight of main girder / long term durability is to be improved by manufacturing the member at a factory / man power in the site work is to be saved by manufacturing at factory.

Study about shear bearing capacity should be mentioned specially in the design. Effectiveness of pre-stress induced at the vertical direction of precast web to improve the compressive fracture capacity was studied by using the non linear finite element analysis method. As result, as indicated fig-2, it was confirmed that the mean shear stress at the fracture load was increased about 30% of it comparing to it which pre-stress was not induced because of the reason that the angle of principle stress is getting larger due to the affection of vertical pre-stress. Consequently, new conception of design to verify the shear capacity was adopted as follows based on this result. Maximum mean shear stress to check the compressive fracture should be 8.0Mpa replacing with 6.0Mpa of it of RC web which is prescribed at 4.3 verification of the member shear force acts in the road bridge specification part-3. This is the value to maintain the safety factor which is obtained from the calculation of analytical value divided by prescribed value of RC web at equal level. As a result, even in case that the thickness of web member is designed by the shear compressive fracture capacity, almost of 25% of thickness is reduced possibly. Accordingly it was found that the specification needs of web thickness are satisfied with 150mm which was the minimum thickness prescribed in the specification for almost all parts. However, 200mm thickness was applied for the web of the pier table portion which has the comparative large height of 6.0m so that not to become too thin considering to maintain the safety against the possible buckling.

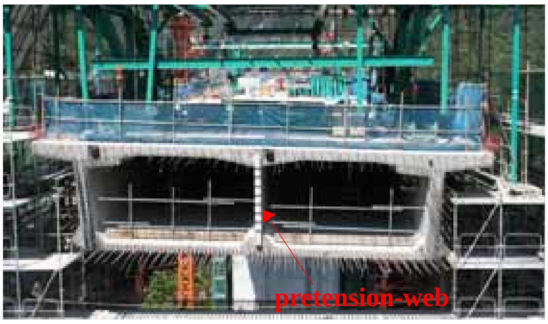

Fig-1 General view of girder section

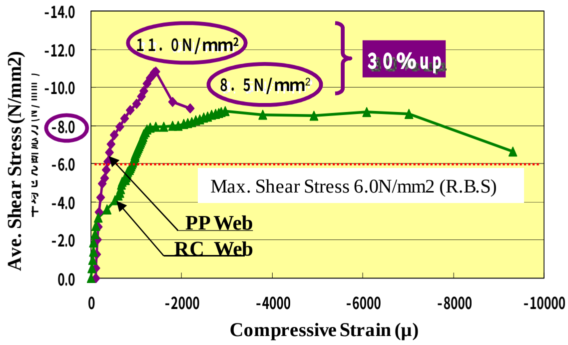

Fig-2 Comparison of shear stress

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Construction records

Concrete Works in Construction of Large Scale Underground LNG Tank
—Construction of Chita-Midorihama No.2 LNG Tank—

Katsunori KOBAYASHI[*1], Atsuhiro FUKADA[*2], Mitsuhiro OKUMA[*3] and Shuji YANAI[*4]

Keywords: LNG underground tank, underground continuous wall, self-compacting concrete, large scale concrete work

Chita-Midrihama No.2 LNG Tank of TOHO Gas Corporation, which has the world's largest class on a capacity of 200,000 kl, has been constructed. The construction work has involved constructing underground continuous diaphragm wall, excavating the inner side (approximately 80m in diameter, 50m in depth), and building the bottom slab and side walls. This report describes the outlines of concrete works in the construction of this tank.

The underground continuous diaphragm wall has a large depth of 102m. Three types of concrete using low heat portland cement, which differed in strength and flowability depending on depth, were placed continuously within the same element. One of the concrete was high strength and self-compacting concrete (SCC) of design strength of 50 N/mm^2. As a result of investigating actual concrete strength by core boring, the quality of the concrete especially with self-compacting concrete was homogeneous, and its strength reduction by underwater placing was also very small (Fig.1).

The bottom slab which has the thickness of 8 m was constructed by continuous concrete placing of the volume of 39,000m^3 in 107 hours (Photo1). Concrete works were completed smoothly by careful preparations for the long time work. Since it was large scale member, it is necessary to reduce thermal cracking. The low heat blended cement, made by mixing moderate heat portland cement, blast- furnace slag and fly ash, was applied. Long time insulated curing was also adopted by using air bubble sheet to reduce self-equilibrated internal stress. With these handle, based on thermal stress analysis, crack was hardly generated.

Construction of the side wall, which has the height of 48.6 m, was divided into eight lifts. Since the side wall was also large scale member, blended cement was used in order to reduce thermal cracking. SCC was applied at the first lift which connects with the bottom slab, because lots of reinforcing bars were arranged in high density and compaction works of concrete were difficult. Concrete works of 3,000m^3, were completed smoothly in 19 hours, because the properties of fresh concrete were excellent and stable. Moreover the method of concrete placing was suitable.

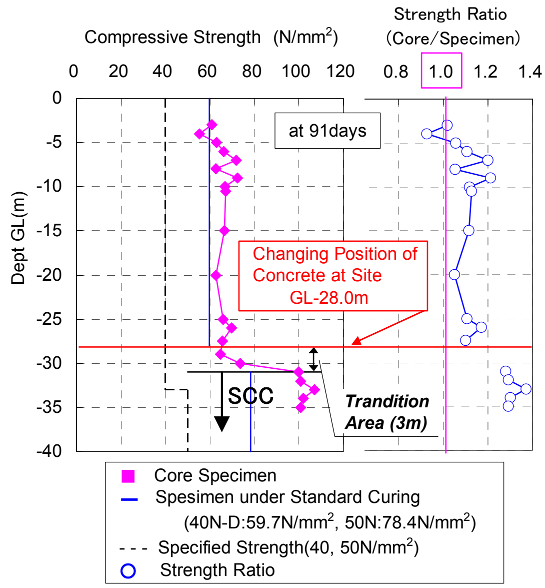

Fig.1 Compressive Strength of Cored Specimens

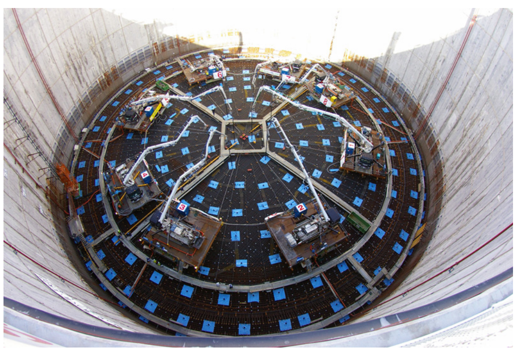

Photo1 View of Concrete Work of Bottom Slab

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Construction records

Performance of the cement blended with large amount of blast furnace slag used in Sakhalin Ⅱ Project

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Keywords: cement blended with large amount of blast furnace slag, GOST, EN standard, durability, marine concrete, concrete works in cold weather

Sakhalin Ⅱ Project proceeds in order to supply LNG and crude oil to users of overseas, and plants and export terminals of them are being constructed in the south of Sakhalin Island. (Photo.1) In these constructions the cement blended with large amount of blast furnace slag was used in quantities of 85 thousands tons and satisfactory outcome were obtained.

The specifications of concrete for each structure mentioned above facilities are shown in Table1.The design strengths of concrete are expressed by the notation as letter B by SNiP. (construction regulations and basis regarding of Russian Federation)

Resistance to freezing and thawing of MOF and JETTY is defined as F300 provided by GOST 10060. And to keep resistance to sea water corrosion, the type of cement for all structures involving in onshore was the blast furnace slag cement conformed to CEM Ⅲ/B, slag content of 66-80% defined by EN standards .(Table.2)

At the site, period of the concrete works in extreme cold weather extends for 7 months from the early of October to the last of April. In this period, curing procedure based on SNiP was adopted.

Concrete was fed warm air by jet heaters till concrete gained the strength of more than 30% of the design strength, and then kept warm with blankets till more than 70% of the design strength in the temporary enclosure.

Photo.1 LNG plant and oil export terminal

There has been no matter with concrete works in the cold weather and little cracks influence on durability. For the concrete used this cement has high resistance to chloride ion permeation and freezing and thawing, its durability and soundness are expected through long time in future. This concrete work is considered to be an example that high durable concrete can be produced in extreme cold weather by making use of good properties of blast furnace.

Tab.1 Concrete specification

Structures		Compressive Strength: Grade	Design Strength (MPa)	Target Strength (MPa)	Durability: Frost Resistance	Seawater Corrosion: Maximum W/C (%)	Minimum Cement Content (kg/m3)
JETTY MOF	In-fill Concrete	B20	20	25.7	F75	45	-
	In-fill Concrete into Cone Cassone, Precast Block MOF	B40	40	51.4	F300	40	400
LNG plant	Lean Concrete	B20	20	25.7	F75	45	—
	Foundation and Structure	B35	35	44.9	F200		400

Tab.2 Properties of cement

Type of cement (EN197-1) / Strength class		CEM Ⅲ/B 42.5N	Test data
Slag content (%)		66-80	68
Blaine specific surface area (cm²/g)		—	4060
Density (g/cm³)		—	2.99
Setting (h-m)	Initial	≧60	2-50
	Final		4-45
Compressive strength (N/mm²)	2d	≧10	10.6
	3d	—	15.8
	7d	—	31.5
	28d	≧42.5 ≦62.5	52.5

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Construction records

Design and Construction of an Apartment Building with CFT Flat Plate Seismic Isolation Structure

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Keywords: Flat plate, CFT, diaphragm, punching shear

Le Corbusier's domino system, a structure consisting only of columns, floor slabs, and stairways, is structurally difficult to achieve in Japan, a country that is prone to earthquakes. The apartment building " IGREK " has a small standard floor area, and the domino system is an effective way of maximizing indoor space; and this was made structurally feasible by using a CFT flat plate seismic isolation structure. The structure consists of four 500-mm diameter CFT columns and a 500 mm RC flat plate. The juncture of the CFT flat plate structure uses a mechanism in which studs are arranged inside the CFT column diaphragm, and stress arising in the steel reinforcement within the RC slab is transmitted to the flat plate by way of the studs (Fig. 1).

Horizontal force application testing was conducted to examine the structural performance of this juncture between the CFT columns and RC flat plate. The test specimen consisted of a skeleton component model with a CFT column on the outer periphery of the building projecting from a flat plate. In the bending force application test of the first stage, the fulcrum was placed at the slab position of the anticipated shear span length of the test specimen, and hysteresis characteristics during an earthquake were verified by repeated peak-to-peak alternative loading until the story drift R was equal to 10/1000. In the shear force application test of the second stage, the fulcrum was moved toward the column; the shear span length was made two-thirds of the value used in the bending force application test; and punching shear strength was clarified by monotonic loading test. Figure 2 shows the relationship between the story drift R and end moment in the bending force application test. Figure 3 shows the final cracking pattern at the top and side surfaces of the slab. Results of the horizontal force application test using a half-scale test specimen indicated that this CFT column flat plate structure showed stable hysteresis characteristics until the story drift R was equal to 8.5/1000 at the end of bending force application, and it was confirmed that juncture was not failed by punching shear failure mode.

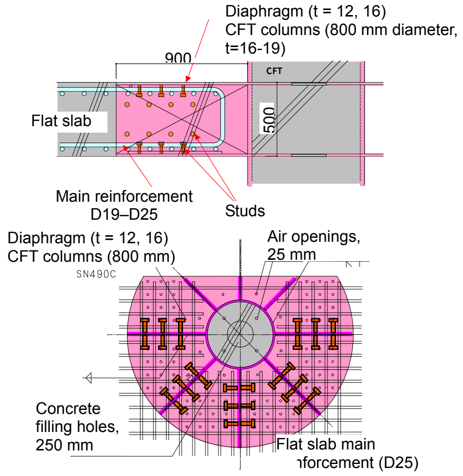

Fig. 1 Detail of CFT flat slab junction

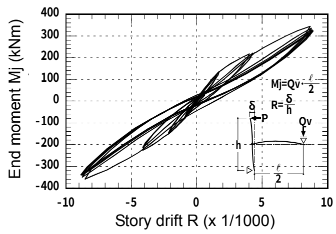

Fig. 2 End moment and story drift (bending force application)

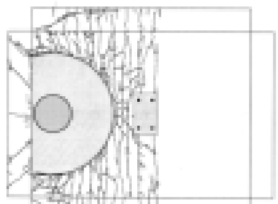

Fig. 3 Final cracking status (top and side surfaces of slab)

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Construction records

High-Rise Apartment House with High-Strength Shear Walls And Low-Yield-Point Steel Dampers

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Keywords: high strength concrete, low yield point steel, shear wall, seismic damper

A building system with reinforced concrete shear walls enables floor-planning flexible; because the shear wall can bear most of seismic force and relieve the load of columns (Fig.1). To apply this system to high-rise buildings, high strength concrete over 100N/mm^2 has been utilized.

Since short-span coupling beams between the shear walls are subjected to large displacement during an earthquake, high ductility and energy absorption performance are required. The coupling beam with low-yield-point steel damper in the mid-span has also been developed (Fig.2).

In this report, the authors are presenting an actual construction of the high-rise apartment house with high-strength shear walls and low-yield-point steel dampers, as summarized in Table 1.

Table 1 Outline of the building

Floors count	48
Roof height	160.9m
Total floor area	97046 m^2
Construction periods	Apr. 2006~Aug. 2008
Specified concrete strength	30~100N/mm^2

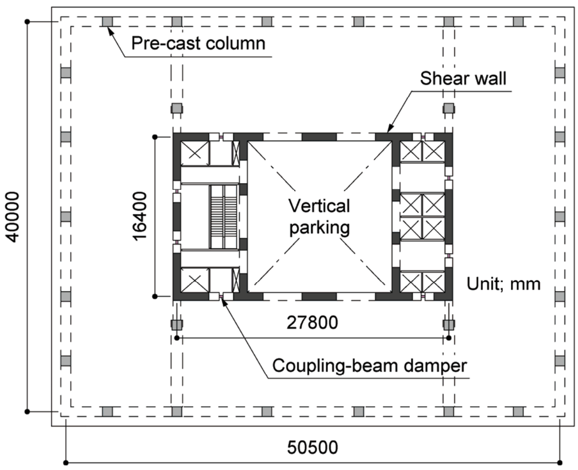

Fig.1 Typical floor plan

Photo 1 Appearance under construction

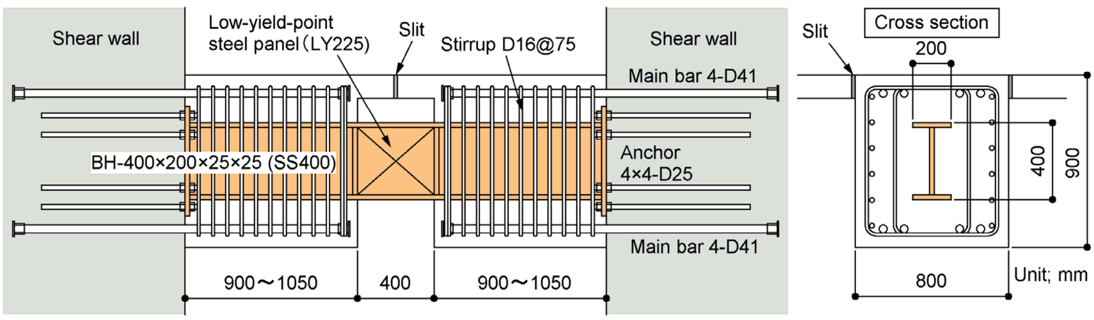

Fig.2 Low-yield-point steel damper (coupling-beam damper)

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Construction records

Design and construction by a precast method of construction in Senpuku Daini Tunnel (the open cut tunnel)

Minoru YAMAMOTO[*1], Toshimune ISHII[*2], Yoshiichi SAJI[*3] and Jun-ichi KAWAMURA[*4]

Keywords: open cut tunnel , precast method of construction, earthquake performance

The north side where Daini Tomei Expressway is Tomei Expressway, the high standard road where I go side by side, pass Shizuoka pref. from Kanagawa pref. and come to Aichi pref. Senpuku tunnel construction accomplishes the part of Daini Tomei Expressway, and is the construction which builds about 90 km of 4 tunnels in a part next to the Senpuku new community which is located in the middle and is spread in the southeast in Mt. Fuji and the foot of a mountain in Mt. Ashitaka mostly of western Tomei Susono IC and Numazu IC from Tokyo.

A precast method of construction (MODULARCH) was adopted in the entrance of tunnel part on the maximum Senpuku Daini Tunnel west side in the country as a freeway tunnel of a large section this time.

A work summary is as follows.

A construction name: Senpuku Tunnel Construction of Daini Tomei Expressway
Order person: Numazu construction office , Yokohama branch ,Central Nippon Expressway Co., Ltd.
Building place: Senpukugaoka, Susono-shi, Shizuoka
A term of construction work: 2004.9.30～2008.3.12
The structural type :2 hinged system precast arch
Calvert extension: Up line 77m and down line 25m
An empty cross-sectional area in a class: 158 square meters (insite high 11.0m, inside width 16.9 m)

MODULARCH is contrived in France The 2 hinged arch structure which came to practical use. Since putting it in Japan, it has been applied to an underpass in the part where Box Calvert has been used up to now for example the fill part which can be put a freeway. Precast Arch Calvert it's possible to reduce a substantial term of construction work was chosen among consideration to the society which is being built to the private facilities in a tunnel neighborhood this time.

It becomes clear by various experiments and simulations about the earthquake performance when supporting soil is good below the medium-scale section. However, I needed the inspection which does earthquake performance with first in the soft Ⅱ kind ground relatively in case of adoption to the light book part in a freeway main line tunnel. So the time history response analysis which chooses as a goal to grasp safety to assumed level 2 seismic ground motion and chooses a structure - limb ground as a two-dimensional FEM by Specifications for Highway BridgeS was performed and inspection of earthquake performance and a precast element joint of the whole structure were considered.

Precast method of a structure was lack of skilled laborer and based on a request in the time as the aging of a site worker. I should be very much obliged if it be the some help when this report will be applied to precast method of various structures from now on.

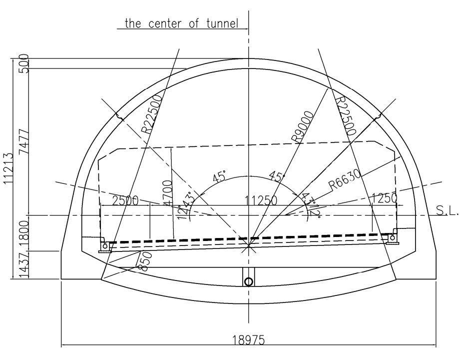

Fig.1. Standard section

Fig.2. View of the western tunnel entrance

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Protection against Erosion of Concrete Pier Constructed in Acid-river with Titanium-sheet Covering Method

Ryo SONOBE[*1], Takeshi TANAKA[*2], Koji SASAKI[*3] and Takashi HABUCHI[*4]

Keywords: surface protection, titanium-sheet, urethane resin, acid resistance, impact resistance

Aomori-Arakawa Bridge constructed in the Tohoku Shinkansen (between Hachinohe and Shin-Aomori station) cut across Arakawa River flowing out from the mountains of Hakkoda.

Arakawa River is an acid river of pH3.5. Therefore, it was concerned that the concrete pier constructed in the river would be eroded by the strong acid river water, and that erosion would be further progressed by impact or abrasion caused by drifting stone or sand, etc.. The structures of Tohoku Shinkansen were designed based on the one hundred years design period. So, the titanium-sheet covering method was applied to the concrete pier for securing the long time durability based on the studies of acid resistance and impact resistance and so on.

In the environments such as seawater, various acids and/or alkalis, titanium-sheet is an excellent material in corrosion resistance and durability, but it was necessary to devise an execution method in site. Titanium-sheet is shown in photo.1, and covering component and procedure of execution of this method are represented in fig.1 and 2.

On the development of this covering method, following several functions were expected; 1) high performance and superior durability of surface protection by titanium-sheet, 2) high adhesion strength by sticking silica sand by urethane resin, 3) relaxation effect of external impact by the elasticity of urethane resin, 4) good working efficiency in site by using epoxy resin for bonding, 5) superior protection effect against deterioration factors by filling epoxy resin inside of titanium-sheet.

Appearance in completion of titanium-sheet covering method applied to Aomori-Arakawa Bridge is represented in photo 2.

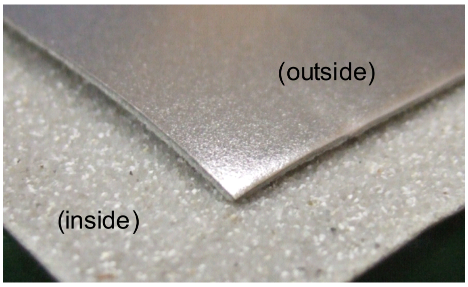

Photo.1 Titanium-sheet with silica sand

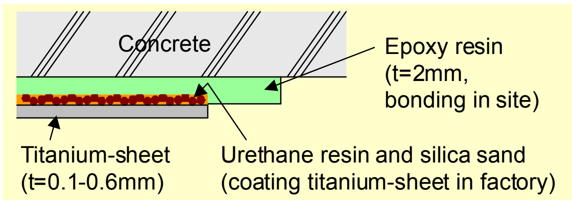

Fig.1 Titanium-sheet covering Component

Photo.2 Appearance in completion

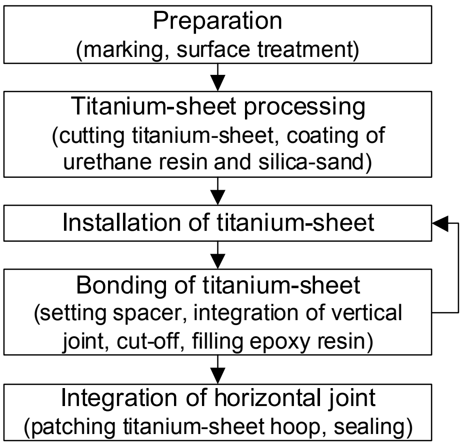

Fig.2 Flow of execution

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Construction records

Single Plane Cable-Stayed Prestressed Concrete Bridge with the World's Longest Center Span Length

—Construction of the Bai Chay Bridge, Vietnam—

Tomoki NAKAMURA*1, Kazuteru TSUCHIDA*2, Naoki NAGAMOTO*3 and Koji HAYASHI*4

Keywords: single plane cable-stayed prestressed concrete bridge, single cell box girder with steel pipe bracings, pneumatic caisson, balanced cantilever erection method

The Bai Chay Bridge, spanning a strait within sight of Ha Long Bay, Vietnam's premier World Heritage site, has the world's longest center span length of 435 m, as a single plane cable-stayed prestressed concrete bridge, with a bridge length of 903 m (Fig. 1).

The main pier foundations were constructed by the pneumatic caisson method. The construction of the caisson structure was carried out on the ground together with the excavation work. After completion of the excavation work and the sinking work of the caisson, the inside of the working chamber was filled with concrete.

The prestressed concrete box girders were constructed by the balanced cantilever erection method and the lengths of each typical segment is 6,5 m. Steel pipe bracings are installed inside the girder to reduce the self weight (Fig. 2). Prestressing tendons were installed in the square steel pipe bracings to resist the tensile force of the stay cables at their anchorage locations. A typical cycle time for casting of a pair of new segments was eight days. From the commencement of the first segment erection to the completion of the center closure, girder construction took approximately one year.

The main pylons, which stand 91,5 m above the deck level, possess varying hollow sections. Construction of each pylon was divided into twenty four lifts. To maximize speed and quality of concrete finishing, a climbing formwork system was utilized. Reinforcement for the pylon lifts and each section of the steel frame to be installed inside the pylon were pre-fabricated at ground level. Concrete of the pylon was placed using the concrete bucket. The high strength concrete (60MPa) was applied to the pylon.

The Bai Chay bridge was opened for traffic in 2nd December 2006. It is strongly hoped that the completion of the bridge will enhance tourism to the World Heritage site of Ha Long Bay and improve the trade links between Vietnam and Southern China.

PROJECT OUTLINE
Project Name : Bai Chay Bridge Construction Project (Package BC-2)
Construction Period : August 2003 – November 2006 (40months)
Owner : No.18 Projects Management Unit Ministry of Transport, Vietnam
Design , Consultant : Japan Bridge & Structure Institute, Inc Pacific Consultants International Transport Engineering Design Incorporation Hyder Consulting-CDC Ltd.
Contractor : Shimizu - Sumitomo Mitsui Joint Operation

Fig.1 Bai Chay Bridge

Fig.2 Steel Pipe Bracing

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Construction records

The design and construction of a complex structure high-rise building using mid-story isolation system

Tsutomu KOMURO[*1], Katsuhiko SOYA[*2], Shin-ichiro KAWAMOTO [*2] and Yasuto KODAIRA[*3]

Keywords: high-rise building, mid-story isolation, HYBRID TASS system, complex structure, RC Layered Construction, press fit method, high-fluidity concrete

This building is a special training school and a condominium that opened in April 2007. To meet the need of offering safe and comfortable dwelling environment for the students, the teaching staffs and the residents against disasters such as earthquakes, a high rise building with mid-story isolation system on the tenths floor where the usage of the building changes was proposed, designed and constructed.

The main structural system is moment-resisting frame consisted of columns and general beams constructed from concrete. The advantage the isolation system enables the large space with the long-span beams (C.S.Beam, PCaPC Beam). As for the isolation system on the tenth floor, the complex isolation system with laminated rubber bearings and elastic sliding bearings (Hybrid TASS System) was adopted. This isolation system which enables the easy adjustment of damping force and the long-period structure is suitable for high rise buildings.

The isolation system is located at the middle part of the building in the vertical direction, which enables the reduction of the response of the upper structure above the isolation system and the reduction of shear force for the lower structure. As a result, in spite of complicated shape, high seismic performance is secured for the whole building, compared to typical buildings.

For the purpose of shortening the construction period the structure was constructed by RC Layered Construction system utilizing the precast beams and columns above the second floor.

For the construction of isolation floor of the tenths floor, the concrete under the base-plate of isolators was filled by the press fit method utilizing the high-fluidity concrete. Through the composition test in the concrete plant and the filling test on site in advance, concrete with very few bubbles of filling rate of 98.5% could be cast.

Thus due to the adoption of mid-isolation system for this high-rise building with complicated shape and usage, high seismic performance of the building was achieved. And the adequate construction period and high quality was achieved due to the industrial methods of PCa elements and the construction procedure based on the plentiful consideration on the mid-story isolation system in advance.

Fig.1 View of Building

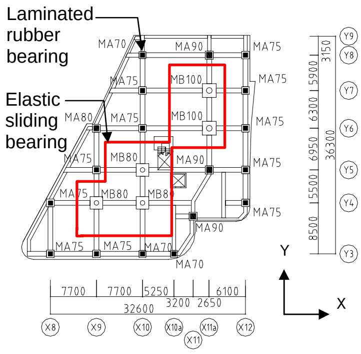

Fig.2 Isolator Plan

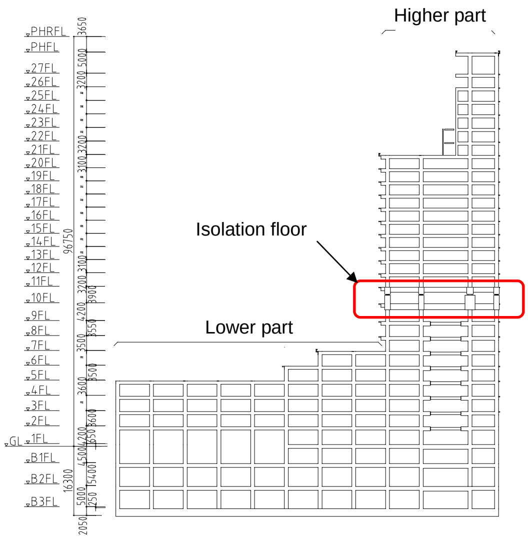

Fig.3 Framing Elevation

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Concrete Journal Vol.45, No.11, pp36-41, Nov. 2007/

Construction records

Construction Method of exposed Black Concrete Walls with Grain Transcript of Japanese Cedar on the Surface

—Construction of Raku Kichizaemon-Kan,Sagawa Art Museum—

Toshiyuki YAMAMOTO[*1], Kohji UEGAKI[*2], Takashi IWASHIMIZU[*3] and Hiroshi TAKEDA[*4]

Keywords: Black concrete, tones of black, Japanese cedar wood grains, pattern transfer, exposed concrete walls, drying shrinkage, ammonia, museum

External and internal walls of the exhibition room and tearoom of Sagawa Art Museum's Raku Kichizaemon-Kan are the exposed decorative black concrete with Japanese cedar wood grain patterns transferred to the surface.

Such highly artistic design requires the following technical challenges related to materials and construction methods:

1. Identification of the optimal mixture proportion of black concrete materials
2. Reduction of cracks due to drying shrinkage and suppression of ammonia gas generation
3. Development of the optimal methods for transferring the cedar wood grain patterns to concrete surface and for installing the concrete walls

These technical challenges were studied and tested in various experiments.

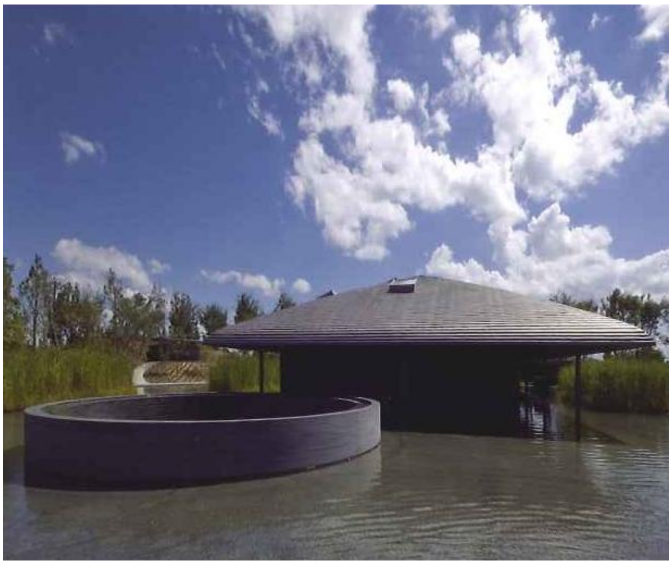

Photo 1 Full view of Raku Kichizaemon-Kan of Sagawa Art Museum

As for the material mixture proportion, the ratio of Fe_3O_4 was tested to identify differences of gray values and 11.1 kg/m^3 was adopted as shown in Fig. 1.

The solutions were implemented with strict quality management. As a result, the desired tone of black was obtained with cedar wood grain patterns successfully transferred to the surface. Also some important areas for technical consideration were identified and their data collected during the actual construction process, which will enable this technology to expand the scope of architectural design in future.

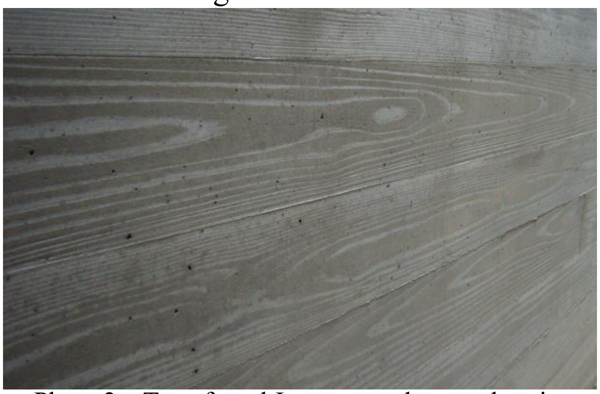

Photo 2 Transferred Japanese cedar wood grain

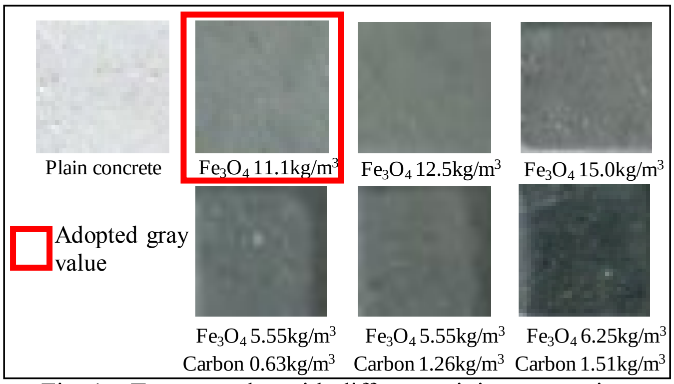

Fig. 1 Tone samples with different mixing proportions

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Concrete Journal Vol.45, No.11, pp42-47, Nov. 2007/

Construction records

Repair/retrofitting of Tedorigawa Bridge Piers Including Measures against Chloride Attack, Scour, and Abrasion

Kenji MATSUDA[*1], Yasunori TSUNO[*2]

Keywords: chloride attack, scour, abrasion, seismic measures, stay-in-place form

Abstract

Tedorigawa Bridge spanning 547 m is a rigid-frame prestressed concrete continuous box girder bridge built in 1972. Being located on the coastline of the Japan Sea, this bridge has been subjected to chloride attack for a long time. Its piers have also suffered scouring and foundation abrasion by waves due to shoreline recession. On the occasion of seismic retrofitting of these piers in 2006, measures against chloride attack, scouring, and abrasion were also carried out as follows：

As seismic retrofitting, six of the seven cylindrical hollow piers with low shear capacities were covered with reinforced concrete 250 mm in thickness.

Air-laden chlorides from ocean waves, particularly during winter, have penetrated deep into the concrete piers. The depth of concrete with a chloride concentration of 1.2 kg/m^3 or more exceeded 120 mm. These highly salinated portions were therefore removed to a depth of 125 mm prior to placing new reinforced concrete. A minimum cover depth of 70 mm was adopted for new reinforcement to protect it from chlorides, along with protective coat on the new concrete.

The shoreline has receded at a rate of approximately 3 m/year. The scouring of pier foundations progressed at a rate of 0.1 m/year, exposing the foundations to a depth of 1.7 m at the largest. As measures to cope with this, rubbles 150 to 200 mm in diameter and sandy soil nearby were placed in the sea to re-form a sandbank. Also, concrete blocks with a weight level of 6 t were placed around the pier foundations to stabilize the sand.

Due to waves including sand and gravel, which repeatedly collide onto the bridge piers in winter, the pier concrete has been eroded at a rate of approximately 10 mm/year. Though the piers had been covered with 6 mm-thick steel plates and 6 mm-thick chloroprene rubber as measures against such abrasion 9 years earlier, the covering was partially worn out and disappeared by the time of retrofitting in 2006. For this reason, stay-in-place forms made of ultrahigh strength fiber-reinforced mortar 50 mm in thickness were used to a level of approximately 2.4m from the bottom.

Various measures to protect the piers were examined, designed, and executed with considerations to the environment. These measures have retained the intended effects so far.

Photo 1　Pier before and after work

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Construction records

Rapid construction of precast concrete caisson with a cross section divided into 3 pieces

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Keywords: precast prestressed-reinforced concrete caisson, rapid construction, PRC, single V-butt welding, bridge over crossing, foundation

The expressway Nagoya-shinpou line was constructed over main roads. A critical challenge posed by this project was the construction of four pier-foundations of a bridge over a large crossing. The original plan was to construct a 42 m long cylinder type foundation 7 m in diameter using the cast-in-place open caisson method. The construction of these foundations was required to be completed in 13 months.

The construction site was adjacent to a large crossing with heavy traffic and located in an area with many residential buildings. In advance of this construction project, the road administration and local residents requested the client to reduce the number of times for material carrying in, especially those for concrete installation that may cause traffic jams, and also to reduce the construction period itself. A value engineering proposal using an alternative construction method for the foundations was therefore offered.

We proposed a rapid construction method using precast prestressed-reinforced concrete caissons for the foundations. The proposal involved the following: (a) each caisson longitudinally divided into 27 rings; (b) each ring divided into 3 pieces in the cross section; (c) each piece fitted at both edges with steel plates into which hoop reinforcements are welded, made in a factory and carried to the site by trailer; (d) three pieces connected with single V-butt weld at the steel plates to form a ring; (e) rings connected with prestressing steel bars and reinforcement bars to form a cylinder type foundation.

It was decided that the weight of each piece should be 172 kN and that the width of each piece should be less than 2.5 m to enable carrying in without special permission from the road administration.

A V-butt weld at the steel plates was employed as the method for connecting pieces because this had the advantage of achieving a short work time. At the same time, this required highly accurate fabrication of the pieces to which the steel plates would be fitted, and a special high-rigidity mold was used to ensure high accuracy.

We installed not only prestressing steel bars but also reinforcement bars for the longitudinal structure, the latter providing ductility for the foundations.

In order to certify the structural safety, cyclic loading tests using two cylinder models made up of 4 precast concrete rings were carried out. Model A was laterally divided into 3 pieces in each ring and Model B was not laterally divided. The results from these tests led to the conclusion that there is no significant difference in terms of seismic performance between the two models and that both have sufficient deformation capacity and stability under earthquake conditions.

This proposal was accepted and the foundations were constructed in 2007 using this technique.

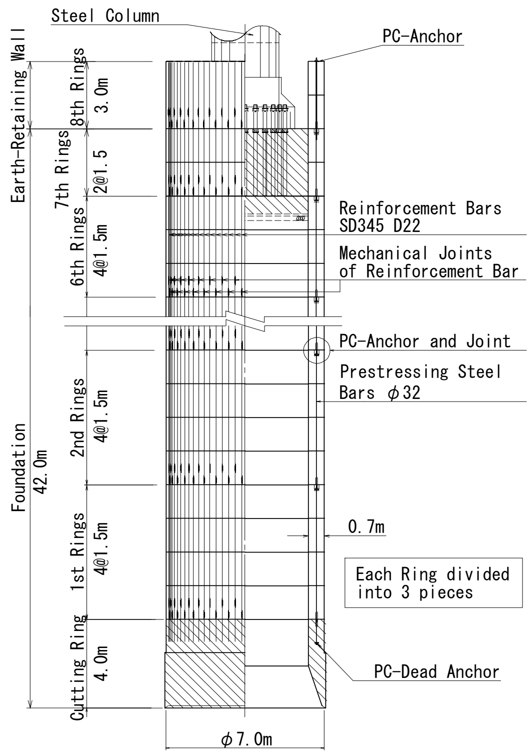

Fig.1 Structural Drawing of Precast Prestressed-reinforced Concrete Caisson

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Construction records

Application of High-Performance, Crack-Reducing Concrete to a Finely Designed Concrete Building

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Keywords: concrete, material, flowability, compactability, crack reducing ability, FEM

1.Introduction

We had the opportunity to construct a finely designed building featuring 3-D arches and external glass walls sharing the same plane. **Figure 1** shows external and internal views of the building, a library that was built.

Figure 2 provides an overview of the mock-up obtained by cutting off sections of the construction members. The main structure of the building consists of steel, while concrete is used for steel buckling prevention, fire protection and aesthetic purposes. The arches consist of I-beams, steel bars, and steel plate through the total cross section. The concrete compaction area was so narrow that high flowability and compactability were required as expected for high-performance concretes. Moreover, the architectural requirement of fare-faced concrete element without contraction joint required the use of crack- reducing concrete.

This paper describes the successful development of new concrete through laboratory tests, mock-up tests, and crack analysis using the finite element method (FEM), and its application at the construction site.

2.Outline of New Concrete:HPCR

This paper focuses developing high performance crack reducing concrete (hereafter HPCR) to apply the finely designed building. **Figure 3** shows slump of HPCR. The required performances for HPCR are: 1) high flowability and compactability and 2) significant crack reducing ability. First, laboratory experiments were conducted to determine HPCR's mix proportion that can meet the above two performance requirements. Second, mock-up experiments were performed to demonstrate HPCR's applicability to this building construction. FEM analysis was finally conducted to reproduce strain behavior of the mock-up specimen and to confirm crack reducing potential of HPCR in this building.

3. Conclusion

The results of the study of the materialsand analyses performed for application to the construction site are summarized below.

(1) HPCR with high flowability and crack reducing ability was developed through laboratory experiments and mock-up experiments.

(2) The stress generated under restraint of the various elements was predicted from the strain data obtained through FEM and a cracking risk was identified. In response, the area of reinforcement was increased for the applicable parts as a measure against cracking.

Fig.1 Exterior and interior view

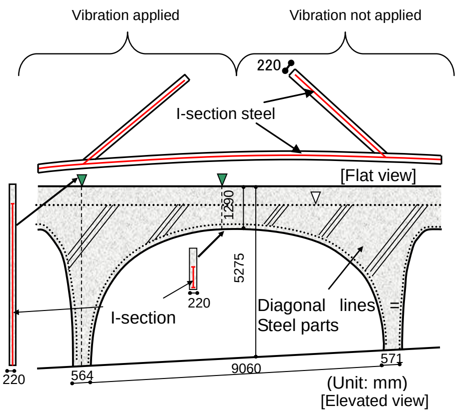

Fig.2 Outline of mockup

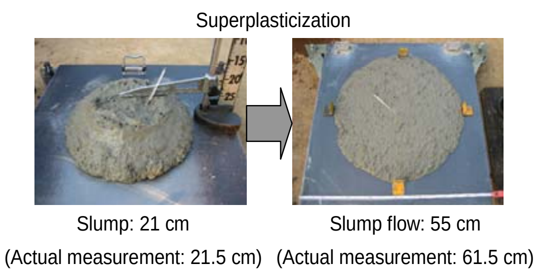

Fig.3 Slump of HPCR

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