CONSTRUCTION PROJECTS IN JAPAN

Yoshiaki Imai [1]

SUMMARY

Recently many remarkable concrete structures are constructing in Japan. This paper introduce the following projects:

1. Fujikawa Bridge
2. Sakata Mirai Bridge
3. Chubetsu Dam
4. Konan Tunnel
5. Under Ground LPG Tank
6. High Strength Concrete (HSC) High Building
7. Bosphorus Crossing Project

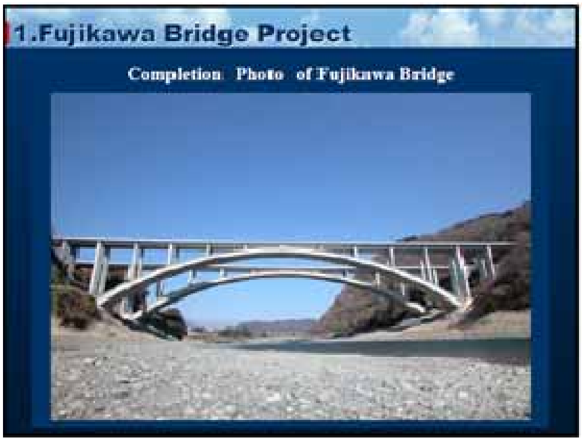
The Fujikawa Bridge is a hybrid arch bridge with a steel girder and a concrete arch rib. The length of the arch span is 265m, which is the longest record of concrete bridges in Japan. Two half arches were progressively built out from the banks, stabilized during construction by temporary stay cables fully anchored on the arch and temporary pylon in the river.

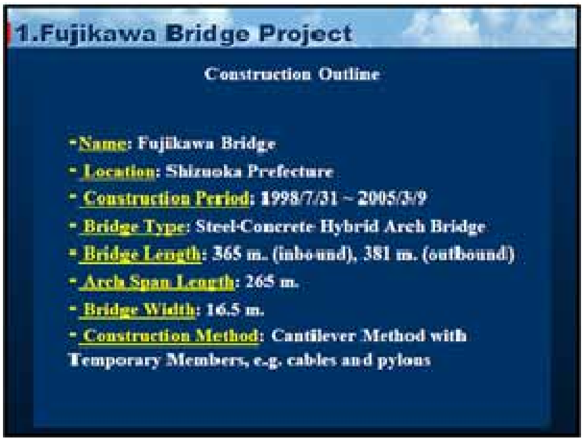
The Sakata-Mirai Bridge was a 50 meter span pedestrian bridge using the ultra-high-strength concrete material “Ductal”. Although the Ductal is a cement based technology, it realize the performance of one rank higher in all respects when compared with a normal concrete. For example the compressive strength is over 210 N/mm^2.

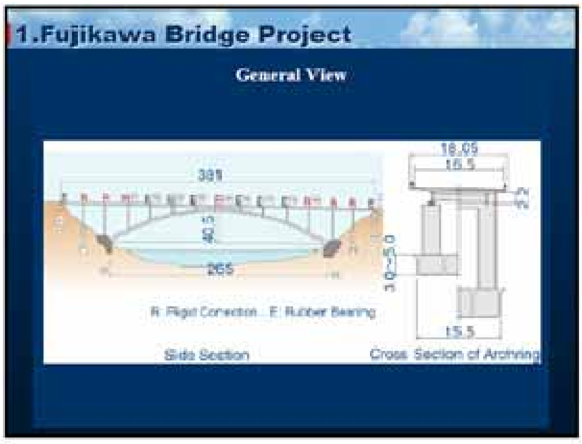
The reinforced concrete using high strength concrete instead of steel are increasing as the structure of high buildings. Recently the 45 stories building was constructed using the concrete with 130N/mm^2.

Finally Marmaray Project is the construction of the railway undersea tunnel across the Strait of Bosphorus connecting Asia and Europe. This is one of the biggest project constructed by a Japanese company .

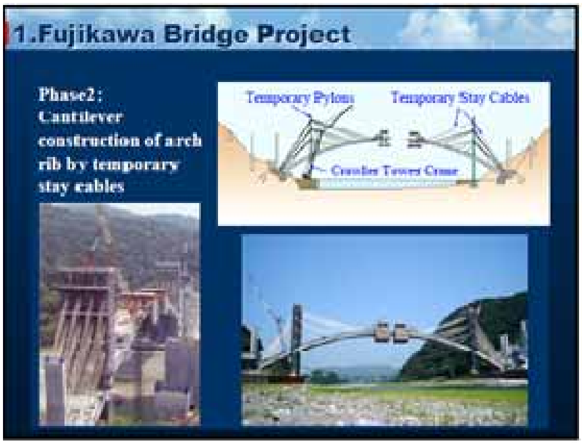
[1] General Manager,Design Dept.,Civil Engineering Div.,TAISAI CORPORATION.
1-25-1 Nishishinjuku,Shinjuku-ku,Tokyo,Japan 163-0606


1.Fujikawa Bridge Project
Completion Photo of Fujikawa Bridge


1.Fujikawa Bridge Project
Construction Outline
•Name: Fujikawa Bridge
• Location: Shizuoka Prefecture
• Construction Period: 1998/7/31 ~ 2005/3/9
• Bridge Type: Steel-Concrete Hybrid Arch Bridge
• Bridge Length: 365 m. (inbound), 381 m. (outbound)
• Arch Span Length: 265 m.
• Bridge Width: 16.5 m.
• Construction Method: Cantilever Method with Temporary Members, e.g. cables and pylons


1.Fujikawa Bridge Project
General View
381
40.5
265
16.05
16.5
2.2
3.0~5.0
15.5
R: Rigid Connection E: Rubber Bearing
Side Section
Cross Section of Archring

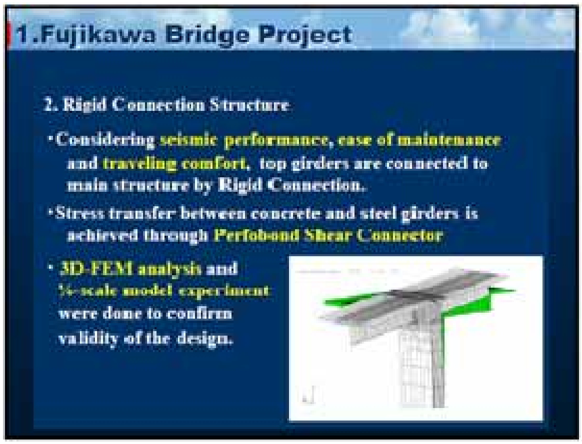

1.Fujikawa Bridge Project
Construction Procedure
Phase1:
Cantilever construction of arch rib by temporary external cables
External Cables
Arch Ring
Traveler
Temporary Support Column
Ground Anchors


1.Fujikawa Bridge Project
Phase2:
Cantilever construction of arch rib by temporary stay cables
Temporary Pylons
Temporary Stay Cables
Crawler Tower Crane

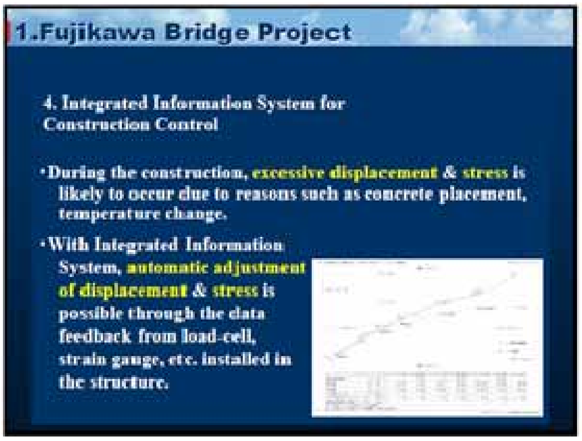

1.Fujikawa Bridge Project
Phase3:
Construction of steel girders by incremental launching method
Steel Girders
Tunnel

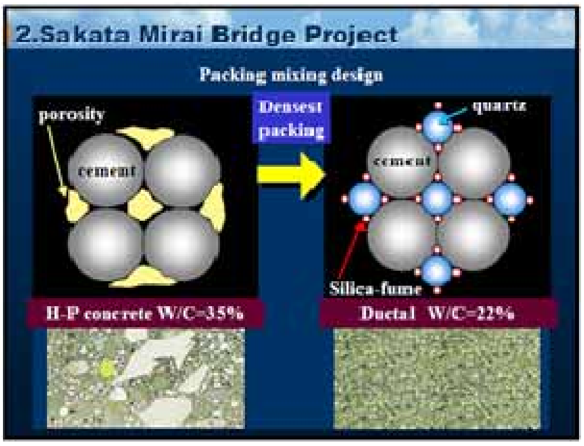

1. Fujikawa Bridge Project
Phase4:
Construction of prefabricated prestressed concrete slab
Precast PC Slabs


1.Fujikawa Bridge Project
Technical Points
1. Reliable Seismic Resistance Design
Fujikawa Bridge
・Important for Japanese economy as a main transportation route (Tokyo ⇔ Nagoya)
・Located in 'Tokai Earthquake Sensitive Region' where strong earthquake is expected in the near future.
To limit and minimize damages due to possible earthquake
'Nonlinear Dynamic Analysis'
・consider
①Material Nonlinearity
② Geometric Nonlinearity
・High Reliability and Accuracy

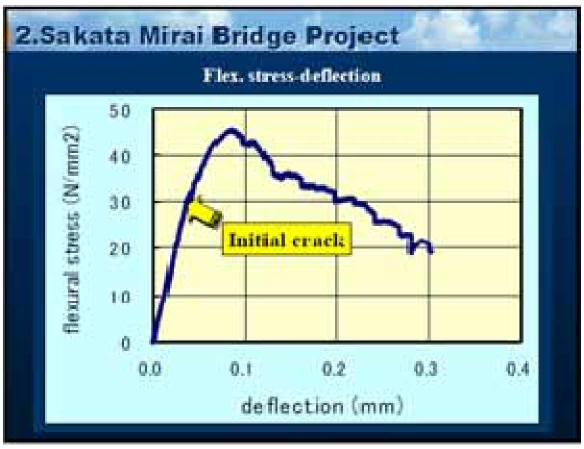

1.Fujikawa Bridge Project
2. Rigid Connection Structure
・Considering seismic performance, ease of maintenance and traveling comfort, top girders are connected to main structure by Rigid Connection.
・Stress transfer between concrete and steel girders is achieved through Perfobond Shear Connector
・3D-FEM analysis and ¼-scale model experiment were done to confirm validity of the design.

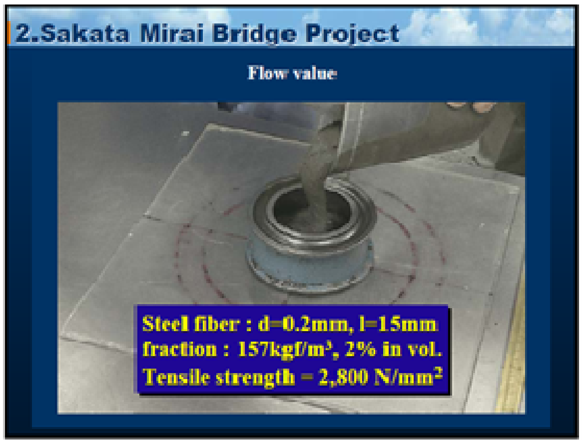

1.Fujikawa Bridge Project
3. On-site Concrete Mix Design with Full-scale Concrete Placement Test
・To satisfy seismic requirement, inside relatively small section , Dense Reinforcement arrangement is necessary.
・Due to inclined arch rib and dense reinforcement, concrete placement and working condition is very difficult.
・To solve the difficulties, high quality superplasticizer (AE) is used to obtain 21-cm slump with 50 N/mm² concrete compressive strength.
・The full-scale concrete placement was tested through pumping system with equivalent horizontal pump power of 380 m.


1.Fujikawa Bridge Project
4. Integrated Information System for Construction Control
・During the construction, excessive displacement & stress is likely to occur due to reasons such as concrete placement, temperature change.
・With Integrated Information System, automatic adjustment of displacement & stress is possible through the data feedback from load-cell, strain gauge, etc. installed in the structure.



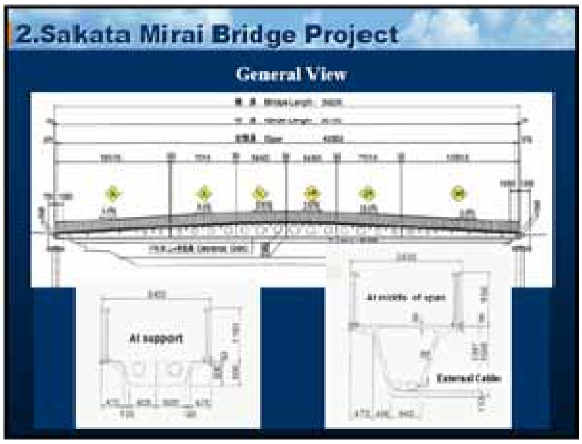
Item	Unit	Ductal	Conventional concrete
Compressive strength	$N/mm^2(kgf/cm^2)$	~210(2100)	~36(360)
Bending strength	$N/mm^2(kgf/cm^2)$	~45(450)	~5(50)
Tensile strength	$N/mm^2(kgf/cm^2)$	[illegible]	~3(30)
Static modulus of elasticity	$kN/mm^2(kgf/cm^2)$	50(500,000)	25(250,000)
Drying shrinkage	μ	50	600~800




2.Sakata Mirai Bridge Project
Flow value
Steel fiber : d=0.2mm, l=15mm
fraction : 157kgf/m^3, 2% in vol.
Tensile strength = 2,800 N/mm^2

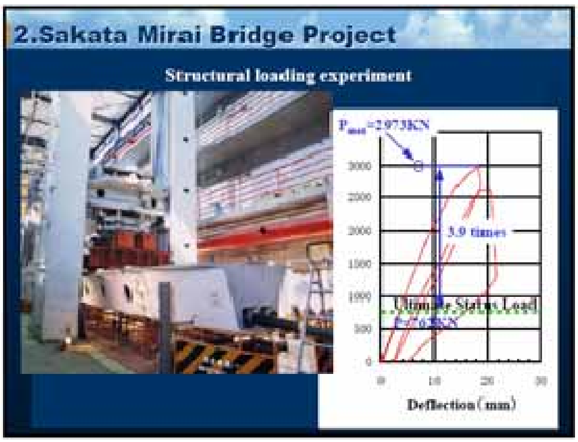

2.Sakata Mirai Bridge Project
Verification of durability
Exposing field tests
Izu national park
Water permeability=10^{-13}~10^{-12} cm/sec
Chloride iron diffusion=0.019x10^{-8} cm^2/sec


2.Sakata Mirai Bridge Project
Outline of project
Sakata-Mirai Bridge Project
Location : Sakata-city, Yamagata prefecture
Constructor : Joint Venture - TAISEI CORPORATION & MAEDA CONCRETE INDUSTRY LTD.
Construction period : 2002 May-October
Structural dimensions
Type of structure : Single span prestrest concrete box girder bridge
Bridge Length : 50.20m
Span : 49.35m
Width : 2.4m (total width)
Girder height : 0.55m (at support), 1.56m (at middle of span)
Erection method : Precast block erection method


2.Sakata Mirai Bridge Project
General View
At support
At middle of span
External Cable


2.Sakata Mirai Bridge Project
Structural design concept
Taking advantage of Ductal
1) Self weight reduction (1/5 of ordinal PC)
2) Ultimate thickness of members
3) All external pre-stressing cables
4) No reinforcement by re-bars
5) Sophisticated view design


2.Sakata Mirai Bridge Project
Structural design concept
Ultimate design
5cm
8 cm

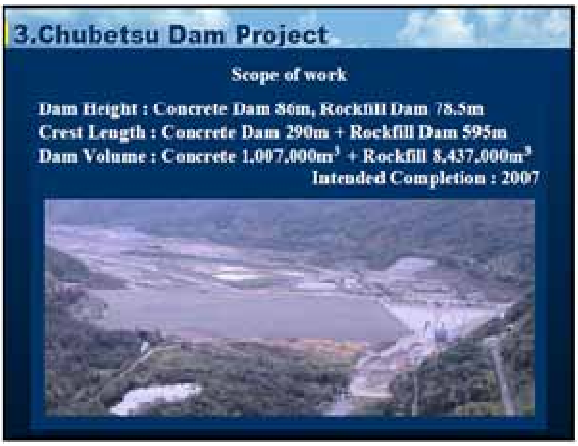

2.Sakata Mirai Bridge Project
Structural loading experiment
Pmax=2973KN
3.9 times
Ultimate Status Load
Deflection (mm)

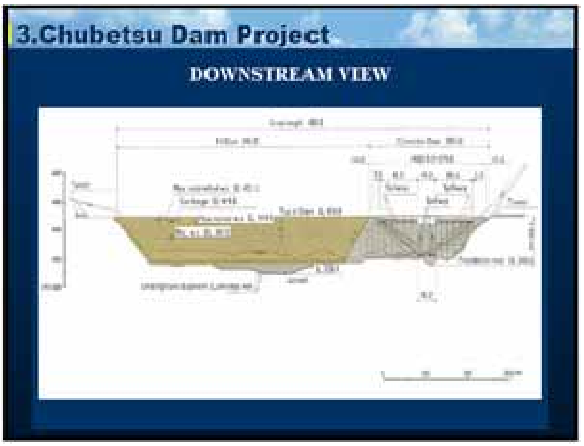

2.Sakata Mirai Bridge Project
Casting of Ductal

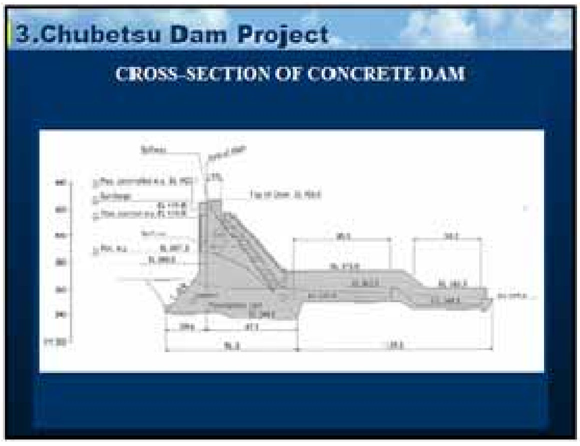

2.Sakata Mirai Bridge Project
Pre-cast blocks assemble

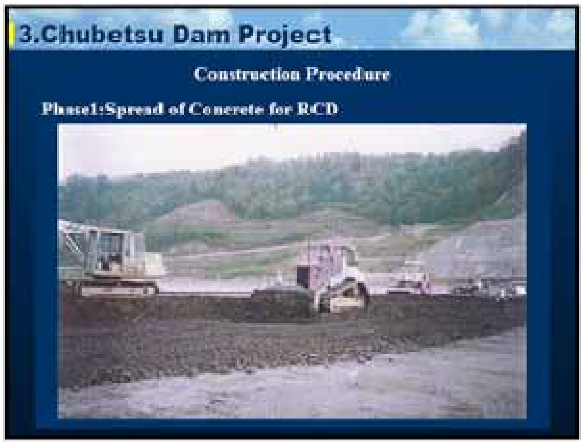

2.Sakata Mirai Bridge Project
Set of block

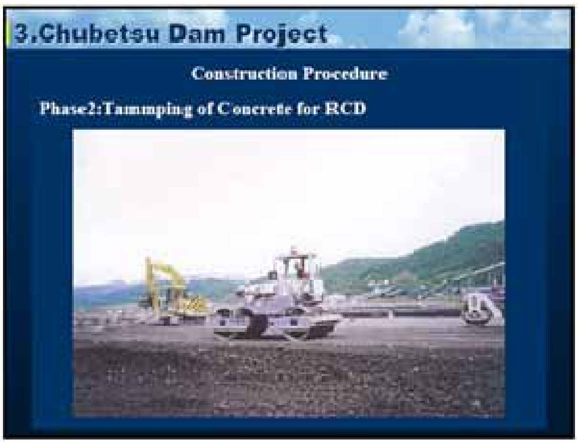

2.Sakata Mirai Bridge Project
Completion of Sakata-Mirai Bridge
Completion in Oct. 2002

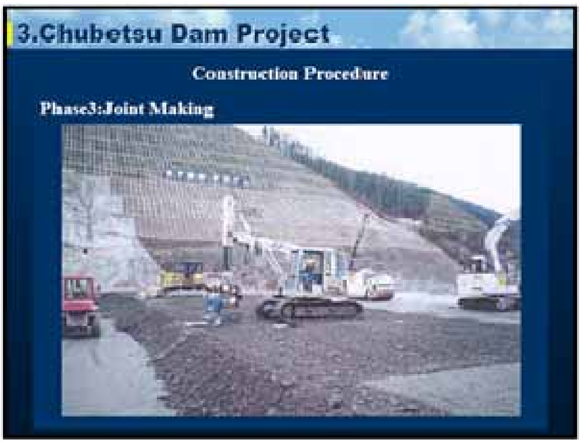

3.Chubetsu Dam Project
Scope of work
Dam Height : Concrete Dam 86m, Rockfill Dam 78.5m
Crest Length : Concrete Dam 290m + Rockfill Dam 595m
Dam Volume : Concrete 1,007,000m³ + Rockfill 8,437,000m³
Intended Completion : 2007

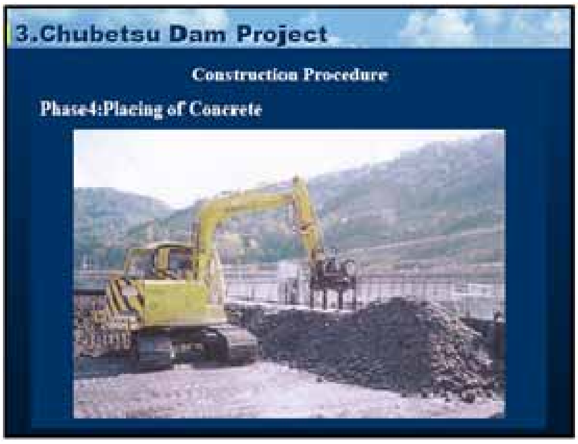

3.Chubetsu Dam Project
DOWNSTREAM VIEW

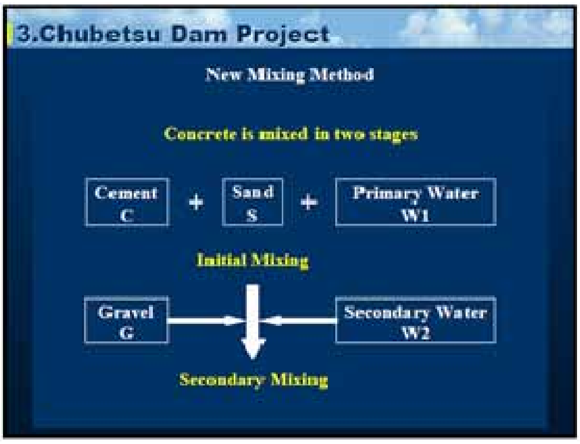

3.Chubetsu Dam Project
CROSS-SECTION OF CONCRETE DAM

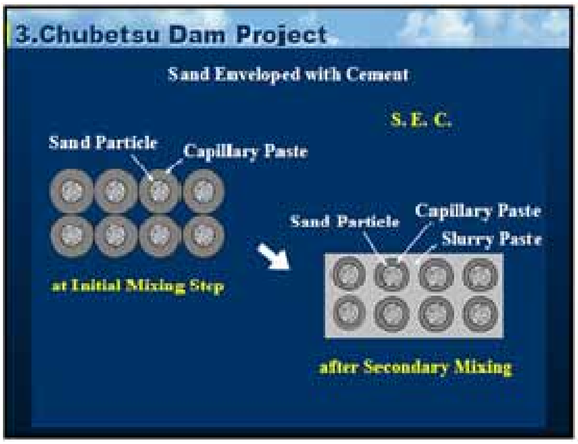

3.Chubetsu Dam Project
Construction Procedure
Phase1:Spread of Concrete for RCD

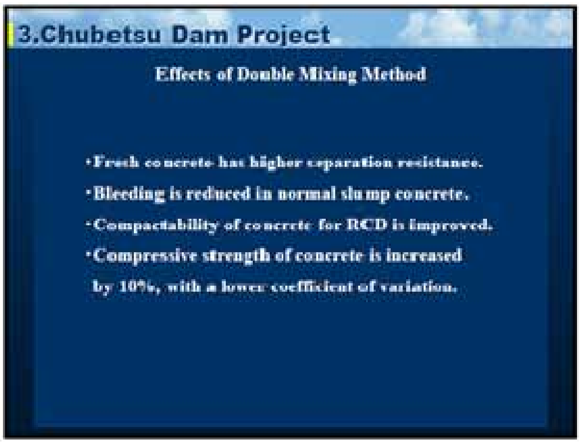

3.Chubetsu Dam Project
Construction Procedure
Phase2:Tammping of Concrete for RCD

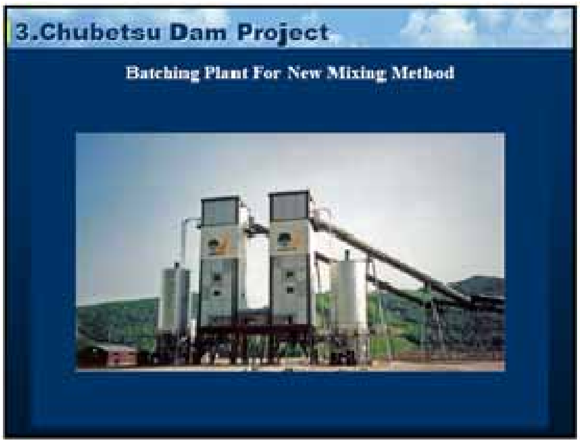

3.Chubetsu Dam Project
Construction Procedure
Phase3:Joint Making


3.Chubetsu Dam Project
Construction Procedure
Phase4:Placing of Concrete

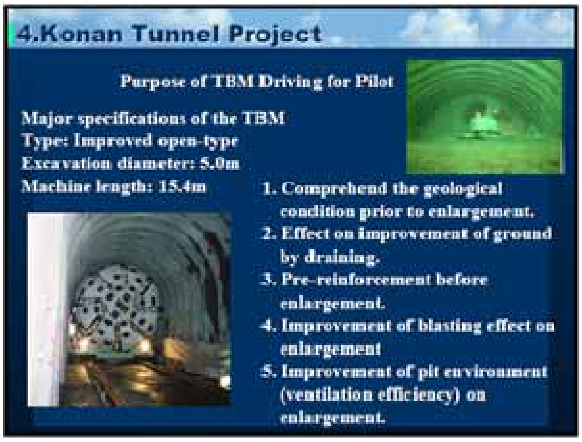

3.Chubetsu Dam Project
New Mixing Method
Concrete is mixed in two stages
Cement C
+
Sand S
+
Primary Water W1
Initial Mixing
Gravel G
Secondary Water W2
Secondary Mixing

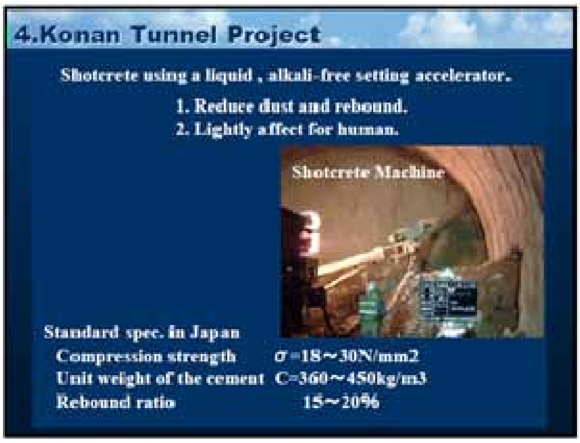

3.Chubetsu Dam Project
Sand Enveloped with Cement
S. E. C.
Sand Particle
Capillary Paste
at Initial Mixing Step
Sand Particle
Capillary Paste
Slurry Paste
after Secondary Mixing


3.Chubetsu Dam Project
Effects of Double Mixing Method
・Fresh concrete has higher separation resistance.
・Bleeding is reduced in normal slump concrete.
・Compactability of concrete for RCD is improved.
・Compressive strength of concrete is increased
by 10%, with a lower coefficient of variation.


3.Chubetsu Dam Project
Batching Plant For New Mixing Method


4.Konan Tunnel Project
Scope of work
Konan Tunnel Secondary-Meishin Expressway
Employer: Japan Highway Public Corporation
TBM Driving for Pilot and Enlargement by NATM
Length: 2,563m
Excavation cross sectional area 190m²
Width 19m,Height 13m

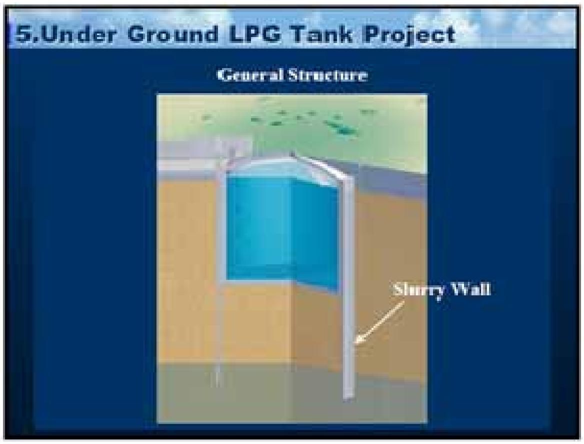

4.Konan Tunnel Project
Purpose of TBM Driving for Pilot
Major specifications of the TBM
Type: Improved open-type
Excavation diameter: 5.0m
Machine length: 15.4m
1. Comprehend the geological condition prior to enlargement.
2. Effect on improvement of ground by draining.
3. Pre-reinforcement before enlargement.
4. Improvement of blasting effect on enlargement
5. Improvement of pit environment (ventilation efficiency) on enlargement.

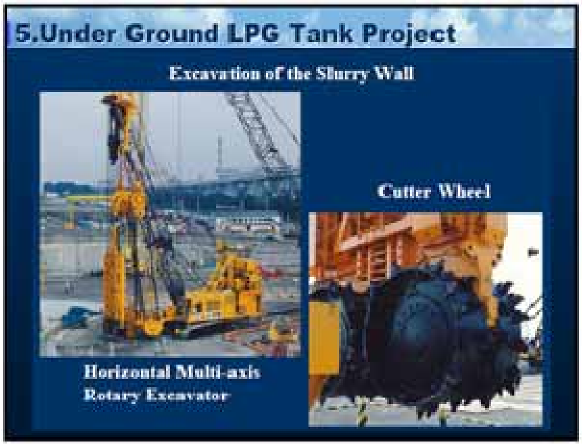

4.Konan Tunnel Project
Shotcrete using a liquid , alkali-free setting accelerator.
1. Reduce dust and rebound.
2. Lightly affect for human.
Shotcrete Machine
Standard spec. in Japan
Compression strength σ=18～30N/mm2
Unit weight of the cement C=360～450kg/m3
Rebound ratio 15～20%


4.Konan Tunnel Project
Vibrator system for improve the quality of the concrete.
→ More dense !
In top of the arch concrete, inner stick vibrators are moved by the wire set up in the vertical direction.
Inner stick vibrator
Steel form for arch concrete
Fixed end
On the steel form
Driving unit
Layout of the inner stick vibrator


4.Konan Tunnel Project
Using the synthetic fibres
to improve the durability and ductility of concrete.
Polypropylene fibres L=48mm
0.3vol% (2.73kg/m3)


4.Konan Tunnel Project
Using the synthetic fibres
to improve the durability and ductility of concrete.
Bending test
(15×15×53cm)
After bending test
(red-colored fibres appeared on the face of fracture.)



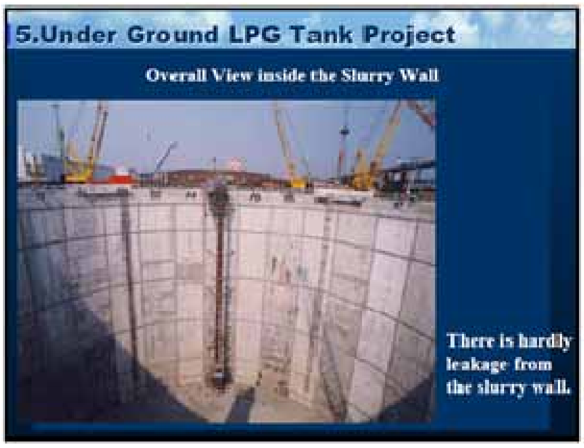


f'ck (91 days)	50 N/mm2	40 N/mm2
Slump Flow	65±5 cm	63±5 cm
Air Content	4±1 %	4±1 %

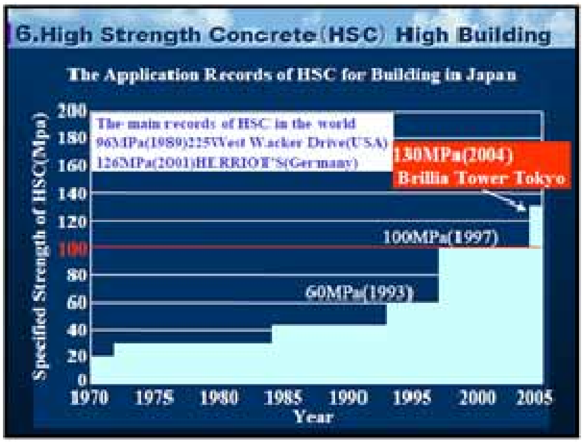
W/P (%)	s/a (%)	Unit Material Weight (kg/m³)					
		Water	Cement	Sand	Gravel	Admixture	
		W	C	S	G	Super plasticizer	Segregation Reducer
30.0	49.3	168	560	783	840	13.7	0.5
35.1	51.8	165	470	868	840	10.8	0.5


5.Under Ground LPG Tank Project
Concrete Placing
Hopper
Concrete is placed directly from the truck agitator into the tremie pipe through hopper installed at the ground level.

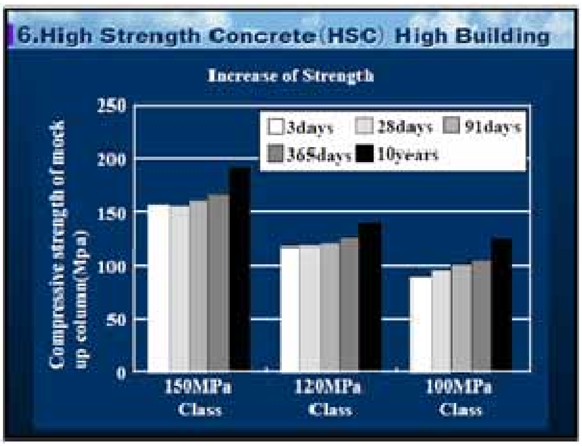

5.Under Ground LPG Tank Project
Excavation inside the Slurry Wall


5.Under Ground LPG Tank Project
Overall View inside the Slurry Wall
There is hardly leakage from the slurry wall.


6.High Strength Concrete (HSC) High Building
OOKAWABATA Project (43stories)
KAWADACHO Project (41stories)
DAIBA Project (32stories)


6.High Strength Concrete (HSC) High Building
The Application Records of HSC for Building in Japan
The main records of HSC in the world
96MPa(1989)225West Wacker Drive(USA)
126MPa(2001)HERRIOT'S(Germany)
130MPa(2004)
Brillia Tower Tokyo
100MPa(1997)
60MPa(1993)
Specified Strength of HSC(Mpa)
0
20
40
60
80
100
120
140
160
180
200
1970
1975
1980
1985
1990
1995
2000
2005
Year


6.High Strength Concrete (HSC) High Building
Admixture
Portland Cement
Slag + Gypsum
Silica Fume
7 : 2 : 1


6.High Strength Concrete (HSC) High Building
Increase of Strength
3days
28days
91days
365days
10years
Compressive strength of mock up column(Mpa)
0
50
100
150
200
250
150MPa Class
120MPa Class
100MPa Class


6.High Strength Concrete (HSC) High Building
Heating Test


6.High Strength Concrete (HSC) High Building
Fiber Mixing Concrete
Organic Fiber
Without Fiber
With Fiber


6.High Strength Concrete (HSC) High Building
Example 1
Concrete Filled Tubular Structure
(CFT structure)
■Steel tubular column
Diameter : 800-900mm
Height : about 90m
■Quality control result
Pumping rate : about 45m³/h
Max.pressure of column: 2.2MPa
ODAKYU
Project :1996
(36stories)
1997 Technical award
(Japan Concrete Institute)


6.High Strength Concrete (HSC) High Building
Example 2
Reinforced Concrete Structure
(RC structure)
■ Using concrete
Max. design strength : 100MPa
(Japan's first record for building)
Mixture strength : 122-132MPa
OOKAWABATA
Project
(43stories)
The Construction Record using
HSC with 100MPa

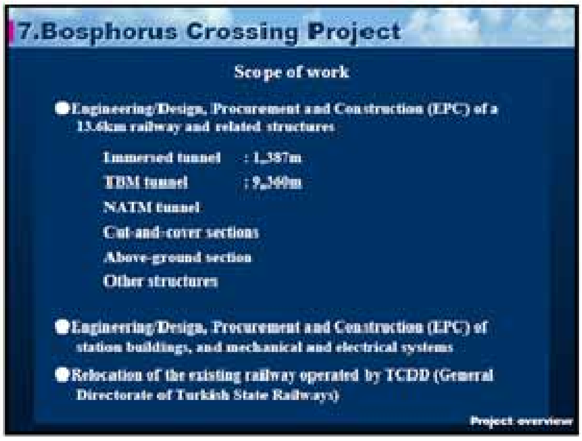

6.High Strength Concrete (HSC) High Building
Example 3
2002 Technical award
(Japan Concrete Institute)
HIROSECHO
Project(32 stories)
The Construction Record using
HSC Pre-cast columns with 100MPa

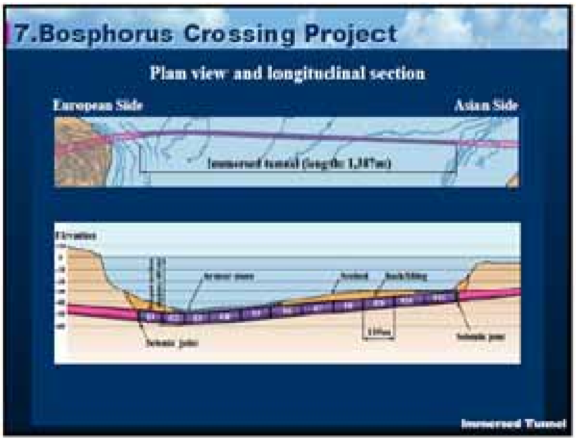

6.High Strength Concrete (HSC) High Building
Example 4
KINSHICHO
Project (45stories)
130 MPa concrete
The Construction Record using
HSC with 100MPa

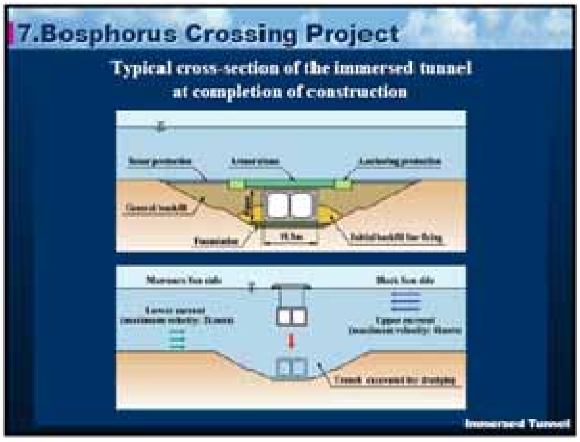

7.Bosphorus Crossing Project
Project Location
Italy
Romania
Russian Federation
Black Sea
Bosphorus Strait
Istanbul
Turkey
Mediterranean Sea
Syria
Cyprus
Project overview

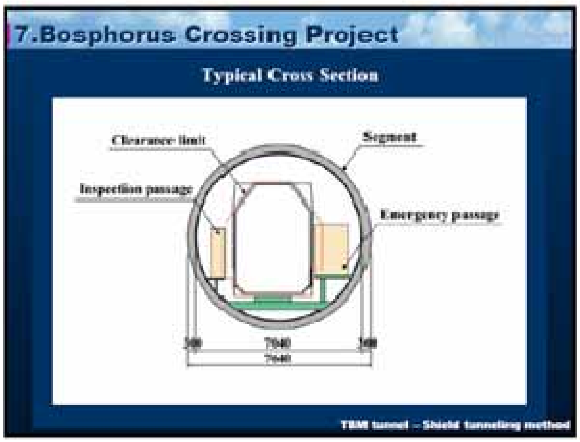

7.Bosphorus Crossing Project
Project Location
Project overview

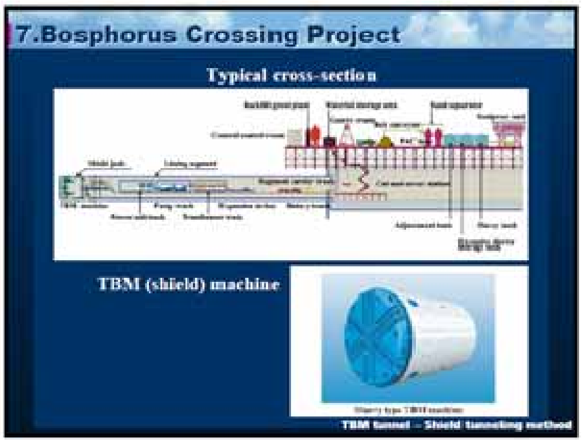

7.Bosphorus Crossing Project
Overview of contracted project
Employer : DLH (General Directorate of Railways, Harbors and Airports Construction), Republic of Turkey
Contractor : TAISEI - GAMA - NUROL JV
Contract sum : Approx. ¥102,300million
Project period : 54months
Project financing : Japan Bank for International Cooperation (JBIC)
Consultant : Pacific Consultants International JV
Project overview

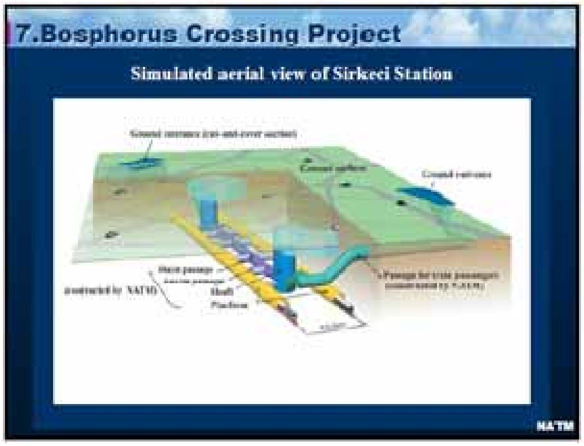

7.Bosphorus Crossing Project
Scope of work
●Engineering/Design, Procurement and Construction (EPC) of a 13.6km railway and related structures
Immersed tunnel : 1,387m
TBM tunnel : 9,360m
NATM tunnel
Cut-and-cover sections
Above-ground section
Other structures
●Engineering/Design, Procurement and Construction (EPC) of station buildings, and mechanical and electrical systems
●Relocation of the existing railway operated by TCDD (General Directorate of Turkish State Railways)
Project overview

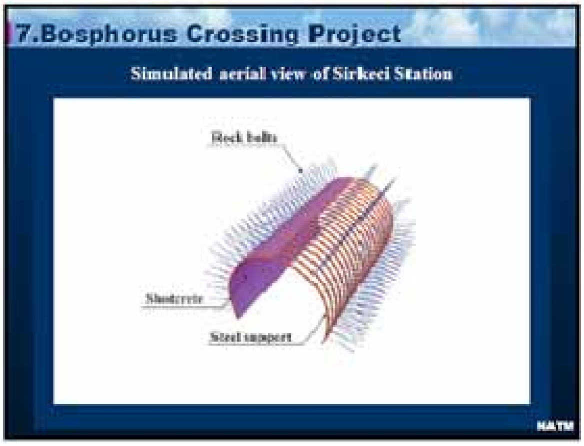

7.Bosphorus Crossing Project
Plan view and longitudinal section
European Side
Asian Side
Immersed tunnel (length: 1,387m)
Elevation
Immersed Tunnel


7.Bosphorus Crossing Project
Typical cross-section of the immersed tunnel at completion of construction
Immersed Tunnel


7.Bosphorus Crossing Project
Typical Cross Section
Clearance limit
Segment
Inspection passage
Emergency passage
TBM tunnel – Shield tunneling method


7.Bosphorus Crossing Project
Typical cross-section
TBM (shield) machine
TBM tunnel – Shield tunneling method


7.Bosphorus Crossing Project
Simulated aerial view of Sirkeci Station
Shaft
Platform
NATM


7.Bosphorus Crossing Project
Simulated aerial view of Sirkeci Station
Rock bolts
Shotcrete
Steel support
NATM