8.6 Study on Bridge Accessories

8.6.1 Bearings

8.6.1.1 Design of Bearings for Main Bridge

(1) Features on Selecting Bearing type for Main Bridge

On the contrary to the continuous girder bridge like Approach Bridge, the bearings are needed only at the end piers for Main Bridge which is supported by 3 V-shaped piers with rigid connection. Therefore, not only vertical force but also horizontal force are dispersed to the piers and it is not necessarily the case that the assembly of laminated elastomeric shoes for dispersing horizontal force is applied.

One of other features in Main Bridge for selection of bearing type is large longitudinal displacement by temperature change and concrete shrinkage due to large length of the bridge.

In this section, a comparative study for selecting the appropriate bearing shoe type on the end pier of Main Bridge is presented by taking into account the above-mentioned features.



Source: Study Team



- (2) Selection of Bearing Type for Main Bridge
 - 1) Conditions of Comparative study

A comparative study was performed, by introducing following alternatives;

- •- Alternative -1: Pot Bearings (Unidirectional and multidirectional bearings)
- •- Alternative -2: Elastomeric Bearings and Anchor Bars
- •- Alternative -3: Elastomeric Bearings with Anchored Plates and Anchor Bars

In cases with elastomeric bearings, Alternatives-2 and 3, anchor bars are to be installed for joint protection during earthquake. In the case with pot bearings, Alternative-1, the unidirectional bearing guides the girder to move in the longitudinal direction so that the joint can be protected from transversal movement of the girder.

2) Result of Comparative Study

The result of comparative study is shown in the table on the next page.

As shown in the table, Alternative -1, Pot Bearing, is recommended because of its advantages in investment cost and adaptability for large displacement.

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	ars					0		0	9	6	0	e	5	4	17
age	Alternative-3 Elastomeric Bearing for seismic force dispersing +Anchor B:		The dimensions in the schematics are tentative. 1050 x 1050 x 32 x 9Layers	Anchors: 6 x D40	 This type is for sharing the seismic horizontal force on all the piers 	 Suitable for continuous grider bridge The whle bearing system with plates and anchors are pre-fablicated. 	 Thick (approx. 40cm) and Large (Approx. 1m x 1m) 	Baaring Shoe (per Ipier) 4463,339,105 VND Anchors & Caps (per pier) 49823,954 VND Total 4515,172,059 VND Rato 4,99	Workability is inferior because of lots of anchors for the bearings and anchor bars should be installed.	Inferior in maintenance because of dificulty in replacement.	Procurement Ratio: 99%	 Unbalanced comparing to the adjacent bearing Inferior in Aesthetics with anchor cap block 	Rubber bearing for seismic force sharing is new	No sigunificant differences among the alternatives	Construction cost is the highest . Inferior in adopting big dispersement. This alternative is suitable for continuous girders such as Approach Bridge. Not Recommended
ā		til.				9		24	œ	12	10	co C	3	4	70
מוואו ואו ואים הפמוווא ואים אים וואים אים אים אים אים אים אים אים אים אים	Alternative-2 Elastomeric Bearing + Anchor Bars		The dimensions in the schematics are tentative. 1050 x 1050 x 32 x 9Layers	Anchors: 6 × D40	- Simple Structure - Dimension can be flexiblly designed	 Need anchor bars with large blockouts which may cause interference with rebar arrangement. 	 Thick (approx, 40cm) and Large (Approx, 1m x 1m) 	Bearing Shoe (per pier) 1.071.716.100 VND Anchors & Caps (per pier) 49.832.954 VND Archors & Caps (per pier) 1.121.549.054 VND Ratio 1.24 1.24 VID	Workability is superior because no anchors for the bearings are needed	Superior in maintenance because of simple method for replacement	Procurement Ratio: 95%	 Unbalanced comparing to the adjacent bearing Inferior in Aesthetics with anohor cap block. 	Commonly used in Vietnam	No sigunificant differences among the alternatives	Construction cost is lower than Alternative-3 but higher than Alternative-1. Inferior in adopting big dispacement. Less Recommended
						10		40	9	6	10	5	3	4	87
	Alternative-1 Pot Bearing	Undereally mobile pot bearing (TGe) Generally mobile pot bearing (TGe)	Hhe dimensions are tentative H= 156, Bu= 640, BGL=700	H= 138, Bu= 610, BGL=660	 Suitable for large displacement and large Suitable for large displacement and large vertical 	reaction - The longitudinal seismic force is not transmitted to the pier under the bearing and the fixed V-	shaped piers will share the force.	Bearing Shoe (per pier) 005,142,374 VMC VMC Total 005,142,374 VMC Ratio 1,00	Workability is Superior because no anchor bars are needed to be instaled.	Inferior in maintenance because of difficulty in replacement.	Procurement Ratio: 100%	 Superior in Aesthetics with smaller bearings. Superior in Aesthetics without anchor bars. 	Commonly used in Vietnam	No sigunificant differences among the alternatives	This alternative is the chiepest and superior in adopting big displacement Recommended
	Max. Point					10		40	10	15	10	5	5	5	100
	Evaluation Items I	Schematics				Structural Aspect and Stability		Construction Cost	Construction Plan and Period	Maintenance	STEP Clearance	Aesthetics	New Technology	Traffic Management/ Environmental Aspect	Evaluation

Table8.6.1-1 Comparison on Type of Bearing for Main Bridge

Table 8.6.1-1 Comparison on Type of Bearing for Main Bridge

Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

- (3) Design of Bearings for Main Bridge
 - 1) Conditions

The conditions for designing the bearings are as follows,

Table 8.6.1-2	Reaction Forces	and Displacements	at Bearings
---------------	-----------------	-------------------	-------------

(1) Service Limit State										
Items		Displacement (m)	Reaction	n Forces (kN)	Nota					
		Displacement (III)	Vertical	Transversal	Note					
D75	Uni-directional	153.4	5855	623						
r/J	Multi-directional	153.4	5728	-						
D70	Uni-directional	151.9	5917	621						
P/9	Multi-directional	151.9	5770	-						

(2) Extreme Event Limit State	
-------------------------------	--

Items		Displacement (m)	Reaction Forces (kN)		Note	
		Displacement (III)	Vertical	Transversal	note	
D75	Left	107.1	9100	2777		
F/J	Right	107.1	9107	-		
D70	Left	109.8	10220	2990		
F/9	Right	109.8	10211	-		

Source: Study Team

2) Results of Design

The items for checking are as follows,

- Thickness of Pot Ring
- Thickness of Pot Bottom
- Dimensions of Upper Plate
- Dimensions of Lower Plate
- Dimensions of Anchor Bolts
- Dimensions of Anchor Dowels
- Checking of Separation

The calculation note is shown in Design Report on Main Bridge. The resultant dimensions are shown in the figure in the next page.







(2) Free Sliding



8.6.1.2 Design of Bearings for Approach Bridge

(1) Outline of design

The design procedure of rubber bearing is as shown in the figure below.





- (2) Hai An side Approach Bridge
 - 1) Design condition
 - a) Design force
 - < CASE-1(5@60m=300m) >

The reaction force of Rubber bearing is shown in the table below.

	Maximum Reaction		Miniumum	Live Load	Dead Load	Dead Load	
No			Reaction	Max	Max	Min	Total
INO	Rmax1 Rmax2		Rmin	R _{L+I} max	Rdmax	Rdmin	ΣRd
	kN	kN	kN	kN	kN	kN	kN
A1	5690	5121	4520	1080	4610	4610	9220
P1	10810	9729	8860	1680	9130	9130	18260
P2	10680	9612	8800	1660	9020	9020	18040
P3	10770	9693	8890	1660	9110	9110	18220
P4	10750	9675	8800	1680	9070	9070	18140
P5	5670	5103	4500	1070	4600	4600	9200
W							91080

Table 8.6.1-3 Reaction force of rubber bearing

Source: Study Team

< CASE-2(53m+3@60m+53m) >

	Maximum Reaction Rmax1 Rmax2		Miniumum	Live Load	Dead Load	Dead Load	
			Reaction	Max	Max	Min	Total
			Rmin	R _{L+I} max	Rdmax	Rdmin	ΣRd
No	kN	kN	kN	kN	kN	kN	kN
P55	5140	4626	4000	1030	4110	4110	8220
P56	10250	9225	8340	1750	8630	8630	17260
P57	10700	9630	8850	1660	9040	9040	18080
P58	10770	9693	9300	1460	9310	9310	18620
P59	10200	9180	8290	1620	8580	8580	17160
P60	5130	4617	3990	1030	4100	4100	8200
W							87540

Table 8.6.1-4 Reaction force of rubber bearing

b) Amount of Movement

< CASE-1 (5@60m=300m) >

	Span Length	Temperatu	Temperature change Δt Δť	
	L	Δt		
Span	m	mm	mm	mm
A1~ P1	59.00	±11.8	±23.6	-35.7
P1~ P2	60.00	±12.0	±24.0	-36.4
P2~ P3	60.00	±12.0	±24.0	-30.1
P3~ P4	60.00	±12.0	±24.0	-27.3
P4~ P5	59.00	±11.8	±23.6	-25.0

Source: Study Team

 $< CASE-2\;(53m+3@60m+53m) >$

	Span Length	Temperatu	Temperature change	
	L	Δt	∆ť	∆scp
Span	m	mm	mm	mm
P55~ P56	51.98	±10.4	±20.8	-28.3
P56~ P57	60.00	±12.0	±24.0	-35.6
P57~ P58	60.00	±12.0	±24.0	-30.3
P58~ P59	60.00	±12.0	±24.0	-27.3
P59~ P60	51.98	±10.4	±20.8	-18.0

Table 8.6.1-6	Amount of	Movement	in each	support
10010 0.0.1 0	/ unount of	100001110111	in ouon	ouppoir

c) Allowable value

< Rubber >

The restriction stress of the body of rubber is as shown in the table below.

Item					Unit	Value	
	Maximum Compression	S1	≦8			8	
sse	stresse	8 <s1<12< td=""><td>σmaxa</td><td>N/mm2</td><td>S1</td></s1<12<>		σmaxa	N/mm2	S1	
I Stre	(At an effective area)	12 <u>≦</u> S1				12	
ssion	Minimum Compression	stress		σmina	N/mm2	1.5	
npre:		S1	≦8			5.0	
Con	Stress amplitude	8 <s1<12< td=""><td>Δσα</td><td>N/mm2</td><td>5+0.375 •(S1-8)</td></s1<12<>		Δσα	N/mm2	5+0.375 •(S1-8)	
		12≦S1				6.5	
		service Loade		γsa	%	70	
Sh	earing distorsion	Fortbauako	Level1	γea	%	150	
		Ealtiquake	Level2	γea	%	250	
		Total distorsion at Service		γta	%	γu/fs	
Local	Shearing distorsion	limitteo	state	fs		1.5	
		Breaking g	rowth rate	γu	%	depends on the table below.	
Tonollo		G	6			1.2	
Stress	Earthquake	G	8	σta	N/mm2	1.6	
21632		G10 or	more			2.0	

Source: Study Team

< Inner steel plate >

Table 8.6.1-8 Allowable value of	of Inner	Steel	Plate
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Kind of Material	unit	Yield Strength	bending stress
SS400	N/mm2	235	140

d) Detail dimension of Bearing

Tahla 8 (6 1-0 Detai	Dimension	of	Rearing
Table 0.0	0. I-9 Delai		0I	Dearing

< CASE-1	(5@60m) >

		b	а	te	n	Σte	ts	Ge
No	function	mm	mm	mm	layer	mm	mm	N/mm2
A1	Dispersion	950	950	30	7	210	6.0	1.20
P1	Dispersion	1200	1200	32	4	128	6.0	1.20
P2	Dispersion	1200	1200	32	4	128	6.0	1.20
P3	Dispersion	1200	1200	32	4	128	6.0	1.20
P4	Dispersion	1200	1200	32	4	128	6.0	1.20
P5	Dispersion	950	950	30	7	210	6.0	1.20

< CASE-2 (53m+3@60m+53m) >

		b	а	te	n	Σte	ts	Ge
No	function	mm	mm	mm	layer	mm	mm	N/mm2
P55	Dispersion	950	950	30	7	210	6.0	1.20
P56	Dispersion	1200	1200	32	4	128	6.0	1.20
P57	Dispersion	1200	1200	32	4	128	6.0	1.20
P58	Dispersion	1200	1200	32	4	128	6.0	1.20
P59	Dispersion	1200	1200	32	4	128	6.0	1.20
P60	Dispersion	950	950	30	7	210	6.0	1.20

Source: Study Team

e) Service Limited state

- Movement at service state

Longitudinal movement of Service limit state is shown in the table below.

Table 8.6.1-10 Longitudinal movement

		Thermal m	ovement (unif	orm temperati	ure change)	Movement	Movement of creep and shrinkage			Combination				
	Expansion	for horizo	ntal force	for bear	ig design	Creep and shrinkage	Dead	amount	Live load	Combination				
	center	Δ	Lt	Δ	.Lť	∆Lscp	∆Ld	ΔĽ'	ΔLr	Δ	L			
		+20°C	-20°C	+40°C	-40°C					+40°C	-40°C			
	L	1	2	3	4	5	6	Ø	8	3+7+8	(4) + (7) + (8)			
No	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm			
A1	-149.00	-29.8	29.8	-59.6	59.6	83.7		83.7		24.1	143.3			
P1	-90.00	-18.0	18.0	-36.0	36.0	48.0		48.0		12.0	84.0			
P2	-30.00	-6.0	6.0	-12.0	12.0	11.6		11.6		-0.4	23.6			
P3	30.00	6.0	-6.0	12.0	-12.0	-18.5		-18.5		-6.5	-30.5			
P4	90.00	18.0	-18.0	36.0	-36.0	-45.8		-45.8		-9.8	-81.8			
P5	149.00	29.8	-29.8	59.6	-59.6	-70.8		-70.8		-11.2	-130.4			

< CASE-1 (5@60m) >

< CASE-2 (53m+3@60m+53m) >

		Thermal m	ovement (unif	orm temperat	ure change)	Movement of creep and shrinkage			Livo load	Combination	
	Expansion		ntal force	for bear	ig design	Creep and shrinkage Dead		amount	Live loau		
	center	Δ	Lt	۵	.Lť	∆Lscp	ΔLd	ΔL'	ΔLr	Δ	L
		+20°C	-20°C	+40°C	-40°C					+40°C	-40°C
	L	1	2	3	4	5	6	\bigcirc	8	3+7+8	(4) +(7)+(8)
No	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
P55	-141.98	-28.4	28.4	-56.8	56.8	75.8		75.8		19.0	132.6
P56	-90.00	-18.0	18.0	-36.0	36.0	47.5		47.5		11.5	83.5
P57	-30.00	-6.0	6.0	-12.0	12.0	11.9		11.9		-0.1	23.9
P58	30.00	6.0	-6.0	12.0	-12.0	-18.4		-18.4		-6.4	-30.4
P59	90.00	18.0	-18.0	36.0	-36.0	-45.7		-45.7		-9.7	-81.7
P60	141.98	28.4	-28.4	56.8	-56.8	-63.7		-63.7		-6.9	-120.5

Source: Study Team

- Design result of Service limit state

The result of the maximum compression stress, the stress amplitude, and the buckling stress is shown in the table below.

< CASE-1 (5@60m) >

		Movement	boorig aroa	Efective		E	3earing stress			Pucklin	a stross	Modulas of
	wovement beang are		beally alea	bearig area	Max	Maximum		Stress amplitude		Ducking Stess		elasticity
		ΔLm	Ae	Acn	σmax	≦σmaxa	σmina	Δσ	≦ ∆oa	σcra	≧σmax	E(💥)
No	0	mm	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
A	1	143.3	0.9025	0.7664	7.42	8.0	5.01	2.42	5.0	17.19	7.42	498.5
P	1	84.0	1.4400	1.3393	8.07	9.4	6.15	1.92	5.5	42.19	8.07	697.6
P2	2	23.6	1.4400	1.4117	7.57	9.4	6.11	1.45	5.5	42.19	7.57	697.6
P	3	30.5	1.4400	1.4033	7.67	9.4	6.17	1.50	5.5	42.19	7.67	697.6
P	4	81.8	1.4400	1.3418	8.01	9.4	6.11	1.90	5.5	42.19	8.01	697.6
P	5	130.4	0.9025	0.7786	7.28	8.0	4.99	2.30	5.0	17.19	7.28	498.5

Table 8.6.1-11 Check result of stress

Source: Study Team

The result of the Shearing strain and rotation is shown in the table below.

Table 8.6.1-12 Check result of transformation performance

		Vertical dis	splacement			Loa	ical shear stra	in		Tensile stress of inner steel	
	Rotation	Compression	1/2*Liveload	Maximum	Vertical	Horizontal	Rotation	Amount	Allowable strain	pla	ite
	δr	<u>≦</u> δc/fv	δc	δο	γc	γs	γr	γt	≦γu/1.5	σs	≦osa
No	mm	mm	mm	mm	%	%	%	%	%	N/mm2	N/mm2
A1	1.58	2.76	0.38	4.69	100.2	68.2	23.9	192.3	333	74.2	140
P1	1.00	1.69		2.62	92.2	65.6	29.3	187.1	333	86.1	140
P2	1.00	1.67		2.46	86.4	18.4	29.3	134.1	333	80.7	140
P3	1.00	1.68		2.49	87.7	23.9	29.3	140.8	333	81.9	141
P4	1.00	1.68		2.60	91.5	63.9	29.3	184.8	333	85.5	142
P5	1.58	2.75	0.37	4.60	98.3	62.1	23.9	184.3	333	72.8	140
Allowable value			≦ 1.00			≦ 70					

Source: Study Team

< CASE-2 (53m+3@60m+53m) >

The result of the maximum compression stress, the stress amplitude, and the buckling stress is shown in the table below.

Table 8.6.1-13 Check result of stress

	Movement	hearig area	Efective		F	3earing stress			Buckling stross		Modulas of longitudinal
	wovement beang area		bearig area	Max	Maximum		Stress ar	mplitude	Ducking Stess		elasticity
	ΔLm	Ae	Acn	σmax	≦σmaxa	σmina	Δσ	≦ ∆oa	σcra	≧σmax	E(※)
No	mm	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
P55	132.6	0.9025	0.7765	6.62	8.0	4.43	2.19	5.0	17.19	6.62	498.5
P56	83.5	1.4400	1.3398	7.65	9.4	5.79	1.86	5.5	42.19	7.65	697.6
P57	23.9	1.4400	1.4113	7.58	9.4	6.15	1.44	5.5	42.19	7.58	697.6
P58	30.4	1.4400	1.4035	7.67	9.4	6.46	1.22	5.5	42.19	7.67	697.6
P59	81.7	1.4400	1.3420	7.60	9.4	5.76	1.84	5.5	42.19	7.60	697.6
P60	120.5	0.9025	0.7880	6.51	8.0	4.42	2.09	5.0	17.19	6.51	498.5

Source: Study Team

The result of the Shearing strain and rotation is shown in the table below.

		Vertical dis	splacement			Loa	acal shear stra	in		Tensile stress of inner steel	
	Rotation	Compression	1/2*Liveload	Maximum	Vertical	Horizontal	Rotation	Amount	Allowable strain	pla	ite
	δr	≦δc/fv	δc	δο	γc	γs	γr	γt	≦γu/1.5	σs	≦σsa
No	mm	mm	mm	mm	%	%	%	%	%	N/mm2	N/mm2
P55	1.58	2.49	0.36	4.18	89.4	63.1	23.9	176.4	333	66.2	140
P56	1.00	1.60		2.49	87.4	65.2	29.3	181.9	333	81.6	140
P57	1.00	1.67		2.46	86.6	18.7	29.3	134.6	333	80.9	140
P58	1.00	1.68		2.49	87.7	23.7	29.3	140.7	333	81.9	141
P59	1.00	1.59		2.47	86.8	63.8	29.3	179.9	333	81.1	142
P60	1.58	2.49	0.36	4.11	87.9	57.4	23.9	169.1	333	65.1	140
Allowable value			≦ 1.00			≦ 70					

Table 8.6.1-14 Check result of transformation performance

Source: Study Team

f) Earthquake

- Movement at earthquake

The amount of the movement at earthquake is shown in the table below.

< CASE-1 (5@60m) >

Table 8.6.1-15 The amount of the movement at earthquake

		Longitudina	al direction		Transvers direction			
	and Effect	Level 1(at	Lev	el 2	Level 1(at	Level 2		
	2nd Ellect	earthquake)	TYPE I	TYPE II	earthquake)	TYPE I	TYPE II	
	ΔL'	ΔLe	ΔLe ΔLe		ΔLe	ΔLe	ΔLe	
No	mm	mm	mm	mm	mm	mm	mm	
A1	83.7	70.8	142.7	142.7	70.8	150.0	150.0	
P1	48.0	70.8	142.7	142.7	70.8	150.0	150.0	
P2	11.6	70.8	142.7	142.7	70.8	150.0	150.0	
P3	18.5	70.8	142.7	142.7	70.8	150.0	150.0	
P4	45.8	70.8	142.7	142.7	70.8	150.0	150.0	
P5	70.8	70.8	142.7	142.7	70.8	150.0	150.0	

< CASE-2 (53m+3@60m+53m) >

		Longitudin	al direction	Transvers direction			
	Secondary	Allo	Lev	el 2	Allo	Lev	el 2
	force	ΔLe	TYPE I	TYPE II	ΔLe	TYPE I	TYPE II
	ΔL'	ΔLe	ΔLe	ΔLe	ΔLe	ΔLe	ΔLe
No	mm	mm	mm	mm	mm	mm	mm
P55	75.8	68.1	144.2	150.0	68.1	150.0	150.0
P56	47.5	68.1	144.2	150.0	68.1	150.0	150.0
P57	11.9	68.1	144.2	150.0	68.1	150.0	150.0
P58	18.4	68.1	144.2	150.0	68.1	150.0	150.0
P59	45.7	68.1	144.2	150.0	68.1	150.0	150.0
P60	63.7	68.1	144.2	150.0	68.1	150.0	150.0

Source: Study Team

- Design result of earthquake

The result of the buckling stress, shearing strain and tensile stress is shown in the table below.

Table 8.6.1-16 The result of the buckling stress, shearing strain and tensile stress $< CASE\mbox{-}1\ (5\ensuremath{@}60m) >$

	Buckling stress				Tensil stress		Shearin	g strain	Tensile stress of inner steel plate	
	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Londitudinal	Transvers
	σce	σce	≦σcra	σte	σte	≦ σta	γse	γse	σs	σs
No	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	%	%	N/mm2	N/mm2
A1	8.52	8.02	28.7			2.0	107.8	71.4	85.2	80.2
P1	9.57	9.83	70.3			2.0	148.9	117.2	102.1	104.9
P2	9.13	9.73	70.3			2.0	120.5	117.2	97.4	103.7
P3	9.28	9.81	70.3			2.0	126.0	117.2	99.0	104.7
P4	9.49	9.77	70.3			2.0	147.3	117.2	101.2	104.3
P5	8.35	8.01	28.7			2.0	101.7	71.4	83.5	80.1
Allowable value							≦ 250	≦ 250	≦ 235	≦ 235

< CASE-2 (53m+3@60m+53m) >

	E	Buckling stres	S		Tensil stress		Shearin	ıg strain	Tensile stress of	Tensile stress of inner steel plate	
	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Londitudinal	Transvers	
	σce	σce	≦σcra	σte	σte	≦ σta	γse	γse	σs	σs	
No	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	%	%	N/mm2	N/mm2	
P55	7.59	7.22	28.7			2.0	107.5	71.4	75.9	72.2	
P56	9.11	9.35	70.3			2.0	154.3	117.2	97.2	99.8	
P57	9.22	9.75	70.3			2.0	126.5	117.2	98.3	103.9	
P58	9.55	10.00	70.3			2.0	131.5	117.2	101.9	106.7	
P59	9.04	9.31	70.3			2.0	152.9	117.2	96.4	99.3	
P60	7.44	7.20	28.7			2.0	101.8	71.4	74.4	72.0	
Allowable value							≦ 250	≦ 250	≦ 235	≦ 235	

- g) Detailed dimension of Rubber bearing
- End support Bearing



Source: Study Team



- Middle support Bearing



Source: Study Team



- (3) Cat Hai side Approach Bridge
 - 1) Design condition
 - a) Design force
 - < CASE-1(53.8m+3@60m+53.8m) >

The reaction force of Rubber bearing is shown in the table below.

	Movimum	Deaction	Miniumum Live Load		Dead Load	Reaction	Dead Load
	Maximum Reaction		Reaction	Max	Max	Min	Total
	Rmax1 Rmax2		Rmin	R _{L+I} max	Rdmax	Rdmin	ΣRd
No	kN	kN	kN	kN	kN	kN	kN
P79	4440	3996	3290	1040	3400	3400	6800
P80	12360	11124	10400	1750	10710	10710	21420
P81	11770	10593	9880	1670	10100	10100	20200
P82	11770	10593	9880	1670	10100	10110	20210
P83	12360	11124	10400	1650	10710	10710	21420
P84	4440	3996	3290	1040	3400	3400	6800
W							96850

Table 8.6.1-17 Reaction force of rubber bearing

Source: Study Team

< CASE-2(53.8m+2@60m+53.8m) >

Table 8.6.1-18 Reaction force of rubber bearing

	Maximum Reaction		Miniumum	Live Load Dead		d Reaction	Dead Load
			Reaction	Max	Max	Min	Total
	Rmax1 Rmax2		Rmin	R _{L+I} max	Rdmax	Rdmin	ΣRd
No	kN	kN	kN	kN	kN	kN	kN
P84	4440	3996	3290	1040	3400	3400	6800
P85	12400	11160	10440	1750	10750	10750	21500
P86	11700	10530	9740	1750	9950	9950	19900
P87	12300	11070	10590	1770	10750	10750	21500
A2	4300	3870	3290	900	3400	3400	6800
W							76500

b) Amount of Movement

< CASE-1 (53.8m+3@60m+53.8m) >

Table 8.6.1-19 Amount of Movement in each support

	Span Length	Temperatu	Temperature change	
	L	∆t	∆ť	∆scp
Span	m	mm	mm	mm
P79~ P80	53.80	±10.8	±21.5	-19.9
P80~ P81	60.00	±12.0	±24.0	-17.9
P81~ P82	60.00	±12.0	±24.0	-18.2
P82~ P83	60.00	±12.0	±24.0	-18.3
P83~ P84	53.80	±10.8	±21.5	-19.7

Source: Study Team

< CASE-2(53.8m+2@60m+53.8m) >

Table 8.6.1-20 Amount of Movement in each support

	Span Length	Temperati	Temperature change		
	L	Δt	$\Delta t'$	∆scp	
Span	m	mm	mm	mm	
P84~ P85	53.80	±10.8	±21.5	-19.5	
P85~ P86	60.00	±12.0	±24.0	-17.3	
P86∼ P87	60.00	±12.0	±24.0	-17.3	
P87 \sim A2	53.80	±10.8	±21.5	-19.5	

c) Allowable value

< Rubber >

The restriction stress of the body of rubber is as shown in the table below.

	Item			Sign	Unit	Value
	Maximum Compression	S1	≦8			8
Stress	stresse	8 < S1	1<12	σmaxa	N/mm2	S1
	(At an effective area)	12≦S1				12
ssion	Minimum Compression	stress		σmina	N/mm2	1.5
npre:		S1	≦8			5.0
Com	Stress amplitude	8 <s1<12< td=""><td rowspan="2">Δσα</td><td>N/mm2</td><td>5+0.375•(S1-8)</td></s1<12<>		Δσα	N/mm2	5+0.375•(S1-8)
		12≦S1				6.5
		service Loade		γsa	%	70
Sh	earing distorsion	Farthquako	Level1	γea	%	150
		Earinquake	Level2	γea	%	250
		Total distorsio	on at Service	γta	%	γu/fs
Local	Shearing distorsion	limitteo	d state	fs		1.5
		Breaking g	growth rate	γu	%	depends on the table below.
Tanaila		G6				1.2
Stress	Earthquake	G	8	σta	N/mm2	1.6
Suess		G10 or	r more			2.0

Source: Study Team

< Inner steel plate >

Table 8.6.1-22 Allowable	value of Inner	Steel Plate
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Kind of Material	unit	Yield Strength	bending stress
SS400	N/mm2	235	140

d) Detail dimension of Bearing

Table 8.6.1-23 Detail Dimension of Bearing

< CASE-1 (53.8m+3@60m+53.8m) >

		b	а	te	n	Σte	ts	Ge
No	function	mm	mm	mm	layer	mm	mm	N/mm2
P79	Dispersion	850	850	32	5	160	6.0	1.20
P80	Dispersion	1300	1300	32	3	96	6.0	1.20
P81	Dispersion	1300	1300	32	3	96	6.0	1.20
P82	Dispersion	1300	1300	32	3	96	6.0	1.20
P83	Dispersion	1300	1300	32	3	96	6.0	1.20
P84	Dispersion	850	850	32	5	160	6.0	1.20

< CASE-2 (53.8m+2@6m+53.8m) >

		b	а	te	n	Σte	ts	Ge
No	function	mm	mm	mm	layer	mm	mm	N/mm2
P84	Dispersion	850	850	32	4	128	6.0	1.20
P85	Dispersion	1300	1300	32	3	96	6.0	1.20
P86	Dispersion	1300	1300	32	3	96	6.0	1.20
P87	Dispersion	1300	1300	32	3	96	6.0	1.20
A2	Dispersion	850	850	32	4	128	6.0	1.20

e) Service Limit state

- Movement at service state

Longitudinal movement of Service limit state is shown in the table below.

< CASE-1 (53.8m+3@60m+53.8m) >

Table 8.6.1-24 Longitudinal movement

	_	Thermal m	ovement (unit	form temperat	ure change)	Movement	of creep an	d shrinkage	Live lead	Combination	
	Expansion	for horizo	ntal force	for bearig design		Creep and shrinkage	Dead	amount	LIVE IDAU	Combination	
	center	Δ	Lt	۵	.Lť	∆Lscp	ΔLd	ΔL'	ΔLr	Δ	L
		+20°C	-20° C	+40°C	-40°C					+40°C	-40°C
	L	1	2	3	4	5	6	Ī	8	3+7+8	4+7+8
No	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
P79	-143.80	-28.8	28.8	-57.5	57.5	47.0		47.0		-10.5	104.5
P80	-90.00	-18.0	18.0	-36.0	36.0	27.1		27.1		-8.9	63.1
P81	-30.00	-6.0	6.0	-12.0	12.0	9.2		9.2		-2.8	21.2
P82	30.00	6.0	-6.0	12.0	-12.0	-9.0		-9.0	-	3.0	-21.0
P83	90.00	18.0	-18.0	36.0	-36.0	-27.3		-27.3	-	8.7	-63.3
P84	143.80	28.8	-28.8	57.5	-57.5	-47.0		-47.0		10.5	-104.5

< CASE-2 (53.8m+2@60m+53.8m) >

	_	Thermal m	ovement (unif	orm temperat	ure change)	Movemen	t of creep and	l shrinkage	Lim load	Combination	
	Expansion length from center ΔLt		ontal force	for bearig design		Cre ep and shrinkage	Dead	amount	Live load	Combination	
			Lt	ΔLť		ΔLscp	ΔLd	$\Delta L'$	ΔLr	Δ	L
		+20°C	-20°C	+40°C	-40°C					+40°C	-40°C
	L	1	2	3	4	5	6	Ī	8	3+7+8	(4) +(7)+(8)
No	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
P84	-113.80	-22.8	22.8	-45.5	45.5	36.8		36.8		-8.7	82.3
P85	-60.00	-12.0	12.0	-24.0	24.0	17.3		17.3		-6.7	41.3
P86	0.00	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0
P87	60.00	12.0	-12.0	24.0	-24.0	-17.3		-17.3		6.7	-41.3
A2	113.80	22.8	-22.8	45.5	-45.5	-36.8		-36.8		8.7	-82.3

Source : Study Team

- Design result of Service limit state

< CASE-1 (53.8m+3@60m+53.8m) >

The result of the maximum compression stress, the stress amplitude, and the buckling stress is shown in the table below.

Table 8.6.1-25 Check result of stress

	Movement	boaria aroa	Efective		E	3earing stress			Pucklin	a stross	Modulas of
	WOVErneni	Deally area	bearig area	Max	imum	minimum	Stress amplitude		Ducking Stress		elasticity
	ΔLm	Ae	Acn	σmax	≦omaxa	omina	Δσ	≦ ∆σa	σcra	≧σmax	E(※)
No	mm	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
P79	104.5	0.7225	0.6337	7.01	8.0	4.55	2.45	5.0	16.93	7.01	351.8
P80	63.1	1.6900	1.6080	7.69	10.2	6.15	1.53	5.8	66.02	7.69	818.0
P81	21.2	1.6900	1.6624	7.08	10.2	5.85	1.23	5.8	66.02	7.08	818.0
P82	21.0	1.6900	1.6627	7.08	10.2	5.85	1.23	5.8	66.02	7.08	818.0
P83	63.3	1.6900	1.6077	7.69	10.2	6.15	1.53	5.8	66.02	7.69	818.0
P84	104.5	0.7225	0.6337	7.01	8.0	4.55	2.45	5.0	16.93	7.01	351.8

	Table 8.6.1-26 Check result of transformation performance												
		Vertical dis	splacement			Loa	acal shear stra	in		Tensile stress of inner steel			
	Rotation	Compression	1/2*Liveload	Maximum	Vertical	Horizontal	Rotation	Amount	Allowable strain	pla	te		
	δr	≦δc/fv	δc	δο	γc	γs	γr	γt	≦γu/1.5	σs	≦σsa		
No	mm	mm	mm	mm	%	%	%	%	%	N/mm2	N/mm2		
P79	1.42	2.44	0.41	4.02	112.4	65.3	23.5	201.3	333	74.7	140		
P80	1.08	1.14		1.73	81.1	65.7	45.8	192.7	333	82.0	140		
P81	1.08	1.09		1.59	74.7	22.1	45.8	142.6	333	75.5	140		
P82	1.08	1.09		1.59	74.7	21.9	45.8	142.4	333	75.5	141		
P83	1.08	1.14		1.73	81.1	65.9	45.8	192.9	333	82.0	142		
P84	1.42	2.44	0.41	4.02	112.4	65.3	23.5	201.3	333	74.7	140		
Allowable value			≦ 1.00			≦ 70							

The result of the Shearing strain and rotation is shown in the table below.

Source : Study Team

< CASE-2 (53.8m+2@60m+53.8m) >

The result of the maximum compression stress, the stress amplitude, and the buckling stress is shown in the table below.

		, ·	Efective			Bearing stress			D 11	Duckling stress			
	Movement	bearig area	bearig area	Max	imum	minimum	Stress a	mplitude	Bucklin	Bucking suess			
	ΔLm	Ae	Acn	σmax	≦σmaxa	σmina	$\Delta \sigma$	$\leq \Delta \sigma a$	σera	$\geq \sigma max$	E(💥)		
No	mm	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2		
P84	82.3	0.7225	0.6525	6.80	8.0	4.55	2.25	5.0	21.17	6.80	351.8		
P85	41.3	1.6900	1.6363	7.58	10.2	6.18	1.40	5.8	66.02	7.58	818.0		
P86	0.0	1.6900	1.6900	6.92	10.2	5.76	1.16	5.8	66.02	6.92	818.0		
P87	41.3	1.6900	1.6363	7.52	10.2	6.27	1.25	5.8	66.02	7.52	818.0		
A2	82.3	0.7225	0.6525	6.59	8.0	4.55	2.04	5.0	21.17	6.59	351.8		

Table 8.6.1-27 Check result of stress

Source : Study Team

The result of the Shearing strain and rotation is shown in the table below.

		Vertical di	splacement			Lo		Tensile stress of inner			
	Rotation	Compression	1/2*Liveload	Maximum	Vertical	Horizontal	Rotation	Amount	Allowable strain	steel p	olate
	δr	≦δc/fv	δel	δο	γc	γs	γr	γt	≦γu/1.5	σs	≦σsa
No	mm	mm	mm	mm	%	%	%	%	%	N/mm2	N/mm2
P84	1.42	1.95	0.33	3.12	109.2	64.3	29.4	202.9	333	72.6	140
P85	1.08	1.14		1.71	80.0	43.0	45.8	168.8	333	80.8	140
P86	1.08	1.08		1.56	73.1	0.0	45.8	118.9	333	73.8	140
P87	1.08	1.13		1.69	79.3	43.0	45.8	168.2	333	80.2	141
A2	1.42	1.89	0.29	3.02	105.7	64.3	29.4	199.5	333	70.3	142
Allowable value			≦ 1.00			≦ 70					

Table 8.6.1-28 Check result of transformation performance

Source : Study Team

f) Earthquake

- Movement at earthquake

< CASE-1 (53.8m+3@60m+53.8m) >

The amount of the movement at earthquake is shown in the table below.

Table 8.6.1-29 The amount of the movement at earthquake

		Longitudina	al direction		Transvers direction			
	Secondary	Level 1(at	Lev	el 2	Level 1(at	Lev	el 2	
	force	earthquake)	TYPE I	TYPE II	earthquake)	TYPE I	TYPE II	
	ΔĽ'	ΔLe	ΔLe	ΔLe	∆Le	ΔLe	ΔLe	
No	mm	mm	mm	mm	mm	mm	mm	
P79	47.0	50.8	117.6	117.6	50.8	150.0	150.0	
P80	27.1	50.8	117.6	117.6	50.8	150.0	150.0	
P81	9.2	50.8	117.6	117.6	50.8	150.0	150.0	
P82	9.0	50.8	117.6	117.6	50.8	150.0	150.0	
P83	27.3	50.8	117.6	117.6	50.8	150.0	150.0	
P84	47.0	50.8	117.6	117.6	50.8	150.0	150.0	

b) CASE-2 (53.8m+2@60m+53.8m)

		Longitudina	al direction		Transvers direction			
	Secondary	Level 1(at	Lev	el 2	Level 1(at	Lev	rel 2	
	force	earthquake)	TYPE I	TYPE II	earthquake)	TYPE I	TYPE II	
	$\Delta L'$	ΔLe	le <u>A</u> Le		ΔLe	ΔLe	ΔLe	
No	mm	mm	mm	mm	mm	mm	mm	
P84	36.8	49.7	103.5	103.5	49.7	150.0	150.0	
P85	17.3	49.7	103.5	103.5	49.7	150.0	150.0	
P86	0.0	49.7	103.5	103.5	49.7	150.0	150.0	
P87	17.3	49.7	103.5	103.5	49.7	150.0	150.0	
A2	36.8	49.7	103.5	103.5	49.7	150.0	150.0	

2) Design result of Earthquake

The result of the buckling stress, shearing strain and tensile stress is shown in the table below.

Table 8.6.1-30 The result of the buckling stress, shearing strain and tensile stress < CASE-1~(53.8m+3@60m+53.8m) >

	E	Buckling stress			Tensil stress		Shearin	g strain	Tensile stress of inner steel plate	
	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Londitudinal	Transvers
	σce	σce	≦σcra	σte	σte	≦ σta	γse	γse	σs	σs
No	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	%	%	N/mm2	N/mm2
P79	7.41	8.28	28.2			2.0	102.9	93.8	79.1	88.3
P80	9.06	10.89	110.0			2.0	150.7	156.3	96.6	116.1
P81	8.41	10.42	110.0			2.0	132.1	156.3	89.7	111.2
P82	8.41	10.42	110.0			2.0	131.9	156.3	89.7	111.2
P83	9.06	10.89	110.0			2.0	150.9	156.3	96.6	116.1
P84	7.41	8.28	28.2			2.0	102.9	93.8	79.1	88.3
Allowable value							≦ 250	≦ 250	≦ 235	≦ 235

< CASE-2 (53.8m+2@60m+53.8m) >

	Buckling stress				Tensil stress		Shearir	ng strain	Tensile stress of inner steel plate	
	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Londitudinal	Transvers
	σce	σce	≦σera	σte	ote	≦ σta	γse	γse	σs	σs
No	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	%	%	N/mm2	N/mm2
P84	7.16	8.70	35.3			2.0	109.6	117.2	76.3	92.8
P85	8.91	10.92	110.0			2.0	125.8	156.3	95.0	116.4
P86	8.12	10.31	110.0			2.0	107.8	156.3	86.7	109.9
P87	8.91	10.92	110.0			2.0	125.8	156.3	95.0	116.4
A2	7.16	8.70	35.3			2.0	109.6	117.2	76.4	92.8
Allowable value							≦ 250	≦ 250	≦ 235	≦ 235

- g) Detailed dimension of Rubber bearing
- End support Bearing
- < P79 and P84 >



 $<\!P85$ and $A2\!>$

SIDE VIEW - CHIẾU CẠNH



< Middle support Bearing >

SIDE VIEW - CHIẾU CẠNH





Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

8.6.2 Expansion Joint

8.6.2.1 Design of Expansion Joint for Main Bridge

(1) Selection of Type of Expansion Joint between Main Bridge and Approach Bridge

In order to select appropriate types of expansion joint for Approach Bridge and Main Bridge, the comparative study was conducted.

- 1) Comparative Study on Type Selection
- a) General

For optimizing the type of expansion joint, the comparative study was performed by introducing various types of expansion joint as follows,

Alternative-1: Rubber Joint (Transversal Type) Alternative-2: Steel Finger Joint Alternative-3: Steel Joint (Module Type) Alternative-4: Aluminum Alloy Joint (Triangle Comb Type)

b) Result of Comparative Study

The result of comparative study is shown in the table on the next page.

As shown in the Table, Alternative-4, Aluminum Alloy Joint (Triangle Comb Type), is recommended because of its advantages in lifecycle cost and durability. In case of large longitudinal displacement, however, because this type of joint has limitation in adapting up to 250m of the expansion, Alternative-2, Steel Finger Joint, which can be fabricated by order-made for adjusting its dimensions, is recommended.

Table 8.6.2-1 Comparison on Type of Expansion

		326	ŀ	, du s		16	0 0	9	ç	1	10	~	\$.9	ida 5	0	10
Alternative No.4 Altanianun Alloy Joint (Triangle comb type)				the head of a minimum component model of a large week and durable spatiest and, soil and start. Waterpoor fundos in the interpo- sent control market by the party yhear on the fundos. If operationery set data part it restarts and starts fallow any horizontal (transverse direction) movement. This is load upp or type.	Allowable Expansion: 230 (±115) Notch Depth: 230mm	Investment ¥ 772,000 /m at first Makeria ¥ 652,000 /m Construction ¥ 120,000 /m 1.	Matternine ¥ 802,000 hn and repair 8 85,000 hn Lafdreyels ene 320,000 hn Liddreyels ene 4300,094 772,000 + 802,000-235) = 2,640,660 hn 1, 2640,660 hn 2 2,540,600 hr	Electore is a bit deep, but there is comparatively no intributed for deep plate. Construction is idean ploted within generation joint which is adjusted in the bridge within all their remixing hars are remedied and a delated. And fitnilly, plating concrete is essented. It is quite wifthied construction method	The body is steed so rightly at high and it is durable. There as a conteen that may abruption of water cut-off rubber set in the point occurs.	It is possible to change parts by parts, but cannot change the way ansion body itself carb. "When need it, it is needed to chip the concrete at large area to change the ray maion body. Durkble Period. Stowess	Procurement Platio: 84%	There is no major difference in spp earance.	Aluminum Alloy Joint is new technology.	Unlater any rep. (gap, app endormanes a track and radia fait factor from strondural viewp out, performanes a quize good for extent layed of goddmi and viorition. These is concern that any step (gap) appear case of standar bruige like steel grider.	It is efficient for wher cut-off because water proof rubber is ret by pressing a threa expension random to the sing joint. There is a consent that real and stand source give to conserving of derive, wh cutses shrup tion at adherine bonding part.	Vehicle running is smooth by triangle face plate and it has artifice to decrease the vehicle running noise. How ever, noise at joint gauge down is possibly big.	Most recommended. It is superior in durability to others as well as steel finger
				art 5		16	» इ	ي چ وا	c E	sta gig	2	×	~	is:	m		99
Alternative No.3 Steel Joint (module type)	And the second			been is set al. The net provides of the firms and solutions. By the set of the net is set al. Then it even al on the expanding detection up principal has control denois before mupped to ham. It is morphic in transverse direction too. This is load suppert type.	A llow while Exp ansion: 240 (±120) Notch Dep th. 400mm	Investment ¥ 782,000 fm at first Material ¥ 622,000 hn Construction ¥ 160,000 hn	Muintennee ¥ £21.000 hm andrepair Material \$ 62.2000 hm Construction # 200,000 hm Liferopeir const.010 years 332,000+ (\$22,000-4) = 4,070,000 hm 4,070,001 /100 = 43,000 year	It is needed to have big blockout for coarset amenier (doc). Weigh the body is big to it would be lage soled construction by heary or	It is steel structure and quite strong. Warenproof rabber is set at bear conduit, so it doestit need to be worried for dipp age off.	It is possible to do small scaled matterance by changing μ arts by a large were, it possibly would be king scaled by table and the single scaled by the state state of the matter of tables and that a king scaled by the state of 20 verses.	Procurement Ratio: 80%	There is no major difference in app earance.	Commonly Used in Vietnam	This system responds to the movements by reading on the goder by beeing at top floation. Some numbers of been adjustment conduit as to a cause the vibration by vehicles running.	As for deninga, simple structure such as seeling rubber put into end bean and middle beam in adopted. So, were agrithered into domin to different from this Mehad side 2. diematives. Regulare instant earnors in needed to keep quality of performance for water cut off	Irup at noise is comparatively big when which ecoses the beam adjustment conduct. Notes which goet through down from the adjustment room is also big	Less recommended. A though durbilly, construction, and water cut-off ability are
_				00		×	a	v	ŝ	4	10	s.	ŝ		-4		
Alternative No.2 Steel Finger Joint				The parasist means to researchy our test efforts of the effect of the parasist parasist provide the parasist provide parasist parasister parasist parasister parasist parasi	Allowable Expansion: Any expansion amount is available. Notch Depth: Approximately 400mm	Investment ¥ 970,000 fm at first Material ¥ 820,000 /m Construction ¥ 150,000 /m 1.3	Maintenance # 1,000,000 hn Maintenance # 1,000,000 hn autopair 820,000 hn Editopair 180,000 hn Pridopair 230,000 hn Pridopair 330,000 hn Pridopair 330,000 hn Pridopair 330,000 hn	Store it is set up before doct allo contrarts planns, in case of steel given example of planns of givine deformation at werey range of ouch contracts planns, and the control of filtuness of both side into plans is quite planns parted.	It is strong from structural wire posts and daught. It is concerned the stripping of the electric scal for wate cut-off ocure.	Equanciam joint itaelf cannot be removed alone, so it need to hare a lot of work such as drip ing consets at Juge area. Dunishe Pereol. 310 verses	Producement Ratio: 85%	There is no major difference in ap pearance.	Commonly used in Vistnam	These say gap is appeared in structural life much right fore place, performance is quite good for earlian lared of geologist and rotation. There is concern that any step areas in case of sheader bridge like steel bridge.	There is indication of wate activity image labor is call maternal. It is concerned that filling about the becommend by stress to be concentrated to boundary face of the elastic seal material	If road surface is not seen by girder rotation, imp act noise between comb-thap edjoints is a comparatively big. But the noise is not easily t go down because of filling of dentite seal material below joint.	Recommended. Its durability is sugenor to others, but comparatively inferiors road environment and construction are set to 08
	- É			ittle the 4		20	0	ite 10	ch to	ہ 2 ی	10	5	\$	18	e s v	ed	55
Alternative No.1 Rubber Joint (Tlansverse Type)				deformations of insight institutions and equal by Materiang deformations of children $T_{\rm eff}$ and $T_{\rm ef$	Allowable Expansion : 200mm (±100mm) Notch Dapth: 180mm	Investment ¥ 721,000 fm at first Material ¥ 601,000 hm Construction ¥ 120,000 fm i	Maniferrance 7 52,000 fm addrepiir Material 6 601,000 fm Constructions 7 15,000 fm Lida cycle cons 500,000 ep 3 721,000 + 732,000 e 9 74,50,000 fm 7,850,000 (100 = 74,80,000 fm 2)	Construction condition does not serious restriction due to hallow dopt in counting does. After steel regramming uput is suchcoved at automage reminizance gares, concrete as placed. Therefore, this is qu aimple way of construction.	Loud is absorbed and distributed by tubber elarvitcy and steel roging, van eitherente, in zie possible deresse awy bad diffet dek place. Funt proci is searred by adopting entbern material with a seq gool for wardheng and oit weistent to gather with all costad structure. But it need any artifice for sear-out of tubbe surface	When replacement, no need to disp the concrete, and it is possible change only device of joint. It takes minimum time for replacement and it is earby constructed. Duration of Link: 10 v enes:	Procurament Ratio: 83%	There is no major difference in appearance.	Transversal Type Rubber Joint is new technology.	impact by the algo serving to a control by untractioner much or not control tubber. It is corresponded to unaren desk placeby rockston of gird Rosk streften watter distinges in good condition by surface tubber pattern, so stip is not easily countred.	The expansion joint is combering of and road arrithoe water farms is good. There are seal material & downpout, which is second wat cut-off function.	Noise is minimum due to absception and distribution of imp set of vehicles persingly the tubble charticity. Each up material is arrest at the water calcuff rubber, so noise is shut off to downward.	Not Recommended. Although the investment cost is the low est, this
			Score	10			6	10		<u> </u>	10	s.	5		w.		100
	General Viaw		Evaluation Item	tructure Asp ect and Stabilêy			Cost Up er Investment Lower Life Cycle)	Construction Plan and Period	M aintenance an d	Durability	STEP Clearance	Aesthetics	New Tedinology		Environmental Impact/ROW / raffic Management		Evaluation

- (2) Design of Expansion Joint between Main Bridge and Approach Bridge
 - 1) Calculation of Necessary Expansion between Main Bridge and Approach Bridge

The necessary expansion between Main Bridge and Approach Bridge was calculated based on the results of the structural analyses for the design of the main girders.

a) Conditions of Analyses

The conditions are as follows;

- Temperature Range: 40 degrees
- Coefficient of thermal expansion: 1.08E-05
- Model of Creep and Shrinkage: CEB-FIP90
- Degree of Humidity: 80%
- b) Results of Calculation

The results of analysis are as follows;

	Main Bridge	Approach Bridge	Total
Movement due to Temperature Alternation	103.8	59.0	162.8
Movement due to Creep & Shrinkage	84.2	58.3	142.5
Total	187.9	117.3	305.2

Table 8.6.2-2 Longitudinal Movement at Ends of Main Girders

Unit: mm

c) Expansion Joint to be applied

The expansion joint to be applied between Main Bridge and Approach Bridge is a steel finger type joint as shown in the figure below because the necessary expansion is more than 250mm. The gap between the edges of the main girders is set as the standard gap of the type of the joint.





(b) Longitudinal Cross Section

Source: Study Team



8.6.2.2 Design of Expansion Joint for Approach Bridge

In the design of Expansion joint, it is necessary to decide the following matters.

- (1) Decision of Expansion gap
- (2) Amount of movement of girder end

When the above-mentioned item is decided, it is necessary to calculate the amount of the movement of girder end. The amount of the movement applies the result of calculation from the structure analysis on a main girder.

Hai an side Approach Bridge (1)

1) Movement of main girder

The amount of the movement is calculated by the structure analysis on the main girder, and is shown in the table below.

							Unit : mm
Iton	Position	E1	P1	P2	P3	P4	E2
nen	Node Num,	1	23	44	65	86	108
1	Dead Load	-8.9	-8.5	-3.8	-2.1	-0.7	-0.7
2	Prestress	26.9	16.1	3.8	-3.1	-7.7	-10.4
3	Creep and Shrinkage	59.6	34.7	10.6	-12.6	-35.3	57.6
4	Temperture 40°C	58.9	35.5	11.7	11.9	35.7	59.2
5	Earth Quick Kh=0.18	142.7	142.6	142.6	142.6	142.6	142.7

Table 8.6.2-3 Amount of the movement

Source: Study Team

Decision of expansion gap 2)

Expansion gap of girder end is decided to the following conditions.

a) Expansion gap when the girder end Segment is set up is assumed to be 30mm.

Expansion gap must be secured for temperature change (temperature increase 40 $^{\circ}$ C) immediately after structure completion.



Source: Study Team

Figure 8.6.2-2 Movement of girder end

Expansion gap from the pier center or front parapet is assumed to be 120mm as shown in the above figure at the point of Creep and shrinkage end.

Expansion gap requirement L=117mm

Therefore, it is provided 120mm as Expansion gap

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3) Design movement of expansion joint

The design movement applied to the expansion joint considers the movement after the girder is completed. Because after girder is completed, expansion joint is set up.

Item	unit	Movement	Remarks
1. Creep and Shrinkage	mm	59.6	
2. Temperature change(40° C)	mm	58.9	
3. design margin	mm	1.5	
Design movement	mm	120.0	

Table 8.6.2-4 The design movement applied to the expansion joint considers the movement after the girder

Source: Study Team

Therefore, the amount of design movement at the abutment and pier is as shown in following table.

Table 8.6.2-5 The amount of design movement at the abutment and pie

Place	unit	Movement	Remarks
Abutment A1	mm	120	
Pier	mm	240	

Source: Study Team

4) Selection of expansion joint

Expansion joint is selected according to the result of comparative Study on Type Selection of main bridge.

The design movement of Hai an side approach Bridge is comparatively small with 120mm and 240mm.Therefore, it adopts made of the aluminum alloy.

- a) Relation between allowance and design movement of expansion joint.
- < A1Abuttment >

Cipec joint Wj -160. allowable movement : allowable expansion gap :	160mm 150mm	> > Ok	Design movement 120 120	mm mm
Cipec joint WY-320. allowable movement : Allowable expansion gap :	250mm 435mm	> > OK	Design movement 240 240	mm mm

< Pier >

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PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

(2) Cat Hai side Approach Bridge

1) Movement of main girder

The amount of the movement is calculated by the structure analysis on the main girder, and is shown in the table below.

							Unit; mr
Iton	Position	E1	P1	P2	P3	P4	E2
nen	Node Num,	1	16	34	52	70	85
1	Dead Load	-1.6	-0.9	0.0	0.0	1.0	1.7
2	Prestress	6.7	3.0	1.1	-0.8	-3.0	-6.6
3	Creep and Shrinkage	41.2	25.0	9.0	-7.3	-23.4	-39.5
4	Temperture 40°C	58.2	36.7	13.0	10.6	34.3	-55.7
5	Earth Quick Kh=0.18	117.6	117.5	117.4	117.3	117.3	117.3

Table 8.6.2-6 Amount of the movement

Source: Study Team

Decision of expansion gap 2)

Expansion gap of girder end is decided to the following conditions.

a) Expansion gap when the girder end Segment is set up is assumed to be 30mm.

Expansion gap must be secured for temperature change (temperature increase 40°C) immediately after structure completion. CL



Source: Study Team

Figure 8.6.2-3 Movement of girder end

Expansion gap from the pier center or front parapet is assumed to be 120mm as shown in the above figure at the point of creep and shrinkage end.

Expansion gap requirement $L=78+20=98mm \rightarrow 120mm$

Therefore, it is provided 120mm as Expansion gap

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3) Design movement of expansion joint

The design movement applied to the expansion joint considers the movement after the girder is completed. Because after girder is completed, expansion joint is set up.

Item	unit	Movement	Remarks
1. Creep and Shrinkage	mm	41.2	
2. Temperature change(40° C)	mm	58.2	
3. design margin	mm	20.6	
Design movement	mm	120.0	

Table 8.6.2-7 The design movement applied to the expansion joint considers the movement after the girder

Source: Study Team

Therefore, the amount of design movement at the abutment and pier is as shown in following table.

Table 8.6.2-8 The amount of design movement at the abutment and pie

Place	unit	Movement	Remarks
Abutment A2	mm	120	
Pier	mm	240	

Source: Study Team

4) Selection of expansion joint

Expansion joint is selected according to the result of comparative Study on Type Selection of main bridge.

The design movement of Hai an side approach Bridge is comparatively small with 120mm and 240mm.Therefore, it adopts made of the aluminum alloy.

- a) Relation between allowance and design movement of expansion joint.
- < A1Abuttment >

Cipec joint Wj -160. allowable movement :	160mm	>	Design movement 120	mm
allowable expansion gap :	150mm	> Ok	120	mm
Cipec joint WY-320.			Design movement	
allowable movement :	250mm	>	240	mm
Allowable expansion gap :	435mm	>	240	mm
		OK		

< Pier >

Oriental	Consi	ıltants	Со.,	Ltd.,	Nippor	١K	loei	Со.,	Ltd.	,	
D4 D E O (~ ~				D / /	~	<u> </u>				

PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

(3) dimension of Expansion joint

< A1 and A2 Abutment >



Sectional view S=1:8

< Pier >

Sectional view S=1:8



Source: Study Team

Figure 8.6.2-4 Expansion Joint on Approach Bridge

8.6.2.3 Joint Protectors

For Main Bridge, the unidirectional pot bearing guides the girder to move in the longitudinal direction so that the joint can be protected from transversal movement of the girder.

For Approach bridge, the laminated elastomeric shoe with side blocks guides the girder to move in the longitudinal direction so that the joint can be protected from transversal movement of the girder.

8.6.3 Railing

8.6.3.1 Comparative Study on Handrail

(1) Conditions of Study

In order to select the most reasonable type of Guardrail, alternatives for comparison are introduced as follows,

- Alternative -1: Aluminum Handrail
- Alternative -2: Steel Handrail
- Alternative -3: Concrete Wall + Steel Handrail
- Alternative -4: Concrete Wall

The handrail is an item which generally requires periodical replacement. Therefore, lifecycle cost is also introduced in addition to investment cost in the evaluation item for cost so that cost for replacement can be evaluated quantitatively.

(2) Result of Study

1) Results of Comparative Study

The table on the next page shows the result of the comparative study.

As shown in the table, results of comparison reveal that Alternative-3, Concrete Wall + Steel Handrail, is most preferable for the following reasons;

- Reinforced concrete wall resists the impact of collision.
- Reasonable Cost.
- Superior in Aesthetics.

The precaution is noted as follows,

Regarding anti-corrosion for concrete wall, appropriate cover is generally considered in accordance with design standards. However, because it will be difficult to keep sufficient cover for costal condition, surface coating is recommended to protect against salt attack.

Handrai
e for
n Typ
nparison o
Col
8.6.3-1
Table

	;	6	20	20	~	12		4	2	3	3	78	
Alternative-4 Concrete Wall	and the second s	Remforced concrete reasists the impact of collision. Due to heavy wait, the dimensions of superstructure and substructure are required to be larger than other alternatives.	Investment ¥ 22,345 (m at first Concrete Costing ¥ 11,520 (m Concrete Costing ¥ 17,825 (m Ratio 1.000	Munitennice ¥ 17.825 (n. autentien ¥ 17.825 (n. autentien ¥ 17.825 (n. Life cycle cast Construction ¥ 17.825 (n. 29.445 (t):2235 () = 23.820 (n. 23.8207 (10) = \$20.149 (n. 12.825 (n.	Construction work is in-situ concrete placing, which is simple and ordinary.	Regarding anti-constant will a proposite correct visi providerad in reconduce with design standards. However, because it is difficult to keep sufficient cover for cossist condition, suffice condag is required to protect against sail attack.	Bára concrete protection is required. Láte y ear 100 y ears	10% (Prelinimary Estimate)	The high wall makes oppressing feelings and shuts the side scenery from driver.	No new technology is used.	No major environmental impact.	This alternative is superior in economic but inferior in aesthetics. Heavy weight is also disadvantage for the superstructure and substructure.	Less Recommended
ndrail	crete wall is made of		16,185 /m 2 13,175 /m 2 Ratio 1.001	8,300 /m 13,175 /m coating 3times 93,785 /m 93,785 /m Ratio 1.132	and rails etting,	oprinte cover is . However . . coastal condition. It attack	ig term, coating as odical cleaning and ycars	1				, economic and	Γ
Alternative-3 oncrete Wall + Steel Ha	1 2 2 2 2 2 2 2 2 2 2 2 2 2	esists the impact of collisio tives 1 and 2.	29,360 /m Material ¥ Concrete Coating ¥	21,475 /m 21,475 /m Alterial ¥ d Concrete Costing ¥ replacement and concrete 00*3+13175*3) = 93,785 / 100 =	rre in-situ concrete placing : ordinary.	wanized. sion for contrete wall, appra nere with design standards to keep sufficient cover for luized to protect against sal uized to protect against sal	l rail is not durable for a lon ive 2 is recommended. Perio d. 3 years, Concrete Walf: 100.	mate)	≩h Alternative-2.	s used.	ital impact.	perior in structural stability.	Most Recommended
0	n 10 Minute Alignment 10 M	Reinforced concrete 1 5 Heavier than Alternat	Investment ¥	Maintenance ¥ and repair Life cycle cost Rail an 29,360+(83	Construction works a which are simple and	Hand Kail is to be gal Regarding articorro- considered in accord because it is difficult surfree confing is req 9	Since galvanized stee described in Alternat repainting are require Life year: Handrail:3(0 62% (Preliminary Esti	Sinilar appearance wi	No new technology ii 3	No major environmen 3	This alternative is sur aesthetics.	
	13 years after completion ed. corresion (true) after.		48,700 /m 6,500 /m Ratio 1.881	48.700 /m 10,000 /m 231,300 /m 2,310 /year Ratio 2.793	necessary to (suffice was ew points . wy the following fixiouss. (2) (20 do so high, enough so high, enough hore area, fluorine	ugh it is durable sy, periodical	1	ust and color			4	Γ
Alternative-2 Steel Handrail	an completion the provided in the provided of	med in case of collision.	00 /m Material ≹ Construction ≩	00 /m Material ¥ Construction ¥ innes /100 y ears 5,200 + (58,700/3) = 231,300 / 100 =	required. Furthennore, it is avoid damage of painted	symmetded. In many cases aesthetic and durability vi anit is generally adopted at uniformity with certain th 1. (3) Althought cost is not dustrial zone and on off s telerable.	medial work is casy. A lift wement of paint technolo ired.		ther strength. òr a long time because of i			n economic points.	t Recommended
	holo in the left side shores an act. If the left side shores and so in the side side side side side side side sid	tructural members are defo	avestment ¥ 55,2 at first	intenance ¥ 58,7 and repair ycle cost Replacement 3 5	o heavy weight, a crane is le very carefully in order to	ter place and a second and a second from the second from the second from the second and and second and second and second and second and and second and seco	: site welding is possible, re g to development and impr ing and repainling are requ car: 30 years	(Preliminary Estimate)	ler appearance owing to hig lifticult to keep aesthetics f ilarity due to re-paintings.	ew technology is used.	ajor environmental impact.	alternative is most inferior i	No
	ars The Inut The Years	5 The	0	Ma 8 Life e	8 hand	In pr paint For p For p reas dural dural 15 In se	Since owin clean Life J	10 88%	Slenc 5 It is o irregt	3 No n	3 No II	This 58	
Alternative-1 Altunium Handrail	The photo in the left side is a bridge constructed in Todyo Bay area 14 ye ago. These is no effect.	The structural members are deformed in case of collision.	Investment ¥ 65,200 /m at first 65,200 /m Anterial ¥ 58,700 /m Construction ¥ 6,500 /m Ratio 2,222	Maintennee ¥ 68,700 m Meterial ¥ 93,00 im and tephic Construction ¥ 10,000 im Life cycle cost Repharement One-construction = 133,000 m 65,300+(68,700-1) = 133,000 m 133,000-100 = 1,330, rent Ratio 1431	The weight is low, which make it easy handling.	Producing conduct conk by least control the superstructure mathematican can result against a shy tattack. Even there is no surface contage, only micro holes (diameter is less than 0. Anni) would be observed and not effective holes (diameter is less than 0. Anni) would be observed and not effective holes (diameter is less than 0. Anni) would be observed and not effective holes (diameter is less than 0. Anni) would be observed and not effective holes (diameter is less than 0. Anni) would be observed and not effective holes (diameter is less than 0. Anni) would be observed and not corresten ability remarkably. Even on-shore or off-shore, it is hardly corrected or mated. In principle, maintenance free.	Since the members are connected by bolks and nuts, exhange/replace of member is easy. Life year: 50years	90% (Prelininary Estimate)	In case with anodized aluminum coating, silver, brown and grey colors are available. The color is hardly faded, it is possible to keep aesthetics for a long time.	No new technology is used.	No major environmental impact.	This alternative is superior in mantenance and aesthetic points.	Less Recommended
tems	, w	t 10		4 64	n 10	15		10	s.	, s	s	100	
Evaluation I	General Vi	Structural Asp ec and Stability		Construction Cos Upper: Investmer Lower: Life cycle	Construction Plai and Period	Mäintenance		STHP Clearance	Aesthetics	New Technology	Environmental Aspect	Evaluation	

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Sign	Value (mm)	Sign	Value (mm)
h1	500	b1	300
h2	700	b2	319
h3	300	b3	500
h4	279		
h5	321		
h6	100		
S	25		
Hr	500		
Н	1126		
c1	150		
c2	140		
c3			
al	88		
a2	112		
a3			
a4	626		
Lp	74		
Bt1	300		
Bt2	19		
Bt3	181		
Bt	500		

The structure and the dimensions of the guardrail is shown in the following figure.

Source: Study Team

Figure 8.6.3-1 Expansion Joint on Approach Bridge

8.6 Study on Bridge Accessories

8.6.1 Bearings

8.6.1.1 Design of Bearings for Main Bridge

(1) Features on Selecting Bearing type for Main Bridge

On the contrary to the continuous girder bridge like Approach Bridge, the bearings are needed only at the end piers for Main Bridge which is supported by 3 V-shaped piers with rigid connection. Therefore, not only vertical force but also horizontal force are dispersed to the piers and it is not necessarily the case that the assembly of laminated elastomeric shoes for dispersing horizontal force is applied.

One of other features in Main Bridge for selection of bearing type is large longitudinal displacement by temperature change and concrete shrinkage due to large length of the bridge.

In this section, a comparative study for selecting the appropriate bearing shoe type on the end pier of Main Bridge is presented by taking into account the above-mentioned features.



Source: Study Team



- (2) Selection of Bearing Type for Main Bridge
 - 1) Conditions of Comparative study

A comparative study was performed, by introducing following alternatives;

- •- Alternative -1: Pot Bearings (Unidirectional and multidirectional bearings)
- •- Alternative -2: Elastomeric Bearings and Anchor Bars
- •- Alternative -3: Elastomeric Bearings with Anchored Plates and Anchor Bars

In cases with elastomeric bearings, Alternatives-2 and 3, anchor bars are to be installed for joint protection during earthquake. In the case with pot bearings, Alternative-1, the unidirectional bearing guides the girder to move in the longitudinal direction so that the joint can be protected from transversal movement of the girder.

2) Result of Comparative Study

The result of comparative study is shown in the table on the next page.

As shown in the table, Alternative -1, Pot Bearing, is recommended because of its advantages in investment cost and adaptability for large displacement.

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	ars					0		0	9	6	0	e	5	4	17
age	Alternative-3 Elastomeric Bearing for seismic force dispersing +Anchor B:		The dimensions in the schematics are tentative. 1050 x 1050 x 32 x 9Layers	Anchors: 6 x D40	 This type is for sharing the seismic nonzontal force on all the piers 	 Suitable for continuous grider bridge The while bearing system with plates and anchors are pre-fablicated 	- Thick (approx 40cm) and Large (Approx 1m x 1m)	Desiring Shore (per lpier) 4,403,534,103 VNU Anchors & Caps (per pier) 4,498,22,954 VND Totel 4,515,172,059 VND Ratio 4,99	Workability is inferior because of lots of anchors for the bearings and anchor bars should be installed	Inferior in maintenance because of dificulty in replacement.	Procurement Ratio: 99%	 Unbalanced comparing to the adjacent bearing Inferior in Aesthetics with anchor cap block 	Rubber bearing for seismic force sharing is new	No sigunificant differences among the alternatives	Construction cost is the highest . Inferior in adopting big displacement. This alternative is suitable for continuous girders such as Approach Bridge. Not Recommended
ā		1.1				9		24	ø	12	10	3	3	4	70
מוואו ואו ואים הפמוווא ואים אים וואים אים אים אים אים אים אים אים אים אים	Alternative-2 Elastomeric Bearing + Anchor Bars		The dimensions in the schematics are tentative. 1050 x 1050 x 32 x 9Layers	Anchors: 6 x D40	 Sumple Surgicular Dimension can be flexibility designed. 	 Need anchor bars with large blockouts which may cause interference with rebar arrangement. 	 Thick (approx 40cm) and Large (Approx 1m x 1m) 	Bearing Shoe (per pier) 1,017,176,100 VNU Anchors & Caps (per pier) 1,21549,054 VND Total 1,121549,054 VND Ratio 1,24	Workability is superior because no anchors for the bearings are needed	Superior in maintenance because of simple method for replacement	Procurement Ratio: 95%	 Unbalanced comparing to the adjacent bearing Inferior in Aesthetics with anchor cap block. 	Commonly used in Vietnam	No sigunificant differences among the alternatives	Construction cost is lower than Alternative-3 but higher than Alternative-1. Inferior in adopting big displacement. Less Recommended
						10		40	9	6	10	5	3	4	87
	Alternative-1 Pot Bearing	Undereally mobile pot bearing (TGe) Generally mobile pot bearing (TGe)	Hhe dimensions are tentative H= 156, Bu= 640, BGL=700	H= 138, Bu= 610, BGL=660 - Suitable for local diadonant and local	 Suitable for large displacement and large vertical 	reaction - The longitudinal seismic force is not transmitter to the pier under the bearing and the fixed V-	snaped piers will share the Torce.	Dearing Sroe (per pier) 903,142,374 VNL VNL Total 905,142,374 VND Ratio 1,00	Workability is Superior because no anchor bars are needed to be instaled	Inferior in maintenance because of difficulty in replacement.	Procurement Ratio: 100%	 Superior in Aesthetics with smaller bearings. Superior in Aesthetics without anchor bars. 	Commonly used in Vietnam	No sigunificant differences among the alternatives	This alternative is the chiepest and superior in adopting big displacement Recommended
	Max. Point					10	T	40	10	15	10	5	5	5	100
	Evaluation Items I	Schematics				Structural Aspect and Stability		Construction Cost	Construction Plan and Period	Maintenance	STEP Clearance	Aesthetics	New Technology	Traffic Management/ Environmental Aspect	Evaluation

Table8.6.1-1 Comparison on Type of Bearing for Main Bridge

Table 8.6.1-1 Comparison on Type of Bearing for Main Bridge

Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.
- (3) Design of Bearings for Main Bridge
 - 1) Conditions

The conditions for designing the bearings are as follows,

Table 8.6.1-2	Reaction Forces	and Displacements	at Bearings
---------------	-----------------	-------------------	-------------

(1) Service Limit State							
	Itoms	Displacement (m)	Reaction	n Forces (kN)	Note		
nems		Displacement (III)	Vertical	Transversal	Note		
D75	Uni-directional	153.4	5855	623			
P/3	Multi-directional	153.4	5728	-			
D70	Uni-directional	151.9	5917	621			
P/9	Multi-directional	151.9	5770	-			

(2) Extreme Event Limit State	
-------------------------------	--

Items		Displacement (m)	Reaction	Note	
			Vertical	Transversal	Note
D75	Left	107.1	9100	2777	
P75	Right	107.1	9107	-	
D70	Left	109.8	10220	2990	
P/9	Right	109.8	10211	-	

Source: Study Team

2) Results of Design

The items for checking are as follows,

- Thickness of Pot Ring
- Thickness of Pot Bottom
- Dimensions of Upper Plate
- Dimensions of Lower Plate
- Dimensions of Anchor Bolts
- Dimensions of Anchor Dowels
- Checking of Separation

The calculation note is shown in Design Report on Main Bridge. The resultant dimensions are shown in the figure in the next page.







(2) Free Sliding



8.6.1.2 Design of Bearings for Approach Bridge

(1) Outline of design

The design procedure of rubber bearing is as shown in the figure below.





- (2) Hai An side Approach Bridge
 - 1) Design condition
 - a) Design force
 - < CASE-1(5@60m=300m) >

The reaction force of Rubber bearing is shown in the table below.

Mavimum Departion		Desstion	Miniumum	Live Load	Dead Load Reaction		Dead Load
No	waximum	Reaction	Reaction	Max	Max	Min	Total
INO	Rmax1	Rmax2	Rmin	R _{L+I} max	Rdmax	Rdmin	ΣRd
	kN	kN	kN	kN	kN	kN	kN
A1	5690	5121	4520	1080	4610	4610	9220
P1	10810	9729	8860	1680	9130	9130	18260
P2	10680	9612	8800	1660	9020	9020	18040
P3	10770	9693	8890	1660	9110	9110	18220
P4	10750	9675	8800	1680	9070	9070	18140
P5	5670	5103	4500	1070	4600	4600	9200
W							91080

Table 8.6.1-3 Reaction force of rubber bearing

Source: Study Team

< CASE-2(53m+3@60m+53m) >

	Maximum Reaction		Miniumum	Live Load Dead Load		Reaction	Dead Load
			Reaction	Max	Max	Min	Total
	Rmax1	Rmax2	Rmin	R _{L+I} max	Rdmax	Rdmin	ΣRd
No	kN	kN	kN	kN	kN	kN	kN
P55	5140	4626	4000	1030	4110	4110	8220
P56	10250	9225	8340	1750	8630	8630	17260
P57	10700	9630	8850	1660	9040	9040	18080
P58	10770	9693	9300	1460	9310	9310	18620
P59	10200	9180	8290	1620	8580	8580	17160
P60	5130	4617	3990	1030	4100	4100	8200
W							87540

Table 8.6.1-4 Reaction force of rubber bearing

b) Amount of Movement

< CASE-1 (5@60m=300m) >

	Span Length	Temperature change		Creep,Shrink age etc.
	L	Δt	Δt Δť	
Span	m	mm	mm	mm
A1~ P1	59.00	±11.8	±23.6	-35.7
P1~ P2	60.00	±12.0	±24.0	-36.4
P2~ P3	60.00	±12.0	±24.0	-30.1
P3~ P4	60.00	±12.0	±24.0	-27.3
P4~ P5	59.00	±11.8	±23.6	-25.0

Source: Study Team

 $< CASE-2\;(53m+3@60m+53m) >$

	Span Length	Temperature change		Creep,Shrink age etc.
	L	Δt	Δt Δť	
Span	m	mm	mm	mm
P55~ P56	51.98	±10.4	±20.8	-28.3
P56~ P57	60.00	±12.0	±24.0	-35.6
P57~ P58	60.00	±12.0	±24.0	-30.3
P58~ P59	60.00	±12.0	±24.0	-27.3
P59~ P60	51.98	±10.4	±20.8	-18.0

Table 8.6.1-6	Amount of	Movement	in each	support
10010 0.0.1 0	/ unount of	100001110111	in ouon	ouppoir

c) Allowable value

< Rubber >

The restriction stress of the body of rubber is as shown in the table below.

	Item			Sign	Unit	Value
	Maximum Compression	S1	≦8			8
ess	stresse	8 <s1<12< td=""><td>σmaxa</td><td>N/mm2</td><td>S1</td></s1<12<>		σmaxa	N/mm2	S1
I Stre	(At an effective area)	12≦	≦S1			12
ssion	Minimum Compression	stress		σmina	N/mm2	1.5
npre:		S1	≦8			5.0
Con	Stress amplitude	8 <s1<12< td=""><td>Δσα</td><td>N/mm2</td><td>5+0.375 •(S1-8)</td></s1<12<>		Δσα	N/mm2	5+0.375 •(S1-8)
		12≦S1				6.5
Shearing distorsion		service Loade		γsa	%	70
		Fortbauako	Level1	γea	%	150
		Lailiquake	Level2	γea	%	250
		Total distorsion at Service limitted state		γta	%	γu/fs
Local	Shearing distorsion			fs		1.5
		Breaking growth rate		γu	%	depends on the table below.
Tonollo		G6				1.2
Stress	Earthquake	G	8	σta	N/mm2	1.6
01000		G10 or	more			2.0

Source: Study Team

< Inner steel plate >

Table 8.6.1-8 Allowable value of	of Inner	Steel	Plate
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Kind of Material	unit	Yield Strength	bending stress
SS400	N/mm2	235	140

d) Detail dimension of Bearing

Tahla 8 (6 1-0 Detai	Dimension	of	Rearing
Table 0.0	0. I-9 Delai		0I	Dearing

< CASE-1	(5@60m) >

		b	а	te	n	Σte	ts	Ge
No	function	mm	mm	mm	layer	mm	mm	N/mm2
A1	Dispersion	950	950	30	7	210	6.0	1.20
P1	Dispersion	1200	1200	32	4	128	6.0	1.20
P2	Dispersion	1200	1200	32	4	128	6.0	1.20
P3	Dispersion	1200	1200	32	4	128	6.0	1.20
P4	Dispersion	1200	1200	32	4	128	6.0	1.20
P5	Dispersion	950	950	30	7	210	6.0	1.20

< CASE-2 (53m+3@60m+53m) >

		b	а	te	n	Σte	ts	Ge	
No	function	mm	mm	mm	layer	mm	mm	N/mm2	
P55	Dispersion	950	950	30	7	210	6.0	1.20	
P56	Dispersion	1200	1200	32	4	128	6.0	1.20	
P57	Dispersion	1200	1200	32	4	128	6.0	1.20	
P58	Dispersion	1200	1200	32	4	128	6.0	1.20	
P59	Dispersion	1200	1200	32	4	128	6.0	1.20	
P60	Dispersion	950	950	30	7	210	6.0	1.20	

Source: Study Team

e) Service Limited state

- Movement at service state

Longitudinal movement of Service limit state is shown in the table below.

Table 8.6.1-10 Longitudinal movement

		Thermal m	ovement (unif	orm temperati	ure change)	Movement	of creep and	d shrinkage	Livo lood	Combi	nation		
	Expansion	for horizo	ntal force	for bear	ig design	Creep and shrinkage	Dead	amount	Live load	Combination			
	center	Δ	Lt	ΔLť		∆Lscp	∆Ld	ΔĽ'	ΔLr	Δ	L		
		+20°C	-20°C	+40°C	-40°C					+40°C	-40°C		
	L	1	2	3	4	5	6	Ø	8	3+7+8	(4) +(7)+(8)		
No	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm		
A1	-149.00	-29.8	29.8	-59.6	59.6	83.7		83.7		24.1	143.3		
P1	-90.00	-18.0	18.0	-36.0	36.0	48.0		48.0		12.0	84.0		
P2	-30.00	-6.0	6.0	-12.0	12.0	11.6		11.6		-0.4	23.6		
P3	30.00	6.0	-6.0	12.0	-12.0	-18.5		-18.5		-6.5	-30.5		
P4	90.00	18.0	-18.0	36.0	-36.0	-45.8		-45.8		-9.8	-81.8		
P5	149.00	29.8	-29.8	59.6	-59.6	-70.8		-70.8		-11.2	-130.4		

< CASE-1 (5@60m) >

< CASE-2 (53m+3@60m+53m) >

		Thermal m	ovement (unif	orm temperat	ure change)	Movement	of creep and	d shrinkage	Live lead	Combination	
	Expansion	for horizo	ntal force	for bearig design		Creep and shrinkage	Dead	amount	Live loau	Combination	
	center		Lt	ΔLť		∆Lscp	ΔLd	ΔL'	ΔLr	Δ	L
		+20°C	-20°C	+40°C	-40°C					+40°C	-40°C
	L	1	2	3	4	5	6	\bigcirc	8	3+7+8	(4) +(7)+(8)
No	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
P55	-141.98	-28.4	28.4	-56.8	56.8	75.8		75.8		19.0	132.6
P56	-90.00	-18.0	18.0	-36.0	36.0	47.5		47.5		11.5	83.5
P57	-30.00	-6.0	6.0	-12.0	12.0	11.9		11.9		-0.1	23.9
P58	30.00	6.0	-6.0	12.0	-12.0	-18.4		-18.4		-6.4	-30.4
P59	90.00	18.0	-18.0	36.0	-36.0	-45.7		-45.7		-9.7	-81.7
P60	141.98	28.4	-28.4	56.8	-56.8	-63.7		-63.7		-6.9	-120.5

Source: Study Team

- Design result of Service limit state

The result of the maximum compression stress, the stress amplitude, and the buckling stress is shown in the table below.

< CASE-1 (5@60m) >

		Movement	boorig aroa	Efective		E	3earing stress			Pucklin	a stross	Modulas of
		woverneni	beally alea	bearig area	Max	imum	minimum	Stress a	mplitude	DUCKIII	iy siless	elasticity
		ΔLm	Ae	Acn	σmax	≦σmaxa	σmina	Δσ	≦ ∆oa	σcra	≧σmax	E(💥)
No	0	mm	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
A	1	143.3	0.9025	0.7664	7.42	8.0	5.01	2.42	5.0	17.19	7.42	498.5
P	1	84.0	1.4400	1.3393	8.07	9.4	6.15	1.92	5.5	42.19	8.07	697.6
P2	2	23.6	1.4400	1.4117	7.57	9.4	6.11	1.45	5.5	42.19	7.57	697.6
P	3	30.5	1.4400	1.4033	7.67	9.4	6.17	1.50	5.5	42.19	7.67	697.6
P	4	81.8	1.4400	1.3418	8.01	9.4	6.11	1.90	5.5	42.19	8.01	697.6
P	5	130.4	0.9025	0.7786	7.28	8.0	4.99	2.30	5.0	17.19	7.28	498.5

Table 8.6.1-11 Check result of stress

Source: Study Team

The result of the Shearing strain and rotation is shown in the table below.

Table 8.6.1-12 Check result of transformation performance

		Vertical dis	splacement			Loa	ical shear stra	in		Tensile stress of inner steel	
	Rotation	Compression	1/2*Liveload	Maximum	Vertical	Horizontal	Rotation	Amount	Allowable strain	pla	ite
	δr	<u>≦</u> δc/fv	δc	δο	γc	γs	γr	γt	≦γu/1.5	σs	≦osa
No	mm	mm	mm	mm	%	%	%	%	%	N/mm2	N/mm2
A1	1.58	2.76	0.38	4.69	100.2	68.2	23.9	192.3	333	74.2	140
P1	1.00	1.69		2.62	92.2	65.6	29.3	187.1	333	86.1	140
P2	1.00	1.67		2.46	86.4	18.4	29.3	134.1	333	80.7	140
P3	1.00	1.68		2.49	87.7	23.9	29.3	140.8	333	81.9	141
P4	1.00	1.68		2.60	91.5	63.9	29.3	184.8	333	85.5	142
P5	1.58	2.75	0.37	4.60	98.3	62.1	23.9	184.3	333	72.8	140
Allowable value			≦ 1.00			≦ 70					

Source: Study Team

< CASE-2 (53m+3@60m+53m) >

The result of the maximum compression stress, the stress amplitude, and the buckling stress is shown in the table below.

Table 8.6.1-13 Check result of stress

	Movement	hearig area	Efective		F	3earing stress			Bucklin	n stross	Modulas of longitudinal	
	WOVETICIL	beany area	bearig area	Maximum		minimum	Stress ar	mplitude	Ducking Stess		elasticity	
	ΔLm	Ae	Acn	σmax	≦σmaxa	σmina	Δσ	≦ ∆oa	σcra	σcra ≧σmax		
No	mm	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	
P55	132.6	0.9025	0.7765	6.62	8.0	4.43	2.19	5.0	17.19	6.62	498.5	
P56	83.5	1.4400	1.3398	7.65	9.4	5.79	1.86	5.5	42.19	7.65	697.6	
P57	23.9	1.4400	1.4113	7.58	9.4	6.15	1.44	5.5	42.19	7.58	697.6	
P58	30.4	1.4400	1.4035	7.67	9.4	6.46	1.22	5.5	42.19	7.67	697.6	
P59	81.7	1.4400	1.3420	7.60	9.4	5.76	1.84	5.5	42.19	7.60	697.6	
P60	120.5	0.9025	0.7880	6.51	8.0	4.42	2.09	5.0	17.19	6.51	498.5	

Source: Study Team

The result of the Shearing strain and rotation is shown in the table below.

		Vertical dis	splacement			Loa	acal shear stra	in		Tensile stress of inner steel	
	Rotation	Compression	1/2*Liveload	Maximum	Vertical	Horizontal	Rotation	Amount	Allowable strain	pla	ite
	δr	≦δc/fv	δc	δο	γc	γs	γr	γt	≦γu/1.5	σs	≦σsa
No	mm	mm	mm	mm	%	%	%	%	%	N/mm2	N/mm2
P55	1.58	2.49	0.36	4.18	89.4	63.1	23.9	176.4	333	66.2	140
P56	1.00	1.60		2.49	87.4	65.2	29.3	181.9	333	81.6	140
P57	1.00	1.67		2.46	86.6	18.7	29.3	134.6	333	80.9	140
P58	1.00	1.68		2.49	87.7	23.7	29.3	140.7	333	81.9	141
P59	1.00	1.59		2.47	86.8	63.8	29.3	179.9	333	81.1	142
P60	1.58	2.49	0.36	4.11	87.9	57.4	23.9	169.1	333	65.1	140
Allowable value			≦ 1.00			≦ 70					

Table 8.6.1-14 Check result of transformation performance

Source: Study Team

f) Earthquake

- Movement at earthquake

The amount of the movement at earthquake is shown in the table below.

< CASE-1 (5@60m) >

Table 8.6.1-15 The amount of the movement at earthquake

		Longitudina	al direction		Transvers direction			
	Level 1(at		Lev	el 2	Level 1(at	Lev	el 2	
	2nd Ellect	earthquake)	TYPE I	TYPE II	earthquake)	TYPE I	TYPE II	
	ΔL'	ΔLe	ΔLe	ΔLe	ΔLe	ΔLe	ΔLe	
No	mm	mm	mm	mm	mm	mm	mm	
A1	83.7	70.8	142.7	142.7	70.8	150.0	150.0	
P1	48.0	70.8	142.7	142.7	70.8	150.0	150.0	
P2	11.6	70.8	142.7	142.7	70.8	150.0	150.0	
P3	18.5	70.8	142.7	142.7	70.8	150.0	150.0	
P4	45.8	70.8	142.7	142.7	70.8	150.0	150.0	
P5	70.8	70.8	142.7	142.7	70.8	150.0	150.0	

< CASE-2 (53m+3@60m+53m) >

		Longitudin	al direction	Tra	nsvers direction	on	
	Secondary	Allo	Lev	el 2	Allo	Lev	el 2
	force	ΔLe	TYPE I	TYPE II	ΔLe	TYPE I	TYPE II
	ΔL'	ΔLe	ΔLe	ΔLe	ΔLe	ΔLe	ΔLe
No	mm	mm	mm	mm	mm	mm	mm
P55	75.8	68.1	144.2	150.0	68.1	150.0	150.0
P56	47.5	68.1	144.2	150.0	68.1	150.0	150.0
P57	11.9	68.1	144.2	150.0	68.1	150.0	150.0
P58	18.4	68.1	144.2	150.0	68.1	150.0	150.0
P59	45.7	68.1	144.2	150.0	68.1	150.0	150.0
P60	63.7	68.1	144.2	150.0	68.1	150.0	150.0

Source: Study Team

- Design result of earthquake

The result of the buckling stress, shearing strain and tensile stress is shown in the table below.

Table 8.6.1-16 The result of the buckling stress, shearing strain and tensile stress $< CASE\mbox{-}1\ (5\ensuremath{@}60m) >$

	E	3uckling stress Tensil stress Shearing strain			Tensil stress		g strain	Tensile stress o	finner steel plate	
	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Londitudinal	Transvers
	σce	σce	≦σcra	σte	σte	≦ σta	γse	γse	σs	σs
No	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	%	%	N/mm2	N/mm2
A1	8.52	8.02	28.7			2.0	107.8	71.4	85.2	80.2
P1	9.57	9.83	70.3			2.0	148.9	117.2	102.1	104.9
P2	9.13	9.73	70.3			2.0	120.5	117.2	97.4	103.7
P3	9.28	9.81	70.3			2.0	126.0	117.2	99.0	104.7
P4	9.49	9.77	70.3			2.0	147.3	117.2	101.2	104.3
P5	8.35	8.01	28.7			2.0	101.7	71.4	83.5	80.1
Allowable value							≦ 250	≦ 250	≦ 235	≦ 235

< CASE-2 (53m+3@60m+53m) >

							-			
	E	Buckling stres	S		Tensil stress			ıg strain	Tensile stress of inner steel plate	
	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Londitudinal	Transvers
	σce	σce	≦σcra	σte	σte	≦ σta	γse	γse	σs	σs
No	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	%	%	N/mm2	N/mm2
P55	7.59	7.22	28.7			2.0	107.5	71.4	75.9	72.2
P56	9.11	9.35	70.3			2.0	154.3	117.2	97.2	99.8
P57	9.22	9.75	70.3			2.0	126.5	117.2	98.3	103.9
P58	9.55	10.00	70.3			2.0	131.5	117.2	101.9	106.7
P59	9.04	9.31	70.3			2.0	152.9	117.2	96.4	99.3
P60	7.44	7.20	28.7			2.0	101.8	71.4	74.4	72.0
Allowable value							≦ 250	≦ 250	≦ 235	≦ 235

- g) Detailed dimension of Rubber bearing
- End support Bearing



Source: Study Team



- Middle support Bearing



Source: Study Team



- (3) Cat Hai side Approach Bridge
 - 1) Design condition
 - a) Design force
 - < CASE-1(53.8m+3@60m+53.8m) >

The reaction force of Rubber bearing is shown in the table below.

	Maximum Deaction		Miniumum	Live Load	Dead Load	Reaction	Dead Load
	Waximum	Reaction	Reaction	Max	Max	Min	Total
	Rmax1	Rmax2	Rmin	R _{L+I} max	Rdmax	Rdmin	ΣRd
No	kN	kN	kN	kN	kN	kN	kN
P79	4440	3996	3290	1040	3400	3400	6800
P80	12360	11124	10400	1750	10710	10710	21420
P81	11770	10593	9880	1670	10100	10100	20200
P82	11770	10593	9880	1670	10100	10110	20210
P83	12360	11124	10400	1650	10710	10710	21420
P84	4440	3996	3290	1040	3400	3400	6800
W							96850

Table 8.6.1-17 Reaction force of rubber bearing

Source: Study Team

< CASE-2(53.8m+2@60m+53.8m) >

Table 8.6.1-18 Reaction force of rubber bearing

	Maximum Reaction		Miniumum	Live Load	Dead Loa	d Reaction	Dead Load
			Reaction	Max	Max	Min	Total
	Rmax1	Rmax2	Rmin	R _{L+I} max	Rdmax	Rdmin	ΣRd
No	kN	kN	kN	kN	kN	kN	kN
P84	4440	3996	3290	1040	3400	3400	6800
P85	12400	11160	10440	1750	10750	10750	21500
P86	11700	10530	9740	1750	9950	9950	19900
P87	12300	11070	10590	1770	10750	10750	21500
A2	4300	3870	3290	900	3400	3400	6800
W							76500

b) Amount of Movement

< CASE-1 (53.8m+3@60m+53.8m) >

Table 8.6.1-19 Amount of Movement in each support

	Span Length	Temperature change		Creep,Shrink age etc.
	L	∆t	∆ť	∆scp
Span	m	mm	mm	mm
P79~ P80	53.80	±10.8	±21.5	-19.9
P80~ P81	60.00	±12.0	±24.0	-17.9
P81~ P82	60.00	±12.0	±24.0	-18.2
P82~ P83	60.00	±12.0	±24.0	-18.3
P83~ P84	53.80	±10.8	±21.5	-19.7

Source: Study Team

< CASE-2(53.8m+2@60m+53.8m) >

Table 8.6.1-20 Amount of Movement in each support

	Span Length	Temperati	Temperature change	
	L	Δt	Δt $\Delta t'$	
Span	m	mm	mm	mm
P84~ P85	53.80	±10.8	±21.5	-19.5
P85~ P86	60.00	±12.0	±24.0	-17.3
P86∼ P87	60.00	±12.0	±24.0	-17.3
P87 \sim A2	53.80	±10.8	±21.5	-19.5

c) Allowable value

< Rubber >

The restriction stress of the body of rubber is as shown in the table below.

	Item			Sign	Unit	Value
	Maximum Compression	S1	≦8			8
sse	stresse	8 < S1	1<12	σmaxa	N/mm2	S1
1 Stre	(At an effective area)	12≦	≦S1			12
ssion	Minimum Compression	stress		σmina	N/mm2	1.5
npre:		S1	≦8			5.0
Con	Stress amplitude	8 <s1<12< td=""><td>Δσα</td><td rowspan="2">N/mm2</td><td>5+0.375•(S1-8)</td></s1<12<>		Δσα	N/mm2	5+0.375•(S1-8)
		12 ≦ S1				6.5
		service Loade		γsa	%	70
Sh	earing distorsion	Farthquako	Level1	γea	%	150
		Laitiquake	Level2	γea	%	250
		Total distorsio	on at Service	γta	%	γu/fs
Local	Shearing distorsion	limitteo	d state	fs		1.5
		Breaking g	growth rate	γu	%	depends on the table below.
		G	6			1.2
Stress	Earthquake	G	8	σta	N/mm2	1.6
Suess		G10 or	r more			2.0

Source: Study Team

< Inner steel plate >

Table 8.6.1-22 Allowable	value of Inner	Steel Plate
--------------------------	----------------	-------------

Kind of Material	unit	Yield Strength	bending stress
SS400	N/mm2	235	140

d) Detail dimension of Bearing

Table 8.6.1-23 Detail Dimension of Bearing

< CASE-1 (53.8m+3@60m+53.8m) >

		b	а	te	n	Σte	ts	Ge
No	function	mm	mm	mm	layer	mm	mm	N/mm2
P79	Dispersion	850	850	32	5	160	6.0	1.20
P80	Dispersion	1300	1300	32	3	96	6.0	1.20
P81	Dispersion	1300	1300	32	3	96	6.0	1.20
P82	Dispersion	1300	1300	32	3	96	6.0	1.20
P83	Dispersion	1300	1300	32	3	96	6.0	1.20
P84	Dispersion	850	850	32	5	160	6.0	1.20

< CASE-2 (53.8m+2@6m+53.8m) >

		b	а	te	n	Σte	ts	Ge
No	function	mm	mm	mm	layer	mm	mm	N/mm2
P84	Dispersion	850	850	32	4	128	6.0	1.20
P85	Dispersion	1300	1300	32	3	96	6.0	1.20
P86	Dispersion	1300	1300	32	3	96	6.0	1.20
P87	Dispersion	1300	1300	32	3	96	6.0	1.20
A2	Dispersion	850	850	32	4	128	6.0	1.20

e) Service Limit state

- Movement at service state

Longitudinal movement of Service limit state is shown in the table below.

< CASE-1 (53.8m+3@60m+53.8m) >

Table 8.6.1-24 Longitudinal movement

	_	Thermal m	ovement (unit	form temperat	ure change)	Movement	of creep an	d shrinkage	Live lead	Comb	ination
	Expansion	for horizo	ntal force	for bear	ig design	Creep and shrinkage	Dead	amount	LIVE IDAU	Comb	mation
	center	Δ	Lt	۵	.Lť	∆Lscp	ΔLd	ΔL'	ΔLr	Δ	L
		+20°C	-20° C	+40°C	-40°C					+40°C	-40°C
	L	1	2	3	4	5	6	Ī	8	3+7+8	4+7+8
No	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
P79	-143.80	-28.8	28.8	-57.5	57.5	47.0		47.0		-10.5	104.5
P80	-90.00	-18.0	18.0	-36.0	36.0	27.1		27.1		-8.9	63.1
P81	-30.00	-6.0	6.0	-12.0	12.0	9.2		9.2		-2.8	21.2
P82	30.00	6.0	-6.0	12.0	-12.0	-9.0		-9.0	-	3.0	-21.0
P83	90.00	18.0	-18.0	36.0	-36.0	-27.3		-27.3	-	8.7	-63.3
P84	143.80	28.8	-28.8	57.5	-57.5	-47.0		-47.0		10.5	-104.5

< CASE-2 (53.8m+2@60m+53.8m) >

	_	Thermal m	ovement (unif	orm temperat	ure change)	Movemen	t of creep and	l shrinkage	Lim load	Combination	
	Expansion	for horizo	ontal force	for bear	ig design	Cre ep and shrinkage	Dead	amount	Live load	Comb	ITALIOIT
	center	Δ	Lt	Δ	Ĺť	ΔLscp	ΔLd	$\Delta L'$	ΔLr	Δ	L
		+20°C	-20°C	+40°C	-40°C					+40°C	-40°C
	L	1	2	3	4	5	6	Ī	8	3+7+8	(4) +(7)+(8)
No	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
P84	-113.80	-22.8	22.8	-45.5	45.5	36.8		36.8		-8.7	82.3
P85	-60.00	-12.0	12.0	-24.0	24.0	17.3		17.3		-6.7	41.3
P86	0.00	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0
P87	60.00	12.0	-12.0	24.0	-24.0	-17.3		-17.3		6.7	-41.3
A2	113.80	22.8	-22.8	45.5	-45.5	-36.8		-36.8		8.7	-82.3

Source : Study Team

- Design result of Service limit state

< CASE-1 (53.8m+3@60m+53.8m) >

The result of the maximum compression stress, the stress amplitude, and the buckling stress is shown in the table below.

Table 8.6.1-25 Check result of stress

	Movement	boaria aroa	Efective		E	3earing stress			Pucklin	a stross	Modulas of
	WOVErneni	Deally area	bearig area	Max	imum	minimum	Stress a	mplitude	DUCKIII	y siless	elasticity
	ΔLm	Ae	Acn	σmax	≦omaxa	omina	Δσ	≦ ∆σa	σcra	≧σmax	E(※)
No	mm	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
P79	104.5	0.7225	0.6337	7.01	8.0	4.55	2.45	5.0	16.93	7.01	351.8
P80	63.1	1.6900	1.6080	7.69	10.2	6.15	1.53	5.8	66.02	7.69	818.0
P81	21.2	1.6900	1.6624	7.08	10.2	5.85	1.23	5.8	66.02	7.08	818.0
P82	21.0	1.6900	1.6627	7.08	10.2	5.85	1.23	5.8	66.02	7.08	818.0
P83	63.3	1.6900	1.6077	7.69	10.2	6.15	1.53	5.8	66.02	7.69	818.0
P84	104.5	0.7225	0.6337	7.01	8.0	4.55	2.45	5.0	16.93	7.01	351.8

	Table 8.6.1-26 Check result of transformation performance												
		Vertical dis	splacement			Loa	acal shear stra	in		Tensile stress	of inner steel		
	Rotation	Compression	1/2*Liveload	Maximum	Vertical	Horizontal	Rotation	Amount	Allowable strain	pla	te		
	δr	≦δc/fv	δc	δο	γc	γs	γr	γt	≦γu/1.5	σs	≦σsa		
No	mm	mm	mm	mm	%	%	%	%	%	N/mm2	N/mm2		
P79	1.42	2.44	0.41	4.02	112.4	65.3	23.5	201.3	333	74.7	140		
P80	1.08	1.14		1.73	81.1	65.7	45.8	192.7	333	82.0	140		
P81	1.08	1.09		1.59	74.7	22.1	45.8	142.6	333	75.5	140		
P82	1.08	1.09		1.59	74.7	21.9	45.8	142.4	333	75.5	141		
P83	1.08	1.14		1.73	81.1	65.9	45.8	192.9	333	82.0	142		
P84	1.42	2.44	0.41	4.02	112.4	65.3	23.5	201.3	333	74.7	140		
Allowable value			≦ 1.00			≦ 70							

The result of the Shearing strain and rotation is shown in the table below.

Source : Study Team

< CASE-2 (53.8m+2@60m+53.8m) >

The result of the maximum compression stress, the stress amplitude, and the buckling stress is shown in the table below.

		, ·	Efective			Bearing stress			D 11		Modulas of
	Movement	bearig area	bearig area	Max	imum	minimum	Stress a	mplitude	Bucklin	g stress	elasticity
	ΔLm	Ae	Acn	σmax	≦σmaxa	σmina	$\Delta \sigma$	$\leq \Delta \sigma a$	σera	$\geq \sigma max$	E(💥)
No	mm	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
P84	82.3	0.7225	0.6525	6.80	8.0	4.55	2.25	5.0	21.17	6.80	351.8
P85	41.3	1.6900	1.6363	7.58	10.2	6.18	1.40	5.8	66.02	7.58	818.0
P86	0.0	1.6900	1.6900	6.92	10.2	5.76	1.16	5.8	66.02	6.92	818.0
P87	41.3	1.6900	1.6363	7.52	10.2	6.27	1.25	5.8	66.02	7.52	818.0
A2	82.3	0.7225	0.6525	6.59	8.0	4.55	2.04	5.0	21.17	6.59	351.8

Table 8.6.1-27 Check result of stress

Source : Study Team

The result of the Shearing strain and rotation is shown in the table below.

		Vertical di	splacement			Lo	acal shear stra	ain		Tensile stress of inner	
	Rotation	Compression	1/2*Liveload	Maximum	Vertical	Horizontal	Rotation	Amount	Allowable strain	steel p	olate
	δr	≦δc/fv	δel	δο	γc	γs	γr	γt	≦γu/1.5	σs	≦σsa
No	mm	mm	mm	mm	%	%	%	%	%	N/mm2	N/mm2
P84	1.42	1.95	0.33	3.12	109.2	64.3	29.4	202.9	333	72.6	140
P85	1.08	1.14		1.71	80.0	43.0	45.8	168.8	333	80.8	140
P86	1.08	1.08		1.56	73.1	0.0	45.8	118.9	333	73.8	140
P87	1.08	1.13		1.69	79.3	43.0	45.8	168.2	333	80.2	141
A2	1.42	1.89	0.29	3.02	105.7	64.3	29.4	199.5	333	70.3	142
Allowable value			≦ 1.00			≦ 70					

Table 8.6.1-28 Check result of transformation performance

Source : Study Team

f) Earthquake

- Movement at earthquake

< CASE-1 (53.8m+3@60m+53.8m) >

The amount of the movement at earthquake is shown in the table below.

Table 8.6.1-29 The amount of the movement at earthquake

		Longitudina	al direction		Tra	nsvers direction	on
	Secondary	Level 1(at	Lev	el 2	Level 1(at	Lev	el 2
	force	earthquake)	TYPE I	TYPE II	earthquake)	TYPE I	TYPE II
	ΔĽ'	ΔLe	ΔLe	ΔLe	∆Le	ΔLe	ΔLe
No	mm	mm	mm	mm	mm	mm	mm
P79	47.0	50.8	117.6	117.6	50.8	150.0	150.0
P80	27.1	50.8	117.6	117.6	50.8	150.0	150.0
P81	9.2	50.8	117.6	117.6	50.8	150.0	150.0
P82	9.0	50.8	117.6	117.6	50.8	150.0	150.0
P83	27.3	50.8	117.6	117.6	50.8	150.0	150.0
P84	47.0	50.8	117.6	117.6	50.8	150.0	150.0

b) CASE-2 (53.8m+2@60m+53.8m)

		Longitudina	al direction		Tra	ansvers direct	ion
	Secondary	Level 1(at	Lev	el 2	Level 1(at	Lev	rel 2
	force	earthquake)	TYPE I	TYPE II	earthquake)	TYPE I	TYPE II
	$\Delta L'$	ΔLe	ΔLe	ΔLe	ΔLe	ΔLe	ΔLe
No	mm	mm	mm	mm	mm	mm	mm
P84	36.8	49.7	103.5	103.5	49.7	150.0	150.0
P85	17.3	49.7	103.5	103.5	49.7	150.0	150.0
P86	0.0	49.7	103.5	103.5	49.7	150.0	150.0
P87	17.3	49.7	103.5	103.5	49.7	150.0	150.0
A2	36.8	49.7	103.5	103.5	49.7	150.0	150.0

2) Design result of Earthquake

The result of the buckling stress, shearing strain and tensile stress is shown in the table below.

Table 8.6.1-30 The result of the buckling stress, shearing strain and tensile stress < CASE-1~(53.8m+3@60m+53.8m) >

	E	Buckling stres	S		Tensil stress		Shearin	g strain	Tensile stress of inner steel plate	
	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Londitudinal	Transvers
	σce	σce	≦σcra	σte	σte	≦ σta	γse	γse	σs	σs
No	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	%	%	N/mm2	N/mm2
P79	7.41	8.28	28.2			2.0	102.9	93.8	79.1	88.3
P80	9.06	10.89	110.0			2.0	150.7	156.3	96.6	116.1
P81	8.41	10.42	110.0			2.0	132.1	156.3	89.7	111.2
P82	8.41	10.42	110.0			2.0	131.9	156.3	89.7	111.2
P83	9.06	10.89	110.0			2.0	150.9	156.3	96.6	116.1
P84	7.41	8.28	28.2			2.0	102.9	93.8	79.1	88.3
Allowable value							≦ 250	≦ 250	≦ 235	≦ 235

< CASE-2 (53.8m+2@60m+53.8m) >

	I	Buckling stres	s		Tensil stress		Shearir	ng strain	Tensile stress of inner steel plate		
	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Allowable	Londitudinal	Transvers	Londitudinal	Transvers	
	σce	σce	≦σera	σte	ote	≦ σta	γse	γse	σs	σs	
No	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	%	%	N/mm2	N/mm2	
P84	7.16	8.70	35.3			2.0	109.6	117.2	76.3	92.8	
P85	8.91	10.92	110.0			2.0	125.8	156.3	95.0	116.4	
P86	8.12	10.31	110.0			2.0	107.8	156.3	86.7	109.9	
P87	8.91	10.92	110.0			2.0	125.8	156.3	95.0	116.4	
A2	7.16	8.70	35.3			2.0	109.6	117.2	76.4	92.8	
Allowable value							≦ 250	≦ 250	≦ 235	≦ 235	

- g) Detailed dimension of Rubber bearing
- End support Bearing
- < P79 and P84 >



 $<\!P85$ and $A2\!>$

SIDE VIEW - CHIẾU CẠNH



< Middle support Bearing >

SIDE VIEW - CHIẾU CẠNH





Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

8.6.2 Expansion Joint

8.6.2.1 Design of Expansion Joint for Main Bridge

(1) Selection of Type of Expansion Joint between Main Bridge and Approach Bridge

In order to select appropriate types of expansion joint for Approach Bridge and Main Bridge, the comparative study was conducted.

- 1) Comparative Study on Type Selection
- a) General

For optimizing the type of expansion joint, the comparative study was performed by introducing various types of expansion joint as follows,

Alternative-1: Rubber Joint (Transversal Type) Alternative-2: Steel Finger Joint Alternative-3: Steel Joint (Module Type) Alternative-4: Aluminum Alloy Joint (Triangle Comb Type)

b) Result of Comparative Study

The result of comparative study is shown in the table on the next page.

As shown in the Table, Alternative-4, Aluminum Alloy Joint (Triangle Comb Type), is recommended because of its advantages in lifecycle cost and durability. In case of large longitudinal displacement, however, because this type of joint has limitation in adapting up to 250m of the expansion, Alternative-2, Steel Finger Joint, which can be fabricated by order-made for adjusting its dimensions, is recommended.

Table 8.6.2-1 Comparison on Type of Expansion

		326	ŀ	, du s		16	0 0	9	ç	1	10	~	\$.9	ida 5	0	10
Alternative No.4 Altanianun Alloy Joint (Triangle comb type)				the head of a minimum component model of a legity weight and durable spatiest and, soil and start. Waterpoor fundors inclusive yours control model weight through your brocker. It opendicately you shope at trustent and starts follow any brockershop for direction) movement. This is load upp or type.	Allowable Expansion: 230 (±115) Notch Depth: 230mm	Investment ¥ 772,000 /m at first Makeria ¥ 652,000 /m Construction ¥ 120,000 /m 1.	Matternine ¥ 802,000 Ån auf repair \$ 85,000 Ån Lidit opide send 32000 Ån Tidit opide send 32000/2018 = 1,641,660 Ån 1, 2640,660 100 = 2,640,660 Ån 1,	Electore is a bit deep, but there is comparatively no intributed for deep plate. Construction is idean ploted within generation joint which is adjusted in the bridge within all that reministration are remedied and a delated. And fitnilly, plating concrete is meaned. It is quite wifthied construction method	The body is steed so rightly at high and it is durable. There as a conteen that may abruption of water cut-off rubber set in the point occurs.	It is possible to change parts by parts, but cannot change the way ansion body itself carb. "When need it, it is needed to chip the concrete at large area to change the ray maion body. Durkble Period. Stowess	Procurement Platio: 84%	There is no major difference in spp earance.	Aluminum Alloy Joint is new technology.	Unlater any rep. (gap, app control between lath lim and right frace from strondural viewp out, performances a quick good for extent layed of goddent and vortation. There is concern that lay risp (gap) appears case of standar brutge life steel grider.	It is efficient for wher cut-off because water proof rubber is ret by pressing a threa expension random to the sing joint. There is a consent that real and stand source give to conserving of derive, wh cutses shrup tion at adherine bonding part.	Vehicle running is smooth by triangle face plate and it has artifice to decrease the vehicle running noise. How ever, noise at joint gauge down is possibly big.	Most recommended. It is superior in durability to others as well as steel finger
				art 5		16	» इ	ي چ وا	c E	sta gig	2	×	~	is:	m		99
Alternative No.3 Steel Joint (module type)	And the second			been is set al. The net provides of the firms and solutions. By the set of the net is set al. Then it even al or in the exploring under disertant principal multi-set of the set of the	A llow while Exp ansion: 240 (±120) Noteh Dep th. 400mm	Investment ¥ 782,000 fm at first Material ¥ 622,000 hn Construction ¥ 160,000 hn	Munichemance ¥ £21,000 hm and reput Material \$ 62,2000 hm Construction # 20,0000 hm Life options 4100 years 782,000+ (\$22,000-4) = 4,070,000 hm 4,070,000 fm0 = 42,000 year	It is needed to have big blockout for coarset a manker (doc). Weigh the body is big to it would be lage soled construction by heary or	It is steel structure and quite strong. Warenproof rabber is set at bear conduit, so it doestit need to be worried for dhip pag off.	It is possible to do small scaled matterance by changing μ arts by a large were, it possibly would be king scaled by table and the single scaled by the start of the start	Procurement Ratio: 80%	There is no major difference in app earance.	Commonly Used in Vietnam	This system responds to the movements by reading on the goder by beeing at top/hottom. Some numbers of been adjustment conduit as to 6 cause the releasing by relation examing.	As for deninga, simple structure such as seeling rubber put into end bean and middle beam is applied. So, were agrithered into domin to different from this Mehad side 2 diematives. Regulare instant earnors is needed to keep quality of performance for wate cut off	Irup at noise is comparatively big when which ecoses the beam adjustment conduct. Notes which goet through down from the adjustment room is also big	Less recommended. A though durbilly, construction, and water cut-off ability are
_				00		×	a	v	ŝ	4	10	s.	ŝ		-4		
Alternative No.2 Steel Finger Joint				The parasist means to researchy our test efforts of the entres of the constrainty of a flexy plate (politic index). The oilstness is and monite dependent of the entry of the entry of the entry of the entry of the entry plate. Since a be concluding all hybridized flow more water flexibles the entry of the entry of the entry of the entry of the locater by charity and grading and tables materials setting below they plate. This is fold supporting any tables materials setting below they plate. This is fold supporting the approximation of the entry of the entry of the support of the support of the entry of the entry of the entry of the entry of the support of the support of the support of the entry of th	Allowable Expansion: Any expansion amount is available. Notch Depth: Approximately 400mm	Investment ¥ 970,000 fm at first Material ¥ 820,000 /m Construction ¥ 150,000 /m 1.3	Maintenance # 1,000,000 hn Maintenance # 1,000,000 hn autopair National # 18,0000 hn Lifereda at 31,000,000 hn Lifereda at 30,000 hn 270,000 + (1,000,002.133) 3300,000 hn 3300,000 ho 3300,000 hn	Store it is set up before doct allo contrarts planns, in case of steel given example of planns of givine deformation at weap stage of out-contracts planns, and the control of filtuness of both side into plans is quite planns parted.	It is strong from structural wire posts and daught. It is concerned the stripping of the electric scal for wate cut-off ocure.	Equanciam joint itaelf cannot be removed alone, so it need to hare a lot of work such as dripp fag consets at Jugs area. Dunishe Pereol. 310 verses	Producement Ratio: 85%	There is no major difference in ap pearance.	Commonly used in Vistnam	These say gap is appeared in structural life much right fore place, performance is quite good for earlian lared of geologist and rotation. There is concern that any step areas in case of sheader bridge like steel bridge.	There is indication of wate activity image labor is call maternal. It is concerned that filling about the becommend by stress to be concentrated to boundary face of the elastic seal material	If road surface is not seen by girder rotation, imp act noise between comb-thap edjoints is a comparatively big. But the noise is not easily t go down because of filling of dentite seal material below joint.	Recommended. Its durability is sugenor to others, but comparatively inferiors road environment and construction are set to 08
	- É			ittle the 4		20	0	ite 10	ch to	ہ 2 ی	10	5	\$	18	e s v	ed	55
Alternative No.1 Rubber Joint (Tlansverse Type)				deformations of insight institutions and equal by Materiang deformations of children $T_{\rm eff}$ and $T_{\rm ef$	Allowable Expansion : 200mm (±100mm) Notch Dapth: 180mm	Investment ¥ 721,000 fm at first Material ¥ 601,000 hm Construction ¥ 120,000 fm i	Maniferrance 7 52,000 fm ad trep in: Material W 601,000 fm Constructions 7 15,000 fm Lids cycle const 2010 or + 73,000 fm 7,802,000 (100 = 7,802,000 fm 7,802,000 fm 7,802,000 (100 = 7,802,000 fm 7,802,000 fm 7,802,0000 fm 7,802,000 fm 7,8	Construction condition does not serious restriction due to hallow dopt in counting does. After steel regramming uput is anchored at anchorage reminiverse pares, concrete as placed. Therefore, this is qu aimple way of construction.	Loud is absorbed and distributed by tubber elarvitety and steel rapidary, and a three most in a possible are deresse awy bud differ derk place. Funt proof is searced by adopting authorn material with a seq good for wathering and on twistient to gather with all costed at turbuture. But it need any artifice for sem-and of tubbe surface	When replacement, no need to disp the concrets, and it is possible change only device of joint. It takes minimum time for replacement and it is earby constructed. Duration of Link: 10 v enes:	Procurament Ratio: 83%	There is no major difference in appearance.	Transversal Type Rubber Joint is new technology.	impact by the algo serving is control by university or more and rubber. It is corresponded to universe deads place by rockston of gird Rosk streftee water efteringes in good condition by surface rubber pattern, so stip is not easily cocurred.	The expansion joint is combering of and road arrithoe water farms is good. There are seal material & downpout, which is second wat cut-off function.	Noise is minimum due to absception and distribution of imp set of vehicles persingly the tubble charticity. Each up material is arrest at the water calcuff rubber, so noise is shut off to downward.	Not Recommended. Although the investment cost is the low est, this
			Score	10			6	10		<u> </u>	10	s.	5		w.		100
	General Viaw		Evaluation Item	tructure Asp ect and Stabilêy			Cost Up er Investment Lower Life Cycle)	Construction Plan and Period	M aintenance an d	Durability	STEP Clearance	Aesthetics	New Tedinology		Environmental Impact/ROW / raffic Management		Evaluation

- (2) Design of Expansion Joint between Main Bridge and Approach Bridge
 - 1) Calculation of Necessary Expansion between Main Bridge and Approach Bridge

The necessary expansion between Main Bridge and Approach Bridge was calculated based on the results of the structural analyses for the design of the main girders.

a) Conditions of Analyses

The conditions are as follows;

- Temperature Range: 40 degrees
- Coefficient of thermal expansion: 1.08E-05
- Model of Creep and Shrinkage: CEB-FIP90
- Degree of Humidity: 80%
- b) Results of Calculation

The results of analysis are as follows;

	Main Bridge	Approach Bridge	Total
Movement due to Temperature Alternation	103.8	59.0	162.8
Movement due to Creep & Shrinkage	84.2	58.3	142.5
Total	187.9	117.3	305.2

Table 8.6.2-2 Longitudinal Movement at Ends of Main Girders

Unit: mm

c) Expansion Joint to be applied

The expansion joint to be applied between Main Bridge and Approach Bridge is a steel finger type joint as shown in the figure below because the necessary expansion is more than 250mm. The gap between the edges of the main girders is set as the standard gap of the type of the joint.





(b) Longitudinal Cross Section

Source: Study Team



8.6.2.2 Design of Expansion Joint for Approach Bridge

In the design of Expansion joint, it is necessary to decide the following matters.

- (1) Decision of Expansion gap
- (2) Amount of movement of girder end

When the above-mentioned item is decided, it is necessary to calculate the amount of the movement of girder end. The amount of the movement applies the result of calculation from the structure analysis on a main girder.

Hai an side Approach Bridge (1)

1) Movement of main girder

The amount of the movement is calculated by the structure analysis on the main girder, and is shown in the table below.

							Unit : mm
Iton	Position	E1	P1	P2	P3	P4	E2
nen	Node Num,	1	23	44	65	86	108
1	Dead Load	-8.9	-8.5	-3.8	-2.1	-0.7	-0.7
2	Prestress	26.9	16.1	3.8	-3.1	-7.7	-10.4
3	Creep and Shrinkage	59.6	34.7	10.6	-12.6	-35.3	57.6
4	Temperture 40°C	58.9	35.5	11.7	11.9	35.7	59.2
5	Earth Quick Kh=0.18	142.7	142.6	142.6	142.6	142.6	142.7

Table 8.6.2-3 Amount of the movement

Source: Study Team

Decision of expansion gap 2)

Expansion gap of girder end is decided to the following conditions.

a) Expansion gap when the girder end Segment is set up is assumed to be 30mm.

Expansion gap must be secured for temperature change (temperature increase 40 $^{\circ}$ C) immediately after structure completion.



Source: Study Team

Figure 8.6.2-2 Movement of girder end

Expansion gap from the pier center or front parapet is assumed to be 120mm as shown in the above figure at the point of Creep and shrinkage end.

Expansion gap requirement L=117mm

Therefore, it is provided 120mm as Expansion gap

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3) Design movement of expansion joint

The design movement applied to the expansion joint considers the movement after the girder is completed. Because after girder is completed, expansion joint is set up.

Item	unit	Movement	Remarks
1. Creep and Shrinkage	mm	59.6	
2. Temperature change(40° C)	mm	58.9	
3. design margin	mm	1.5	
Design movement	mm	120.0	

Table 8.6.2-4 The design movement applied to the expansion joint considers the movement after the girder

Source: Study Team

Therefore, the amount of design movement at the abutment and pier is as shown in following table.

Table 8.6.2-5 The amount of design movement at the abutment and pie

Place	unit	Movement	Remarks
Abutment A1	mm	120	
Pier	mm	240	

Source: Study Team

4) Selection of expansion joint

Expansion joint is selected according to the result of comparative Study on Type Selection of main bridge.

The design movement of Hai an side approach Bridge is comparatively small with 120mm and 240mm.Therefore, it adopts made of the aluminum alloy.

- a) Relation between allowance and design movement of expansion joint.
- < A1Abuttment >

Cipec joint Wj -160. allowable movement : allowable expansion gap :	160mm 150mm	> > Ok	Design movement 120 120	mm mm
Cipec joint WY-320. allowable movement : Allowable expansion gap :	250mm 435mm	> > OK	Design movement 240 240	mm mm

< Pier >

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(2) Cat Hai side Approach Bridge

1) Movement of main girder

The amount of the movement is calculated by the structure analysis on the main girder, and is shown in the table below.

							Unit; mr
Item Position Node Num,		E1	P1	P2	P3	P4	E2
		1	16	34	52	70	85
1	Dead Load	-1.6	-0.9	0.0	0.0	1.0	1.7
2	Prestress	6.7	3.0	1.1	-0.8	-3.0	-6.6
3	Creep and Shrinkage	41.2	25.0	9.0	-7.3	-23.4	-39.5
4	Temperture 40°C	58.2	36.7	13.0	10.6	34.3	-55.7
5	Earth Quick Kh=0.18	117.6	117.5	117.4	117.3	117.3	117.3

Table 8.6.2-6 Amount of the movement

Source: Study Team

Decision of expansion gap 2)

Expansion gap of girder end is decided to the following conditions.

a) Expansion gap when the girder end Segment is set up is assumed to be 30mm.

Expansion gap must be secured for temperature change (temperature increase 40°C) immediately after structure completion. CL



Source: Study Team

Figure 8.6.2-3 Movement of girder end

Expansion gap from the pier center or front parapet is assumed to be 120mm as shown in the above figure at the point of creep and shrinkage end.

Expansion gap requirement $L=78+20=98mm \rightarrow 120mm$

Therefore, it is provided 120mm as Expansion gap

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3) Design movement of expansion joint

The design movement applied to the expansion joint considers the movement after the girder is completed. Because after girder is completed, expansion joint is set up.

Item	unit	Movement	Remarks
1. Creep and Shrinkage	mm	41.2	
2. Temperature change(40° C)	mm	58.2	
3. design margin	mm	20.6	
Design movement	mm	120.0	

Table 8.6.2-7 The design movement applied to the expansion joint considers the movement after the girder

Source: Study Team

Therefore, the amount of design movement at the abutment and pier is as shown in following table.

Table 8.6.2-8 The amount of design movement at the abutment and pie

Place	unit	Movement	Remarks
Abutment A2	mm	120	
Pier	mm	240	

Source: Study Team

4) Selection of expansion joint

Expansion joint is selected according to the result of comparative Study on Type Selection of main bridge.

The design movement of Hai an side approach Bridge is comparatively small with 120mm and 240mm.Therefore, it adopts made of the aluminum alloy.

- a) Relation between allowance and design movement of expansion joint.
- < A1Abuttment >

Cipec joint Wj -160. allowable movement :	160mm	>	Design movement 120	mm	
allowable expansion gap :	150mm	> Ok	120	mm	
Cipec joint WY-320.			Design movement		
allowable movement :	250mm	>	240	mm	
Allowable expansion gap :	435mm	>	240	mm	
		OK			

< Pier >

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(3) dimension of Expansion joint

< A1 and A2 Abutment >



Sectional view S=1:8

< Pier >

Sectional view S=1:8



Source: Study Team

Figure 8.6.2-4 Expansion Joint on Approach Bridge

8.6.2.3 Joint Protectors

For Main Bridge, the unidirectional pot bearing guides the girder to move in the longitudinal direction so that the joint can be protected from transversal movement of the girder.

For Approach bridge, the laminated elastomeric shoe with side blocks guides the girder to move in the longitudinal direction so that the joint can be protected from transversal movement of the girder.

8.6.3 Railing

8.6.3.1 Comparative Study on Handrail

(1) Conditions of Study

In order to select the most reasonable type of Guardrail, alternatives for comparison are introduced as follows,

- Alternative -1: Aluminum Handrail
- Alternative -2: Steel Handrail
- Alternative -3: Concrete Wall + Steel Handrail
- Alternative -4: Concrete Wall

The handrail is an item which generally requires periodical replacement. Therefore, lifecycle cost is also introduced in addition to investment cost in the evaluation item for cost so that cost for replacement can be evaluated quantitatively.

(2) Result of Study

1) Results of Comparative Study

The table on the next page shows the result of the comparative study.

As shown in the table, results of comparison reveal that Alternative-3, Concrete Wall + Steel Handrail, is most preferable for the following reasons;

- Reinforced concrete wall resists the impact of collision.
- Reasonable Cost.
- Superior in Aesthetics.

The precaution is noted as follows,

Regarding anti-corrosion for concrete wall, appropriate cover is generally considered in accordance with design standards. However, because it will be difficult to keep sufficient cover for costal condition, surface coating is recommended to protect against salt attack.

Handrai
e for
n Typ
nparison o
Col
8.6.3-1
Table

	;	6	20	20	~	12		4	2	3	3	78	
Alternative-4 Concrete Wall	and the second s	Remforced concrete reasists the impact of collision. Due to heavy wait, the dimensions of superstructure and substructure are required to be larger than other alternatives.	Investment ¥ 22,345 (m at first Concrete Costing ¥ 11,520 (m Concrete Costing ¥ 17,825 (m	Munitennice ¥ 17.825 (n. autentien ¥ 17.825 (n. autentien ¥ 17.825 (n. Life cycle cast Construction ¥ 17.825 (n. 29.445 (t) 7.825 (s) = 10.8220 (n. 29.445 (t) 7.825 (s) = 20.97 (s) = 20.97 (set	Construction work is in-situ concrete placing, which is simple and ordinary.	Regarding anti-constant will a proposite correct visi providerad in reconduce with design standards. However, because it is difficult to keep sufficient cover for cossist condition, suffice condag is required to protect against sail attack.	Bára concrete protection is required. Láte y ear 100 y ears	10% (Prelininary Estimate)	The high wall makes oppressing feelings and shuts the side scenery from driver.	No new technology is used.	No major environmental impact.	This alternative is superior in economic but inferior in aesthetics. Heavy weight is also disadvantage for the superstructure and substructure.	Less Recommended
ndrail	crete wall is made of		16,185 /m 2 13,175 /m 2 Ratio 1.001	8,300 /m 13,175 /m coating 3times 93,785 /m 93,785 /m Ratio 1.132	and rails etting,	oprinte cover is . However . . coastal condition. It attack	ig term, coating as odical cleaning and ycars	1				, economic and	Γ
Alternative-3 oncrete Wall + Steel Ha	and the second s	esists the impact of collisio tives 1 and 2.	29,360 /m Material ¥ Concrete Coating ¥	21,475 /m 21,475 /m Alterial ¥ d Concrete Costing ¥ replacement and concrete 00*3+13175*3) = 93,785 / 100 =	rre in-situ concrete placing : ordinary.	wanized. sion for contrete wall, appra nere with design standards to keep sufficient cover for luized to protect against sal uized to protect against sal	l rail is not durable for a lon ive 2 is recommended. Perio d. 3 years, Concrete Walf: 100.	mate)	≩h Alternative-2.	s used.	ital impact.	perior in structural stability.	Most Recommended
0	n 10 Minute Alignment 10 M	Reinforced concrete 1 5 Heavier than Alternat	Investment ¥	Maintenance ¥ and repair Life cycle cost Rail an 29,360+(83	Construction works a which are simple and	Hand Kail is to be gal Regarding articorro- considered in accord because it is difficult surfree confing is req 9	Since galvanized stee described in Alternat repainting are require Life year: Handrail:3(0 62% (Preliminary Esti	Sinilar appearance wi	No new technology ii 3	No major environmen 3	This alternative is sur aesthetics.	
	13 years after completion ed. corresion (true) after.		48,700 /m 6,500 /m Ratio 1.881	48,700 /m 10,000 /m 231,300 /m 2,310 /year Ratio 2.793	necessary to (suffice was ew points . wy the following fixiouss. (2) (20 do so high, enough so high, enough hore area, fluorine	ugh it is durable sy, periodical	1	ust and color			4	Γ
Alternative-2 Steel Handrail	a an complet which pass of durary respanning is delay durary respanning is delay unamin which was added in vuri	med in case of collision.	00 /m Material ≹ Construction ≩	00 /m Material ¥ Construction ¥ innes /100 y ears 5,200 + (58,700/3) = 231,300 / 100 =	required. Furthennore, it is avoid damage of painted	symmetded. In many cases aesthetic and durability vi anit is generally adopted at uniformity with certain th 1. (3) Althought cost is not dustrial zone and on off s telerable.	medial work is casy. A lift wement of paint technolo ired.		ther strength. òr a long time because of i			n economic points.	t Recommended
	holo in the left side shores an act. If the left side shores and so in the side side side side side side side sid	tructural members are defo	avestment ¥ 55,2 at first	intenance ¥ 58,7 and repair ycle cost Replacement 3 5	o heavy weight, a crane is le very carefully in order to	ter place and a second and a second from the second from the second from the second and and second and second and second and second and and second and seco	: site welding is possible, re g to development and impr ing and repainling are requ car: 30 years	(Preliminary Estimate)	ler appearance owing to hig lifticult to keep aesthetics f ilarity due to re-paintings.	ew technology is used.	ajor environmental impact.	alternative is most inferior i	No
	ars The Inut The The Vence	5 The	0	Ma 8 Life e	8 hand	In pr paint For p For p reas dural dural 15 In se	Since owin clean Life J	10 88%	Slenc 5 It is o irregt	3 No n	3 No II	This 58	
Alternative-1 Altunium Handrail	The photo in the left side is a bridge constructed in Todyo Bay area 14 ye ago. These is no officie.	The structural members are deformed in case of collision.	Investment ¥ 65,200 /m at first 65,200 /m Anterial ¥ 58,700 /m Construction ¥ 6,500 /m Ratio 2,222	Maintennee ¥ 68,700 m. and tephi 26,000 m. Life cycle cost Repharement On-construction ¥ 10,000 m. Life cycle cost Repharement On-construction = 133,000 m. 65,200+(68,700-1) = 133,000 m. 133,000-100 = 1.330, vent 1401 m.	The weight is low, which make it easy handling.	Producing conduct conk by least control the superstructure matter constraint control and control and the contr	Since the members are connected by bolks and nuts, exhange/replace of member is easy. Life year: 50years	90% (Prelininary Estimate)	In case with anodized aluminum coating, silver, brown and grey colors are available. The color is hardly faded, it is possible to keep aesthetics for a long time.	No new technology is used.	No major environmental impact.	This alternative is superior in mantenance and aesthetic points.	Less Recommended
tems	, w	t 10		4 64	n 10	15		10	s.	. 5	s	100	
Evaluation I	General Vi	Structural Asp ec and Stability		Construction Cos Upper: Investmer Lower: Life cycle	Construction Plai and Period	Mäintenance		STHP Clearance	Aesthetics	New Technology	Environmental Aspect	Evaluation	

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Sign	Value (mm)	Sign	Value (mm)
h1	500	b1	300
h2	700	b2	319
h3	300	b3	500
h4	279		
h5	321		
h6	100		
S	25		
Hr	500		
Н	1126		
c1	150		
c2	140		
c3			
al	88		
a2	112		
a3			
a4	626		
Lp	74		
Bt1	300		
Bt2	19		
Bt3	181		
Bt	500		

The structure and the dimensions of the guardrail is shown in the following figure.

Source: Study Team

Figure 8.6.3-1 Expansion Joint on Approach Bridge

CHAPTER 9 ELECTRIC WIRING AND LIGHTING FACILITY

9.1 General

This Chapter describes the design base of the electric wiring and lighting facility for the Lach Huyen Port Construction Project.

9.1.1 Design concept for Electric Wiring.

- 1) All cable to be used for roadway lighting shall be of the type and size shown on the Drawings.
- 2) Cables shall be pulled into a pole through conduit installed in the foundation of the pole and shall be connected to the terminals in the terminal box installed in the pole.
- 3) The mounting boxes of all poles shall include an approved terminal block and circuit fuse rated 6 amperes 220 volts accessible through the access plate of pole. The circuit fuse shall protect both the poles and electrical control ballast.
- 4) Cables installed in the pole shall have two conductors of minimum cross section of 2.5 mm².
- 5) Cables shall be attached to the lighting fixture so that lighting fixture terminals do not carry the cable weight.
- 6) Power supply cables to lighting fixture shall be attached to the terminal block so those terminal blocks do not carry the cable weight which shall be fixed by cable tie before reached terminal block.
- 7) All cables shall be delivered with an appropriate test certificate and approved by the Engineer before use.

9.1.1.2 Design concept for Lighting Facility.

The design for the road lighting facility shall maximize the efficient use of energy source as appropriate for the area served. To save energy, the following design criteria are applied to the lighting facility:

1) High pressure sodium vapour lamp(HPSV) is recommended for road lighting with reasons listed below.

Luminaries for the road light shall be selected in the products being available in the local market to secure easy maintenance and execute economical design.

The following product is presently available in Vietnam:

1

Mercury vapour lamp	
High pressure	(pressure sodium lamp will be preferably used
sodium vapour lamp	for the highway lighting **)
Low pressure	
sodium vapour lamp	
Fluorescent lamp **Reasons why used in high	ghway
*Being presently used for the	highway in Vietnam
*Being most efficient and ma	intain long life 132lm/w against 50lm/w of mercury vapour lamp
*10000 hours against 9000 ho	ours of fluorescent lamp
10000 nours against 2000 ne	
*Low insect gathering	

- 2) Lighting control of road lighting will employ photocell switches which shall be required minimum maintenance activity.
- 3) Layout of road lighting will be technically well designed.

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9.1.2 Scope of Works

The work covers the design of the complete lighting facility for the following items;

- 1) The road lighting facility for Tan Vu Interchange, Dinh Vu Intersection and approach and main Bridge.
- 2) The navigation bridge light at the main Bridge for the ship.
- 3) The signal system on Tan Vu interchange shall be considered since the previously planned run-about has been changed to T-junction.
- 4) The lighting system inside the box girders in the bridge section between Km 4.5 and Km 9.99.

9.2 Design standards

The design, manufacture, test and installation of electrical equipment will comply with the latest edition of the standards, codes and regulations, consisting of the following:

- 1) · Standard of Electrical Facilities 11TCN 18; 19; 20; 21- 2006.
- 2) Construction Code of Vietnam QCXDVN 01:2008
- 3) Vietnamese Construction Standard TCXDVN 259:2001 Standard for designing the lighting system of road, street, and urban squares.
- 4) Vietnamese Construction Standard TCXD 333:2005 Design standard for artificial lighting outside urban public and technical infrastructures.
- 5) Vietnamese Standard TCVN 4756:89 Specification on grounding for electrical equipment.
- 6) The letter No1175/TCT-ĐHDA HN-HP dated 29th Oct 2008 of VIDIFI. JSC. Subject: Accepting the electric detail design application plan, Hanoi-Haiphong Expressway Project.
- 7) Technical Regulation on Rural Electric Power Grid by Ministry of Industry 57/2000/QĐ-BCN.
- 8) IEC 60038: Standard voltages.
- 9) IEC 60044: Instrument transformers
- 10) IEC 60076: Power Transformers
- 11) IEC 60228: Conductors of insulated cables.
- 12) IEC 60265: High-voltage switches
- 13) IEC 60269: Low-voltage fuses. Structure.
- 14) IEC 60282: High-voltage fuses
- 15) IEC 60287: Electric cables Calculation of the current rating
- 16) IEC 60331: Test for electric cables under fire conditions Circuit integrity.
- 17) IEC 60364: Low-voltage electrical installations
- 18) IEC 60439: Low-voltage switchgear and controlgear assemblies.
- 19) IEC 60502: Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um=1.2 kV) up to 30 kV (Um=36 kV).

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- 20) IEC 60529: Degrees of protection provide by enclosure (IP code).
- 21) IEC 60715: Dimensions of low-voltage switchgear and controlgear. Standardized mounting on rails for mechanical support of electrical devices in switchgear and controlgear installations.
- 22) IEC 60724: Short-circuit temperature limits of electric cables with rated voltages of 1 kV (Um = 1, 2 kV) and 3 kV (Um = 3, 6 kV)
- 23) IEC 60787: Application Guide for the Selection of Fuse-Links of High-Voltage Fuses for Transformer Circuit Applications
- 24) IEC 60811: Common test methods for insulating and sheathing materials of electric cables and optical cables.
- 25) IEC 60840: Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) Test methods and requirements.
- 26) IEC 60947: Low-voltage switchgear and controlgear.
- 27) IEC 61557: Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. Equipment for testing, measuring or monitoring of protective measures.
- 28) IEC 61558: Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V
- 29) IEC 62271: High-voltage switchgear and controlgear

9.3 Design conditions

9.3.1 Service conditions

The project area has a hot, humid and tropical atmosphere. Moreover, the surrounding environment has a high degree of salinity.

All electrical equipment, cables, accessories and fittings which form part of the electrical installation shall be fully suitable for use in the following specified service conditions:

1)	Altitude above mean se	:	2.0 n	1					
2)	Ambient temperature	- Maximum	:	45 °C					
		- Minimum	:	5 °C	2				
3)	Relative humidity	- Maximum	:	100%	,)				
4)	Climatic atmosphere		: ገ	Tropica	al				
5)	Wind pressure	: This value shall be Bridge in this Project.	followe	d the	design	criteria	of	Road	and
6)	Earthquake	: This value shall be Bridge in this Project.	followe	d the	design	criteria	of	Road	and
7)	Salt contamination	: This value shall be Bridge in this Project.	followe	d the	design	criteria	of	Road	and

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9.3.2 Design criteria

(1) Electrical system

It is connected with Network of the following electric power company, and the electric power is supplied to substation in four places.

These substations shall be connected by 35kV or 22kV underground transmission line and equipped 35(22) kV/400-220V or 22 kV/400-220V receiving transformer, lighting distribution panel and associated accessory

Power Supply Substation (Power	Power Receiving Substation						
company)	Name	Location	Transformer				
Tan Vu Power Station	SUBSTATION	Around Tan Vu	3ph/4w-31.5kVA-				
	"A"	Interchange	22/0.4 kV				
(Hai An Power	SUBSTATION	3ph/4w-31.5kVA-					
Company)	"B"	22 /0.4 kV					
	SUBSTATION	At the West Side of	3ph/4w-50				
	"C"	Bridge	kVA- 22 /0.4 kV				
Ninh Tiep Power Station (Cat Hai Power Company)	SUBSTATION "D"	At the Eest Side of Bridge	3ph/4w-31.5 kVA- 35 /0.4kV				

Table 9.3.2-1 Technical parameters of power receiving and distribution system

Source : Study Team

(2) Allowable Voltage Drop

The maximum allowable voltage drops between distribution transformer and the furthest fixture shall not exceed 5%.

(3) Cable sizing

The cables shall be covered to the maximum current demand.

The voltage drop was calculated, and the size of the cable for the wiring to each substation and the illuminator confirmed and selected the tolerance.

To refer to the Calculation sheets.: Attachment 9.3.2. (3)

(4) Lighting Arrangement

The lighting fixture shall be designed and arranged for each area so as to meet the following illumination level:

The acceptable value has been shown in the Chapter 4.2 of TCXDVN 259-2001 as below.

- Interchange and Intersection : $\geq 1.2 \text{ Cd/m}^2$ (Minimum luminance on ground)
- : $\geq 1.2 \text{ Cd/m}^2$ (Minimum luminance on ground) Bridge

The arrangement of the illuminator was designed as follows.;

- 1) At the Tan Vu intersection, arrangement shall be made for 2 poles of polygonal beacon light, 17m in height, each pole holds 4 beacon lights of HPS-400W.
- 2) At the road section on HN-HP expressway, arrangement shall be made for 2 lights poles of 12m illuminating the road from opposite
- 3)On the road sections of Tan Vu-Lach Huyen at the Tan Vu intersection, No.1 intersection and the residential area, lighting poles of 11m in height are arranged at the distance of 30m to 33m from pole to pole.
- 4) In the middle of the intersection No.1, one polygonal light (mast lamp) which could be lowered and raised to the height of 25m in the center of the roundabout.
- 5)On the bridge, two lines of lighting poles with the height of 11m are arranged in alternate lines with the 40m distance from pole to pole on the same line.
- 6) Inside the box girders, to serve the purposes of routine maintenance during the operation, fluorescent lights are arranged for lighting.
- (5) Earthing system

The exposed metal frames of all electrical apparatus and machinery not forming parts of the electric circuits, neutral of transformers, etc., shall be earthed.

1) Earthing conductor, plate and rods

The following materials shall be used for earthing systems;

- a) Earthing conductor: Annealed copper stranded conductor.
- b) Earthing plate: 90 cm square, 1.5 mm thickness copper plate or equivalent.
- c) Earthing rods: 16 mm diameter, 3 m length copper clad steel rod with coupling.
- d) Connectors: Compression type connectors which shall be able to connect the annealed copper stranded conductors each other, earthing plate and rod.
- 2) Earthing works
 - a) Earthing rods, plate and conductors shall be buried deeper than 0.6 M or more from the ground surface.
 - b) The connection between earthing conductor and ground rod, plate and equipment connection conductor shall be electrically and mechanically rigid.
 - c) Earthing systems of the instruments equipment shall be done by separately from common ground.
 - d) The earthing for transformer neutrals and lightning arresters, earthing rod shall be installed in additionally for interconnections with earthing mesh.
 - e) Boundary fences shall be earthed by means of earthing rods, separately from the main earthing mesh.

(6) Lightning Protection

Structures which are made of metal and be electrically continuous do not require a separate down conductors for lightning connection.

Structures and equipment outside the protection zones shall be directly earthed as close to the base as possible.

(7) Wiring design

1) Medium voltage wiring:

Medium voltage wire line supply between transformers and supply from connection power which is using underground cable, will has anti-proof and anti-corrosion, it will pass in HDPE pipe and bury underground with minimum depth 0.7 m along side walk.

2)Low voltage wiring:

- Low voltage wiring for electric supplying on the road will pass in HDPE pipe and bury underground with minimum depth 0.7 m to lighting poles.
- Lighting axial cable low voltage wiring on the bridge will pass on cable support bar inside box girder to the lighting control box.
- Low voltage wiring for lighting supply on the bridge will pass in HDPE pipe inside parapet concrete of the bridge.

9.4 Equipment and Material

9.4.1 General

- (1) The design shall be based on suitable protection of personnel and equipment during operation and maintenance, reliability of service, ease of maintenance, the provision of future loads, and convenience of operation.
- (2) It is necessary to select the design considered enough to reduce it to the salt damage and the equipment.
- (3) All equipment and materials to be furnished shall be commercially well known, proven for use in plant applications and designed and manufactured according to good engineering practice.
- (4) The standardization of equipment shall be stressed.
- (5) All equipment and materials to be supplied shall be new, and within 3(three) years after manufactured.

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9.4.2 Equipment

(1) Type of structure for transformer (Substation)

Transformer, supplying electricity for lighting, is in saline area. Therefore, beside requirement of equipment property is anti-corrosion, the equipment is also put in closed area in order to mitigate impact of onshore wind to the equipment.

Figure 9.7-4 shows two type of transformer: synchronized type and hanging type for study and comparison;

Based on comparison results and in order to satisfy the above requirement, JICA Study Team recommends a synchronized transformer for lighting supply.

- (2) Lighting distribution board
 - 1) The lighting distribution board installed in the area shall be of outdoor use, metal enclosed cubicle type, and self-standing type, corrosion resistant, vermin-proof.
 - 2) The distribution board shall be enclosed the distribution transformer and shall include necessary protection devices, circuit breakers and accessories be mounted on steel base channels.
 - 3) The distribution transformer shall be enclosed into the distribution board to be the following specifications in consideration of a surrounding environment;
 - a) Type : ONAN
 - b) Rating
 - Substation "A" & "B" : 31.5kVA-22/0.4kV-50Hz, Un%=4%, Δ/Y_0-11 , Udc $\pm 2x2.5\%$
 - Substation "C": 50kVA-22/0.4kV-50Hz, Un%=4%, ∆/Y0 -11, Udc ± 2x2.5%
 - Substation "D": 50kVA-35(22)/0.4kV-50Hz, Un%=4%, ∆/Y0 -11, Udc ±2 x2.5%
 - 4) The degree of protection provided by an enclosed shall be IP54 in accordance with IEC 60529, as a minimum.
 - 5) The road lighting of each area shall preferably be automatically controlled by photo-electric cell devices.

(3) Structural and architectural lighting pole

As the project runs through area of aerodynamic lad, with great impact of wind, it is necessary to design the architectural structure in harmony with the total architecture of the Project, to ensure the phototropism, without causing the confused eyesight, and particularly, the wind-facing area must be made smallest for resistance against tremendous typhoons in the Eastern Sea. Upon the requirements, JICA Study Team proposes that:

1) The light poles have no extension arm but only one pole, directly fixed on the top of the pole.

After having studied and compared three types of light poles as shown on Figure 9.7-1, alternative 1-Pole without extension arm is recommended.

- 2) The 17m high polygonal beacon light pole is installed with 4 beacon lights attached directly to tube beams. These two poles are located at the Tan Vu intersection. To refer to Figure 9.7-7.
- 3) The 25m high polygonal beacon light pole is installed with 8 beacon lights attached to the ring holder of the movable set. To refer to Figure 9.7-8.
- 4) The traffic lights set it installed on the 6.2m pole which can be raised at 7m, positioned in the center of roundabout lighting the lanes.
- 5) Lighting pole material is also studied and compared with two alternative: steel pole and moulded aluminum. Result of the comparison and recommended alternative of steel -pole are shown on the drawing Figure 9.7-2
- (4) Selection type of lights

The lights should be corrosion proof when they are operated in saline environment.

Moreover, the lights shall be designed to perform automatically the electricity economization function.

Therefore, JICA Study Team proposed the following alternatives:

- 1)The road lights are of two-compartment optical lighting, in full operation of both compartments during the peak time, and one light is operative during the low time alternatively to ensure the lasting long life of the equipment.
- 2) The beacon light for street lighting at Tan Vu intersection is operated with 2 levels of capacity; running at full capacity during the peak time and automatically retuning to lower capacity during the low demand time to ensure economical consumption of electricity.
- 3) Beacon light for Intersection No.1 is the light of twin power mains, with 2 bulbs and one optical set. During the peak time, the mains operate at maximum capacity, and during the low time, the mains will automatically return to half capacity with one light off for economical purpose.
- 4) Two types with different shape are compared as shown on the drawing Figure 9.7-3.

Result shows the alternative 1 although is more expensive than alternative 1 but it has much predominant advantages which are very suitable to apply for Works locating in maritime area of which salty moistures corrosion and erosion is high, as follows:

- Control gear tightness level of IP65 to prevent from erosion of electrical detail due to sea condition;
- Aerodynamic resistance area = 0.048 m^2 of luminaire unit is small;
- Optical compartment tightness level of IP66 is followed by seal safe technology.
- Service life of the luminaire is durable.

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(5) Road Lighting fixture

In the selection of lamps and fittings consideration should be given to ensure the maximum lamp life, the minimum likelihood of internal moisture accumulation, and also effects of vibration, operating temperature, and breathing.

Types of road lighting fixture and pole shall be shown on the alternative comparison sheet which shall be issued for the decision of TAC and/or PMU2.

Lamps of lighting fixture shall be shown on the alternative comparison sheet which shall be issued for the decision of TAC and/or PMU2.

Materials of lighting pole shall be shown on the alternative comparison sheet which shall be issued for the decision of TAC and/or PMU2.

Types of road lighting fixture shall be of high power factor suitable for stable operation in tropical climate and weatherproof type.

Lighting supports for outdoor lighting shall be of base plate type steel poles painted with suitable colour. Ballast, fuse and terminals shall be equipped in the pole and other attachments necessary for wiring and fixing of the lighting fixtures shall also be provided with the pole.

- (6) Navigation lighting unit
 - 1) Navigation lighting design should be followed below mentioned standard.

* 22 TCN 269-2000 Regulations on Navigation Signals Equipped for Domestic Waterways in Vietnam.

- 2) Lighting unit shall be bracket mounted type and minimum class of degree protection shall be IP65 for entire optical unit and suitable for humid and tropical atmosphere.
- 3) The type:BH-140A proposes though there are the type:BH-140A and the type:BH-998P/ To refer to Figure 9.7-5.
- (7) Lighting System inside Box Girders

Lighting System inside Box Girders contains following equipments,

- 1) Unamour Electric Cable (Cu/XLPE?PVC-0.6/1KV-4C),
- 2) Electric wire (Cu/PVC-0.6KV-1C),
- 3) Flexible Conduit Pipe (HDPE),
- 4) Luminaries (Fluorescent 40W and 20W),
- 5) Electrical Panel (Board Distribution),
- 6) Cable Connection (Pull Box).

The typical drawing of the lighting system is shown in Figure 9.7-8.

9.4.3 Material

- (1) Cable
 - 1) Cable sizing

Conductor size for cables shall be adequate for the load requirements, voltage drop, short circuit current, and diversity factor for individual circuit application.

2) Type of lighting cable

Lighting cables shall be of 600V cross-linked polyethylene insulated PVC sheathed (XLPE/PVC), steel wire armored or steel tape armored PVC outer-sheathed power

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cable (XLPE/SWA/PVC or XLPE/DSTA/PVC) type with suitable cable heads with terminals.

- (2) Steel conduits and flexible conduits
 - 1) Steel conduits
 - (a) Steel conduits shall be steel, hot-dipped galvanized and equipped with couplings and thread protector caps. All surfaces and threads shall be coated with zinc. The sectional areas of a steel conduit shall be, at least, 2.5 times the total cross sectional area of cables to be pulled in.
 - (b) Rigid steel conduits shall be installed for all exposed cable route.
 - (c) PVC coated conduits shall be installed for corrosive area cable route.
 - (d) Couplings and elbows shall be of the same materials as conduit pipes.
 - 2) Flexible conduits
 - (a) Flexible metal conduits shall be used for flexible cable connection route. Flexible metal conduits shall have an interlocked flexible galvanized steel core with a permanently bonded outer polyvinyl chloride jacket.
 - (b) Flexible conduits to be installed inside concrete and below ground shall be HDPE or equivalent.
- (3) Boxes and Fittings

The pull boxes, outlet boxes, fittings and covers shall be of mild steel and/or cast iron alloy with adequate strength and have sufficient size to provide free space for all conductors enclosed.

Pull boxes shall be of hot dip galvanized steel and sufficient size to accommodate the connected conduits and enclosed conductors.

Boxes and fittings shall be plated by melting zinc or coated with rust-preventive paint and tow or more finish coatings.

Outlet boxes shall be of hot dip galvanized steel, square and of sufficient size to accommodate all the required conductors enclosed in the box.

(4) Supporting Steel Materials

The supporting steel materials shall be of hot-dipped galvanized steel with adequate strength for support conduits, cable tray and/or wiring duct.

9.5 Inspection and Test

- (1) Major electrical equipment shall be tested and inspected at manufacturer's shop before shipping in accordance with the requirements of the applicable code and standard.
- (2) All equipment and materials shall be performed in process and/or upon completion of construction activities on all the equipment and/or installation.

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9.6 Drawings

- (1) Shop drawings for the electrical equipment shall at least include: Dimensional outline drawings, floor plans, including anchor bolt locations and cable entrance locations.
 - 1) Equipment weight.
 - 2) Schematic (wiring) diagrams.
 - 3) Bill of material describing components of multi-component equipment.
- (2) Installation working drawings shall at least include.

1) Complete one line diagrams showing power distribution with necessary ratings, specification, cable size, and so on.

- 2) Lighting distribution board layout with necessary detail for installation.
- 3) Cabling layout for lighting cabling work.
- (3) Road Lighting fixture layout and cabling layout.
- (4) Layout plans showing all earthing wires.
- (5) Typical installation method of the electrical equipment, local equipment, junction and pull boxes, cables, etc,
- (6) Cable schedule showing:
 - 1) Cable number, number of conductor, conductor size, and length.
 - 2) Type of insulation, shielding, armor and jacket if applicable.
- (7) Lighting panel and fixture schedules.
- (8) Other information and drawings necessary for construction work.

9.7 Figures

Several typical drawings listed below are shown in the next pages for illustration of the works.

Figure 9.7-1: Typical Lighting Pole and High Mast

Figure 9.7-2: Lighting Pole Material

- Figure 9.7-3: Street luminaries
- Figure 9.7-4: Lighting transformer Station
- Figure 9.7-5: Navigation Light

Figure 9.7-6: 17m High Mast

Figure 9.7-7: 25m High Mast

Figure 9.7-8: Plan of Lighting Inside Box Girder

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Source : Study Team







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CHAPTER 10 CONSTRUCTION PLANNING

10.1 PROJECT OUTLINE

- 10.1.1 Work Content
- 10.1.1.1 Work Content

The Works contain following major items.

- 1) Temporary Works
- 2) Hai An side works
 - (1) Soft soil treatment works
 - (2) Road works
 - (3) Approach Bridge works
 - (4) Box culvert and pipe culvert works
 - (5) Cam river bridge works
- 3) Main bridge works
- 4) Cat Hai side works
 - (1) Soft soil treatment works
 - (2) Road works
 - (3) Approach bridge works
 - (4) Box culvert and pipe culvert work

10.1.1.2 Bridge type and working method

Bridge type and working method are as follows.

- 1) Approach Bridge
 - Foundation Steel Pipe Pile and Bored Pile
 - Superstructure PC Segment Span-By-Span Method (SBS Method)-Hai An side Cast in-place Cantilever Method -Cat Hai side
- 2) Main Bridge
 - Foundation Steel Pipe Sheet Pile (SPSP) serving for temporary cofferdam as well
 - Superstructure Cast in-place cantilever method

Major Work Quantity 10.1.2

Major work quantity is shown below table.

	Description	Unit	Quantity
Ι	Bridge	m	
I-1	Approach Bridge Section-1	m	
	Steel Pipe Pile D=1.1m	t	
	Bored Pile D=1.5m	m	
	RC Pile 350x350	m	
	Concrete 50Mpa	m3	
	Concrete 28Mpa	m3	
	Reinforcement Bars	t	
	PC Tendon 19S15.2	t	
	PC Tendon 12S15.2	t	
	PC Tendon 1S28.6	t	
	Embankment	m3	
	Geotextile	m2	
	Sub-base Course	m3	
	Base Course	m3	
	Asphalt Concrete Binder Course t=70mm	m2	
	Asphalt Concrete Surface Course t=50mm	m2	
	Asphalt Concrete Surface Course t=75mm	m2	
I-2	Main Bridge section	m	
	Steel Pipe Sheet Pile D=1.2m	t	
	Concrete 40Mpa	m3	
	Concrete 28Mpa	m3	
	Reinforcement Bars	t	
	PC Tendon 19S15.2	t	
	PC Tendon 1S28.6	t	

Table 10.1.2-1 Major Work Quantity

-			
	Asphalt Concrete Surface Course t=75mm	m2	
I-3	Approach Bridge Section-2	m	
	Steel Pipe Pile D=1.1m	t	
	Bored Pile D=1.5m	m	
	RC Pile 350x350	m	
	Concrete 40Mpa	m3	
	Concrete 28Mpa	m3	
	Reinforcement Bars	t	
	PC Tendon 19S15.2	t	
	PC Tendon 12S15.2	t	
	PC Tendon 1S28.6	t	
	Embankment	m3	
	Geotextile	m2	
	Sub-base Course	m3	
	Base Course	m3	
	Asphalt Concrete Binder Course t=70mm	m2	
	Asphalt Concrete Surface Course t=50mm	m2	
	Asphalt Concrete Surface Course t=75mm	m2	
Π	Road		
II-1	Hai An Side		
	Embankment	m3	
	Slope Protection	m3	
	Soft Soil Treatment-Sand Drain Pile	m	
	Geotextile	m2	
	Sand Blanket	m3	
	RC Pile 350x350mm	m	
	Structural Concrete 28Mpa	m3	
	Reinforcement Bars	t	
	Sub-base Course	m3	
	Base Course	m3	
	Asphalt Concrete Binder Course t=70mm	m2	
	Asphalt Concrete Surface Course t=50mm	m2	

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II-2	Cat Hai Side		
	Embankment	m3	
	Slope Protection	m3	
	Soft Soil Treatment-Sand Drain Pile	m	
	Geotextile	m2	
	Sand Blanket	m3	
	RC Pile 350x350mm	m	
	Structural Concrete 28Mpa	m3	
	Reinforcement Bars	t	
	Sub-base Course	m23	
	Base Course	m3	
	Asphalt Concrete Binder Course t=70mm	m2	
	Asphalt Concrete Surface Course t=50mm	m	

Source: Study Team

10.1.3 Major Materials to be incorporated in the works

Major materials to be incorporated in the works are shown on the table below.

Table 10.1.3-1 Major Materials

	Procurement From					
Major Material	Vietnam	Japanese Firm in Vietnam	Japan			
Embankment Material	0					
Crushed Stone for Road	0					
Sand for Sand Drain Pile	0					
Material for Geotextyle	0					
RC Square Pile	0					
Asphalt Concrete	0					
Guard Rail, Lighting Post etc	0					
Water Pipe	0					
Cement		0				
Coase Aggregate for Concrete	0					
Fine Aggregate for Concrete	0					
Steel Bar		0				
PC Wire		0				
Steel Pipe Pile		(O)	0			
Steel Pipe Sheet Pile		0	0			
Shoe		(O)	0			
Expansion Joint		(O)	0			
SBS Erection Girder			0			

Source: Study Team

10.2 TEMPORARY FACILITIES

10.2.1 Temporary Facilities Outline

Temporary facilities contains following major items.

- 1) Temporary offices and plant yard.
- a) Temporary office for contractor with contractors' accommodation.
- b) Concrete batching plant- 1set x 90m3/hr
- c) Asphalt plant-2set x 200t/hr (one in Cat Hai)
- d) PC Segment fabrication yard-5 casting beds
- e) Material stockyard
- f) Machinery work shop
- 2) Temporary access road
- a) Entrance Access Road from public road
- b) Site Access Road
 - Mound type road
 - Mound type with sand/soil filled tube
 - Steel staging type road
 - Temporary bridges
- 3) Temporary jetty (Hai An side and Cat Hai side)

Marine Concrete Batching Plant-2x 60m3/hr

- 4) Dredging work
- 5) Navigation channel safety measures
- 6) Existing utilities and connection

Temporary facilities are shown on Appendix Fig. No. CP-10-1 and CP-10-2.

10.2.2 Summary of Temporary Facilities

Summary of temporary facilities are shown on the table below.

Description	Location	Code Nam	Length or Area	Top widt	Controlled By		Not
1 Temp. Road			71104				<u>^</u>
1-1 Entrance Acces sRoa	d						
Hai An side	KM 0 KM 2.4 KM 3.2 KM 8 1	A-1 A-2 B C Temp letty	1.5km 2.3km	3m 3m 6m 6m	Hai An PC Hai An PC Hai An PC Hai An PC	VIDIFI DVIZ DVIZ	Access from public road to KM0 (Existing Road) Access from A-1 to KM0.4 (Existing Road) Access from DVIZ internal road to Access from DVIZ internal road to Compound-2 Access to marine vascel and Cat Hai
	KW 0.1	10mp seas					Access to marine vesser and cat trai
Cat Hai side	KM 9.6	Temp Jetty					Access to marine vessel and Hai An
1-2 Site Accsee Road and Bridge	KM 0-KM4.1 KM4.1-KM8.1	Туре-А Туре-В	4.1km 4.0km	5m x 2 5m x 2	Hai An PC		Including temporary bridge at KM1.7
	KM10.5-KM10.9	Туре-С	6.0km	6m	CatHai PC		
2. Site Compound							
-	KM 1.8 KM3.4 North	Compound-1 Compound-2	50,731m2 91,800m2		Hai An PC Hai An PC	DVIZ	Road material stockpile Concrete, Asphalt, Segment Plant
	KM 7.9	Compound-3	40,171m2			NAMDV	Contractor's office Stockpile for piling, Erection girder
	KM 9.8 KM 10.0	Compound-4 Compound-5	28,019m2 45,295m2		CatHai PC CatHai PC		Stockpile for piling, Road material stockpile, Traveller, (asphalt plant-altanative)
	KM 15.5	Compound-6 Compound-7	16,028m2 40,448m2		CatHai PC CatHai PC		Stockpile for unsuitable material Road material stockpile, Asphalt Plant
3. Dredging Area	KM8.1-KM9.0						
4. Dumping Area	KM7.5-KM8.1	CX2A, CX3A				NAMDV	
5. Ferry Terminals	Hai An and Cat H	lai Ferry Tern	ninals		Hai Phong O Waterway T Company	ne Member raffic Protection	Equipment and material loading and unloading

Table 10.2.2-1 Summary of Temporary Facilities

Source: Study Team

10.2.2.1 Site Compound

Site Compound-2 is a property of Dinh Vu Industrial Zone JSC and their conditions are to be strictly observed.

Site Compoud-3 is a property of Nam Dinh Vu Industrial Park and until now no detail discussion was made.

10.2.3 Temporary Access Road

10.2.3.1 Entrance access road

As the site in Hai An side is isolated, entrance access roads from existing public road are essential. For this purpose three entrance access roads were selected. Entrance access road A be a direct access to Km0.0 point. However, the underpass has been planned with the new expressway. Therefore, Entrance access road A will be limited use for emergency vehicles, etc. Entrance access road B be a direct access to Km2.4 and Entrance access road C be a direct access through Site Compound-2. Other than those land access a marine access to Km1.7 Cam River for sand, aggregate material delivery and temporary jetty at Km8.1 be provided. At Cat Hai side a temporary jetty at Km9.65 be an access point, however existing ferry facility be alSourceful subject to detailed negotiation with Hai Phong One Member Waterway Traffic Protection Company.

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Source: Study Team





Source: Study Team



10.2.3.2 Site access road

Along the permanent road line site access road is also essential to work at several working spots.

For this purpose, mound type roads, Site Access Road A and Site Access Road D, are assumed to be constructed along the section between Km 0.0 and Km 4.1 in Hai An side and between Km10.0 and Km16.6 in Cat Hai side except for except Cam River diversion bridge and box culvert locations.

Mound type roads with sand/soil filled tube, Site Access Road B, are assumed to be constructed for the area affected by sea water, between Km 4.1 and Km8.1 and between Km 9.7 and Km10.0, including mainly the bridge section.

A mound type road widened from the existing dike, Site Access Road C, is for temporary access for the period until the land acquisition and clearance is completed in the residential area between Km 10.0 and Km10.9 in Cat Hai Island.

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(a) Hai An Side



(b) Cat Hai Side

Figure 10.2.3-3 Plan View of Site Access Roads



Figure 10.2.3-4 Typical Cross Sections of Site Access Roads

10.2.3.3 Dredging work

Dredging work is selected in between Km8.1 and Km9.0 in order to allow marine activities instead of steel staging construction. Dumping areas are designed at the locations indicated on the figure below. The dumping area is controlled by Nam Dinh Vu Industrial Park. Therefore close discussion with them be essential in prior to commencement the dredging work.



Source: Study Team



10.2.3.4 Temporary Jetty

Two temporary jetties be constructed at Km8.1 and Km9.62 in order to supply material and equipment to marine activities and transport the same to Cat Hai area as shown below.



Figure 10.2.3-6 Temporary Jetty

10.2.4 Navigation Channel Safety

There exists navigation channel (Nam Trieu Channel) between Hai An side and Cat Hai island, also there exist Dinh Vu-Cat Hai Ferry operation. The study team made series of discussion with Maritime Administration of Hai Phong and Nothern Vietnam Maritime Safety. The conclusion is for safety purpose two temporary navigation channels having a width of 80m each be established by means of installing additional buoys indicating limited temporary navigation channel and the construction working areas. In addition two monitoring stations are to be established with a speed boat each in order to monitor and communicate with any vessels passing the area and the controller always keep contact with marine police.

After completion of the bridge permanent navigation system be installed on the bridge.

Navigation system to be employed for construction purpose and permanent system are shown on Appendix Fig. No. CP-10-3, CP-10-4 & CP-10-5 and summary of equipment to be employed is shown on the table below.

Table 10.2.4-1 Navigation Safety Equipment

Description of equipment	Number		
Signal Buoys for waterway	4		
Signal Buoys in construction area	6		
Monitoring station	2		
Speed boat	2		

1. Main Bridge Foundation and Girder construction stage

2. Bridge surface work stage and after completion of the bridge

All buoys, monitoring stations and speed boats are same as stage 1	
Star Board Hand Mark	4
Port Hand Mark	4
Pier Light	6

Source: Study Team

10.2.5 Existing Utilities and Connection

Existing utilities were surveyed near the site. Followings are findings.

1) Electricity

Hai An side : 750kva supply is available at Site Compound-2 with 2.2kv. Supply conditions are to be agreed with DVIZ.

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Cat Hai side: 250kva supply is available from existing overhead line near Site compound-7 and step down transformer of pole mounting type was recommended by Hai Phong Power One Member Liability Company.

2) Water

Hai An side: Daily 500m3 supply is available at Site Compound-2.

Supply conditions are to be agreed with DVIZ.

Cat Hai side: No tap water supply is expected.

10.2.6 Access to and Possession of Site

Due consideration of the provisions of the official documents, a letter, PMU2/110923-2 dated 23th of September, 2011, was submitted to PMU2 in order to draw their attention to the responsibility of the Employer under the Contract as follows;

- (1) The Contract binding the Employer and the Contractor
 - 1) Minutes of Discussion dated 18th June 2010 states that Guidelines for Procurement under

Japanese ODA Loans (March 2009) shall be adopted for the Contract document.

2) Accordingly, FIDIC (MDB Harmonised Edition) shall be the basis of the Conditions of

Contract.

- 3) In accordance with the latest version of FIDIC Red Book (MDB Harmonised Edition) Clause
 - 2.1

"the Employer should give the Contractor right of access to, and possession of, all parts of the Sitewithin the time (or times) stated in the Contract Data. The right and possession may not be exclusive of the Contractor."

4) FIDIC Red Book defines "Site" in Clause 1.1.6.7 that" means the places where the Permanent

Works are to be executed and to which Plant and Materials are to be delivered, and any other places as may be specified in the Contract as forming part of the Site."

(2) Suggestions

It is very clear from agreed contract mechanism that access roads and plant yards for the Contractor's use are to be prepared by the Employer. If those land arrangement and land acquisition are left to the Contractor, it will obviously cause delay to the contract period which is estimated as 36 months without any spare time for land arrangement.

Also such situation may cause unnecessary dispute procedure based on the Contract.

The Detailed Design documents are made with an assumption that the Employer will fulfill his obligation under the Contract in respect of Site availability.

In order to avoid any future troubles, it will be necessary for the Employer to complete site arrangement including land acquisition for the Contractor's use without any hindrance before the Contractor will enter into the Contract.

10.3 SOFT SOIL TREATMENT AND EMBANKMENT WORK

10.3.1 Soft Soil Treatment Works

Road embankment design is controlled by residual settlement value of 30cm for embankment and 10cm for behind bridge abutment. In order to achieve those requirement accelerated settlement measures using Sand Compaction Piles(SCP), Sand Piles, PV Piles together with surcharge embankment are selected for embank section. For behind bridge abutment piled slab is selected.

Following shows construction sequences for sand drain pile and embankment works.



Source: Study Team

Table 10.3.1-1 Soft Soil Treatment and Embankment Work Procedure

Construction outline is shown on Appendix Fig .No. CP-10-6.

10.3.2 Geo-textile Sheet Spreading Works

Surface unsuitable material be removed or pushed away using either swamp type bulldozer or backhoe and the surface be replaced by sand layer. Geo-textile sheet be spread over the replace sand layer with utmost care for sheet jointing. On top of Geo-textile layer sand blanket be laid for ground water discharge purpose coming through PV drain and Sand drain piles.

10.3.2.1 SCP, PV Drain and Sand Drain Piling Works

SCP, Sand drain/PV drain piling rig sit on the sand blanket layer and drive steel tube into the ground and form sand column by means of vibration or insert drain sheet. Utmost care be paid for stability of the rig as heavy vibration equipment held by the rig at height.

Supply of sand be made by dump trucks and sand be loaded into the hopper either by shovel car or manually.

10.3.2.2 Soil Embankment Works

Embankment material be selected from existing borrow pits or any other sources after confirming volume and quality tests.

Material be transported by dump trucks or ships and laid using bulldozers with required thickness at each layer.

Compaction machines compact material to ensure required density.

10.3.2.3 Box Culvert and Pipe Culvert Works

In order to maintain existing water flow crossing the road embankment pipe culverts and box culverts are designed. Before embankment work commence temporary pipes are to be installed after PV Drain or Sand Drain works to allow water flow. Permanent pipe culvert or box culvert are to be constructed after designed settlement has been achieved.

10.4 ROAD WORKS

10.4.1 Road Works Outline

After completion of consolidation settlement box culvert and pipe culvert work commence. Any temporarily installed pipes are to be removed and subgrade preparation work follows. Aggregate base course material and asphalt treated base course material be well compacted with tire roller, vibration roller and grader. Where working space is narrow small tandem roller or hand roller be used.

Following asphalt treated base course compaction and testing, primer be spread and asphalt binding course be laid using asphalt finisher and compacted using tire roller, macadam roller.

Asphalt treated base course, asphalt binding course and asphalt surface course be produced by site batching plants. Road work procedure is shown below.



Source: Study Team



10.4.2 Sub grade, Sub -base course and Base- course Works

10.4.2.1 Sub grade

Sub-grade surface be well graded using motor grader. Any foreign materials be removed and soaked materials be replaced by good material. After preparation works sub-grade surface be well compacted using tier roller and macadam roller to receive selected Subgrade material.

In order to achieve smoothness motor grader and manual grading be repeated.

10.4.2.2 Aggregate base course

Material for aggregate base course be selected from borrow pits and tested. Selected material be transported using dump trucks and unloaded at working spot, spread using bulldozer and backhoe and compacted using tier roller and macadam roller to the thickness required.

Surface be well graded using motor grader and manual operation to achieve required thickness and smoothness.

10.4.3 Asphalt Treated Base Course and Pavement Works

10.4.3.1 Asphalt plant

In order to meet quality requirement and delivery requirement two 200t/hr capacity asphalt batching plant be established on site. One is to be at Hai An side and another one is to be at Cat Hai side.

10.4.3.2 Asphalt treated base course, asphalt binder course and surface course

Material be transported from site asphalt plants using dump truck.

Asphalt treated base course, asphalt binder course and asphalt surface course material be received by finisher and laid controlling thickness with a sensor system.

Laid asphalt concrete be immediately compacted using tire roller, macadam roller and tandem roller before temperature exceeding specified limit.

10.5 APPROACH BRIDGE

10.5.1 Approach Bridge Works Outline

Two different types of superstructure design for Approach Bridge are selected, namely PC Segment Span By Span (SBS) Method for Hai An side and Cast-in-place Cantilever Method for Cat Hai side. Foundation pile design has also two different types, namely Steel Pipe Pile and Bored Pile . Working platform has three different types, namely Filled Ground, Steel Staging and off-shore.

10.5.2 Approach Bridge (SBS Method) Working Sequence

Construction sequence is shown below.



Source: Study Team



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10.5.3 Sub Structure Works

10.5.3.1 Construction sequence for substructure

Construction sequence for sub structure is shown below.



Source: Study Team

Figure 10.5.3-1 Construction sequence for Approach Bridge sub structure

10.5.3.2 Construction of working platform and piling works

During the time of construction of the temporary access road the working platforms be constructed. Due to several different types of working platform piling activity require different type of machineries. Following table shows relation in between type of platform and piling machinery.

Pier Nr.	A1	P1-P50	P51-P60	P61-P75	P79-P82	P83-P87,A2
Foundation Pile Type	Steel Pipe Pile	Steel Pipe Pile	Steel Pipe Pile	Bored Pile	Bored Pile	Steel Pipe Pile
Platform Type	Filled Ground	Steel platform	Off shore	Off shore	Off shore	Filled Ground
Piling Method	Hydraulic Hammer 12.5t	Hydraulic Hammer 12.5t	Hydraulic Hammer 12.5t	Bored Pile Machine	Bored Pile Machine	Hydraulic Hammer 12.5t
Piling Machine	Crawler Crane 150t	Crawler Crane 150t	Crawler Crane 200t Barge 1000t	Crawler Crane 120t Barge 1000t	Crawler Crane 120t Barge 1000t	Crawler Crane 150t

 Table 10.5.3-1 Approach Bridge Piling Machinery and Working Platform

Source: Study Team

Construction outline for piling work is shown on Appendix Fig. No. CP-10-7.

(1) Works on the filled platform (for A1, P83-A2)

a) In prior to the piling works guide piles and frame installation works be taken place.

b) Crawler Crane 150t be used for steel pipe pile driving with 12.5t capacity hydraulic hammer, and 100t crawler crane with 60Kw hydraulic vibration hammer be used for steel sheet pile driving

(2) Works on the steel platform (P1-P50)

Woks are same as item 1) above.

(3) Works off-shore (P51-P82)

- a) Temporary .cofferdam sheet pile driving is carried out utilizing 150t crawler crane with 60 Kw hydraulic piling hammer on 1000t barge. Following temporary cofferdam steel pipes piles are driven utilizing 200t crawler crane for P51-P60. For P61-P82 bored pile stand pipe and also steel staging be installed for bored pile driving working platform.
- b) Bored pile be formed using reverse-circulation method with roller bit. For hole wall stability bentonite liquid be used and fresh liquid be maintained with bentonite circulation method in order to prevent sedimentation.
- c) Steel cage be installed in the hole using 120t crawler crane and concreting work follow using marine concrete batching plant (60m3/hr).

10.5.3.3 Excavation, pile cap and pier construction works

(1) Works on the filled platform (for A1, P83-A2)

For excavation works a backhoe (0.8m3) be used and 10t dump truck be used for hauling.

After excavation truck crane (20t) be used for strut and walling works and structure concrete works follow.

(2) Works on the steel platform (P1-P50)

The works be carried out by the same procedure as described in (1) above.

(3) Works off shore (P51-P75)

The works be carried out by the marine equipment and concrete be supplied by a marine batching plant of the capacity 60m3/hr.

(4) Works off-shore (P79-P82)

After bored pile construction all procedures for pile cap and pier construction be carried out marine equipment.

After bored piles complete steel staging to receive pile cap structure be installed on those steel stand pipe for bored pile. This working platform be used for pile cap & pier form work, steel work and concrete work.

All concrete work be carried out using off shore equipment and where pier height be more than 4m one pour be limited to 4m to avoid concrete segregation.
10.5.3.4 Pier head construction work

(1) P1-P75

After pier work complete pier head work follow and pier head structure be constructed by means of cast in-place method.

For those pier head construction in between P1-P75 temporary support system be either bracket system or frame support sitting on the pile cap concrete.

(2) P79-A2

In between P79 and A2 super structure is designed as cast in-place cantilever type pier head length is 15m long in order to accommodate 2sets of traveler form on it. Pier head structure be constructed on the steel staging. Due to cast in-place cantilever method pier head structure need to be strengthen by introducing temporary shoe and temporary tie-in method into pier structure using pc bars.

Detail is stated in Section 10.5.6 hereinafter.

10.5.4 Fabrication of PC Segments

For the purpose of PC segment production a fabrication yard be established in the plant yard with an area of approximate 40,000m2.

Plan for segment fabrication yard is shown on Appendix Fig. No. CP-10-8.

10.5.4.1 PC segment fabrication outline

All PC segments be fabricated with short-line match casting method, and 5 sets of casting bed be established.

Form-

Form Facility composed from edge form, side form, inner form, and bottom form.

The edge form be equipped with sliding mechanism in order to satisfy with change in length of segments.

The side form be equipped with open and close mechanism by the jacks.

The inner form be equipped with the shifting mechanism.

The bottom form for old segment be supported by the mobile platform equipped with the vertical jacks enable to adjust vertical alignment.

Steel bar-

Steel bar cages are prepared at adjacent steel bar fabrication yard and pre-arranged steel bar cage be shifted using tower crane (180t/m) on the bottom form at the fabrication platform and fixed.

Following steel bar cage and sheath installation inner form be slide and fixed.

Concrete-

Concreting work be carried out after confirmation of survey check for form position, height, and angle and concrete be supplied from adjacent land concrete batching plant(90m3/hr.) with concrete pump car (60m3/hr.).

Old segment to be used for next segment-

Freshly complete segment be removed and set back from the casting bed by means of sliding on the rail and be used as a external end shutter for new segment.

Stock yard-

The old segment used as a external form be removed after new segment concrete work and transferred to stock yard using gantry crane (30mx80t)

10.5.4.2 Fabrication Sequence

PC segment fabrication sequence is shown below.





10.5.4.3 PC segment fabrication cycle time

Work Item	Working Time	1	2	3	4	5	5	7	8	9	10	11	12	24
Remove curing sheet	^{min} 10													
Survey	30													
Remove side & inner form	60													
Remove old segment to stock	60													
Shift fresh segment	30				þ									
Fix bottom form	30													
Adjust new segment position	30					ב								
Fix side form	30													
Steel bar cage positioning	60													
End shutter adjusting	30													
Main cable sheath positioning	80													
Inner form fixing	80													
Steel final positioning	30													
Cleaning	30									Ľ				
Concreting	120													
Finishing	30													
Curing														

PC segment fabrication cycle time is sown below.

Source: Study Team



10.5.4.4 Geometry control

In order to satisfy vertical and horizontal alignment geometry control be assured using survey tower and bottom form adjusting for the old segment. The new segment be always kept level and straight alignment.

The survey tower be kept on the center line of the fabrication platform.

The old segment horizontal and vertical adjustment be made by hydraulic bottom form jacks and controlled by the survey work.

Geometry control system is shown below.



Source: Study Team



10.5.4.5 Segment stockpile

Fabricated segments be transferred to stockpile yard using gantry crane. Segments are stacked in the stockpile yard in two layers .

PC segment stockpile number is shown below.



Source: Study Team

Figure 10.5.4-4 Segment fabrication and installation program showing stockpile number

10.5.4.6 Segment transport

All segments be loaded on the low bed trailer (80t) using gantry crane(30m 80t) established in the segment stock pile yard and segments be transported to the desired position and lifted using the erection girder which be elected and sit on the pier heads. Only for P50-P75 all segments be lifted

Transport distance be 2.3km in average and all segments be transported through temporary access road.

10.5.5 Segment Erection Work (Span By Span Method)

10.5.5.1 Outline

Segments erection be carried out using three erection girders simultaneously.

Each erection girder be assembled on temporary supports frame by frame and finally sit on the supporting columns which sit on the pier head after adjusting.

Each PC segment be lifted by lifting devices on the erection girder and rolled to the position from one end toward other end. When new segment comes to close to adjacent segment installed already, contact surface be pasted using chemical bonding glue and temporarily stressed. This process be repeated until all segments be positioned.

Finally small gap in between be filled using cement mortar with external hanging form and whole segments be stressed.

After those works complete the erection girder be rolled forward to next pier position and finally be dismantled on the bridge.

For erection work at P50-P75 the erection girder is designed purposely to receive segment at rear portal on the deck and the erection girder carry segment through foot support, by which all segments are to be delivered on the complete deck surface from P50.

Segment erection outline is shown on Appendix Fig. No. CP-10-9 and CP-10-10.

10.5.5.2 Assembling of Erection Girder

Assembling works of three erection girder be taken place at A1-P1-P2, P25-P26-P27 and P50-P51-P52.

For assembling at A1-P2 and P25-P27 temporary girder support be established at 7.5m spacing to meet 150t crawler crane lifting capacity. All girder pieces are to be lifted and positioned on the temporary supports and joined, finally foot supports sitting on the piers receive the girder weight.

For assembling at P50-P52, girder support be erected first at 15m spacing. 15m long girder piece be pre-assembled on the land works compound-3 and transferred by barge and lifted and positioned by using floating crane of 300t.

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10.5.5.3 Erection of PC Segment

(1) A1-P50

In between A1-P50 each pc segment be delivered by mulch axle trailer to the lifting position which be designated for every span and lifted by the lifting gear on the erection girder and rolled to the final position. Contact surface glue application and temporary stressing follow.

(2) P50-P75

In between P51-P75 all segments are to be once lifted at P50 by lifting gantry crane and unloaded on the trailer sitting on the complete bridge surface, then transferred to the erection girder rear end and lifted by the lifting gear on the girder. The segment passes through the girder foot to the position and rotated 90 degree to meet adjacent segment. Due to necessity of segment rotation 6 pieces of segment be temporarily stocked on the temporary store platform adjacent to the younger pier in prior to erection work for the concerned section. Those stocked segments are to be erected at last.

10.5.5.4 Shifting of Erection Girder

Erection girder be shifted to the next position by means of sliding using rolling gears sitting on the supporting towers and the girder be received by new supporting tower sitting on the next pier head.

10.5.5.5 Dismantling of Erection Girder

After completion of all segment erection the girder be dismantled using 100 t cranes and temporary supports on the bridge surface.

10.5.5.6 Segment erection cycle time

Segment erection work cycle time is shown below.

THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM FINAL REPORT

Day															
Work Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Erection Girder Move Forward Fixing Erection Girder					anananan		aaaaaaa		anananaa	anananan					
Segment Erection and Temp. Fixing						2.5nr	/day								
Gap Filling														******	
Curing															
Stressing															
Preparation for Moving															

Source: Study Team

Figure 10.5.5-1 Segment Erection Work Cycle Time

10.5.6 Cast in-place Cantilever Method

In between P79 to A2 Cast-in-place Cantilever Method be applied for super structure construction.

After completion of pier structure pier head be constructed by cast in-place method of which length be 15m at P80, P81, P82, P83, P85, P86 and P87. At P79, P84 and A2 the girder be constructed independently by cast-in place method as on those piers no form travelers will be used.

In addition at P80, P81, P82, P83, P85, P86 and P87 pier head be sit on the temporary shoes and tightened with pier structure by PC bars in order to stabilize the structure to meet additional load introduced by cantilever method.

Pier head temporary measure is shown below.



Source: Study Team

Figure 10.5.6-1 Pier Head Temporary Shoe Detail

Working program is shown below.



Source: Study Team

Figure 10.5.6-2 A2-P79 Cantilever Method Working Program

10.6 MAIN BRIDGE

10.6.1 MAIN BRIDGE WORK OUTLINE

In between P76 to P78 the bridge cross existing navigation channel, therefor long span bridge is designed and Cast-in-place Cantilever Method is selected. For foundation structure Steel Pipe Sheet Piles (SPSP) Foundation is selected which serves temporary cofferdam and part of the permanent structure.

Navigation requirement and the main bridge construction activities are shown on Appendix Fig. No. CP-10-3,4 & 5.

In prior to commencement of any marine activities, all necessary safety measures be taken place such as installation of demarcation buoys, provision of monitoring stations and speed boats as described in 10.2.4 before.

After piling works sea bed excavation, replacement of soft layer by rock and concrete, pile cap be constructed in dry condition and pier structure will follow. As pier structure is inclined and pier head structure is with height steel supporting system be installed before formwork.

Following pier head structure construction two sets of form traveler be installed at both pier head end. Main bridge girder structure be constructed block by block and one side by other with 3m to 5m length each.

Upon reaching final block small gap between the structure extended from one pier and adjacent pier be filled by concrete using the form traveler. Then final stressing work takes palace and the form traveller be dismantled.





Source: Study Team



Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

10.6.2 Main Bridge Overall Working Program

Work Itom	Dove	Month	2	3	4	5	6	7	6	0	10	11	12	13	14	21
1 SPSP Driving & Water Tight	92					5	0	,	0	,	10		12	15		
2 Pile Cap	91															
3 Pier Base Slab & Pier	99															
4 Pier Head	94										C					
5 Bridge Girder	239															

Overall working program for Main Bridge is shown below.

Source: Study Team



Work Item	Days	Month 1	Month 2	Month 3		Month 4
1. GuidePile & Frame Work	12					
2. SPSP Driving work	62	[Av. 1.18 da	ny/no.		
3. SPSP Joint Watertight Work	7					
4. SPSP Pile Concreting Work	11				L	
TOtal	92					

Source: Study Team

Figure 10.6.2-2 Main Bridge Foundation Work Program

Work Item	Days	Month 4	Month 5	Month 6	Month 7
1. Excavation	10				
2. Replacement & Base	14				
3. Strut & Wailing Work	19				
4. Pile Head Treatment	9				
5. Pile Cap Steel Bar&					
Concrete Work	39				
TOtal	91				

Source: Study Team



Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM FINAL REPORT

Work Item	Days	Month 7	Month 8	Month 9	Month 10
1. Pier Base Working Pla	9				
2. Ditto Steel Fixing	7				
3. Ditto Formwork	5				
4. Ditto Concreting	9				
5. Pier Support Structure	41				
6. Ditto Formwork	6				
7. Ditto Steel Bar Fixing	4				
8. Ditto Concreting	18				
TOtal	99				

Source: Study Team



Work Item	Days	Month 10	Month 11	Month 12	Month 13
1. Pier Head Support Str	24				
2. Ditto External Formw	26				
3. Ditto Inner Formwork	24				
4. Ditto Steel Bar Fixing	11		Ľ		
5. Ditto Concreting	9				
TOtal	94				

Source: Study Team

Figure 10.6.2-5 Main Bridge Pier Head Construction Program

		MONTH									
Worl Item	Days	13	14	15	16	17	18	19	20	21	22
1. Form Traveller Installation	11										
2. Main Girder Construction	154			14 Bk	ock x 11 d	lays					
3. Center Closure	31										
4. Side Closure	31										
5 Dismantle Form Traveller	12										
TOTAL	239										

Source: Study Team

Figure 10.6.2-6 Main Bridge Girder Construction Program

Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

10.6.3 Main Bridge Sub-structure Construction Method

10.6.3.1 SPSP Driving Work

In prior to commencement of SPSP driving, guide piles and frame be installed. In order to make sure proper positioning 2 lines of frame be installed and guide gear be used for positioning.

SPSP be positioned using vibration hammer and piles be driven down to reach refusing strata and hydraulic driving hammer together with high pressure water jet system be used for final penetration.

For 1st stage driving vibration hammer of 240kw capacity with 250t crawler crane sitting on 2000t barge be used and for 2nd stage driving 15t capacity hydraulic driving hammer with 300t crawler crane sitting on 2000t barge be used. In order to maximize working distance a hanging driving method be applied.

SPSP driving working method is shown on the Appendix Fig. No. CP-10-11.

10.6.3.2 To prevent water seepage through SPSP joint

All SPSP has been driven down to the required depth and closed, mud inside joint pipe be removed using high washer system and replaced by mortar grout to be pumped to prevent water seepage through joint.

Soil inside of SPSP itself also be removed using clamshell bucket and replaced by concrete.

10.6.3.3 Excavation and replacement of soil for foundation

After securing water tightness at SPSP joint and concreting inside pipes, excavation work proceed using clamshell bucket and rock material be dropped and leveled. On top of rock material base slab concrete be poured using floating type batching plant and concrete pump. Concrete surface level and smoothness be confirmed by divers.

10.6.3.4 Dewatering, strut & wailing and pile cap concrete

Following base slab concrete dewatering inside of the shell proceed together with strut & wailing installation work. Pile cap construction be carried out under dry condition and form work and steel bar fixing work proceed using 50t crane sitting on 1000t barge and material supply barge.

Considering size and height of pile cap be concreted in 2 stages.

10.6.3.5 Pier construction

Pier base structure be constructed after pile cap concrete complete.

As pier is designed inclined shape steel supporting stage be constructed to support both pier and pier head structure.

Both Pier Base and Pier Colum be constructed in 3 stages of concreting.

Pier column and pier head construction method outline is shown on Appendix Fig. No. CP-10-12.

10.6.4 Pier Head construction

10.6.4.1 Pier Head construction outline

Main bridge pier head having 30m long be supported by steel supporting system sitting on pile cap and SPSP piles. Concreting procedure be divided into 3 pours. 1st be bottom slab, 2nd be web wall and 3rd be top slab.

Working sequence is shown below.





10.6.5 Main Bridge Girder Construction Method

10.6.5.1 Main Bridge girder construction outline

Main bridge girder be constructed using two sets of form traveler sitting on both end of pier head.

Form traveler be anchored on completed concrete structure and every span length be varied to suit equal weight as section of the girder vary(3m to 5m in length) so that external wall shutter be cut out after every pour. One form traveller serves for 14 blocks.

Construction sequence is shown below.



Source: Study Team



Main Bridge girder construction method and form traveler are shown on Appendix Fig. No. CP-10-13 and CP-10-14.

10.6.5.2 Main Bridge Girder 1 block standard cycle time

Main Bridge construction cycle time is shown below.

Work Item Days	1	2	3	4	5	6	7	8	9	10	11
Stressing											
Form traveller installation											
Bottom slab & wall steel											
Sheath fixing											
Inner form installation											
Top slab steel bar fixing											
End shutter fixing											
Concreting											
Curing											
PC wire installation											
Preparation for stressing											

Source: Study Team

Figure 10.6.5-2 Main Girder Construction Cycle Time

10.7 PROGRAM

10.7.1 Total construction period

Total construction period in this report is 36 months.

In comparison with 32 months construction period in Basic Design Report following additional requirement and time impact are taken.

Reasons	Time Impact
1.No site access road outside embankment structure is allowed	
Consequence-1 Road access road need to be replaced	
Consequence-2 Drainage work is to be after pavement work	2 months
2.Pavement structure design changed from Cement Treated Base	
Course to Asphalt Treated Base Course	2 months
Total	4 months

10.7.2 Basis of program

10.7.2.1 Documents referred

Program is made in accordance with the guide book published for estimation work for works under Ministry of Land, Infrastructure and Transport in Japan, similar guide book and JICA guide line.

Where items are not specified in the book working rate is established using available items with reasonable adjustment or work experiences under similar nature either in Japan or Vietnam.

10.7.2.2 Working efficiency

(1) Land work

In accordance with JICA guide line published for works under international cooperation project gross working time factor is specified as 1.35.

Hence gross working time be 1.35 x net working time.

(2) Marine work

a) The above guide line allows exceptional case such as wind or wave effect.

For this project wave height controls work efficiency and gross working factor of 2.26 is chosen. Gross working time is 2.26 x net working time.

 $(1 \div 0.4428 = 2.26)$

b) In accordance with the report issued by JICA study team in July 2010 Sec.7 Natural Conditions, 7.2.3 Meteorological Feature is described.

Occurrence factor of wave height less than 0.5m is 44.28%

c) Japanese published book for Marine work construction indicates limit of meteorological condition for marine work activities.

Recommended working condition for marine activities such as driving piles, concreting and transporting is under wave height of 0.5m

For reference extract of those books are shown below.

Ways				1	Vara He	ight (m)	· · · · ·				Tatal	
Direction.	Û +	0.25	0.19	-0.5	0.5	-1.0	19-	-15	1.3	11	1	
C	Nr	5	Mr	25	Nr	0.0	Nr		24	35	Nr	1.
N		-	3	0.09	57	1.74	1	0.24	1	0.03		-
NE	-	-	9	0.00	41	1.43	16	0.49	0	0.00	-	-
E	-	-	10+	1.60	844	29.71	63	1.92	5	3.11	-	-
3E	-	-	27	1.13	419	13.07	89	3.71	é	0.15	-	
5	1000	-	4	0.12	145	4.34	75	3.28	13	9.7	-	
SW		-	0	0.00	10	05.0	1	0.15	1	0.03	-	-
W	-	-	0	0.00	1	0.03	D-	0,00	0	0.00	-	-
NW	-	-	0	0.00	19	0.30	Ũ	0.00	Ū	0.00	-	
Total	1226	37,34	128	694	1,597	+7,32	236	7.80	.26	0.79	1:283	170

Table 10.7.2-1 Frequency in Occurrence of Normal Wave Height by Direction

Source: Study Team

-					
	Sea Condition	Wave height	Wind Speed	Max. Current	Rainfall
Work Item		(m)	(m/s)	(kt)	(mm/day)
Transport	Self Propel	1.0	12	2	-
	Non self	0.6	10	2.5	9
Dredging	Pump	0.6	11	2	10
	Grab	0.6	11	2	10
Other Works	Anchoring	0.5	10	2	8
	Immersing Work	0.4	6	1	2
	Lifting	0.5	7	1	5
	Piling	0.4	8	1	4
	Filling	0.7	10	2	10
	Concreting	0.5	9	2	5
	Diving	0.5	8	1	10
SEP	SEP Operation	1.3	12	2	9
	SEP Moving	0.5	10	1	7

Table 10.7.2-2T Work Limit natural conditions for marine activity

Source: Marine Construction Work

10.7.3 Construction Program

Time Space Diagram (Appendix CP10-15) attached shows overall construction sequence and major critical activities.



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10.7.4 Network Program

Detailed network program is shown below

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THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM FINAL REPORT

THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VI	et nam
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Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

41.2.2.0

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Source: Study Team.



10.7.5 Work Days Calculation

Work days calculation for Pier 30, Pier 75, Pier 77 and road pavement work are shown on the following figures.

Place	P30						Remark: Land Work		
	Work Item	Q'ty	Unit	Working	Unit	Net Working Day	Net Working Day	Gross Woking Days	Party Nr.
				Rate		(8 Hr Work)	(10Hr Work)	X1.35	
1	Guide Pile Driving H400x15mx27nr	27	nr	12	nr/day	2.3	1.8	2.4	
2	Ditto Extraction	27	nr	43	nr∕day	0.6	0.5	0.7	
3	Guide Frame Installation H300x160.6n	15.1	t	1.7	Days/10t	2.6	2.1	2.8	
4	Ditto Removal	15.1	t	1	Days/10t	1.0	0.8	1.1	
5	Steel Pipe Pile DrivingD1100,t12	16	nr	7.7	Days/10nr	12.3	9.9	13.3	
	L=46+3.25m, Top +2.35								
	α=1.22,β=1.24,Ta=5.1 T=7.71								
6	Steel Sheet Pile Driving	146	nr	25	nr/day	5.8	4.7	6.3	
	Type III 10mx146nr								
7	Excavation 13X13X(+2.35+0.7)	515.5	m3	180	m3∕day	2.9	2.3	3.1	
8	Strut & wailing	13.5	t	1.7	Days/10t	2.3	1.8	2.5	
								~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
9	Ditto Remova	13.5	t	1	Davs/10t	1.4	1.1	1.5	
*******								******	
10	Pile Head Treatment	16	本	1	dav/nr	16.0	12.8	4.3	4.0
11	Preparation for Pile Cap & Blinding C	1		1	sum		1.0	1.0	
12	Pile Cap Formwork	110	m2	3.2	dav/100m2	3.5	2.8	3.8	
			=						
13	Pile Can Steel Bar Fixing	30.2	+	0.2	dav/t	6.0	4.8	6.5	
14	Pile Cap Concreting	302.5	m3						
17	Casting	1	times	1	day/time	1.0	1.0	1.0	
	Curing	1	times	2	day/time	2.0	2.0	2.0	
	Guring	· · · · ·	times	<u> </u>		2.0	2.0	2.0	
15	Pier Working Platform	320	m2	25	$d_{\rm W}/100m^2$	8.0	6.4	8.6	
		520	1112	2.0		0.0	0.7	0.0	
16	Pier Steel Bar Fixing	10.1	+	0.2	dav/t	2.0	16	22	
		10.1	L	0.2	day/ t	2.0	1.0	£.2	
17	Diar Formwork	147	m2	2.1	$d_{0} \sqrt{100m^2}$	4.6	3.6	10	
		147	1112	5.1		4.0	5.0	4.5	
10	Diar Constating	102	2						
10		102	11.0		al		0.0		
	Casting	2	times		day/time	2.0	2.0	2.0	
	Guring	۷	times	۷	day/ time	4.0	4.0	4.0	
10		100	_	07	0 / 1				
19	Backtilling	120	៣៤	3/	m3∕day	3.2	2.6	3.5	
	Sharet Dile Faturet	140		40			0 7	0.7	
20	Sneet Pile Extraction	146	nr	43	nr⁄day	3.4	Z./	3./	
							70.0		
1	I OTAI WORKING DAYS		I.	1	1	1	/2.3	81.2	1

Source: Study Team

Figure 10.7.5-1 Work Days Calculation for Pier 30 Substructure Works

Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

#### THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM FINAL REPORT

	Working Days Calculation Sheet	1							
Place	: P75		1	1		1	Remark: Marin	e Work	
	Work Item	Q'ty	Unit	Working	Unit	Net Working Day	Net Working Day	Gross Woking Days	Party Nr.
				Rate		(8 Hr Work)	(12Hr Work)	X2.26	
	Guide Pile Driving H400x15mx14nr	14	nr	12	nr/day	1.2	0.8	1.8	
_									
2	Ditto Extraction	14	nr	43	nr/day	0.3	0.2	0.5	
	Guide Frame Instaalation H300x96m	16.45	t	1.7	Days/10t	2.8	1.9	4.2	
4	Ditto Removal	16.45	t	1	Days/10t	1.0	0.7	1.5	
5	Working Platform Pile H400x15mx	6	nr	12	nr∕day	0.5	0.3	0.8	
6	Ditto Extraction	6	nr	43	nr/day	0.1	0.1	0.2	
7	Working Platform Pile	14.1	t	1.7	Days/10t	2.4	1.6	3.6	
	H300x300x12.5x8本								
	H150x150x12,5x12本								
8	Ditto Removal	14.1	t	1	Days/10t	1.0	0.7	1.5	
9	Steel Sheet Pile Driving	160	nr	25	nr∕day	6.4	4.3	9.6	
	Type III 40m								
10	Bored Pile D1500, 42m	12.0	nr	1.96	day/nr	23.5	15.7	21.2	
11	Excavation	156.3	m3	180	m3/day	0.9	0.6	1.3	
12	Strut&Wailing	45.3	t	1.7	日/10t	3.9	2.6	5.8	2.0
13	Ditto Removal	45.3	t	1	Days/10t	4 <u>.</u> 5	<u>3.</u> 0	6 <u>.</u> 8	
14	Pile Head Treatment	21.195	m3	0.5	m3/day	8.0	5.3	12.1	4.0
15	Preparation for Pile Cap & Blinding C	1		1	sum		1.0	1.0	
16	Pi <b>l</b> e Cap Formwork	124	m2	3.2	day/100m2	4.0	3.2	7.2	
17	Pile Cap Steel Bar Fixing	37.4	t	0.2	day/t	7 <u>.</u> 5	6 <u>.</u> 0	13.5	
18	Pi <b>l</b> e Cap Concreting	374	m3						
	Casting	2	time	1	day/time	2.0	2.0	2.0	
	Curing	2	time	2	day/time	4.0	4.0	4.0	
				Γ		I			
19	Pier Working Platform	504	m2	2.5	day/100m2	6.3	5.0	11.4	2.0
				I					
20	Pier Steel Bar Fixing	31.1	t	0.2	day/t	6.2	5.0	<u>11.</u> 2	
				I					
21	Pier Formwork	306	m2	3.1	day/100m2	9.5	7.6	17 <u>.</u> 2	
22	Pier Concreting	311.6	m3						
	Casting	4	time	1	day/time	4.0	4.0	4.0	
	Curing	4	time	2	day/time	8.0	8.0	8.0	
*****									
23	Backfil	57.5	m3	37	m3/dav	1.6	1.0	2.3	
				Ť					
24	Sheet Pile Extraction	160	nr	43	nr/dav	3.7	3.0	6.7	
				1					
	Total Working Davs						87.4	159.4	
	· · · · · · · · · · · · · · · · · · ·		-						

Source: Study Team

#### Figure 10.7.5-2 Work Days Calculation Sheet for Pier 75

#### THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM FINAL REPORT

Place	ce: P77 Remark: Marine Work								
	Work Item	Qʻty	Unit	Working	Unit	Net Working Day	Net Working Day	Gross Woking Days	Party Nr.
				Rate		(8 Hr Work)	(20 Hr Work)	X2.26	
1	Guide Pile Driving H400x35mx52nr	52	nr	7	nr/day	7.4	3.0	6.7	
2	Ditto Extraction	52	nr	30	nr/day	1.7	0.7	1.6	
3	Guide Frame Instalation H300x156m	14./	t	1./	Days/10t	2.5	1.0	2.3	
4	Ditto Remova	14./	t	11.00	Days/TUt	1 <u>.</u> 0	0.0	1.3	
5	1 = 49 8m	44	nr	11.02	day/ Turr	52.0	20.0	47.0	
6	SPSP Driving-1	14	nr	11.82	dav/10nr	16.5	6.6	15.0	
Ű	L=48.8m				uuy, toni				
7	SPSP JOINT Removal of Soil	1696.2	m	250	m∕day	3.4	1.4	3.1	2 Parties
8	SPSP Joint Grouting	2191.2	m	250	m∕day	4.4	1.8	4.0	2 Parties
9	Excavation Inside Pipe	452.2	m3	53	m3∕day	8.5	3.4	7.7	
10	Concreting Inside Pipe	497.4	m3	125	m3∕day	4.0	1.6	3.6	
11	Excavation Inside Shell	1587	m3	143	m3/day	11.1	4 <u>.</u> 4	10 <u>.</u> 0	
12	Strut & Wailing Installation	68.4	t	4	t/day	17.1	6.8	15.5	
13	Concreting for Strut & Wailing	44.9	m3	11	m3∕day	4.1	1.6	3.7	
14	Stone Replacement	198	m3	19	m3∕day	10.4	4_2	9.4	
15	Base Concrete in water	595	m3	125	m3/day	4_8	1.9	4.3	
16	Stud	700	nr	200	nr/day	3.5	1.4	3.2	
	Pile Head Treatment	14	nr	1	nr/day	7.0	2.8	6.3	2 Parties
	Pile One Otavil P	·			1				
	Pile Cap Steel Bar	65.9	t	0.2	day/t	13.2	10.5	14.2	
10	Dila Can Conservation	6EO	2						
19	Pile Cap Concreting	009	timo		day/time	8.0	0.0	0.0	
	curing	3	time	2	day/time	0_U 16.0	16.0	8 <u>.</u> 0	
	Guring	5	unie	<u> </u>	day/ time	10.0	10.0	10.0	
20	Pier Base Working Platform	387	m2	2.5	dav/100m	9.7	3.9	8.7	
						······			*****
21	Pier Base Steel Bar Fixing	66	t	0_2	day/t	13_2	5.3	7_1	
22	Pier Base Formwork	315	m2	3 <u>.</u> 1	day/100m	9 <u>.</u> 8	3.9	5.3	
23	Pier Base Concreting	660	m3						
	concreting	3	time	1	day/time	3.0	3 <u>.</u> 0	3.0	
	curing	3	time	2	day/time	6.0	6.0	6.0	
24	Pier Support Structure	166.7		1.7	Days/10t	28.3	11.3	25.6	
25	Ditto Remove	166.7		1	Days/10t	16.7	6.7	15.1	
20	Pier Form Work	437	mz	3.1	day/100m	0.8	Z./	0.1	2 Parties
27	Pior Stool Bar Fiving	11	+	0.2	dov/t	4.4	1.9	4.0	2 Portion
~~~~~		44	ι	0.2	uay/ t	<b>F</b> . <b>T</b>	1.0	4.0	
28	Pier Concreting	442	m3						
20	concreting	6	time	1	day/time	6.0	6.0	6.0	
	curing	6	time	2	day/time	12_0	12.0	12.0	
29	Pier Head Supporting Structure	196		1.7	Days/10t	16.7	6.7	15.1	2 Parties
	Ditto Remove	196		1	Days/10t	9.8	3.9	8.9	2 Parties
30	Pier Head Formwork Externa	928_2	m2	3.1	day/100m	28.8	11.5	26.0	
		767.5-							
31	Pier Head Formwork Internal	/0/.58		3.7	day/100m	26.2	10.5	23.7	
21	Pier Head Steel Bar Fiving	R 4	+	0.0	day/t	120	F 1	11 @	
31		04		U.2	uay/ι	12.0	J.I	0.11	
32	Pier Head Concreting	636	m3						
	concreting	3	time	1	day/time	3.0	3.0	3.0	
	curing	3	time	2	day/time	6.0	6.0	6.0	
33	SPSP Cut & Remove	40	nr	2.3	day∕10nr	9.2	3.7	0.0	
34	Form Traveller Installation	1	LS	11.0	Day	11.0	11.0	11.0	
	Ditto Removal	1	LS	6.0	Day	6.0	6.0	6.0	
35	Main Span Girder Construction	14	BLK	11.0	day∕BLK	154.0	154.0	154.0	
36	Center Closure	1	LS	31.0	day	31.0	31.0	31.0	
37	Side Span Closure	1	LS	31.0	day	31.0	31.0	31.0	
38	Form Traveller Removal	1	LS	6.0	∪ay	6.0	6.0	6.0	<u> </u>
	Total Working Days						450.4	614.9	

Source: Study Team

Figure 10.7.5-3 Time Calculation for Pier 77 Works

THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM FINAL REPORT



Source: Study Team



10.8	Machine List	
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In accordance with the working method and site condition suitable type and capacity of machineries are selected.

10.8.1 Machinery selection study

Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd., PADECO Co., Ltd. and Japan Bridge & Structure Institute Inc.

Selection study is shown on the table below.

Plant and Machine		Selection Study							
1 Concrete Plant									
1-1 Land Concrete Plant	90m3/hr plant is selected.								
	(Study)								
	Total concrete volume for	land batching plant is 7	/3,000m3						
	and detail as below.	0.1							
	Approach Bridge	22000 m3							
	Segment	46000							
	Box Culvert	2000							
	Others	3000							
	Total	73000							
	1) Average supply is	7000m3/month whic	h is daily 320m3 av						
	2) Most critical demand is 5 segments +pier pile cap concrete								
	180+310=490m3 per day								
	Therefore 81m3/hr supply	is required.							
1.2 Marine Concrete Plant	2 no 60m3/hr are selected								
1-2 Warme Concrete F and	(Study)								
	Total concrete volume for	marine batching plant i	is 60.000m3						
	Total coherete volume for	marine batening plant i	s 00,000m5						
	Bored Pile	18,500							
	Pier Structure	38,500							
	Super Structure	13,000							
	Box Culvert etc	10,000							
	Total	80,000							
	1) In average	6500m3/month	296m3/day						
	2) Most critical demand is 98	0 times concreting in 1	3months						
	Daily demand is 3.4 location	ons for marine batching	a plant to move						
	Therefore 2 marine batchi	ng plant is required	, paint to 110 (c)						
		ng paint is required.							
	Most critical volume dema	nd is 310m3 in one day	7						
	Therefore 52m3/hr supply	is required							
		is required.							
2 Asphalt Plant	200t/hr plant each for Hai	An and Cat Hai work	is selected.						
	(Study)								
	Most critical demand is as	phalt binder coursea a	nd sourface course works						
	in six locations								
	Daily demand is 3x2300m2	2x(0.07+0.06)x1.05x2.3	32=t						
	Considering supply situation	n daily output is contro	led to 2185t/day						
	Therefore 200t/hr supply is	s required.	-						
	· · · · · · · · · · · · · · · · · · ·								

Table	10.8	8.1-1	Machine	Selection	Study

Working Location	Lifting	Hanging	Boom	Distance	Required	Land or	Selected
Work Item	Weight	Height	Length		Capacity	Marine	Capacity
A1-P50 Steel Pile Driving	41.2+1.2=42.4t	25+11+5+1 =42m	51m	14m	150t-43t	Land	150t
P50-P75, P79-P82 Bored Pile	12t	45+5+1 =51m	60m	20m	120t-18.6t	Marine	120t
P50-P75, P79-P82 Sheet Pile Driving	8.3t	30+5+1 =36m	40m	20m	120t-19.5t	Marine	120t
P76-P78 SPSP Driving	41.2+1.2=42.4t	42m	51m	20m	200t-43t Referred to N	Marine HAT TAN BI	300t RIDGE
Temp. Jetty	42.4t	42m	51m	12m	150t-43t	Land	150t

Source: Study Team

10.8.2 Machine list

In accordance with machine selection study and the construction schedule machine allocation is shown on the table below.

THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM FINAL REPORT

No	Work Item	Work	Plant Item	Plant	No
110.	work nem	Description	T lant from	Capacity	110.
1	Land Plant Area	Desemption		cupuony	
1-1	Concrete Plant	Hai An	Concrete Batching Plant	90m3/hr	1
			Truck Mixer	5.5m3	10
			Wheel Loader	3m3	2
			Generator	250kva	2
			Compressor	5.5m3	1
			Concrete Pump Car	90m3/hr	5
			1		
1-2	Asphalt Plant	Hai An. Cat Hai	Asphalt Plant	200t/hr	2
			Dump Truck	10t	24
			Generator	250kva	2
			Compressor	5.5m3	2
			Wheel Loader	3m3	2
1-3	Segment Fabricatio	n Plant	Segment Fabrication Bed		5
		Hai An	Gantry Crane	30mx80t	2
			Gantry Crane	12mx7.5t	2
			Tower Crane	180tm	3
			Steam Curing Facility		1
			Mulch Axle Trailer	80t	5
			Folk Lift		3
			Generator	250kva	2
			Compressor	5.5m3	3
			@ 5 0)		
		Segment Litting Place	(PSU)	20	1
			Gantry Crane	30mx80t	1
1-4	Machine Yard		Crawler Crane	80t	1
			Generator	100kva	1
			Compressor	5.5.m3	2
			Welding Machine		4
			Folk Lift		2
			Diesel Lorry	2000L	2
			Flat Lorry	20t	5
			Water Tanker	2000L	5
1-5	Temp. Jetty		Crawler Crane	200t	2
			Passenger Boat		10
2	Marine Concrete Pl	ant	Concrete Batching Plant	60m3/hr	2
			Wheel Loade	2m3	2
			Back Hoe	0.3m3	2
			Generator	250kva	2
			Compressor	5.5m3	2
			Barge	2000t	2
			Barge	1000t	2
			Concrete Pump	90m3/hr	2
3	Temporary Work				
3-1	Ent. Access Road		Bull Dozer(swamp type)	21t	5
			Back Hoe	0.8m3	5
			Dump Truck	10t	12
			Tire Roller	10t	5
			Vibration Roller	5t	5

Table	1082-1	Machine allocation plan			
Taute	10.0.2-1	Machine anocation plan			
No.	Work Item	Work	Plant Item	Plant	No.
-----	------------------	---------------	------------------------	----------	-----
		Description		Capacity	
3-2	Temp. Compund		Bull Dozer(swamp type)	21t	9
			Back Hoe	0.8m3	9
			Dump Truck	10t	10
			Tire Roller	10t	8
			Vibration Roller	5t	4
			Crawler Crane	70t	2
			Vibration Hammer	160kw	2
			Barge	1000t	4
			Sand Pump	6 inch	19
			Water Pump	3 inch	13
3-3	Site Access Road	Km0.0-Km4.5 &	Bull Dozer(swamp type)	21t	8
		Km9.94-Km15	Back Hoe	0.8m3	8
			Dump Truck	10t	30
			Tire Roller	10t	8
			Vibration Roller	5t	8
			Sand Pump	6 inch	20
			Backhoe	0.5m3	40
			Generator	30kva	20
			Air Compressor	3.5m3	20
			Barge	100t	20
			TagBoat		8
			Anchor Boat		8
			Non-staging piler	~~	10
			Crawler Crane	35t	10
			Welding set	201	10
			Generator	30kva	10
		Km4.5-Km7.5	Sand Pump	6 inch	10
			Backhoe	0.5m3	16
			Generator	100kva	8
			Generator	30kva	5
			Air Compressor	3.5m3	8
3-4			Crawler crane	30t	8
			Crawler crane	120t	7
			Crawler crane	150t	4
			Diesel Pile Hamma	4.5t	4
			Vibro Hamma	240kva	4
			welding set		8
			Barge	500t	15
			Barge	100t	13
			Tag boat		5
			Anchor boat		5
	Temporary Jetty		Crawler Crane	150t	4
	Construction		Crawler Crane	150t	4
			Haydraulic VibHammer	160kw	2
			Barge	1000t	4
			Barge	1000t	4
			Tug Boat	250hp	1
			Anchor Boat		1
			Generator	200kva	2
			Compressor	5m3	2
			Welding Set		8

THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PRO	JET IN VIET NAM
FI	JAL REPORT

No.	Work Item	Work	Plant Item	Plant		Nos.		Location			
		Description		Capacity	A1-P50	P51-P60	P61-P75	P76-P78	P79-P82	P83-A2	
	4 Pier Piling Work										
			Crawler Crane	300t				2			
			Crawler Crane	250t				2			
			Crawler Crane	150t	6					1	
			Crawler Crane	120t		6	6		4	1	
			Crawler Crane	100t						1	
			Vibration Hammer	240kw				2			
			Vibration Hammer	120kw	6					1	
			Vibration Hammer	60Kw		3					
			Hydraulic Hammer	15t				2			
			Hydraulic Hammer	12t	6	3				1	
			Hammer Sleeve		6	3		2		1	
			Flat Truck	10t	6					1	
			Trailer Truck	150t	6					1	
			Generator	200kva				2		1	
			Generator	100KVA	6	3	3	-	2	-	
			Compressor	5m3	6	3	3	2	2	1	
			Welding set	5110	6	2	3	2	2	1	
			Bored Pile Reverse Circulation	D1500	0	5	3	2	2		
			Bentnite Mixing Plant	D1500			3		2		
			Barge	2000t			2	2	-		
			Barge	2000t				2			
			Barge	1000t		3	3		2		
			Barge	1000t		3	3		2		
			Tug Boat			1	1	1	1		
			Anchor Boat			1	1	1	1		
			Grout Pump					2			
			Grout Mixer					2			
-	Pler Structure				A 1 P/0	NOS. P50 P60	D61 D75	D76 D79	D70 D92	D92 A 2	
			Hydraulic Crane	25t	0	1 30-1 00	r 01-r 75	170-178	1 /9=1 82	2	
			Crawler Crane	150t	9	2	6	3	5	2	
			Crawler Crane	100t	9	-	0	2	5		
			Generator	50kv a	9	2	6	3	5	2	
			Compressor	5m3	9	2	6	3	5	2	
			Welding Set		9	2	6	3	5	2	
			Concrete Vibrator		9	12	36	18	30	12	
			Flat Truck	20t	9					2	
			Lifting Truck	10t	9					2	
			Backhoe	0.8m3	9					2	
			Dump Truck	10t	16				-	4	
			Grab Hammer	1000-		2	0	3	5		
			Barge	1000t		2	0	3	2		
			Tug Boat	250hn		1	1	1	1		
			Anchor Boat	2.50np		1	1	1	1		
			- menor bout								
1		1									
1				1	1						
				1	1						
1											

No	Work Item	Work	Plant Item	Plant		Nos /Loacati	on
1101	, on the second	Description		Capacity	A1-P25	P25-P50	P50-P75
6	Super Structure Ap	proach BridgeA1-P75					
6-1	Girder Construction	1	Erection Girder Type-1		1	1	
			Erection Girder Type-2				1
6-2	Erection Girder Ass	ebling Foundation					
	and Assembling		Crawler Crane	150t	1	1	
			Vibration Hammer	160kw	1	1	1
			Generator	200kva	1	1	1
			Welding Set		1	1	1
			Flat Truck	20t	1	1	1
			Floating Crane	300t			1
			Crawler Crane	200t			1
			Barge	1000t			1
			Barge	1000t			1
			Tug Boat	250hp			1
			Anchor Boat	, î			1
6-3	Erection Girder Ten	nporary Stock Founda	tion				
			Crawler Crane	200t			1
			Vibration Hammer	160kw			1
			Generator	200kva			1
			Welding Set				1
			Crawler Crane	150t			1
			Barge	1000t			1
			Barge	1000t 250hr			1
			Anchor Boat	250np			1
			Allelioi boat				1
6-4	Segment Erection						
	U		Crawler Crane	100t	1	1	
			Generator		1	1	1
			Compressor		1	1	1
			Cable Pusher		1	1	1
			Grout Mixer		1	1	1
			Grout Pump		1	1	1
			Crawler Crane	150t			1
			Barge	1000t			1
6.5	Fraction Girder Dis	mantling					
0-5	Election Onder Dis	manning	Crawler Crane	150t	2	2	2
			Crawler Crane	100t	2	2	-
			Trailer	50t	4	4	
			Welding Set		4	4	
			Crawler Crane	200t			2
			Barge	1000t			2
			Tug Boat	250hp			1
			Anchor Boat				1
			Floating Crane	300t			1

No	Work Itom	Work	Diant Itam	Dlant	N	Jos /Logartics	
INO.	work item	Description	r lant nem	Canacity	P75-P79	P79-A2	1
7	Super Structure P7	5-A2		cupacity	110117	177112	
7-1	Girder Construction	n	Form Traveller Type-1		4		
			Form Traveller Type-2			4	
			Crawler Crane	150t	2	1	
			Crowler Crops	100+	2	1	
				1001	2	1	
			Generator	TOOKVa	2	2	
			Compressor	5m3	2	2	
			Cable Pusher		4	4	
			Grout Pump		4	4	
			Grout Mixer		4	4	
			Barge	1000t	1	1	
			Tug Boat	250hp	1	1	
			Anchor Boat		1	1	
					P75 P79	P84 A 2	
7-2	Side Span Foundat	ion Construction			175,175	104,712	
			Crawler Crane	200t	1		
			Crawler Crane	150t		1	
			Vibration Hammer	160kw	1	1	
			Generator	100kva	1	1	
			Compressor	5m3	1	1	
			Welding Set		1	1	
			Barge	1000t	1		
			Barge	1000t	1		
			Tug Boat	250hp	1		
			Anchor Boat		1		
			Trailer	50t		2	
7-3	Segment Temporar	y Stock Platform					P50-P75
			Crawler Crane	200t			1
			Vibration Hammer	160kw			1
			Generator	100kva			1
			Compressor	5m3			1
			Welding Set	1000			1
			Barge	1000t			1
			Barge	1000t			1
			Tug Boat	250np			1
			Anchor Boat				I
1	1	1	1	1	1		

No.	Work Item	Work	Plant Item	Plant	ľ	los./Loacatio	n
		Description		Capacity	Km0.0-Km4.5	Km10.0-Km15	5.63
8	Unsuitable Soil Rep	lacement					
			Bulldozer(swampy type)	D60	10	10	
			Buckhoe	0.8m3	10	10	
			Dump Truck	10t	5	5	
			Sand Pump	6inch	4	4	
			Generator		4	4	
			Backhoe	1.4m3	1	1	
			Dump Truck	10t	15	15	
			Bulldozer	21t	2	2	
						-	
9	Geo-textile and Cov	er sand					
,	Ceo texale and cov	or sund	Backfoe	1.4m3	1	1	
			Dump Truck	10+	15	1	
			Dullip Huck		15	15	
			Buildozer	200	2	2	
			Flat Lorry	20t	2	2	
10	PV Drain		PV Drain machine		13	9	
			Bulldozer	D60	4	3	
			Flat Lorry	20t	6	4	
11	Sand Drain		Sand Drain Machine		19	12	
			Bulldozer	D60	19	12	
			Dump Truck	10t	10	6	
			Backhoe	1.4m3	1	1	
12	Sand Compaction P	Pile	Sand Compaction Pile Machine		6	2	
			Bulldozer	D60	6	2	
			Dump Truck	10t	4	2	
			Backhoe	1.4m3		1	10
12	D'1 1 C1 1 D'1'		יים אינים	120/	Kml./	AI	A2
15	Plied Slab Pliling		Philip Kig	1201 2.5+	4	2	2
			Crawlor Cropo	5.5t	4	3	2
			Truck Crane	20t	2	2	2
			Flat Lorry	20t	2	2	2
			Generator	100kva	4	3	2
			Compressor	3.5m3	2	2	2
			Welding Set		4	3	2
			8				
14	CAM River Bridge						Km1.7
	_		Crawler Crane	150t			1
			Vibration Hammer	160kw			1
			Hydrulic Hammer	12t			1
			Generator	100kva			1
			Compressor	5m3			1
			Welding Set				1
			Barge	1000t			1
			Tug Boat	250hp			1
			Anchor Boat				1
			Crawler Crane	100t			1
			Backhoe	0.8m3			1
			Cable Pusher				1
			Grout Mixer				1
			Grout Pump				1

No.	Work Item	Work	Plant Item	Plant		Nos./Loacati	on
		Description		Capacity	Km0.0-4.5	Km10-15	
15	Temporary Bridge	*			Km1.7&3.2	Km15.1	
			Crawler Crane	150t	1	1	
			Crawler Crane	100t	1	1	
			Vibration Hammer	160kw	1	1	
			Generator	100kva	1	1	
			Compressor	5m3	1	1	
			Welding Set		1	1	
			Barge	1000t	1	1	
			Tug Boat	250hp	1	1	
			Anchor Boat	- I	1	1	
			Crawler Crane	100t	1	1	
			chumbr chumb	1000	-		
16	Box Culvert Constr	uction					
10			Backhoe	0.8m3	5	5	
			Crawler Crane	50t	5	5	
			Dump Truck	10+	5	5	
			Water Pump	finch	5	5	
			water rump	501		5	
			Generator	50kva	5	5	
			Compressor Elet Truels	5m3	5	5	
			Flat Truck	20t	5	5	
17	Embankment Filling	y Work					
17	Linoanknent i ming	WOIK	Backhoe	1.4m3	8	8	
			Dump Truck	10t	100	100	
			Bulldozer	D6	6	6	
			Tire Roller	20t	6	6	
			Vibration Roller	5t	6	6	
18	Subgrade						
			Motor Grader	3.1m	2	2	
			Tire Roller	20t	2	2	
			Vibration Roller	3t	2	2	
10	Aggragate Bass C	urse 1st lever					
19	Aggregate Base Co	buise-ist layer	Motor Grader	3.1m	2	2	
			Macadam Roller	3.111 12t	2	2	
			Tire Roller	20t	2	2	
			Vibration Roller	3t	2	2	
			Backhoe	0.8m3	1	1	
			Dump Truck	10t	8	10	
			r r		-		

NT.	W/ 1 L	337 1		DI d	T	NT	
No.	Work Item	Work	Plant Item	Plant	Km0.0 Km4.5	Nos./Loacati	on 5.63
		Description		Capacity	KIII0.0-KIII4.3	KIII10.0-KIII1.	0.05
20	A gamaata Pasa Co	l aurea 2n d lavar					
20	Agglegate base Co	Juise-2110 layer	Motor Crador	2 1m	2	2	
			Magadam Ballar	3.111 12t	2	2	
			Tira Pollor	12t 20t	2	2	
			Vibration Pollar	201	2	2	
			Backhoe	0.8m3	1	1	
			Dump Truck	10t	8	10	
			Dump Huck	100	0	10	
21	Aggregate Base Co	urse-3rd laver					
			Motor Grader	3.1m	2	2	
			Macadam Roller	12t	2	2	
			Tire Roller	20t	2	2	
			Vibration Roller	3t	2	2	
			Backhoe	0.8m3	1	1	
			Dump Truck	10t	8	10	
			, , , , , , , , , , , , , , , , , , ,				
22	Asphalt Treated Ba	ase Course-1					
			Finisher	3.5m	2	2	
			Macadam Roller	12t	2	2	
			Tire Roller	20t	2	2	
			Vibration Roller	3t	2	2	
			Dump Truck	10t	8	10	
23	Asphalt Treated Ba	ase Course-2					
			Finisher	3.5m	2	2	
			Macadam Roller	12t	2	2	
			Tire Roller	20t	2	2	
			Vibration Roller	3t	2	2	
			Dump Truck	10+	~	10	
			Dump Huck	101	0	10	
24	Asphalt Bindar Co						
24	a sphan bilder (0)		Asphalt Finisher	3.5m	2	2	
				3.511	2	2	
			I ITE KOller	201	2	2	
			Macadam Roller	12t	2	2	
			Vibration Koller	3t	12	12	
			Dump Truck	101	12	12	
25	Asphalt Surface Co						Km4 5-10
2.5	rispitan Surface Co		Asphalt Finisher	3.5m	2	2	2 2
			Tire Roller	20t	2	2	2
			Macadam Roller	12t	2	2	2
			Vibration Roller	3t	2	2	2
			Dump Truck	10t	12	12	14
			r ····				
			1				

No.	Work Item	Work	Plant Item	Plant		Nos./Loacati	on
		Description		Capacity	Km0.0-4.5	Km10-15	Km4.5-Km10
26	Drainage	^ 					
	-		Backhoe	0.3m3	2	2	
			Dump Truck	10t	4	4	
			Soil Compactor	500kg	10	4	
			Flat Truck	20t	1	1	
				200		-	
27	Solid Soding &						
27	Dinron		Paalthaa	0.2m2	10	10	
	кіргар		Dulld	0.5005	10	10	
			Buildozer	10	10	10	
			Dump Truck	10t	10	10	
			Soil Compactor	500kg	4	4	
28	Gurdrail						
			Gurdrail Piler		1	1	
			Flat Truck	20t	1	1	
29	Curve Stone						
			Flat Truck	20t	1	1	
30	Parapet Wall						
50	Tatapet Wall		Flat Truck	20t	1	1	1
			Trach Crops	201	1	1	1
			Thuck Chane	201	1	1	1
31	Lighting		Flat Truck	20t	1	1	1
			Truck Crane	20t	1	1	1
32	Navigation Safety						
	i la iguiloir burety		Monitoring Station Parga				2
							2
			Speed Boat				2
			Tug Boat				1
L				1			

Source: Study Team