Kursus Pengenalan kepada Struktur Jambatan dan Pembinaan Jambatan Jenis Konvensional dan Integral

JKR

BAHAGIAN REKABENTUK JAMBATAN
CAWANGAN JALAN

12 Feb 2019

JADUAL

Tarilk/ Masa	8.30 – 9.30pg	9.30 – 10.30 pg	10.30 - 11.00 pg	11.00 – 1.00 tgh	1.00 – 2.30 ptg	2.30 – 4.30 ptg	4.30 - 5.00 ptg
20/2/2019	Tajuk 1 Pengenalan Kepada Jambatan	Tajuk 2 Komponen Jambatan dan Fungsi	Minum Pagi	Tajuk 3 Asas Kepada Rekabentuk Struktur Jambatan	Makan Tengahari & Solat	Tajuk 4 Introduction to Bridge Construction	Minum Petang
21/2/2019	Tajuk 1 Method of Bridge Construction		Minum Pagi	Tajuk 2 Supervision of Bridge Works	Makan Tengahari & Solat	Tajuk 3 Do's & Don'ts	Minum Petang

OBJEKTIF KURSUS

Memberi pengetahuan dan pemahaman kepada pegawai JKR tentang :-

- Jambatan jenis konvensional dan integral yang dibina di Malaysia
- Kriteria rekabentuk
- Pengurusan pembinaan, kaedah pembinaan, penyeliaan dan kawalan Kualiti kerja-kerja pembinaan jambatan

Berkongsi pengalaman terhadap masalah-masalah pembinaan jambatan – do and don't

Meningkatkan kompetensi pegawai JKR dalam penurusan projek pembinaan jambatan

TOPIK 1 : PENGENALAN KEPADA JAMBATAN

WHAT IS BRIDGE?

Bridge is a structure which covers gap corresponding to the responsibility in carrying a free flow of transport and is the most significant component of a transportation system

Why bridges need to be built?

Bridges need to be provided to carry right of way across a natural or artificial obstacle such as a river, canal, water course, ravines or another road or another railway or connecting an island

WHAT IS BRIDGE?

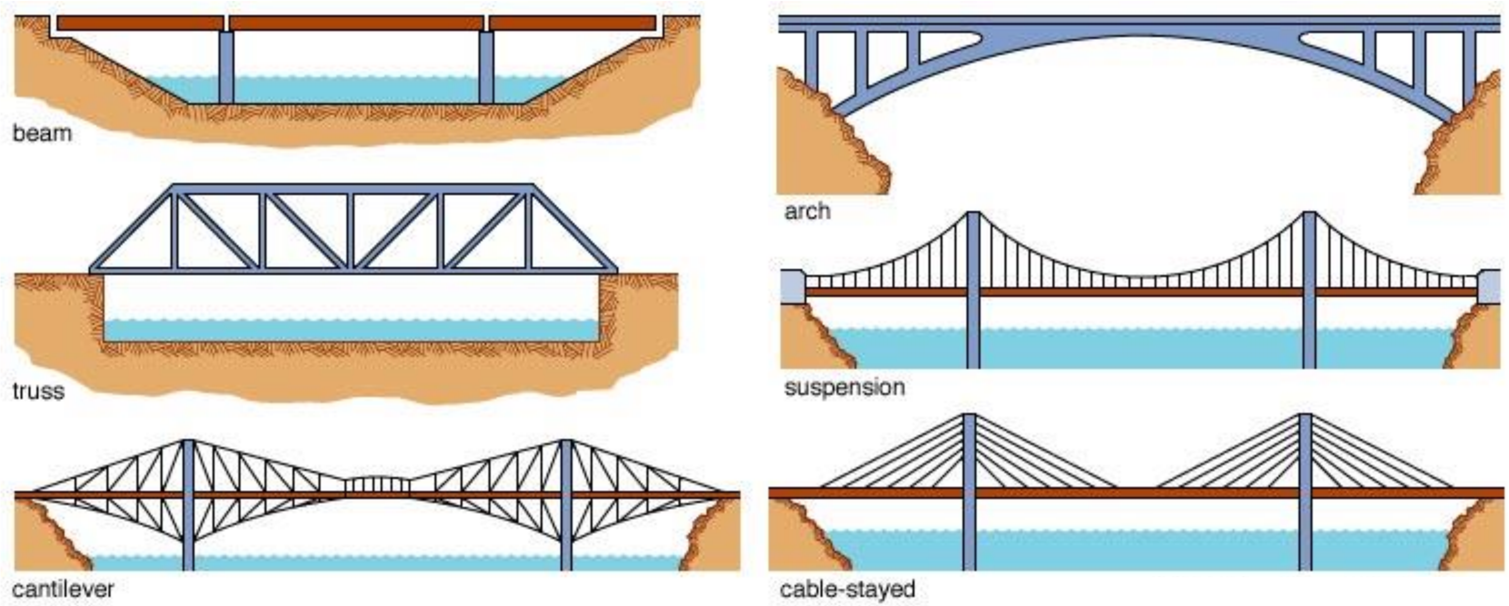




WHAT IS BRIDGE?

- Road or Highway Bridges
  - Any bridge on roads and highways
- Railway Bridges
  - Any bridge on railways
- Flyover or Overpass Bridges
  - Bridges for grade-separation with other roads, highways or railways at intersection
- Viaducts
  - Bridges to support elevated roads, highways, or railways, which are built mainly at where ground space is limited in urban area or embankment is difficult for ground is soft
- Overhead Footbridges
  - Bridges for pedestrian crossing

TYPE OF BRIDGE

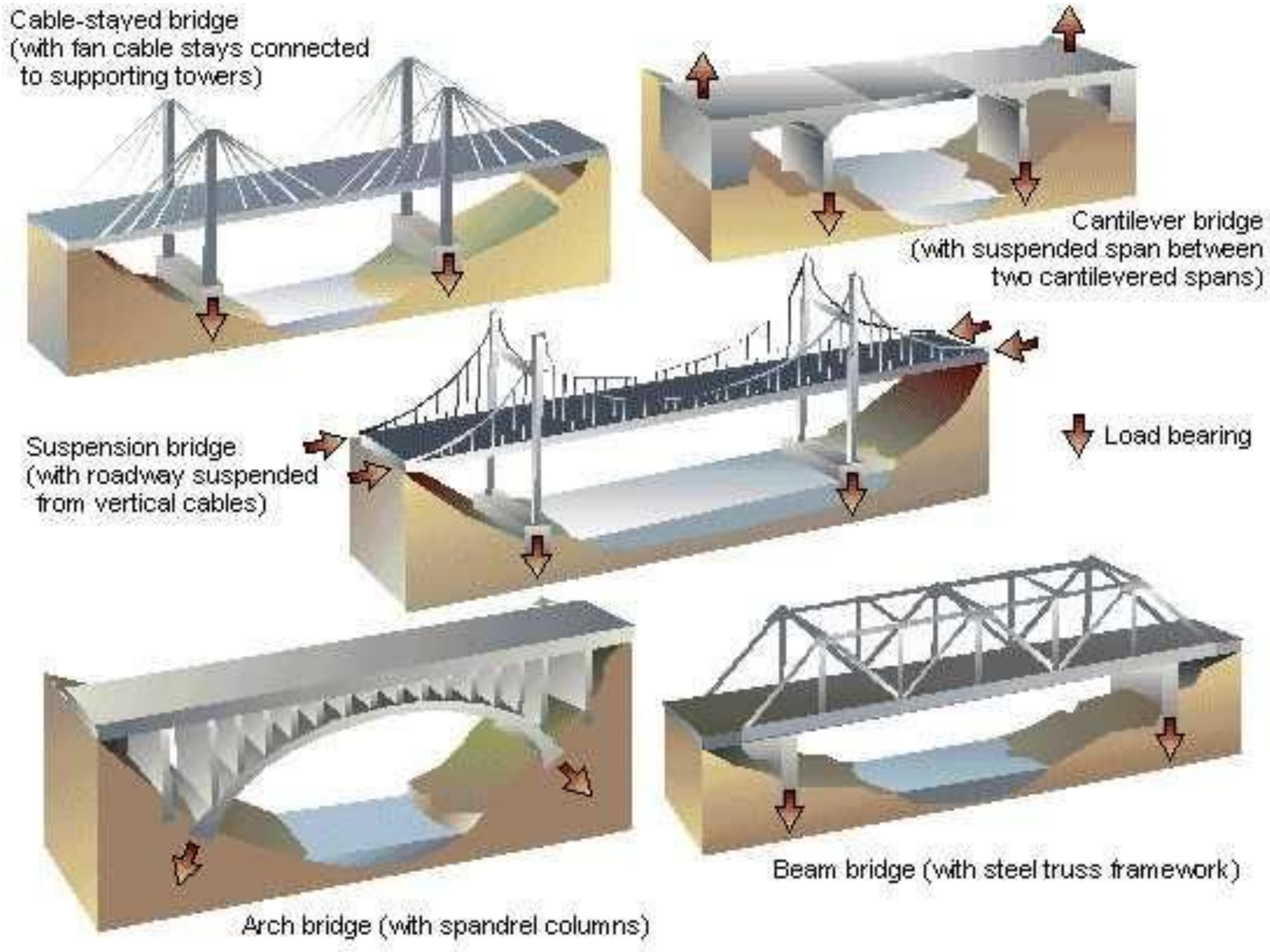


Rigid Frame Bridge

TYPE OF BRIDGES

Structural Type	Range of span(m)
Slab	<12
Reinforced beam + slab	10 – 25
Voided slab	10 - 25
Prestressed beam + slab	20 – 40
Reinforced box girder	30 – 50
Prestressed box girder	30 – 200
Cable stayed	90 – 290
Concrete arch	90 – 300
Steel arch	100 – 500
Suspension	300 - 1400

BRIDGE – LOAD PATH

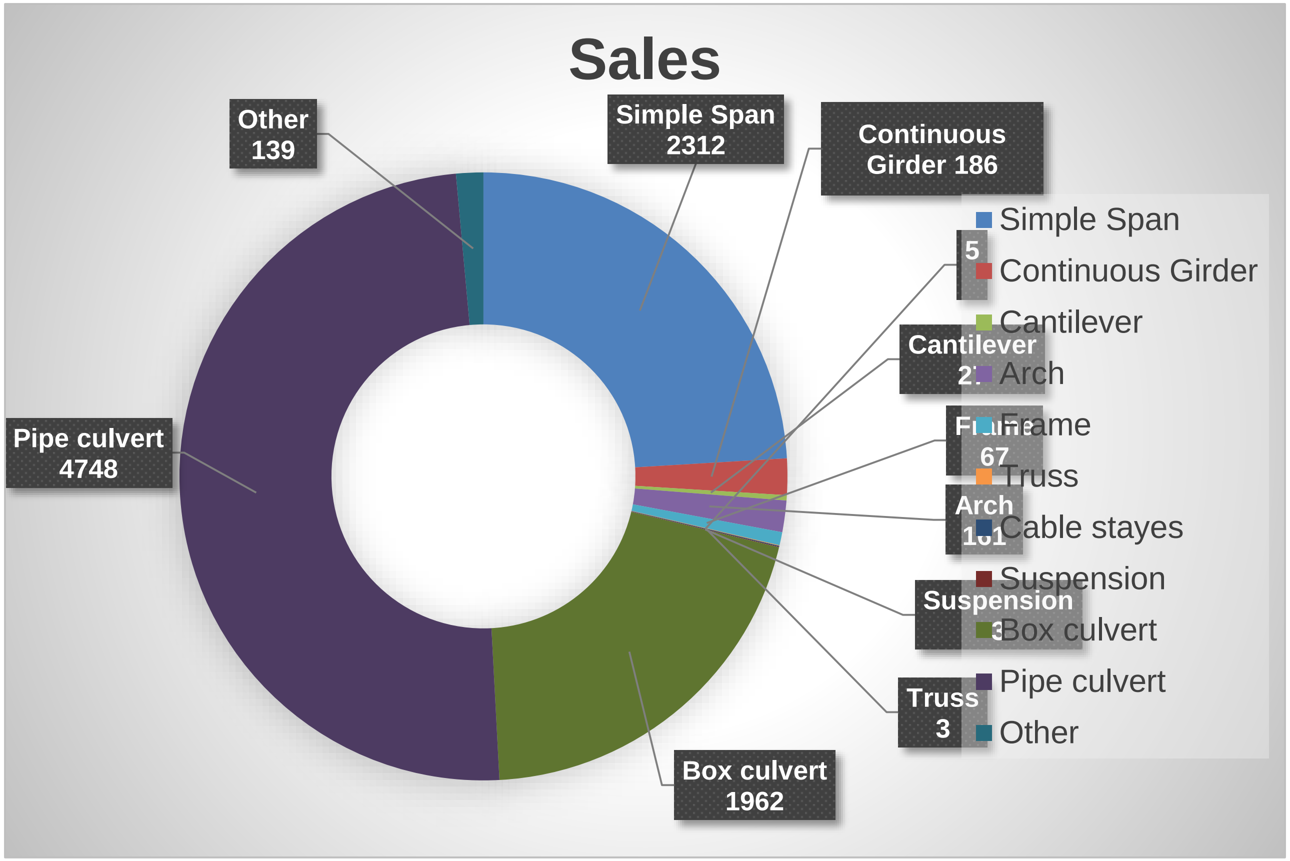


Several types of bridges
Microsoft Corporation

NOS. OF BRIDGE (2019)

		TYPEOF BRIDGE (MATERIAL)		
State	**No of Bridges**	**Steel**	**Concrete**	**Masonry**
Perlis	313	1	311	1
Kedah	821	40	777	4
P. Pinang	418	26	243	149
Perak	1568	101	1464	3
Selangor	889	50	839	0
N. Sembilan	554	74	476	4
Melaka	243	8	234	1
Johor	1420	52	1368	0
Pahang	1858	181	1666	11
Terengganu	922	73	849	0
Kelantan	535	58	477	0
W. Persekutuan	74	4	70	0
Total	**9615**	**668**	**8774**	**173**

NOS. OF BRIDGES – system type



System Type	Total
Simple Span	2312
Continuous Girder	186
Cantilever	27
Arch	161
Bailey	2
Frame	67
Truss	3
Box Culvert	1962
Pipe Culvert	4748
Cable-Stayed	5
Suspension	3
Other	139
Total	**9615**

BRIDGES IN MALAYSIA

1920 - 1950	Steel Bridge + Steel Buckle Plate Bridge
1930	RC Beam
1950	Precast RC Beam
1960	Prestress Concrete Beam (span : 16 – 50m)
1974	Longest Precast Box Girder
1985	Cable-stayed (Penang Bridge)
2000	Longer + Asthetic on Cable-stayed

BRIDGES IN MALAYSIA

- **Many steel truss bridges were built especially in East Malaysia (Sabah and Sarawak).**

SULTAN ISKANDAR BRIDGE

Completed in 1932.
Across Perak River.
Federal Route 1.

Longest steel arch bridge in Malaysia at 285m long.

BRIDGES IN MALAYSIA

KUALA BESUT BRIDGE

Completed in 1984. Total length is 510.0m long. PC concrete bridge crossing Sg. Besut in Terengganu.

16 No. simply supported span,

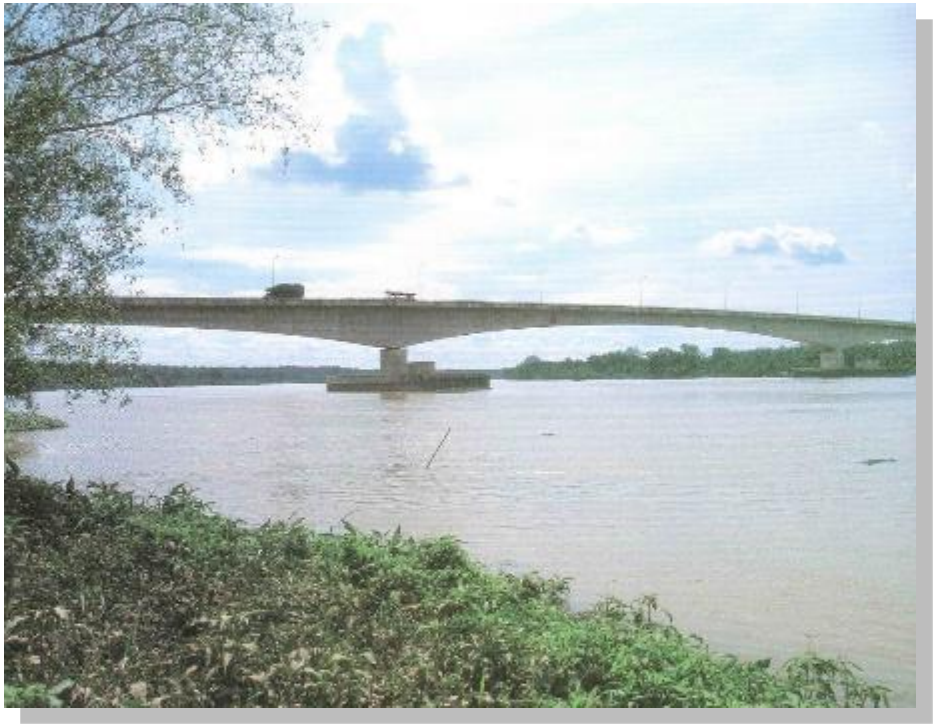
PULAU INDAH BRIDGE

Completed in 1994. Total length is 1.0km long. PC concrete bridge to West Port in Pulau Indah.

25 No. simply supported span, each 40.0m long.

BRIDGES IN MALAYSIA

- For longer spans, prestressed concrete box girders have been used, the first of which was constructed in 1974.



SULTAN YUSSUF BRIDGE

Completed in 1988. Total length 1.3km long. PC box girder bridge crossing Sg. Perak on FT5 near Teluk Intan town in Perak

Max span length = 160.0m

BRIDGES IN MALAYSIA

NORDIN BRIDGE

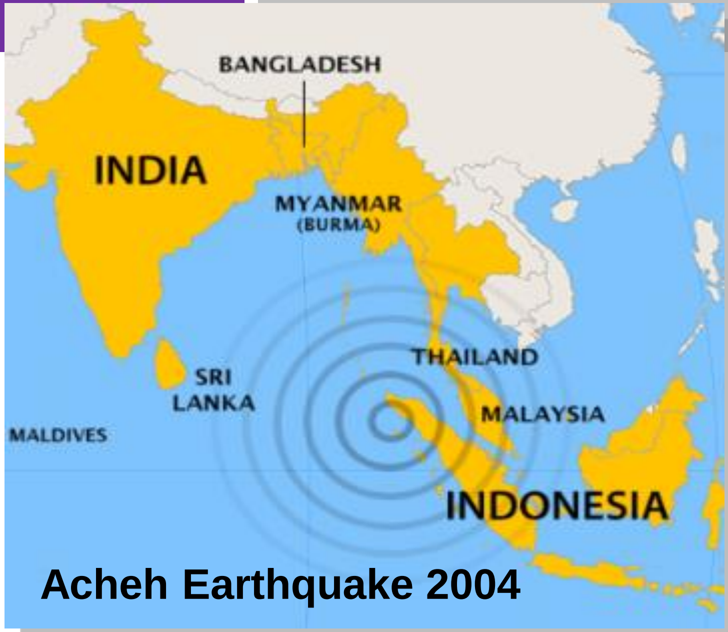
Completed in 1999. Total length 279m long. PC box girder bridge crossing Sg. Perak on FT73 in Perak

BRIDGES IN MALAYSIA

PENANG BRIDGE

- The Penang Bridge was the first cable-stayed bridge built in Malaysia after independence. Completed in 1985.
- At 13.5km long, it is currently the fourth longest bridge in Asia. Main span 225m, vertical clearance 30m at the centre span for navigation.
- A 3-lane dual carriageway

BRIDGES IN MALAYSIA

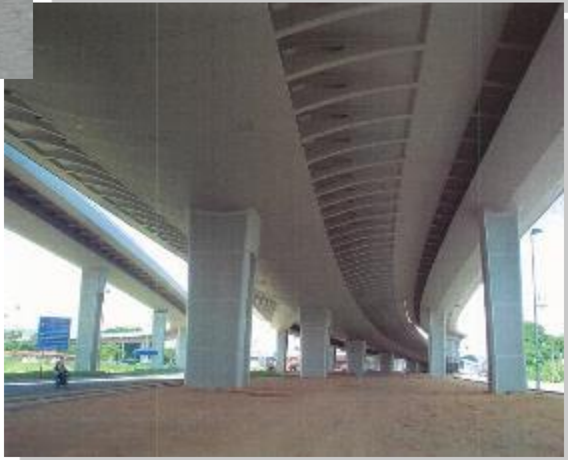


PENANG BRIDGE DESIGN CONSIDERATIONS :

- Earthquake magnitude up to 7.5 on the Richter scale.
- Type HA loading to BS 153 + 45 units HB loading guided along centreline of each 2-lane carriageway.
- Ship impact load of 1000 kN acting horizontally through the centreline of the pier and perpendicular to the longitudinal axis of bridge.

BRIDGES IN MALAYSIA

- From 2000 onwards, many cable-stayed bridges were designed and built over longer spans for economic and



SG. PERAI BRIDGE

Completed in 2003. Total length 1.6km long. Cable-stayed bridge at Butterworth Outer Ring Road (BORR) in Penang.

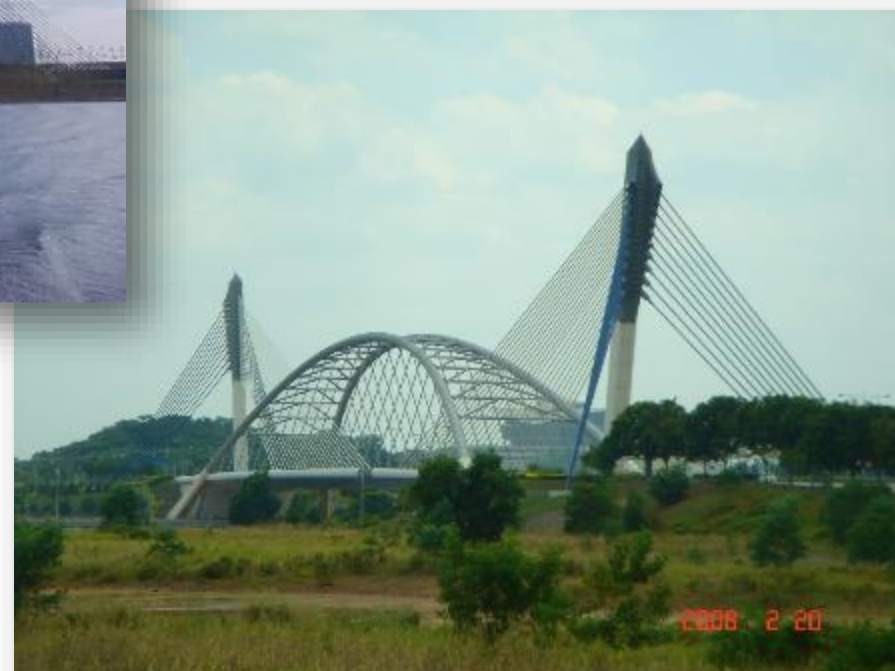
Max span length = 185.0m

BRIDGES IN MALAYSIA

SULTAN ABDUL HALIM BRIDGE (SECOND PENANG BRIDGE)

- Dual carriageway toll bridge in penang.
- It connects Batu Kawan in Seberang Perai with Batu Maung.
- The total length : 24km (15 miles) with length over water at 16.9km
- Completed in 2014

BRIDGES IN MALAYSIA



SERI SAUJANA BRIDGE

Completed in 2002. Single span 300m long cable-stayed arch bridge at Putrajaya.

3-lane dual carriageway.

BRIDGES IN MALAYSIA

SERI WAWASAN BRIDGE

Completed in 2003. Single span futuristic cable-stayed bridge at Putrajaya.

3-lane dual carriageway.

BRIDGES IN MALAYSIA

LANGKAWI SKYBRIDGE

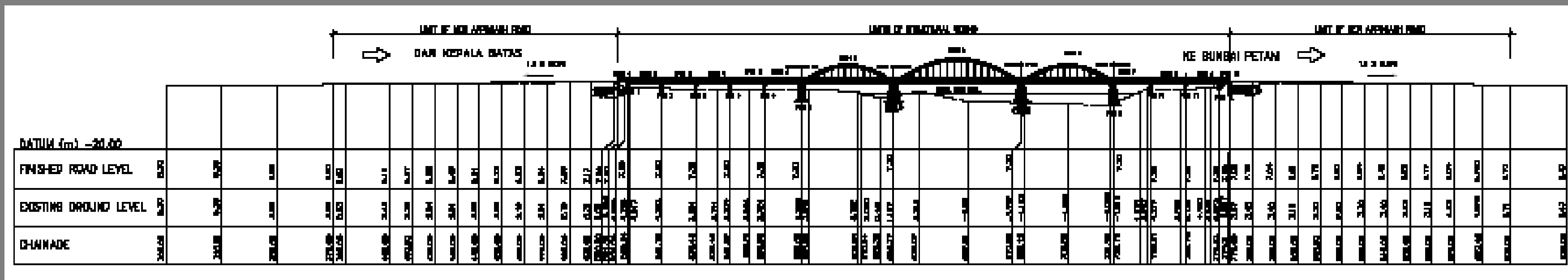
Built in 2005 at 700m above sea level.

Span 125m long.

BRIDGES IN MALAYSIA

- The original bridge which was built before the Second World War was bombed during the war. It was reconstructed around 1957 and was known as The Jambatan Merdeka to commemorate Malaysia's independence. The bridge has 13 spans with a total length of 273m crossing Sungai Muda River on Federal Route 1.
- The new Merdeka Bridge was designed to meet the same concept of existing bridge which reflect the heritage and history of the area and contribute in improving the environment for the entire community.
- The new bridge's form and alignment blend well with the existing bridge, surrounding, portraying a picturesque image to the environment.

BRIDGES IN MALAYSIA



MAIN TECHNICAL DETAILS

❖ Type Of Bridge	: Arch Bridge
❖ Overall Length	: 273 meter
❖ Arch Length	: Type A (56.916 meter) Type B (41.076 meter)
❖ Max. Height Of Arch	: Type A (7.836 meter) Type B (5.411 meter)
❖ Type Of Foundation	: Bored Pile (600mm Diameter at Abutment A & B) (1200mm Diameter = Abutment A & B)
❖ Carriageway Width	: (Standard R5 With 3500mm)

DESIGN CODES

Engineering practice in Malaysia has been traditionally based on British Standards. Over the years, bridges in Malaysia have been designed to:

- ✓ **BS 153: 1954 (revised in 1972) – based on a working load and permissible stress method.**
- ✓ **BS 5400: 1978 (revised in 1990, 2005, 2006) – based on limit state concept.**
- ✓ **JKR Specification for Bridge Live Loads**
- ✓ **BD 37/01 – Loads for Highway Bridges**
- ✓ **EURO CODE - BS EN 1991-2:2003 Eurocode 1: Actions on structures (Part 2: Traffic loads on bridges)**

DESIGN CODES

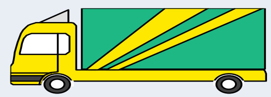
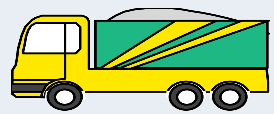
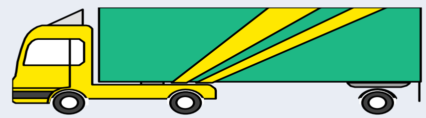
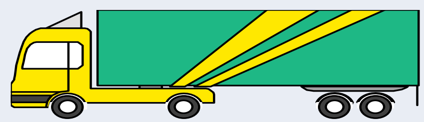
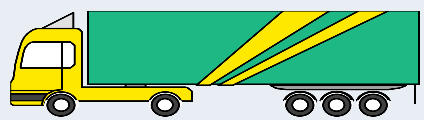
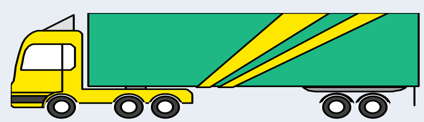
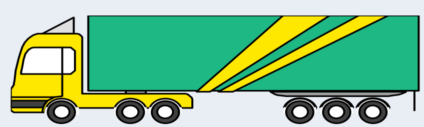
Existing stock of bridges in Malaysia were designed to many different bridge design codes.

	1970	1985	1990	1996	YEAR
Code ??	BS153 (HA + HB)		BS5400 (HA + HB)	JKR (LTAL +SV)	BD37/88 (rev 2001) (HA + HB)

Weight Restriction Order (WRO)

Bil	Tahun	Polisi	Had Berat
2	WRO 1989	Short Term Axle Load (STAL)	GVM : 38 tonne Single Axle Load : 10 tonnes
3	WRO 2003	Medium Term Axle Load (STAL)	List I GVM : 44 tonne Single Axle Load : 12 tonnes List II GVM : 38 tonne Single Axle Load : 10 tonnes
4	WRO 2018	Medium Term Axle Load (STAL)	List I GVM : 50 tonne Single Axle Load : 12 tonnes List II GVM : 44 tonne Single Axle Load : 12 tonnes

HAD BERAT MUATAN – WRO2018

Type of Vehicle	Scheme	Max Vehicle Weight
2 Axle – Rigid Vehicle (1 + 1)		**19,000 kg**
3 Axle – Rigid Vehicle (1 + 2)		**27,000 kg**
3 Axle – Articulated Vehicle (1 + 1 + 1)		**31,000 kg**
4 Axle – Articulated Vehicle (1 + 1 + 2)		**39,000 kg**
5 Axle – Articulated Vehicle (1 + 1 + 3)		**45,000 kg**
5 Axle – Articulated Vehicle (1 + 2 + 2)		**45,000 kg**
6 Axle – Articulated Vehicle (1 + 2 + 3)		**50,000 kg**

AXLE LOAD STUDY

Bil	Tahun	Kajian
1	1986 - 1988	National Axle Load Study (RPT)
2	1986 – 1988	The study on the Maintenance and Rehabilitation of Bridges in Malaysia (JICA)
3	1994 - 1995	Determination of the Structural Capacity of Existing Bridges in Peninsular Malaysia (DESSAU)
4	1996	The Study on the Standardization of Bridge Design in Malaysia (JICA)
5	2004 - 2005	Kajian ke atas Pemeriksaan, Inventorisasi dan Penyenggaraan Jambatan Persekutuan di Sabah dan Sarawak (KTA)
6	2010 - 2011	Study of Bridge Capacity on Federal Routes in Sabah, Sarawak and Labuan for Compliance with Weight Restriction (Federal Routes) (Amendment) Order 2003
7	2012 - 2013	A Comprehensive Study on the Vibration of Highway Bridges
8	2014 - 2016	Axle Load Study (Bridges) on Federal and Major State Routes in Peninsular Malaysia

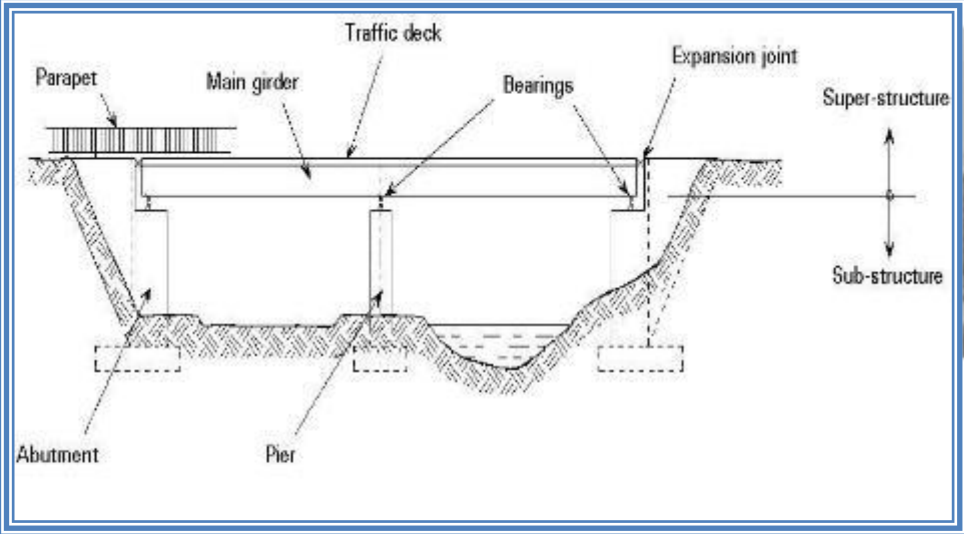
SESI SOAL JAWAB

TOPIC 2 : BRIDGE COMPONENTS

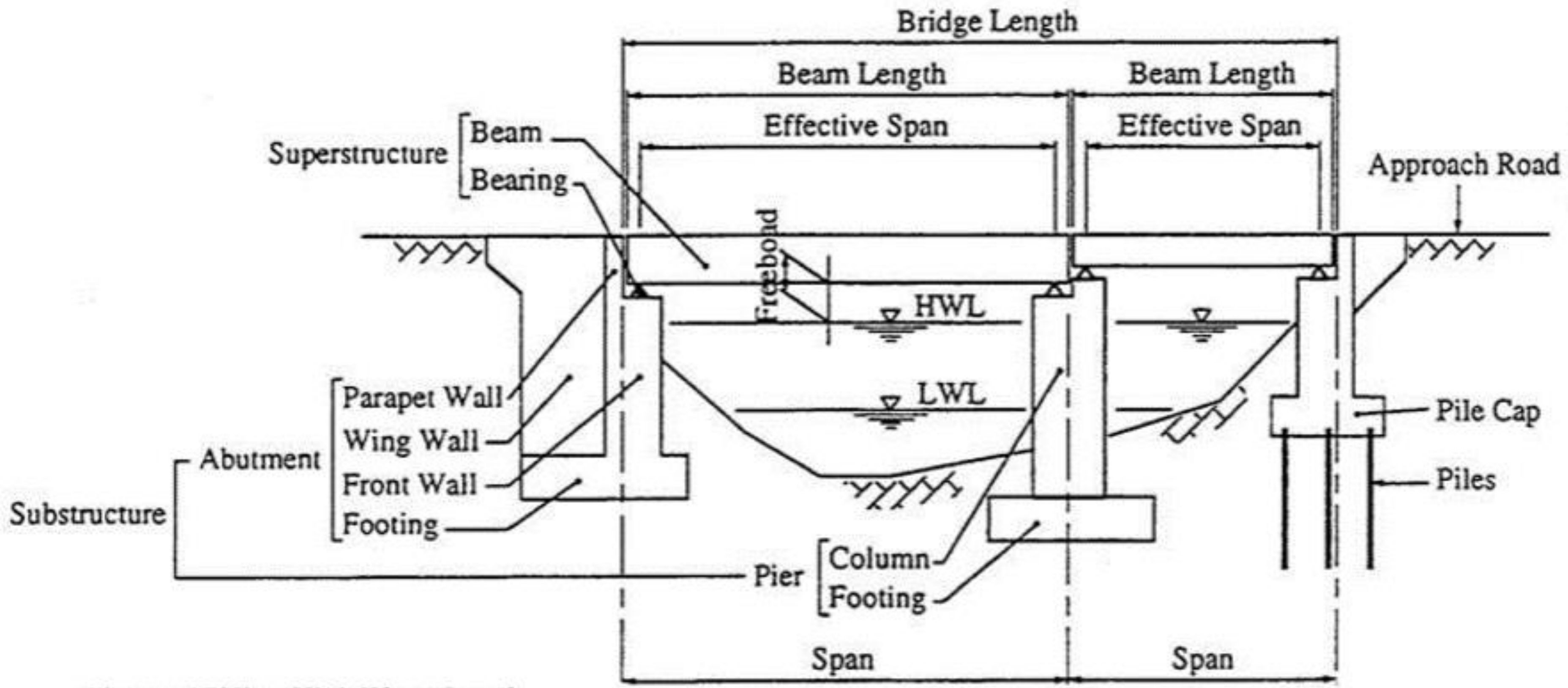
BRIDGE COMPONENT

According to Departmental Standard BD 37/01 "Load for Highway Bridges", components of a bridge is categorized into:

i. Superstructure – in a bridge, that part of the structure which is supported by the piers & abutments
ii. Substructure – in a bridge, the wing walls & the piers, towers & abutments that support the superstructure
iii. Foundation – that part of substructure in direst contact with & transmitting load to the ground



BRIDGE COMPONENT



Notes : HWL = High Water Level
LWL = Low Water Level

BRIDGE COMPONENT

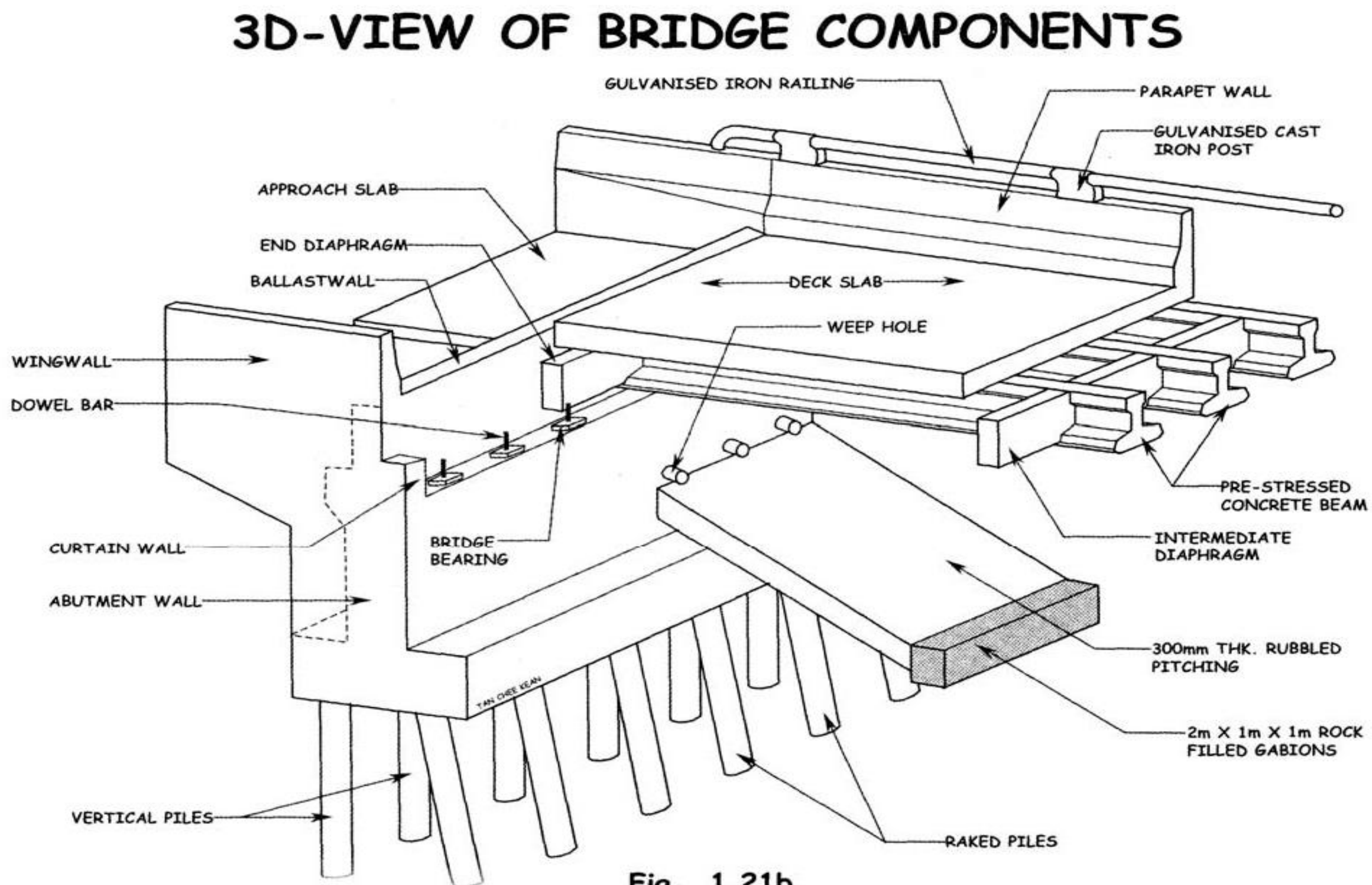
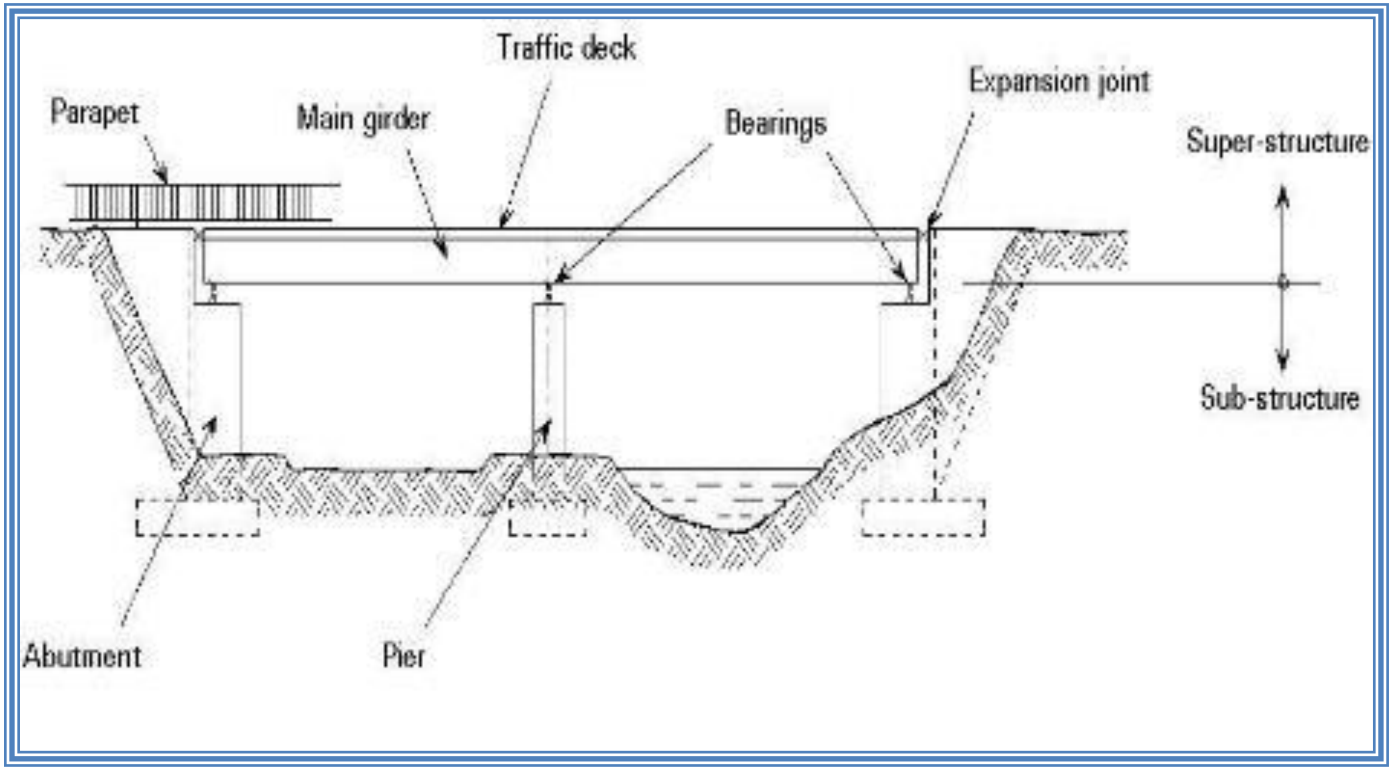


Fig. 1.21b

BRIDGE COMPONENT-SUPERSTRUCTURE

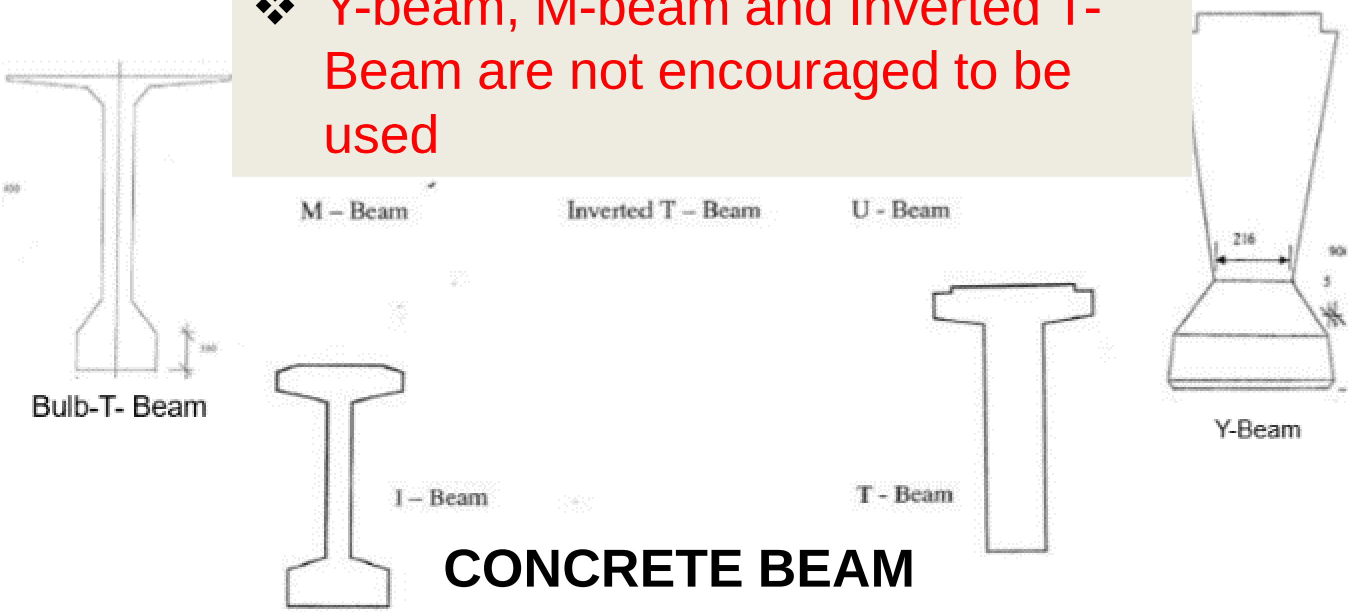
Superstructure consist of:

- ❖ Beams & girder
- ❖ Deck slab
- ❖ Diaphgram



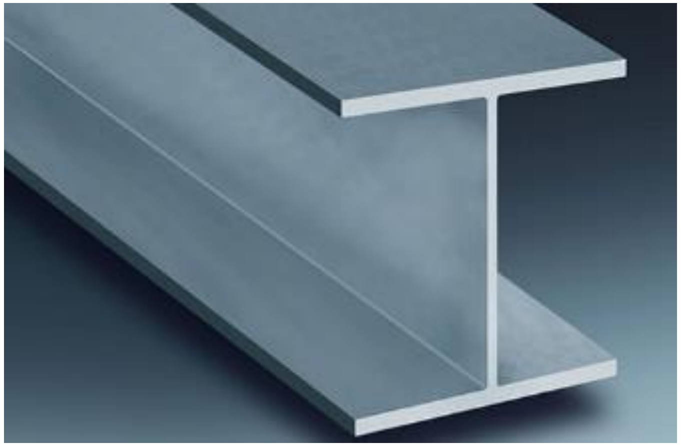
SUPERSTRUCTURE - Beam

- Y-beam, M-beam and Inverted T-Beam are not encouraged to be used



CONCRETE BEAM

SUPERSTRUCTURE - Beam

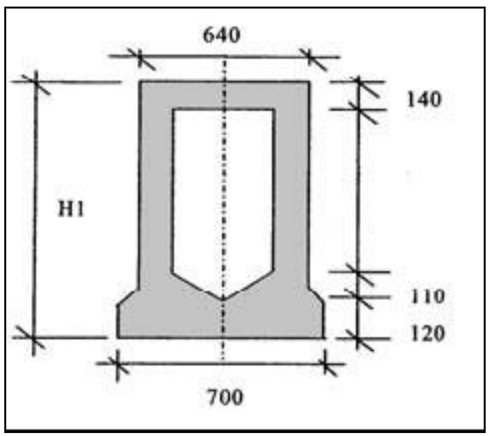


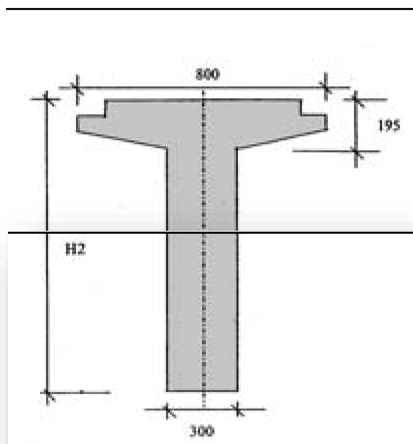
STEEL BEAM

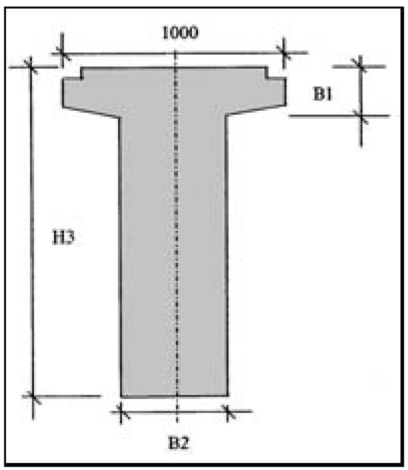
SUBSTRUCTURE - Beam

JKR Standard Beam

i. Pre-tensioned concrete hollow slab (PRHS)
ii. Pre-tensioned Concrete Composite T-Beam (PRT)
iii. Post-tensioned Concrete Composite T-Beam (PTT)





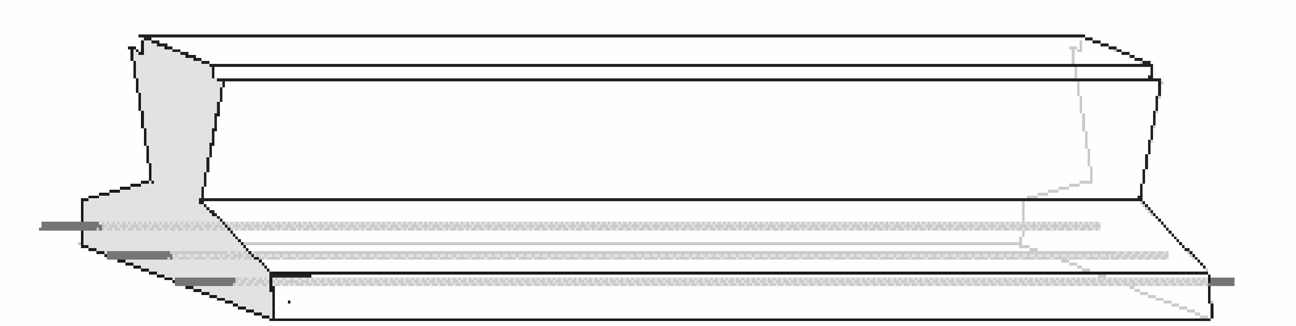


PRHS	H1 (mm)	SPAN (m)
PRHS1	500	10.5
PRHS2	600	12.5
PRHS3	700	14.5
PRHS4	800	16.5
PRHS5	900	18.5
PRHS6	1000	20.5

PRT	H2 (mm)	SPAN (m)
PRT1	1250	18.6
PRT2	1350	20.6
PRT3	1400	22.6

PTT (End)	B1 (mm)	B2 (mm)	PTT (Inter.)	B1 (mm)	B2 (mm)	H3 (mm)	SPAN (m)
PTT1	270	550	PTT1	300	360	1800	25.7
PTT2	270	550	PTT2	300	360	1900	28.7
PTT3	270	550	PTT3	300	360	2000	30.7
PTT4	270	550	PTT4	300	360	2100	32.7
PTT5	270	550	PTT5	300	360	2300	35.7
PTT6	270	550	PTT6	300	360	2700	40.7
PTT7	270	550	PTT7	300	360	2850	45.7

Pre-tensioned Prestressed Beam



Stage 1	Stage 2	Stage 3	Stage 4
Tendons and reinforcement are positioned in the beam mould	Tendons are stressed to about 70% of their ultimate strength	Concrete is cast into the beam mould and allowed to cure to the requirement initial strength	When the concrete has cured the stressing force is released and the tendons anchor themselves in the concrete.

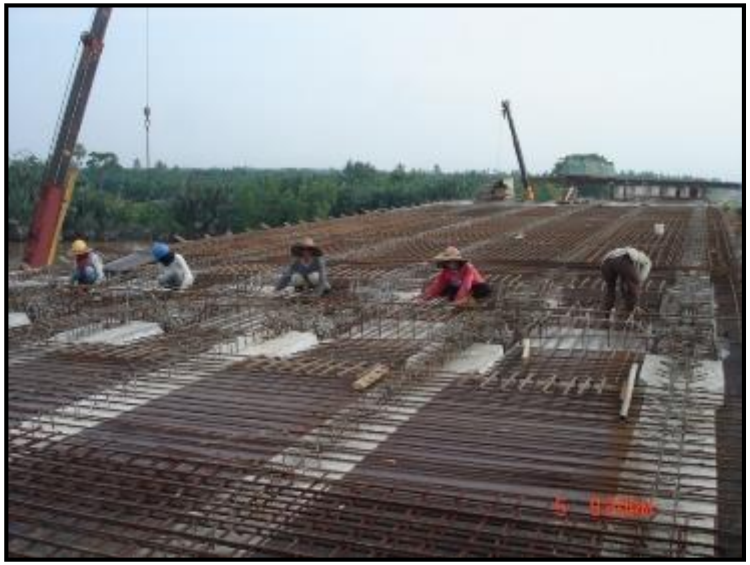
SUBSTRUCTURE - Beam

Post-tensioned Prestressed Beam

Stage 1	Stage 2	Stage 3	Stage 4
Cable ducts and reinforcement are positioned in the beam mould. The ducts are usually raised towards the neutral axis at the end to reduce the eccentricity of the stressing force.	Concrete is cast into the beam mould and allowed to cure to the required initial strength.	Tendons are threaded through the cable ducts and tensioned to about 70% of their ultimate strength.	Wedges are inserted into the end anchorages and the tensioning force on the tendons is released. Grout is pumped into the ducts to protect the tendons.

SUPERSTRUCTURE - Deck

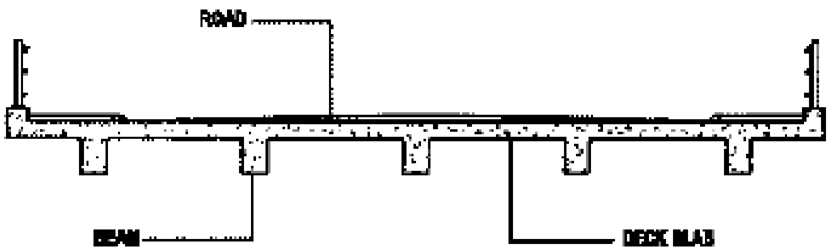
CAST IN-SITU BRIDGE DECK



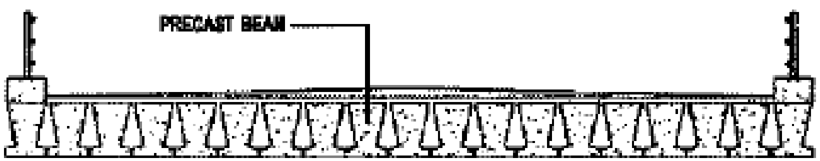
- Superelevation : 2.5% - max 6%
- Water run-off efficiently drain through water down pipe
- Different type – depend on beam

SUPERSTRUCTURE - Deck

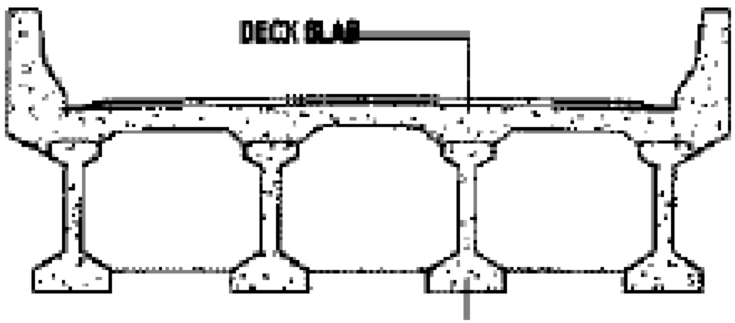
1. Reinforced Concrete Beam (Fig. 1.10) (RCB)



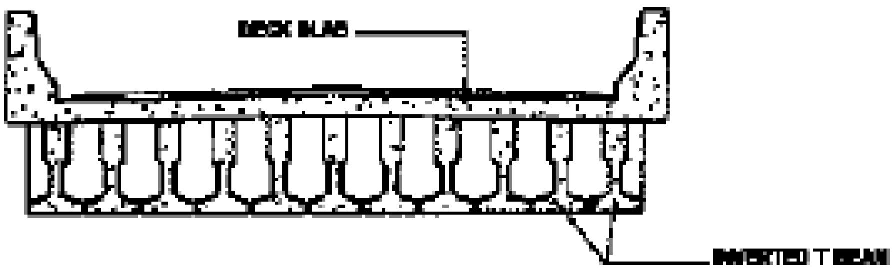
2. Precast Reinforced Concrete beam (Fig. 1.11) (PRCB)



3. Prestressed Concrete I-Beam (Fig. 1.12) (PCB)

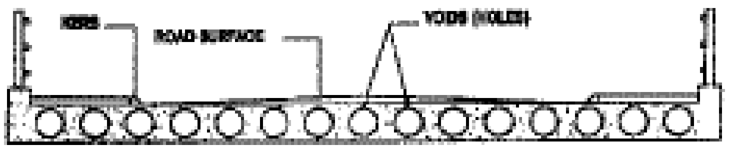


4. Prestressed Inverted Tee Beam (Fig. 1.13) (IT)

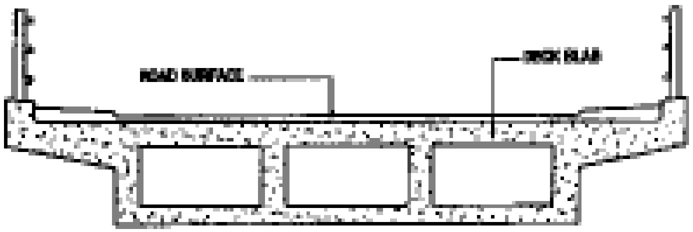


SUPERSTRUCTURE - Deck

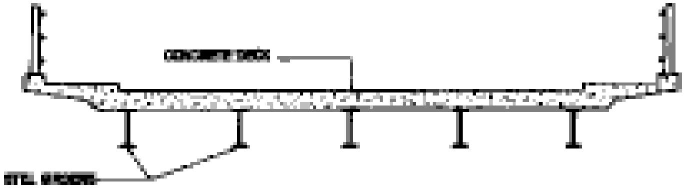
6. Voided Concrete Slab (Fig. 1.15) (VCS)



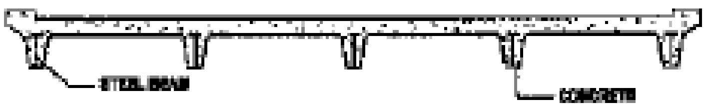
7. Concrete Box Girder (Fig. 1.16) (CBG)



8. Steel Beam and Concrete Slab (Fig.1.17) (SBC)



9. Steel Beam Encased and Slab (Fig.1.18) (SBE)



10. Steel Buckle Plate (SBP) (Fig.1.19)

SUPERSTRUCTURE - Diaphragm

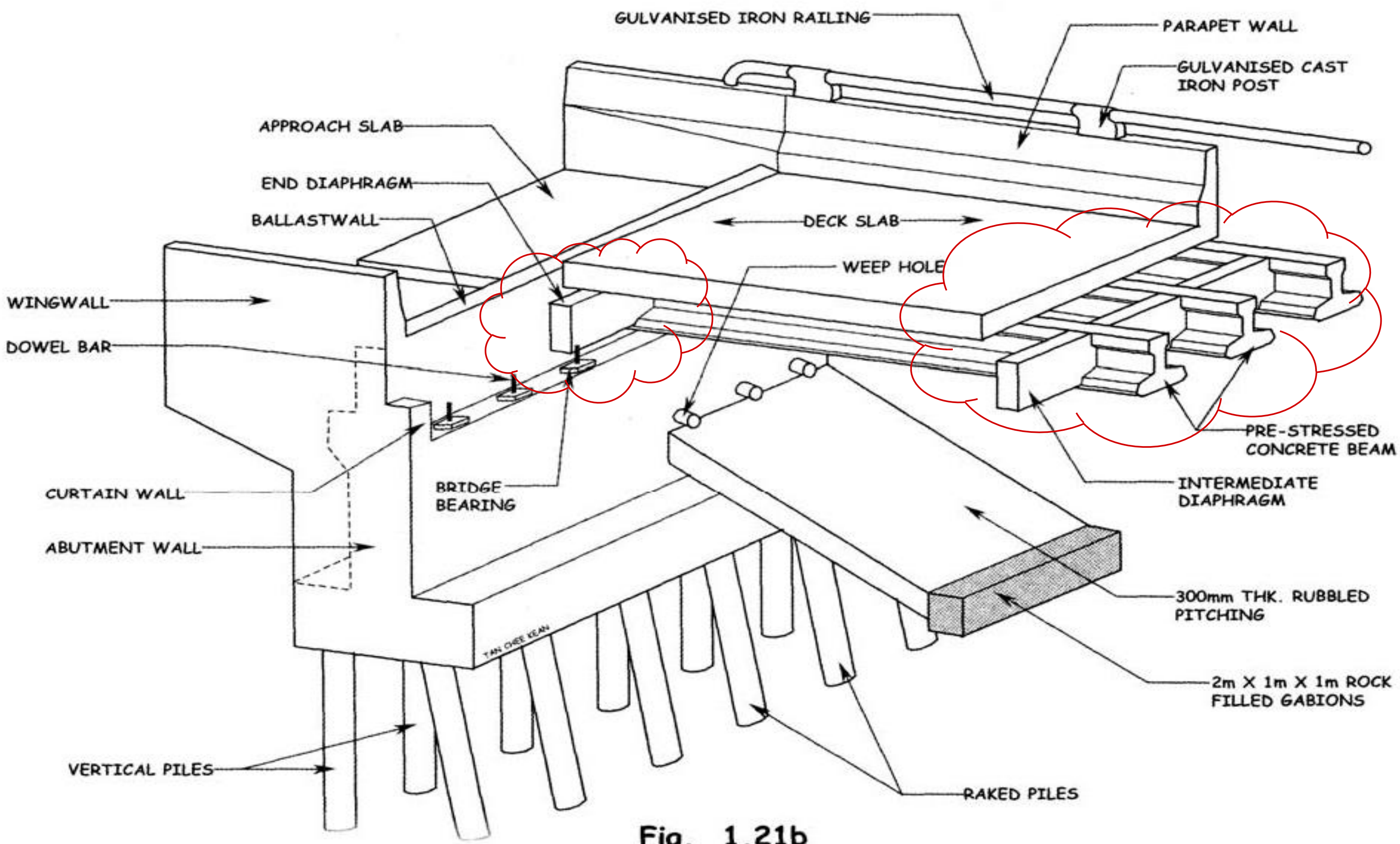
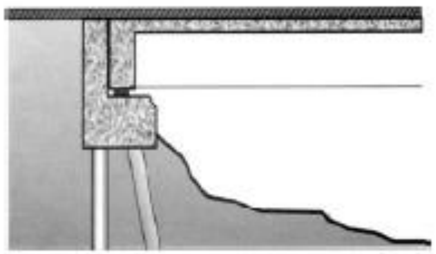


Fig. 1.21b

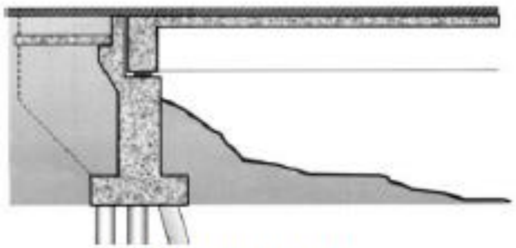
SUPERSTRUCTURE - Abutment

Abutments

Abutments is normally composed of footing (pile cap), ballast wall, bridge seat, wing walls, curtain walls and sometime approach slab seat on corbel

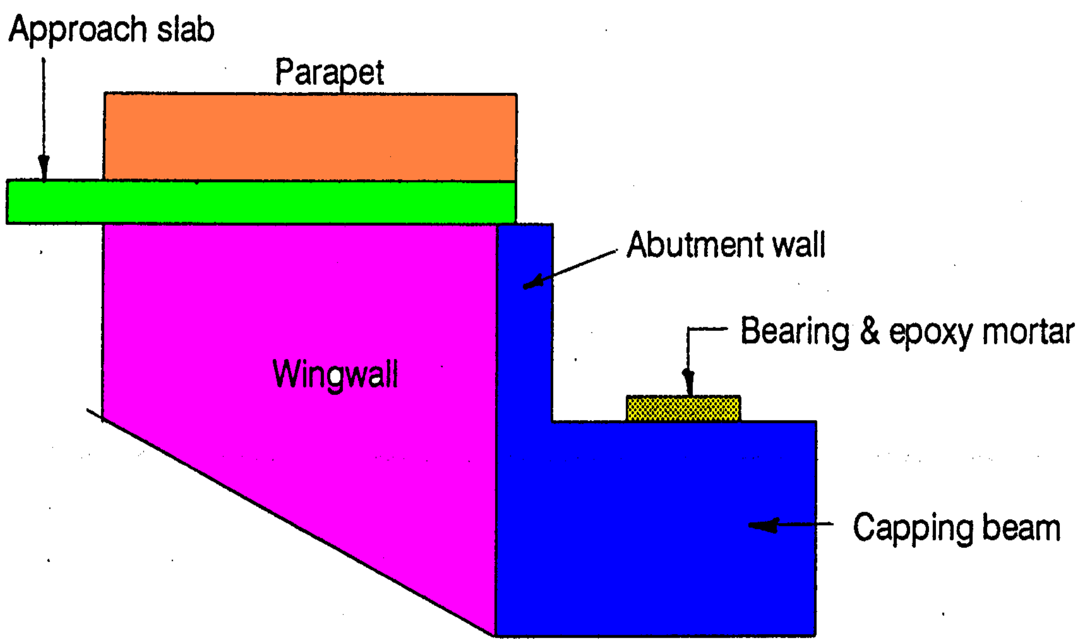


Bank Seat

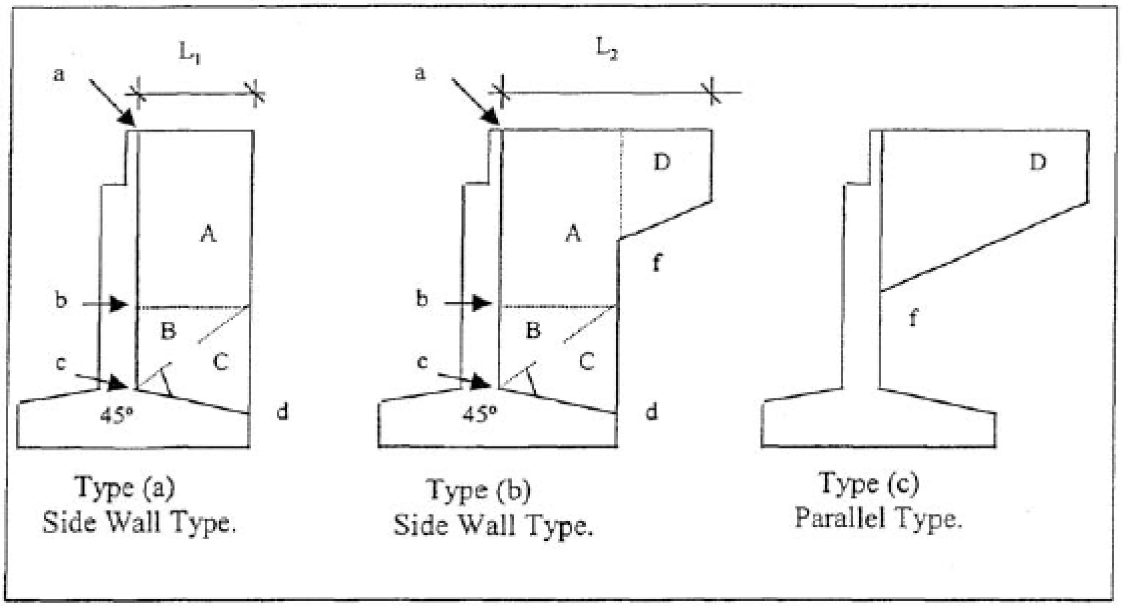


Retaining Wall

Pile Bents



SUBSTRUCTURE – Wing wall



SUBSTRUCTURE – Approach Slab

Approach Slab

A Reinforced concrete slab used at the approaches of a bridge to prevent settlement of approach pavement.

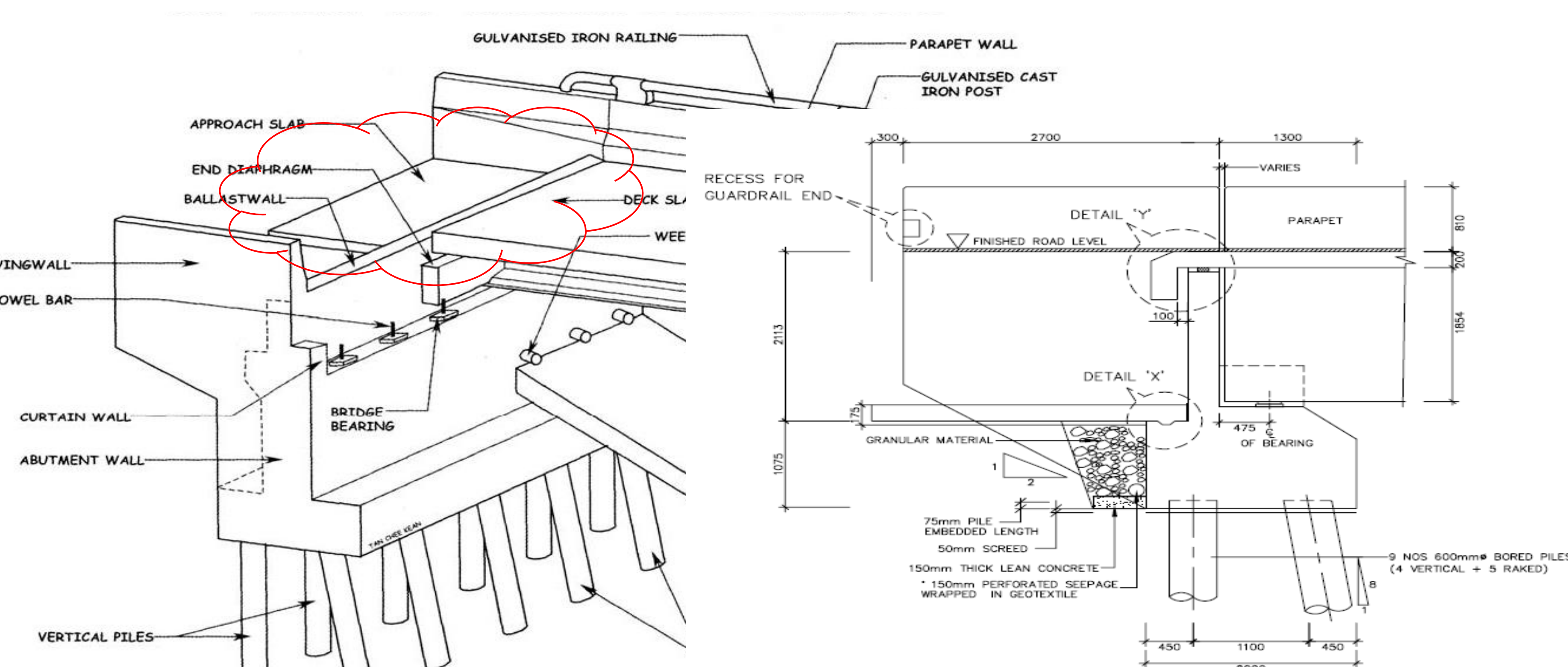


Fig. 1.21b

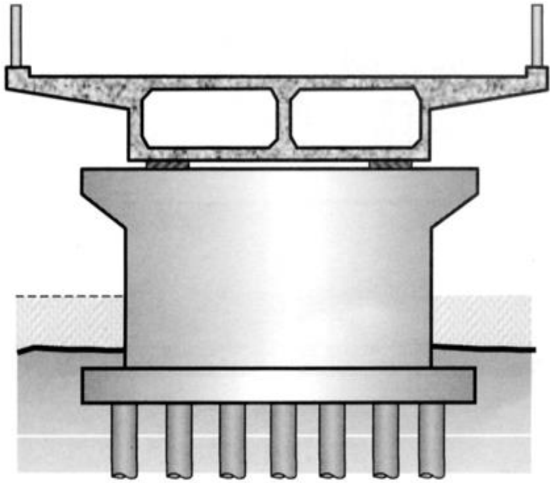
SUBSTRUCTURE - Piers

- **Pier is normally composed of capping beams (cross head), footings, column and caps**

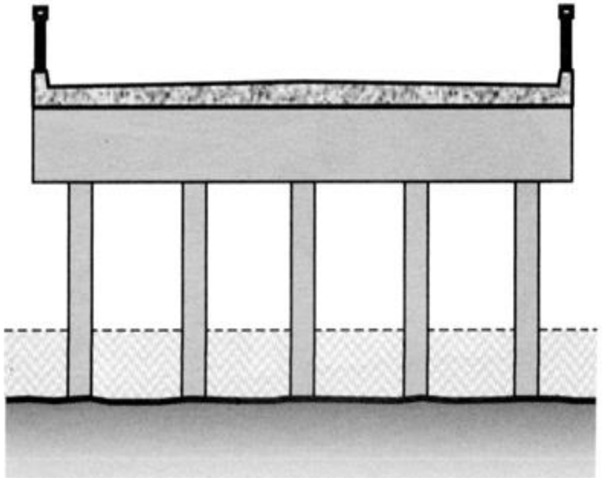
- **Type of piers :**
  - **i. Wall**
  - **Pile Bents**
  - **Multiple Column/ Single Leg Pier**

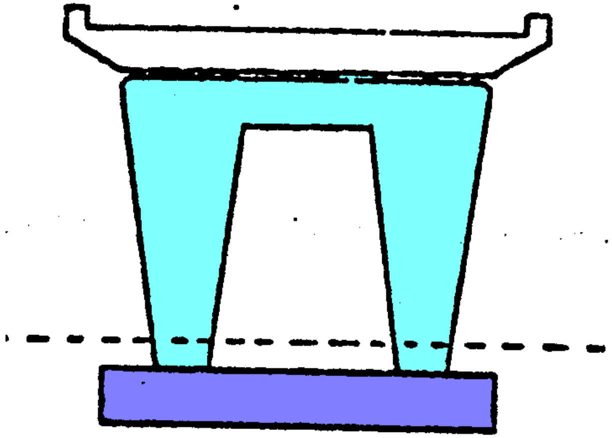
SUBSTRUCTURE - Piers

Wall type

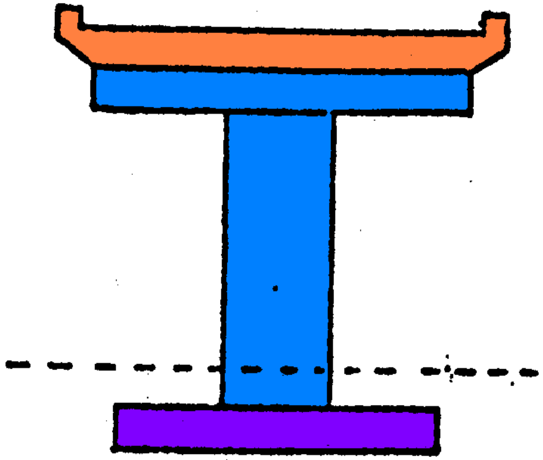


Pile bent

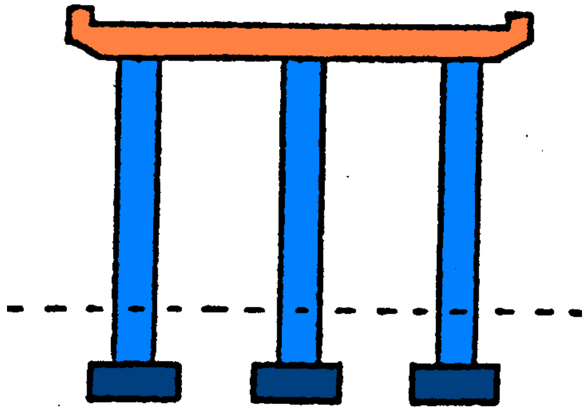




Portal Pier



Single Leg Pier



Multi Column Pier

SUBSTRUCTURE - Piers

Types and Choice of Piers

- **Solid pier** – recommended for river bridges; less exposed area to deterioration. For pier in river, edges are rounded to minimize flow resistance.
- **Multiple columns** – more exposed areas prone to deterioration
- **Pile bents** – very commonly used in 1950s because of its economical design. Not recommended for river bridges especially if the current condition is bad. Pile bent tolerance is specified in the code similar to piling requirements.
- **Cantilever pier** – the use of cantilever will increase the span. Although the bending moment is smaller, the construction is more difficult.
- **Voided box** – can be used in river bridges but the construction is tedious and formwork is complicated.

Types of Foundation

- **Spread/strip foundation – where load of the bridge is transmitted directly to the ground through the base of the substructure**
- **Piled foundation – where the structural members of the piles are utilised to transmit the loads from the bridge to firmer soil strata underneath.**
- **Combination of both (piers being piled with abutments on strip footing)**

Types of Piles commonly used in Malaysia

- Timber piles / bakau
- Precast RC piles
- Prestressed concrete piles
- Steel piles : H-bearing & Cylindrical piles
- Bored piles
- Micropiles
- Spun piles

ACCESSORIES

Such as;

- expansion joint
- parapet & handrail
- guardrail
- brass plaque
- signages
- road ligthings
- etc

ACCESSORIES – Expansion Joints

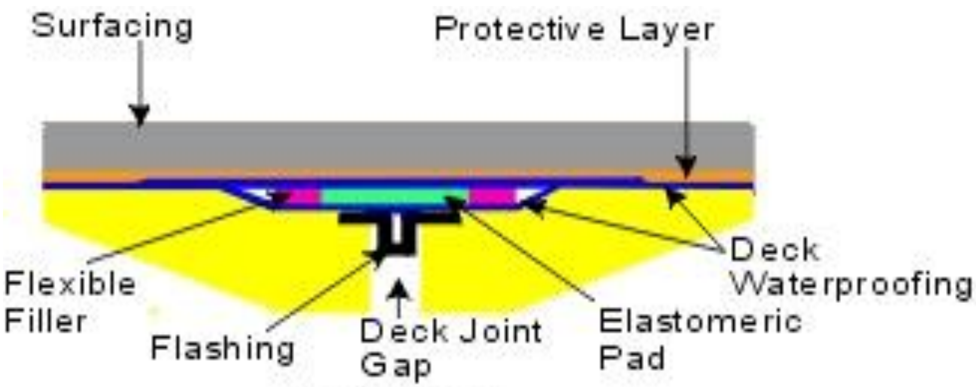
Choice of Bridge Joints

- Accommodate the translations due to possible shrinkage & expansion due to temperature changes.
- Where the deck and substructure have been designed to incorporate deck joints then the following guidance is given in BD 33/94 for the range of movements that can be accomm

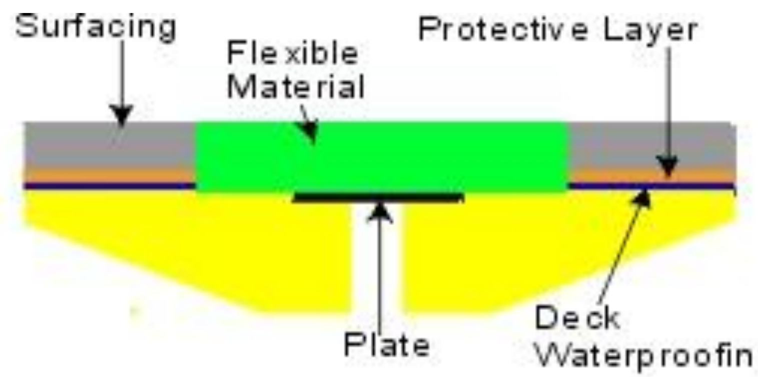
JOINT TYPE	Total Acceptable Longitudinal Movement		Maximum Acceptable Vertical Mvement Between Two Sides of Joint (mm)
	Minimum (mm)	Maximum (mm)	
1. Buried joint under continuous surfacing.	5	20	1.3
2. Asphaltic Plug joint.	5	40	3
3. Nosing joint with poured sealant.	5	12	3
4. Nosing with preformed compression seal.	5	40	3
5. Reinforced Elastomeric.	5	*	3
6. Elastomeric in metal runners.	5	*	3
7. Cantilever comb or tooth joint.	25	*	3

ACCESSORIES – Expansion Joints

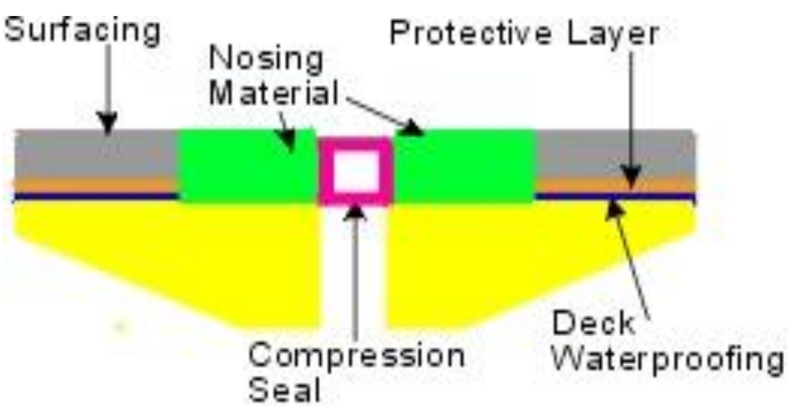
Types of Joints



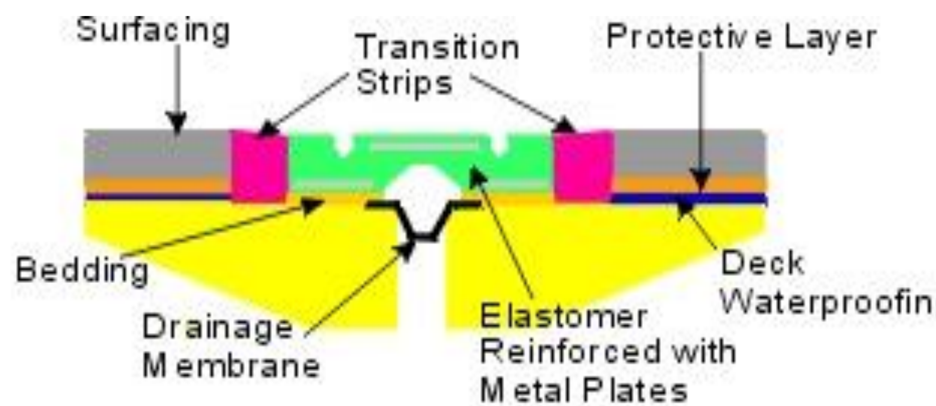
BURIED



ASPHALTIC PLUG



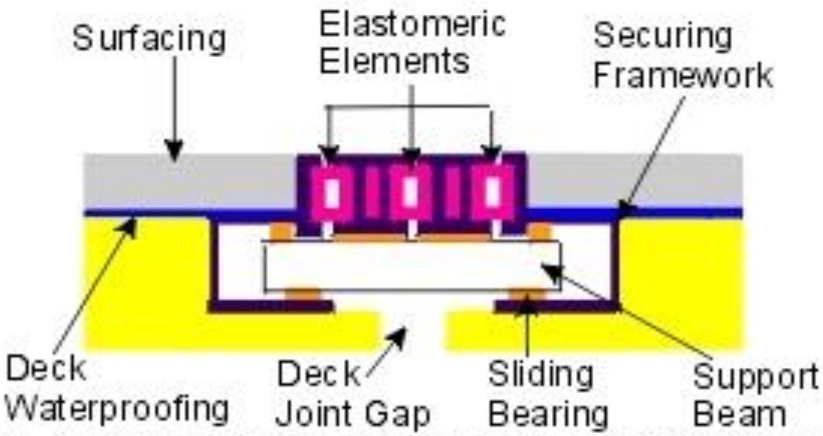
NOSING



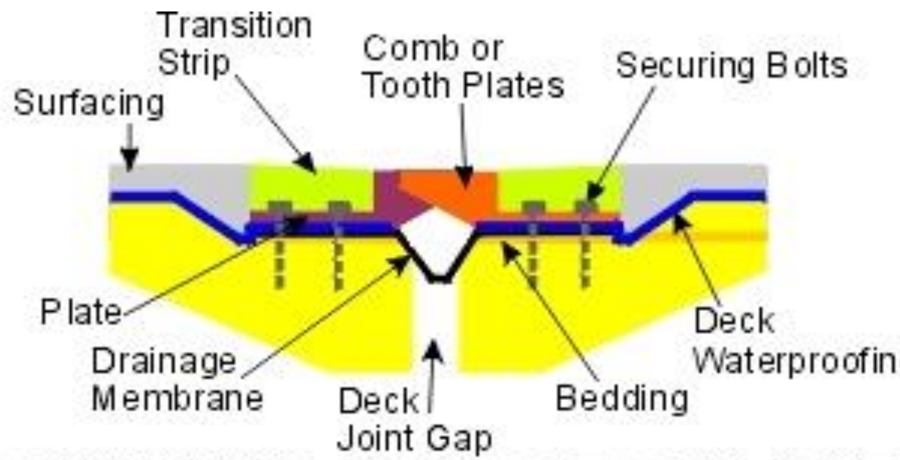
REINFORCED ELASTOMERIC

ACCESSORIES – Expansion Joints

Types of Joints



ELASTOMERIC IN METAL RUNNERS

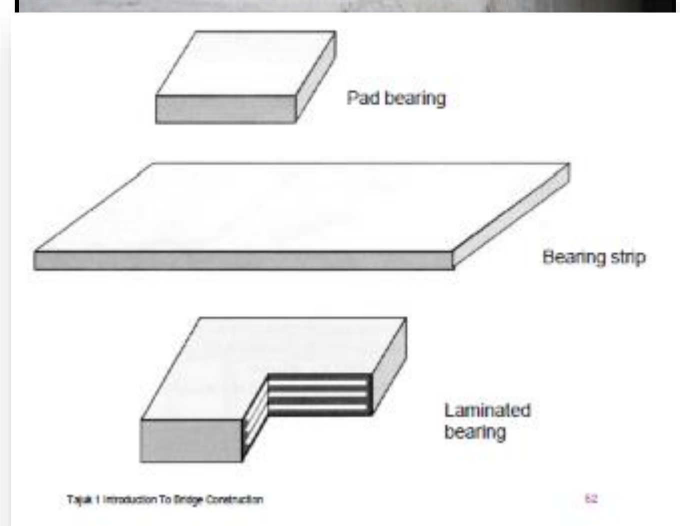


CANTILEVER COMB OR TOOTH JOINT

ACCESSORIES - BEARING

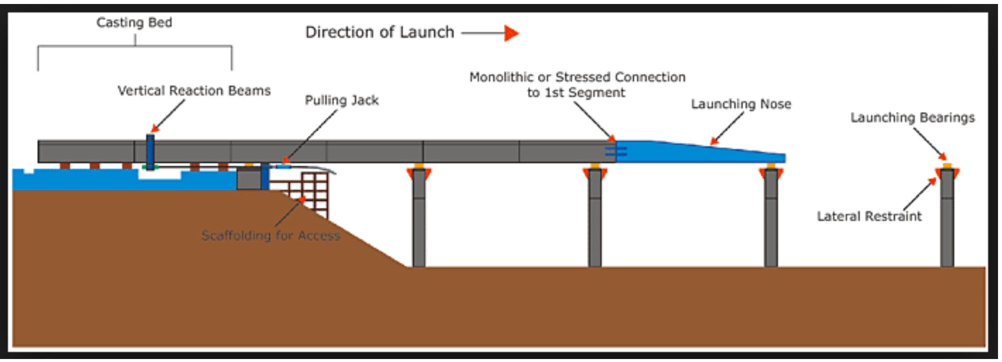
Mechanical Bearing

Laminated Bearing



Rubber Bearing Strip

CONSTRUCTION METHOD



Incremental launching

Balance Cantilever

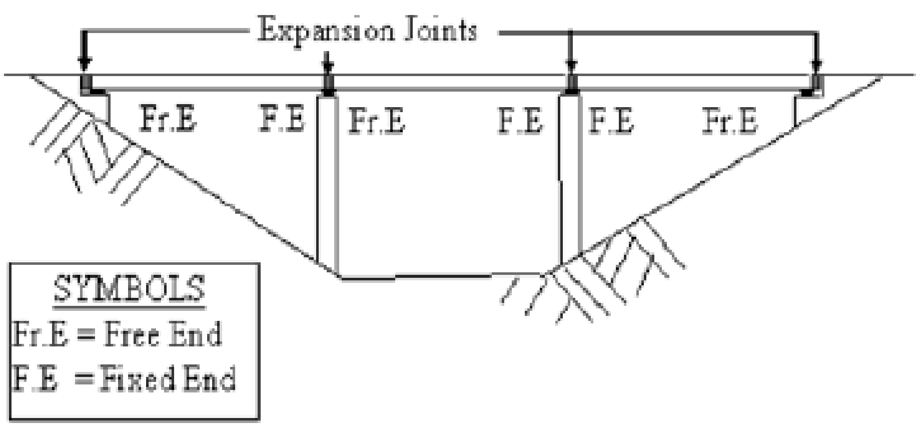
Span by Span

SESI SOAL JAWAB

TOPIC 3 : INTEGRAL BRIDGE

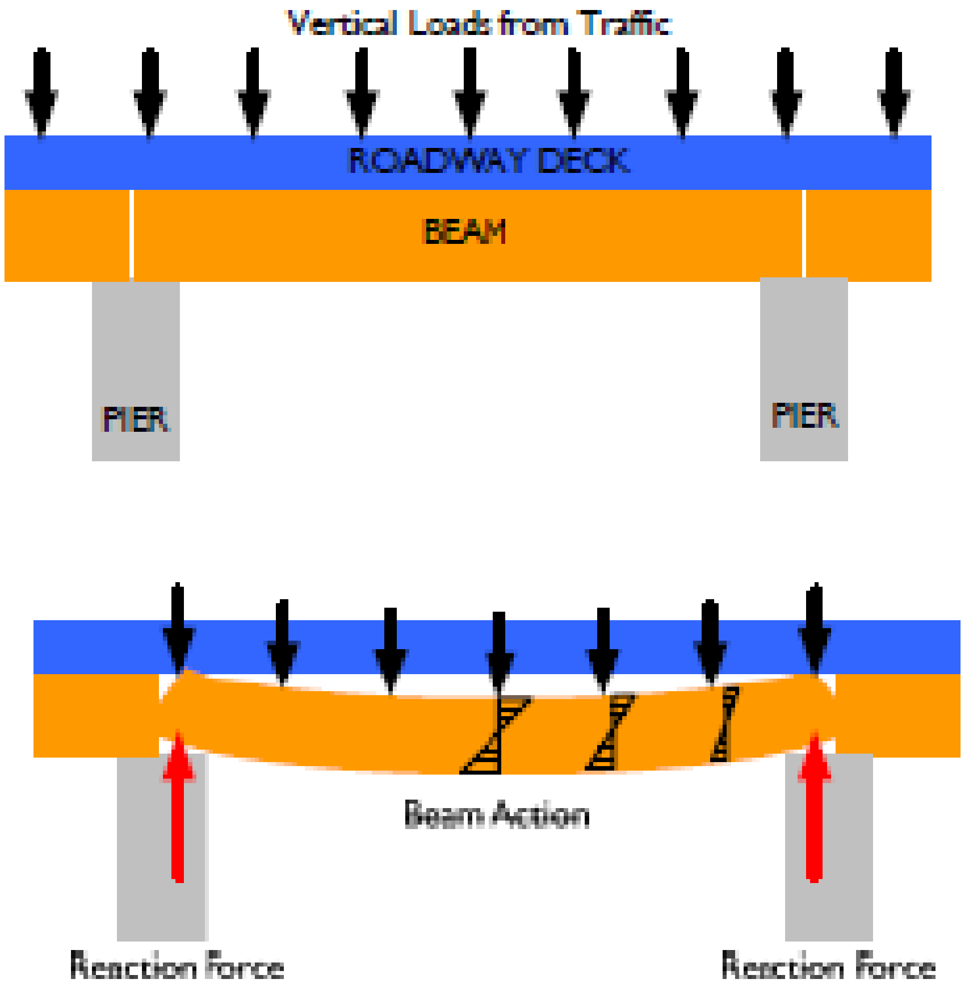
CONVENTIONAL BRIDGE

- Conventional bridge means the structural design, method of construction are not really complex and this type of bridges are widely constructed in many placed.
- Simple supported prestresses beam-slab concrete bridges either single or multiple span are the most type that constructed in Malaysia and others countries due to simplicity and economic
- How ever this type of bridge is not economic in term or life cycle cost.
- Expansion joints in bridge decks are prone to leak and allow the ingress of water, contamination into the bridge deck, be… …ulting in sever durabilit…



CONVENTIONAL BRIDGE

- The most basic type of bridge
- Typically consists of a beam simply supported on each side by side a pier and can be made continuous later
- Typically in expensive to build



INTEGRAL BRIDGE

JKR

- Integral bridge is jointless bridge where the deck is continuous and connected monolithically or cast integrally with their substructure

- Integral bridge accommodate superstructure movement without conventional expansion joints thus eliminate the problems associated with movement joints and bearings

- With superstructure rigidly connected to the substructure and with flexible substructure piling, the superstructure is permitted to expand and contract

- The concept is based on the theory that due to the flexibility of piling, thermal stresses are transferred to the substructure by way of rigid connection between the superstructure and substructure

INTEGRAL BRIDGE

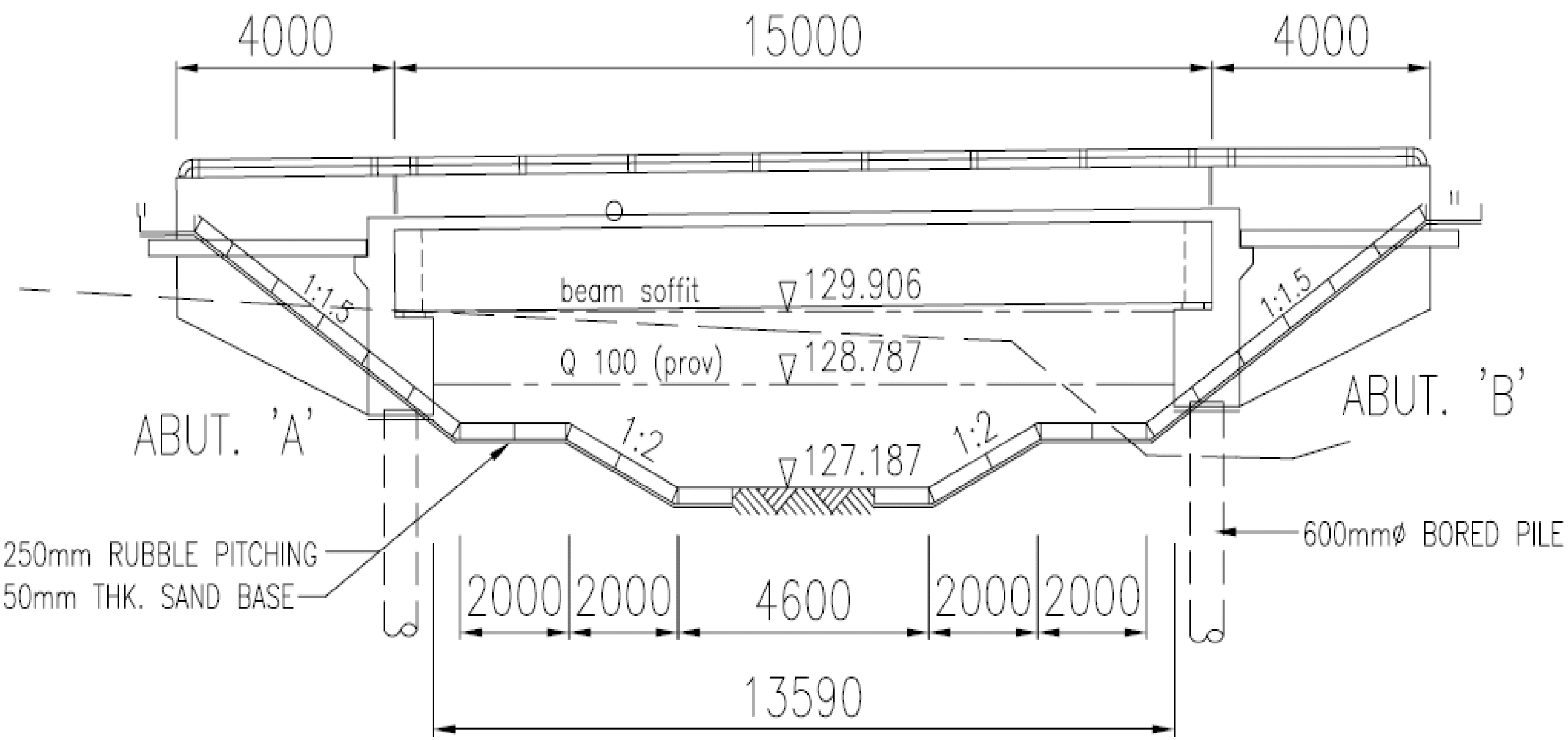
- A positive connection with the ends of the beams is provided by rigidly connecting the beams by encasing them in reinforced concrete

- This provides the full transfer of temperature variation and live load rotational displacement to the abutment piling

- Based od BA42/96 : "the design of integral bridge" bridge decks up to 60m in length and with skews not exceeding 30o are generally requires to be continuous over intermediate supports and integral with their abutments.

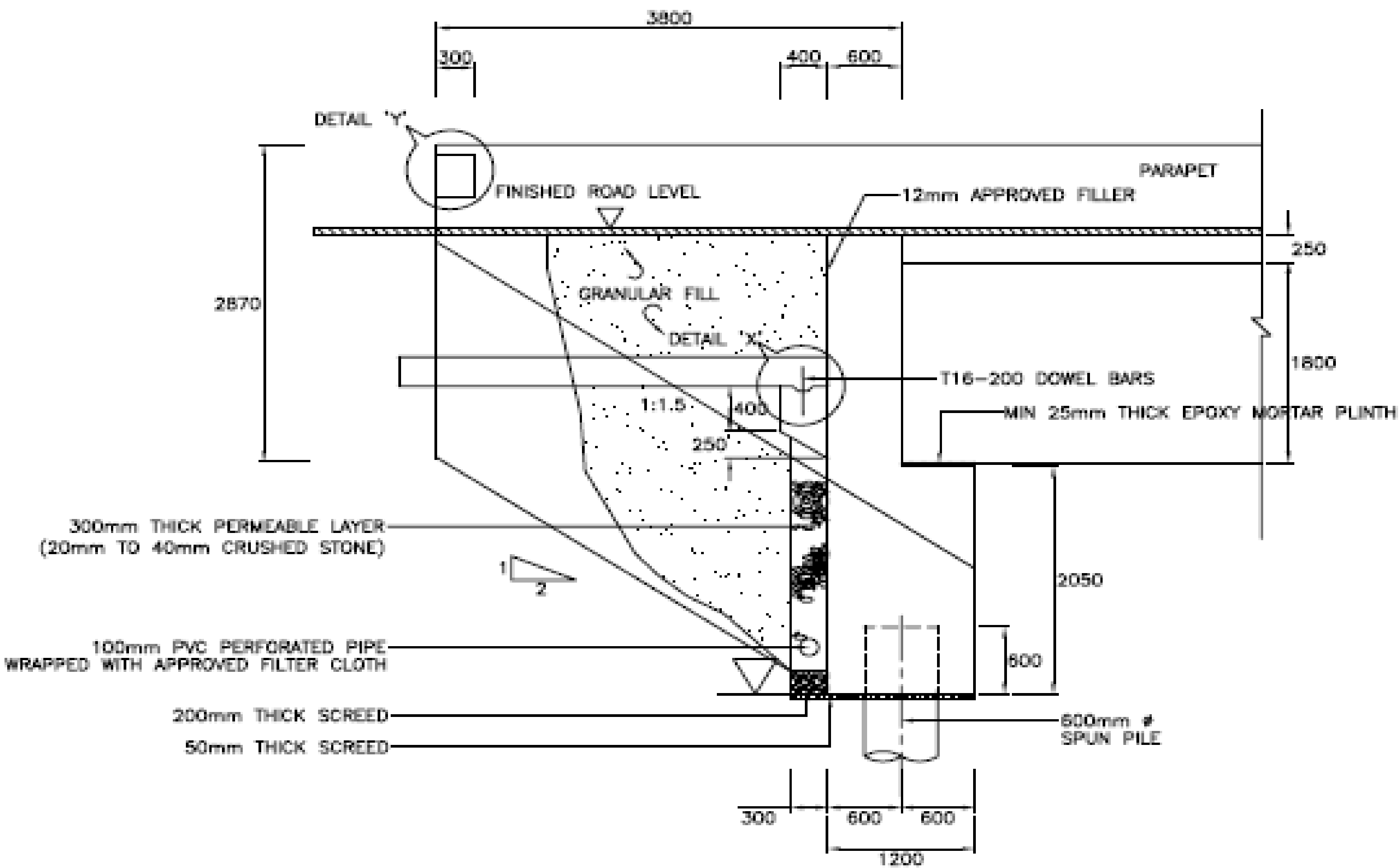
INTEGRAL BRIDGE

FULLY INTEGRAL BRIDGE



INTEGRAL BRIDGE

FULLY INTEGRAL BRIDGE

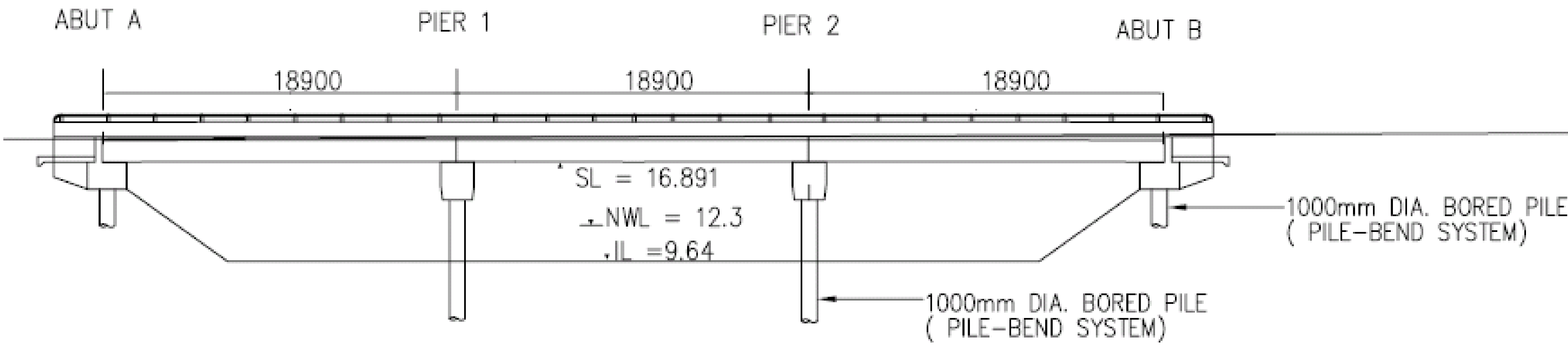


ABUTMENT ELEVATION

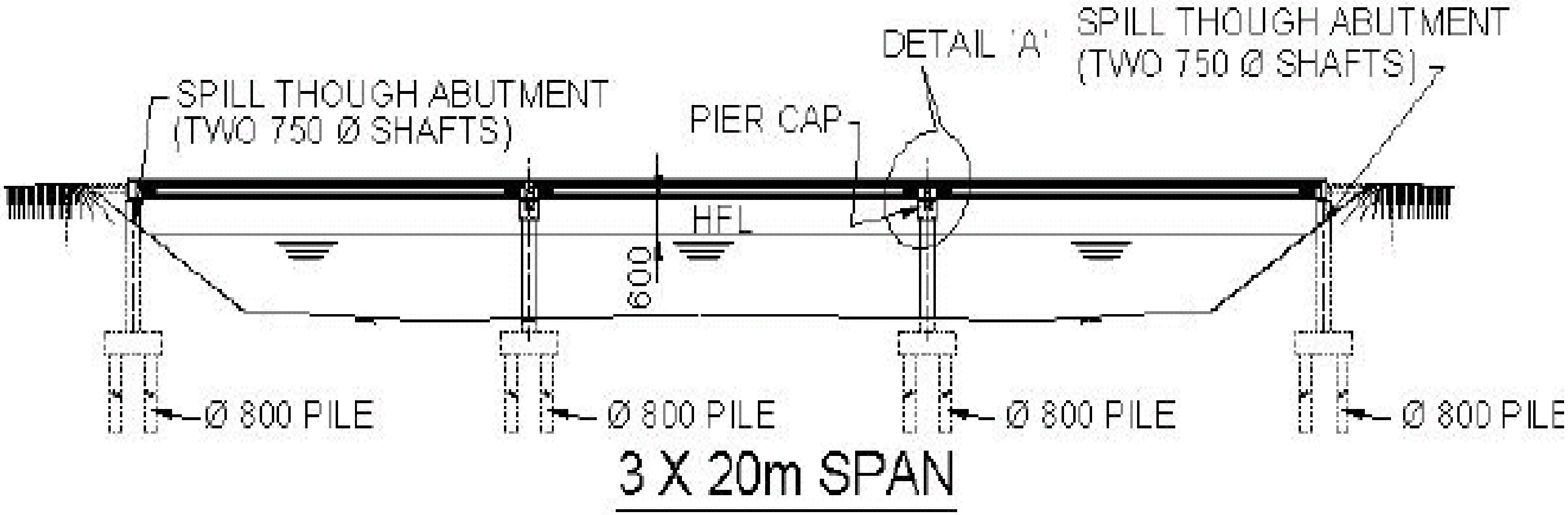
SCALE 1 :40

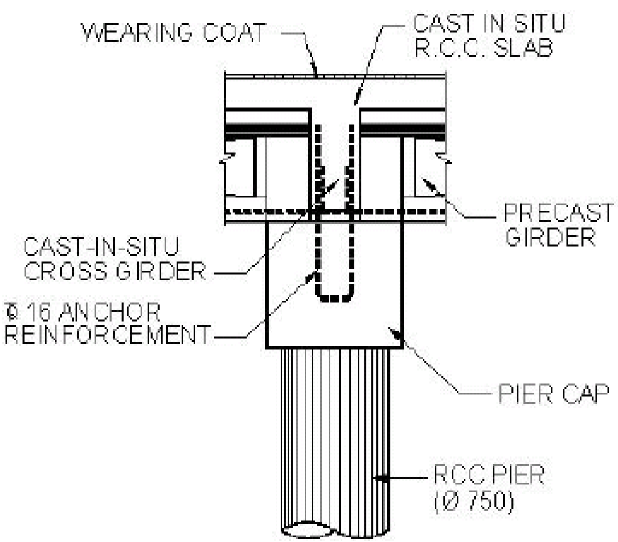
INTEGRAL BRIDGE

Which one of integral bridge concept is more robust?



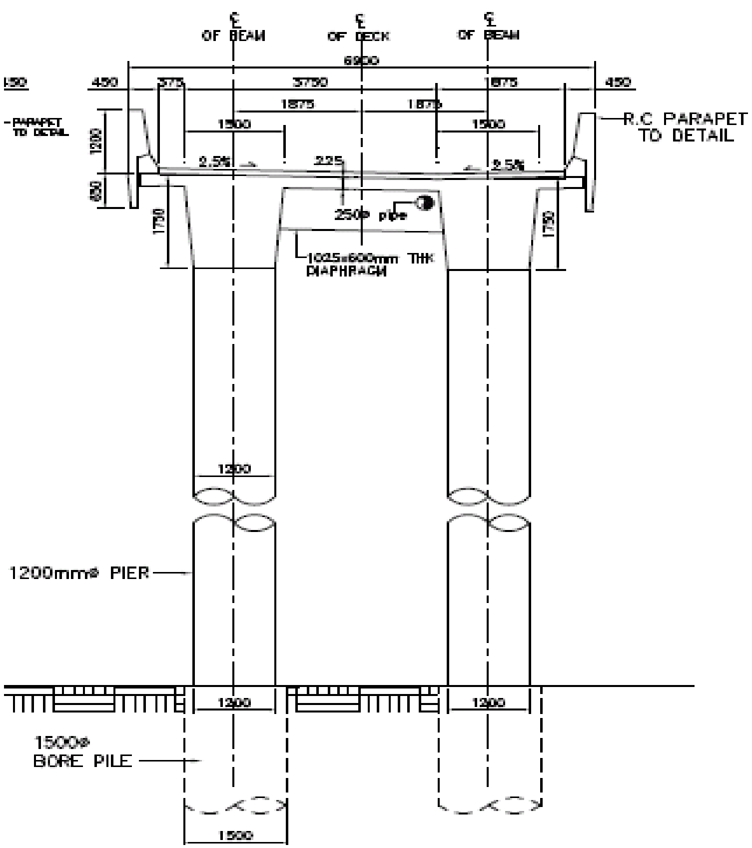
INTEGRAL BRIDGE

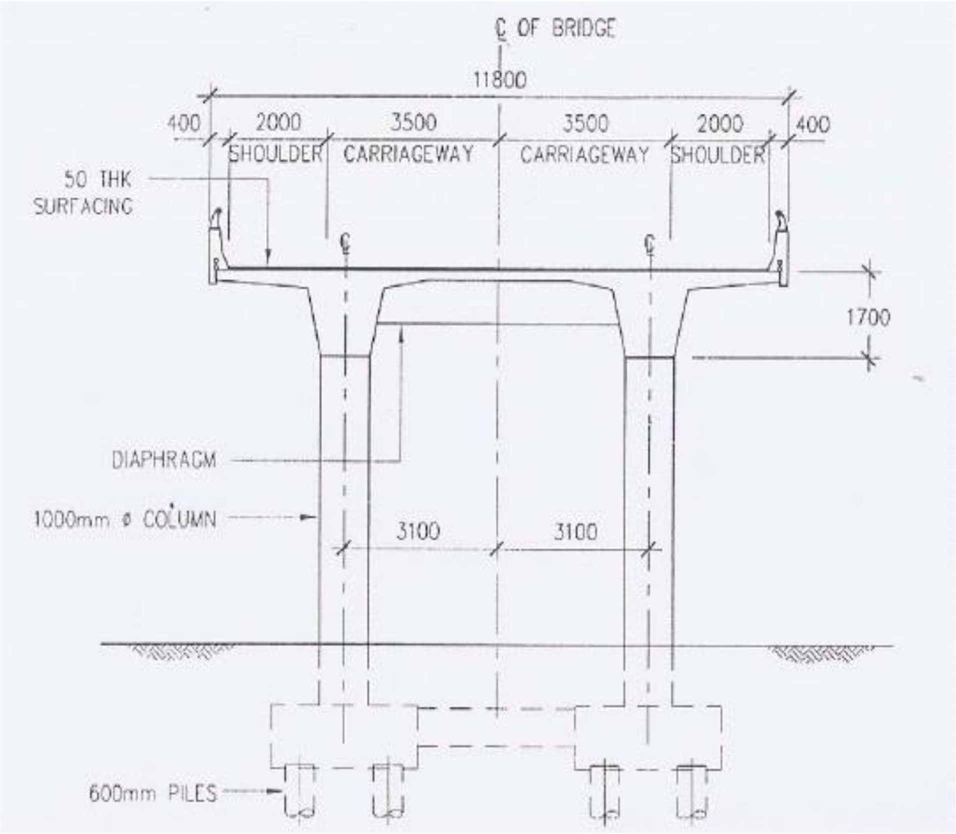




INTEGRAL BRIDGE

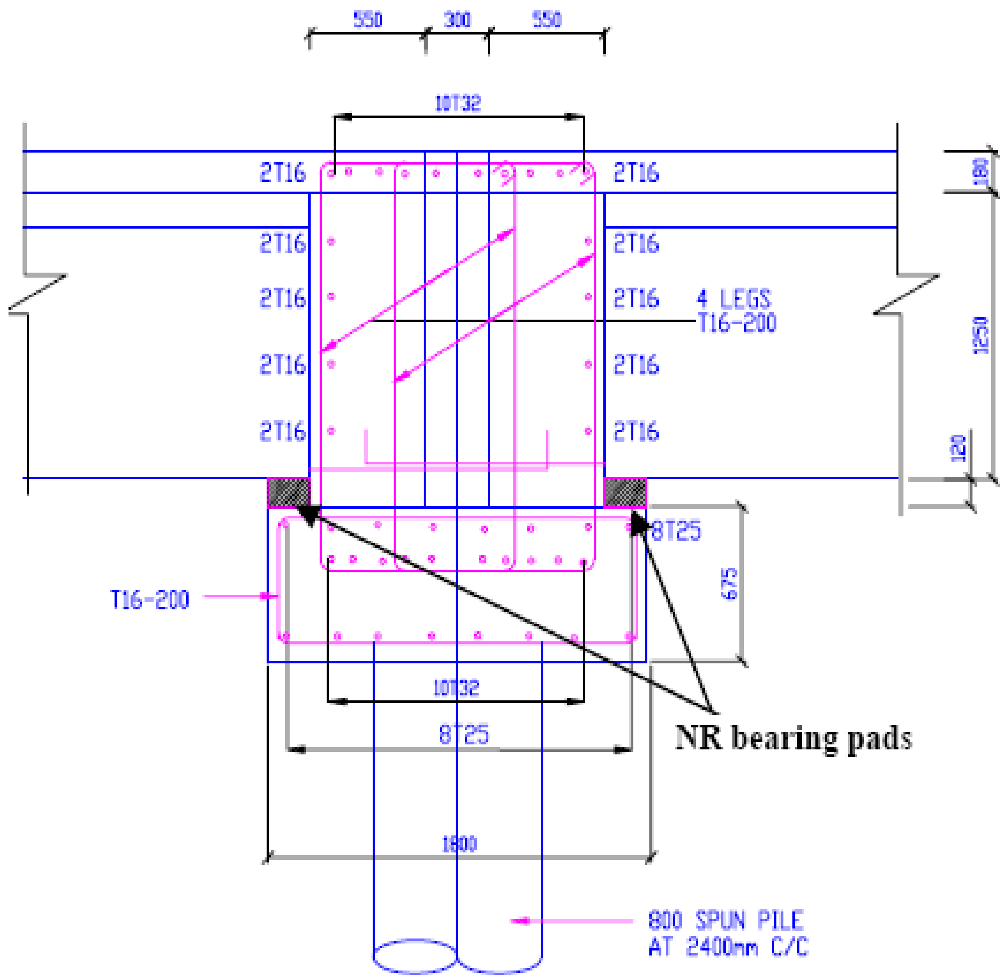
TYPICAL CROSS SECTION OF INTEGRAL BRIDGE





INTEGRAL BRIDGE

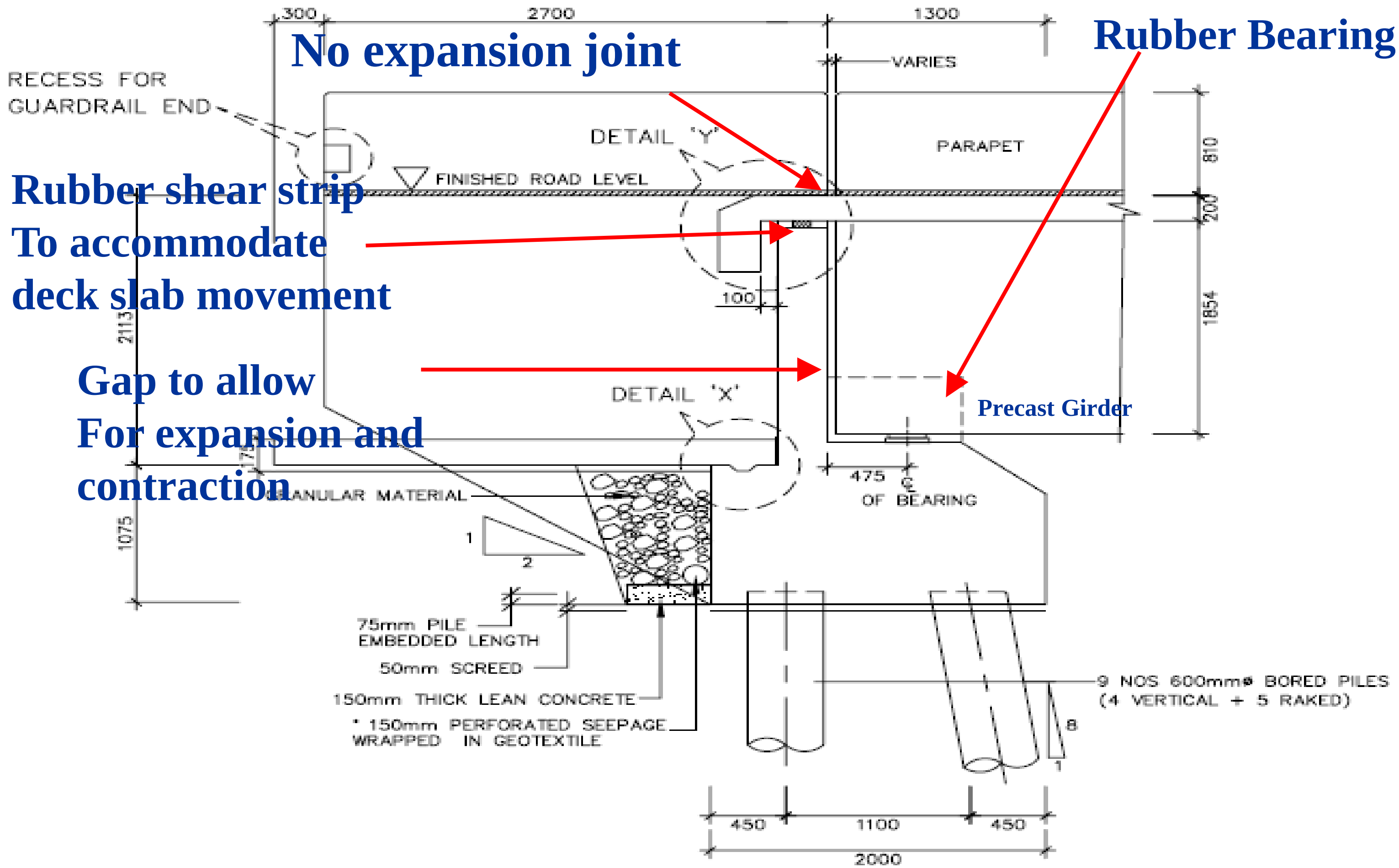
- Typical detailing for fully integral pier for Kuala Kurau Elevated bridge
- The pier was constructed as a pile-bent system



Rebar detail showing fully integral connection

INTEGRAL BRIDGE

SEMI INTEGRAL BRIDGE



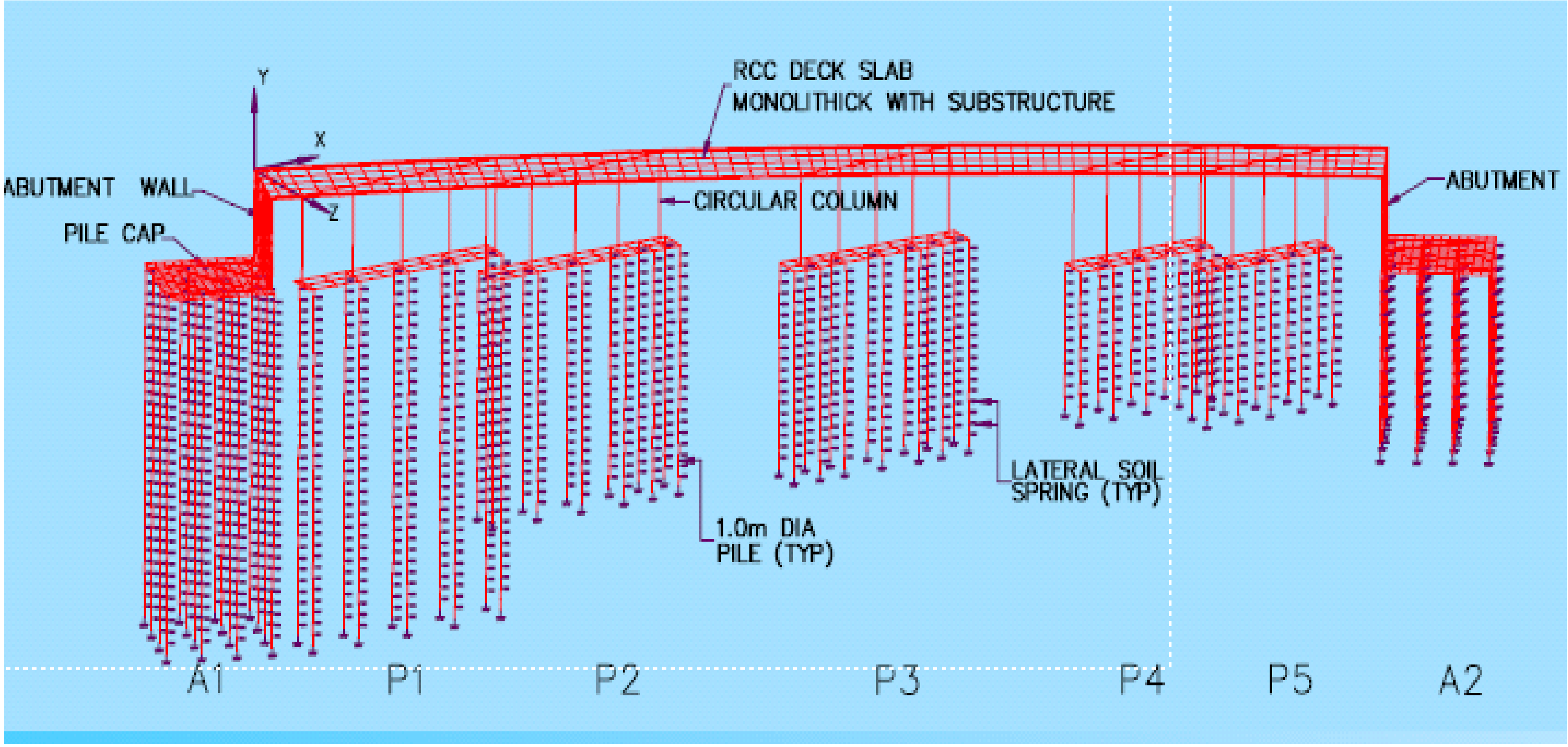
INTEGRAL BRIDGE ANALYSIS

- **Analysis of an integral bridge**
  - **Must model all columns, pilecaps including pile and abutments**
  - **Must model soil springs stiffness**
- **Probably best to use a 3D space frame**
- **Very similar to a standard 3D space frame but some following additions and modification such as below:**
  - **More sensitive to axial creep & shrinkage effects**
  - **Bending moments from the deck will affect substructure**
  - **Soil pressure behind abutment walls affect the deck**
  - **More sensitive to soil stiffness at foundation level**

INTEGRAL BRIDGE

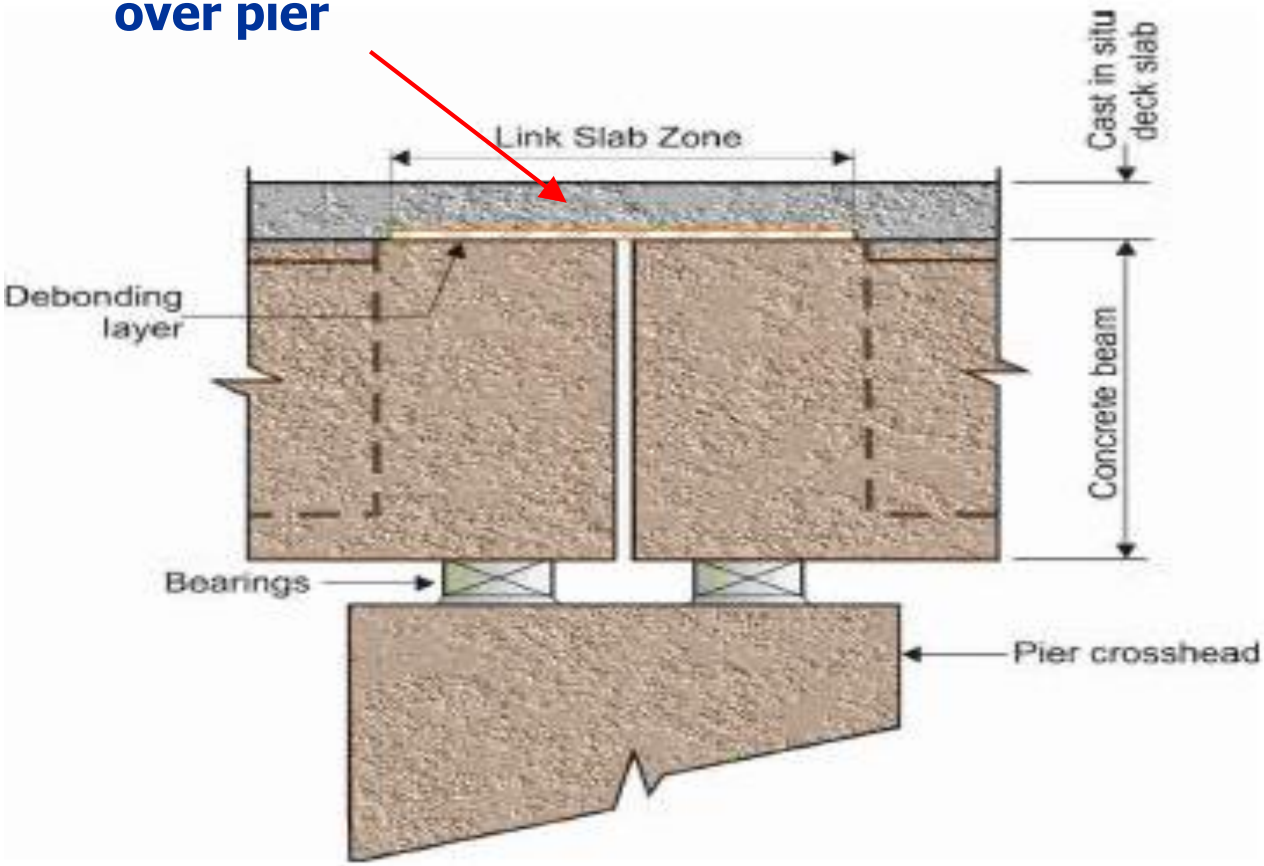
TYPICAL MODEL WITH SOIL SPRINGS STIFFNESS

6 SPAN INTEGRAL



INTEGRAL BRIDGE

Continuous Deck Slab over pier

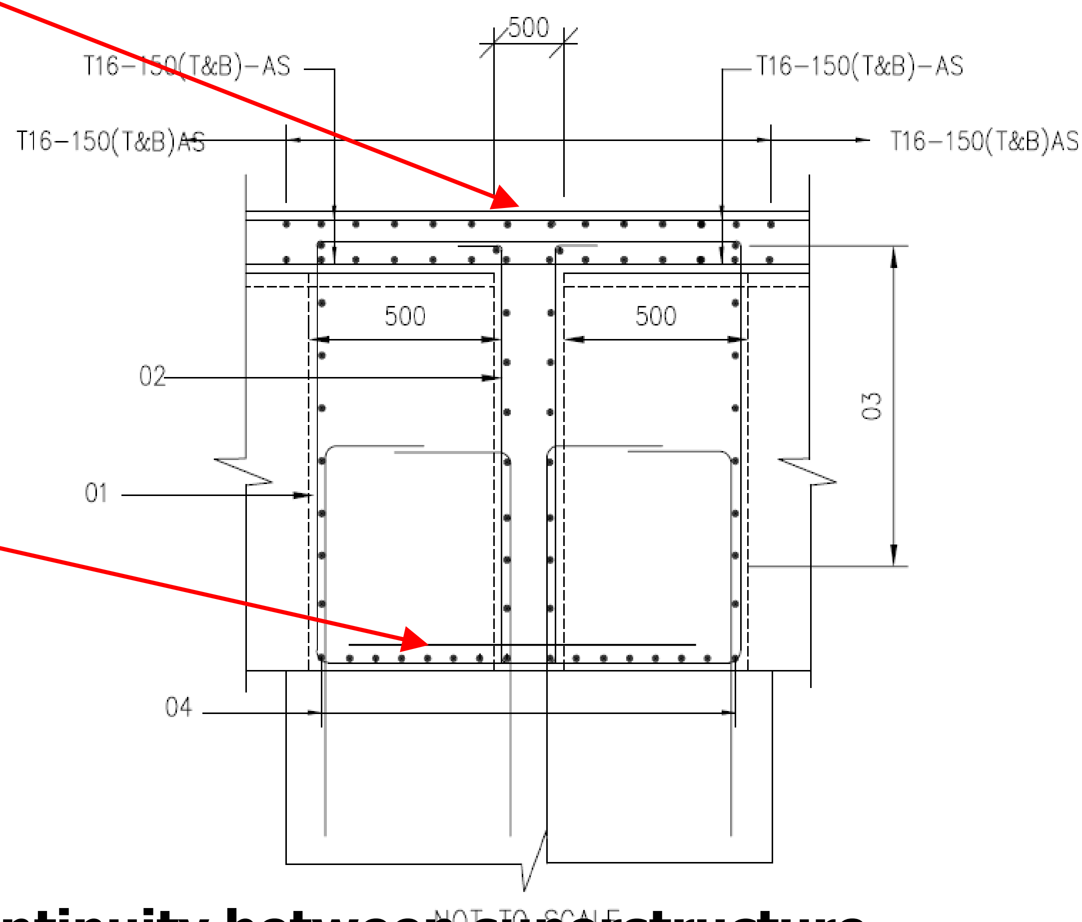


Configuration of deck slab continuity over pier for Multispans Semi-Integral

INTEGRAL BRIDGE

Continuous deck slab over pier

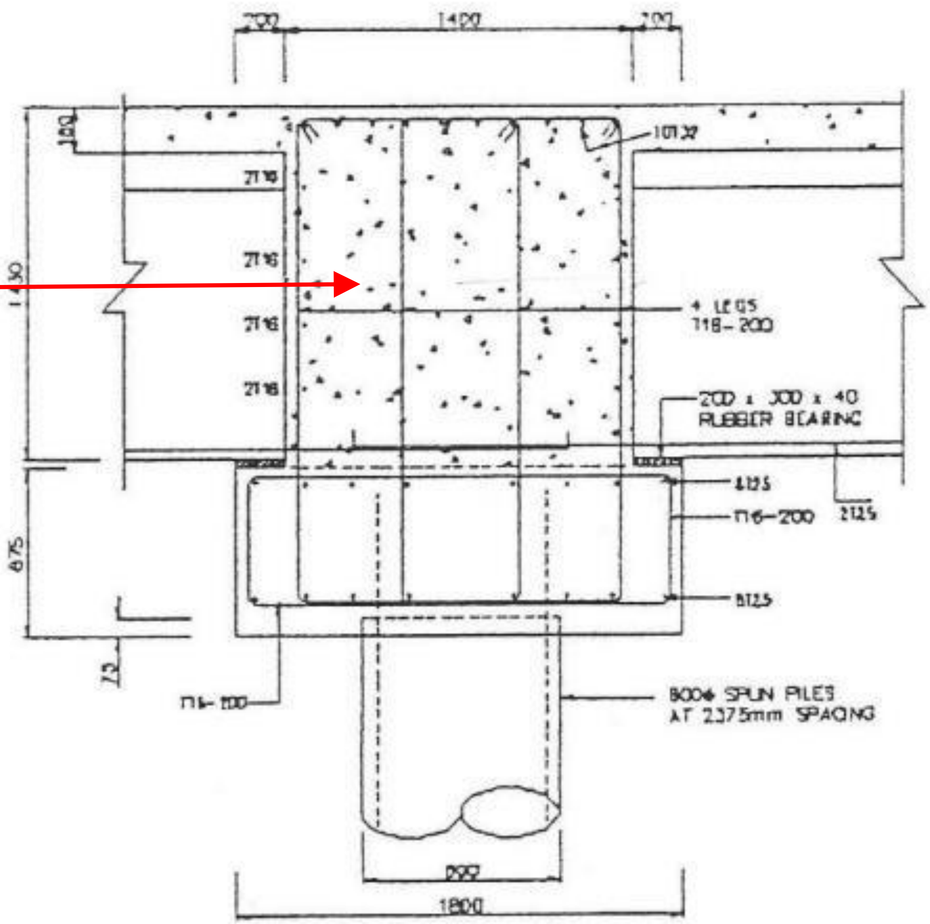
Bottom reinforcement is provided to resist tensile stress due to creep and shrinkage effect



Typical Continuity between superstructure And substructure for multi-span fully integral bridge

INTEGRAL BRIDGE

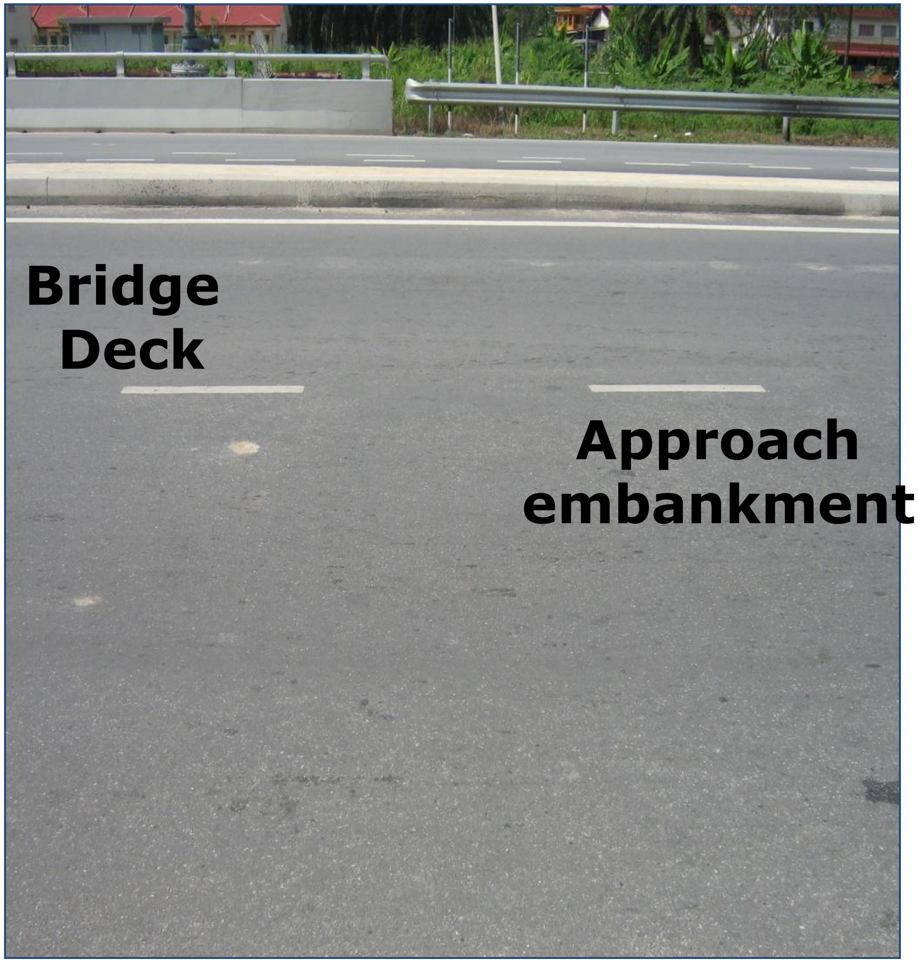
Continuous diaphragm over pier



Typical Continuity between superstructure
And substructure for multi-span fully integral bridge

INTEGRAL BRIDGE

- Elimination of expansion joint offers better riding comfort



Continuous pavement surface between bridge deck and approach embankment

Maintenance Issues

- Normal bridges have expansion joints and bearings to permit thermal expansion and contraction.

- Requirements for an Expansion joint:
  - i) Water tightness
  - ii) Smooth ride ability
  - iii) Low noise level
  - iv) Wear resistance (5 years guarantee max.)

- Performance of joint system is disappointing on PWD record.

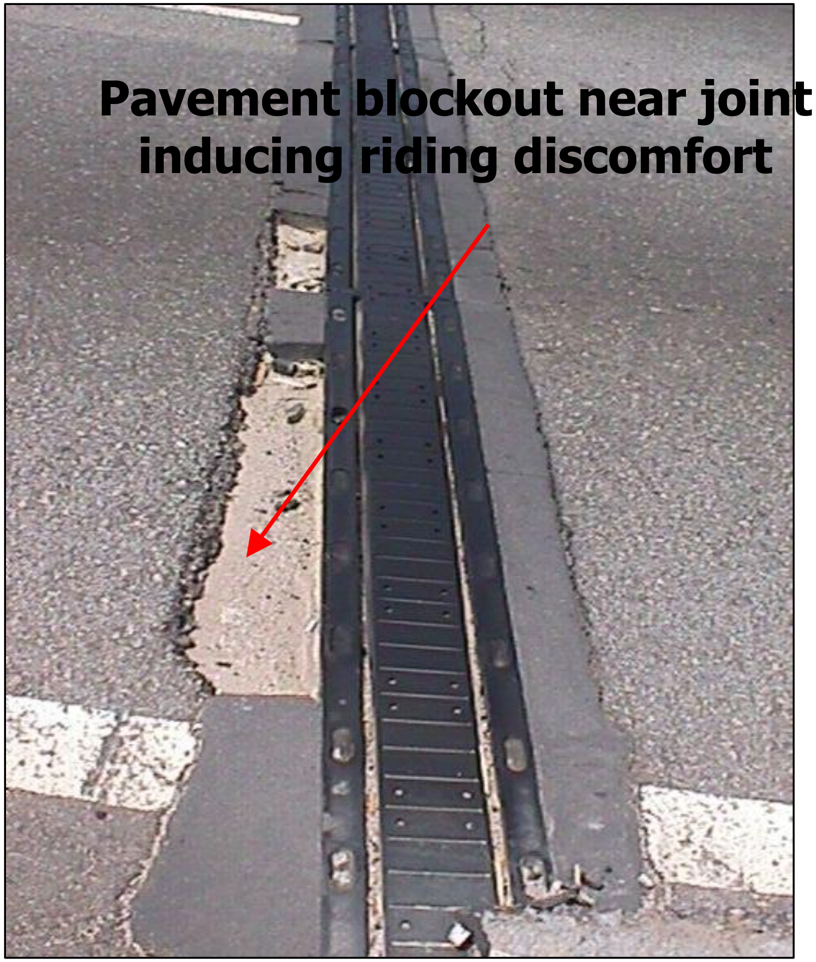
INTEGRAL BRIDGE

Transverse Cracking causing water intrusion

Failure at Expansion Joint

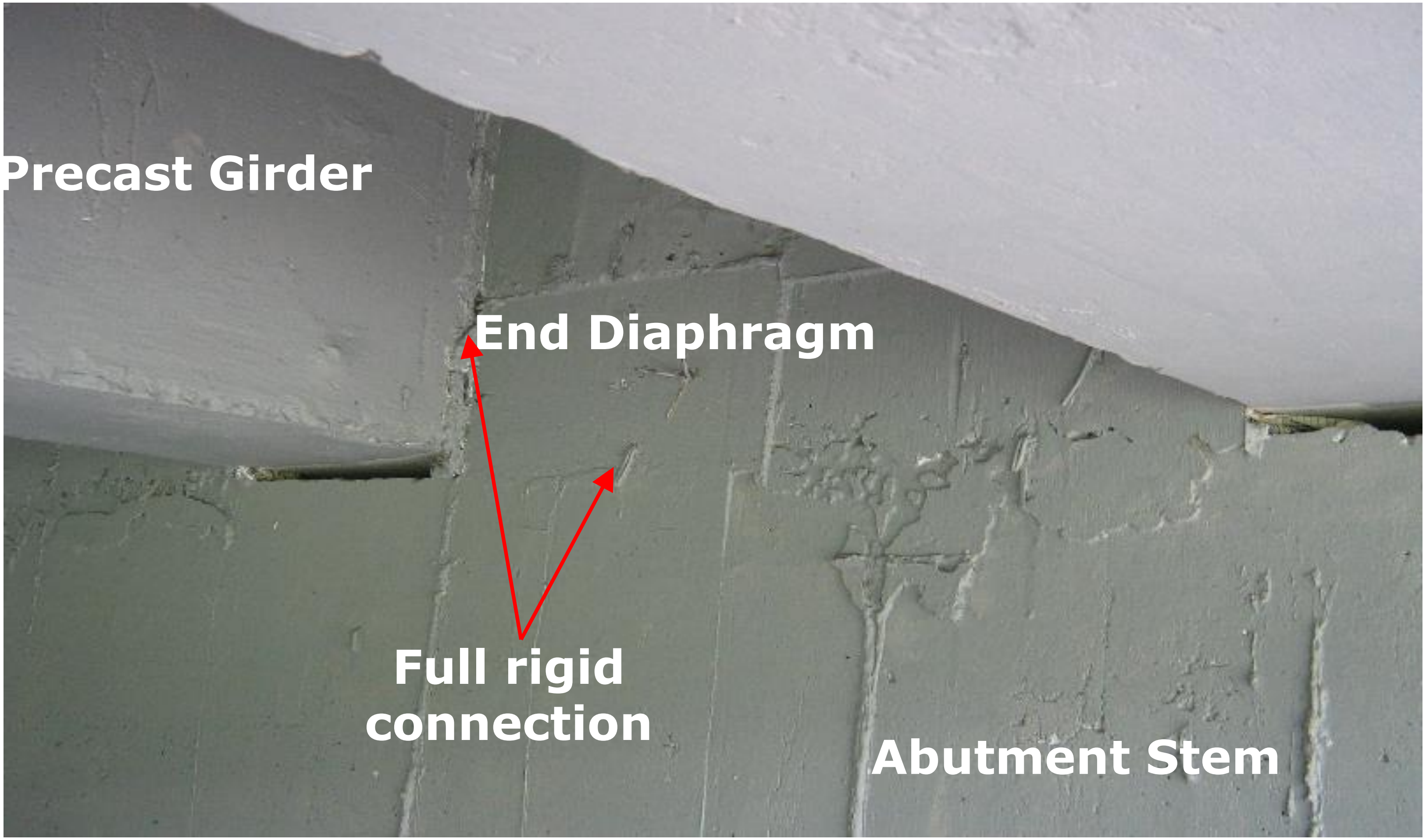
INTEGRAL BRIDGE

Water stain due
to joint leakage



Expansion joint failure

INTEGRAL BRIDGE



INTEGRAL BRIDGE

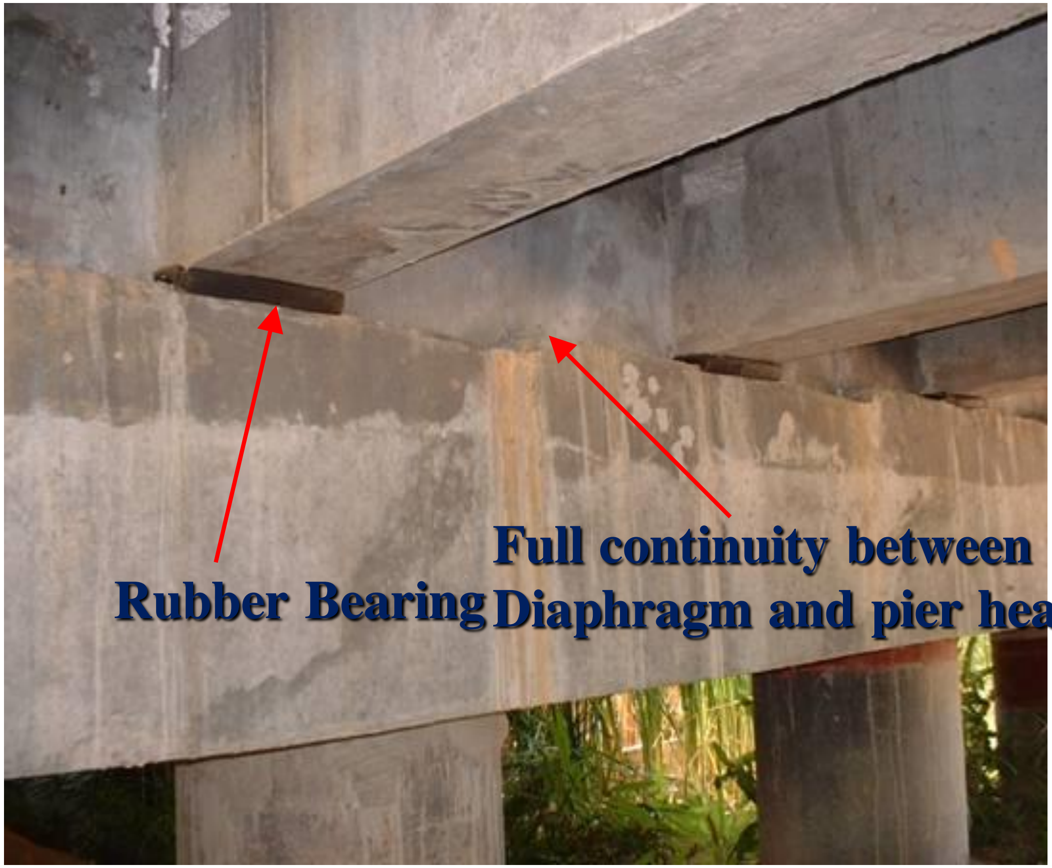
Rigid connection between precast beam Diaphragm and abutment – as constructed

INTEGRAL BRIDGE

INTEGRAL BRIDGE

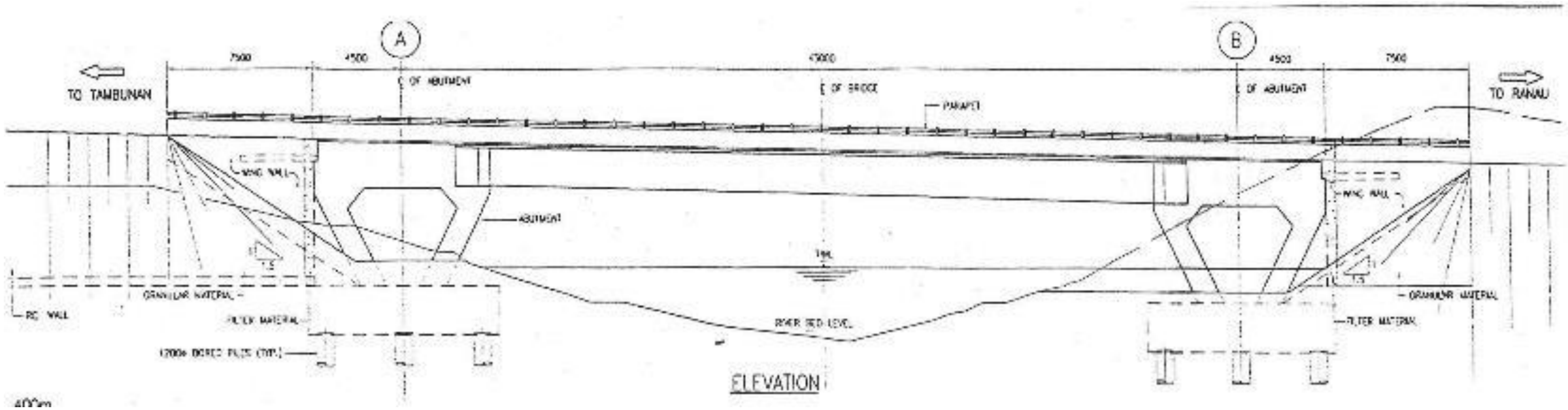
INTEGRAL BRIDGE

- The semirigid flexible pier at Kuala Krau Elevated bridge
- Rubber bearing is used to cater for rotational movement of the girder
- Length of integral structure = 260m



Fully Integral Pier – Elevated bridge, Kuala Kurau
Completed and opened for traffic in Mac 2005

INTEGRAL BRIDGE



Jambatan Sg Kenipir, Sabah

Full continuity at pier - 2004

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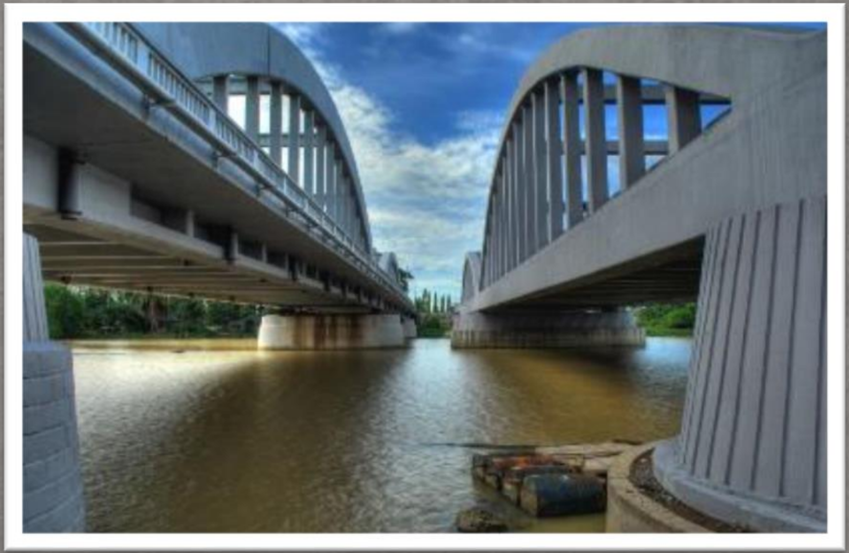

TOPIC 4 : BRIDGE DESIGN

Pengenalan

- **Analisa-analisa yang terlibat dalam rekabentuk jambatan:-**
  - **Hidraulik**
  - **Hidrologi**
  - **Struktur**
  - **Geoteknik**
  - **Seismik**

- **Pengetahuan asas rekabentuk jalan juga diperlukan:-**
  - **Piawai Jalan**
  - **Geometri Jalan**
  - **Pavmen**
  - **Pengurusan Trafik**

BRIDGE DESIGN

Basic Knowledge Required in Bridge Design

- Choice of Bridge
  - Bridge Type & System
  - Method of Construction
  - Temporary Works
- Structures
  - Code of Practices
  - Structural Analysis
    - Modeling
    - Loadings
    - Limit State Design (ULS & SLS)
    - Grillage analysis
    - Plate bending
  - Section Analysis
    - Stresses & Strains
    - Tie & Strut analogy
    - Prestressing
  - Detailing
- Hydrology & Hydraulic
  - Design Peak Discharge
  - Hydraulic Capacity
  - Hydrostatic
  - Hydrodynamic
- Geotechnical
  - Foundation
    - Deep foundation
    - Shallow foundation
  - Earth Pressure
  - Earth Retaining
  - Ground Treatment
    - Piled embankment
    - EPS

Basic Knowledge Required in Bridge Design

- Road Geometry
  - Road Standard
  - Horizontal & Vertical Profiles
  - Road Safety
  - Road Furniture
  - Traffic Management
- Pavement
  - Pavement Structures
- Environmental
  - Aspects & Impacts
- Social Impacts

Functional Considerations

- Site Survey Data
- Soil Investigation Data
- Hydrological Requirements
- Bridge Concept & Configuration
- Preliminary Design
- Details Design
- Engineering Drawings
- Bill of Quantities & Taking-off
- Specification
- Table Tender Document

Functional Considerations

1. The clearance requirements
2. The type & magnitude of the loading to be carried
3. The topography & geology of the site
5. Methods of construction & erection
6. Local constructional skills & material
7. Inspection & maintenance
8. Aesthetic
9. Environmental Aspects & Impacts
10. Cost of the Project
11. Life Cost Cycle

1.3.4 Bridges of total length not exceeding 60.0 meters with skews not exceeding 30° shall be designed as an integral bridge.

1.3.5 For multi-span bridge, the superstructure shall be structurally continuous with the minimum use of expansion joints as possible. Continuity connection by using the tied deck slab only is not allowed. Whenever possible, the abutment shall be designed as a semi-integral type without the needs of having the expansion joints.

1.3.6 Where the substructures are slender and flexible enough to abridge the bending moments at the superstructure, the bridge shall be designed with integral pier crosshead between the superstructure and substructure without the needs of having any form of bearings.

1.3.7 Beam of less than 30.0 m span shall be designed and constructed by using the JKR standard Beam Sections where applicable. Other types of beam may be used subjected to the approval of JKR. The contractor and consultant are responsible to undertake and carried out the stability calculation and checking during the launching and positioning of beam prior to deck slab and diaphragm casting. The contractor and consultant must also ascertain that adequate bracing system is properly designed and placed onto the correct positions and subject to approval of JKR

1.3.8 A single pier crosshead that is carrying a 6-lane carriageway on a single deck shall be designed and constructed as a precast prestressed element members. The construction of the crosshead shall be in the form of segmental construction.

1.3.9 Public utility services

Where applicable, the bridge shall be designed to cater for water pipe under full service load conditions, telecommunications and/or other utility services cables or ducting. Details of the utility services cables or ducting shall be obtained from relevant agencies or authorities by the Consultants. High tension or high voltage cables or ducting shall not be permitted at anywhere on the bridge.

1.3.10 Bridge Parapets

Bridge parapets shall be precast and of New Jersey Barrier type. Bridge parapets shall be design and construct with decorative façade and subject to approval of JKR. Cast in-situ parapets shall use formworks (Type F3 - smooth surface). All parapet bridge shall be applied with aesthetical surface coating on inner and outer side of the parapet. Parapet on the bridges that are located in the area subjected to environmental conditions of chloride and sulphate attack shall be coated in accordance to clause 1.4.14.

Bridge parapet shall be installed with reflector plate at minimum interval of 1.5m spacing. The reflector plate shall also be installed at the guardrail on both approaches towards the bridge.

1.3.12 Surface Coating

Protective surface coating shall be applied to the structures that are exposed to environmental condition of chloride or sulphate attacks. The coating shall be applied to all exposed members of the superstructure and substructure and/or to the area deemed to be subjected to environmental condition attacks or to a specific area as directed by JKR.

Surface coating for aesthetical purpose without the needs of protective surface coating shall be applied in case where the structures located in the major town, or as an iconic monumental structures at which the area is not prone to environmental condition attacks .The surface coated area shall be determined by JKR.

Surface coating to serve as the function of protective as well as for aesthetical purpose shall be applied where the structures are located in major town and also subjected to environmental condition attacks. The surface coating shall be mixed and combined in a single application and shall not be applied in layer on top of the other.

1.3.13 Lighting

All bridges shall be provided with road lighting including the suitable lighting post, supports and cabling. The spacing of the post shall be based on the illumination requirements. For bridge span less than 20m, the lighting shall be provided at both approach part of the bridge inclusive of supports, post, cabling and all related items to the completeness of road lighting.

Bridge lighting shall be of linear lighting system fixed to the bridge. The light fixture shall be of appropriate brightness aimed at the roadway and shielded to prevent glares to motorists. The used of facade, spotlight and floodlight lighting at the bridge shall be testing and commissioning as approved by JKR. Where required by the navigational authorities, appropriate navigational lighting aids shall be provided.

1.3.14 Outlet drain pipe or rain water downpipe shall be provided on the deck at suitable position as to collect the surface runoff from the deck and discharge to the nearest discharging point inclusive of all collector pipes. The minimum size of outlet pipe shall be 150mm depending on the amount of surface runoff and spacing of the outlet pipe. Scupper drain on the deck may be provided as appropriate.

1.3.15 Access for inspection under the bridge in the form of staircase or platforms must be incorporated in the design. Adequate height clearance at the abutment area must be provided for the bearing inspection.

1.3.16 Cast in-situ box culvert:

Box culvert of size 1.5 m and above in height and/or width shall be designed as cast in-situ type including the approach slab. Culverts with the height of embankment or fill is more than 3m shall be designed and constructed as cast in-situ box shaped type. The foundation of the culvert shall be based on-site soil bearing pressure. Sand bedding layer shall not be used as the base layer of the culvert.

1.3.18 Retaining structures at approach embankment

The maximum height of any type of retaining structure at approach embankment shall be maximum of 6.0m unless approved otherwise by JKR.

1.3.19 Stringent measures shall be taken to prevent long-term discontinuities and unacceptable driving condition as a result of differential settlement between the bridge and the approach embankments.

1.3.20 Footbridges

Footbridges shall be designed in compliance to BD 29/17 or as approved otherwise by JKR. For dual carriageway with permitted speeds in excess of 50 km/h, a single span shall be provided spanning both carriageways to avoid the need for support in the central reserve. Both ramps and staircases shall be provided for access.

The staircase of the footbridge shall have minimum tread width of 260mm and a maximum riser of 180mm. The inclination angle of the steps shall be maximum of 34^{o}.

1.4.1 Latest Malaysian, British Standards, Eurocode and Codes of Practice shall be adopted for design of structures. The principal standards but not limited to are as the following:

(i) The latest version of British Standard Institution BS 5400: Steel, Concrete and Composite Bridges, BS EN 1990, BS EN 1991, BS EN 1992, BS EN 1993 and BS EN 1994.

(ii) Bridge loading shall follow The Highways Agency, UK BD 37/01: Loads for Highway Bridges, BS EN 1992-2. Prestressed member should be design for Class1 under Load Combination 1 with HA and HA+30 units HB. Load Combinations 2 to 5 is designed for Class 2 with HA and HA+45 units HB.

(iii) Integral bridges shall follow BA 42/96 Amendment No. 1: The Design of Integral Bridges.

(iv) Foundations, Retaining wall structures and Reinforced Earth shall follow BS 8004: Foundation, BS 8002 : Code of Practice for Earth Retaining Structures , BD 3/78: Reinforced and Anchored Earth Retaining Walls and Bridge Abutments for Embankments [Rev. 1987], BS EN 1997 : Geotechnical Design.

(v) Vehicle Impact shall follow BD 60/04: Design of Highway Bridges for Vehicle Collision Loads or BS EN 1991:Part 2 :Traffic Loads On Bridges.

(vi) Vessel impact
Shall establish appropriate ship collision forces and follow the latest version of AASHTO Guide Specification And Commentary For Vessel Collision Design of Highway Bridges, Second Edition (2009) , BS EN 1991:1-7: Accidental Action.

(vii) Expansion Joints in Bridge Decks
Shall follow BD 33/94 and BA 26/94. Expansion Joints for Use in Highway Bridge Decks. The expansion joints shall be guaranteed by the manufacturer to have a minimum effective live of 10 years in the prevailing climate and traffic condition.

(vii) Parapet shall be in accordance to BD 52/93: The Design of Highway Bridge Parapets and in compliance to Arahan Teknik (Jalan) 1/85 (Pindaan 1/89) Manual on Design Guidelines of Longitudinal Traffic Barrier and REAM GL- 9/2006 :Guidelines on Design and Selection of Longitudinal Traffic Safety Barrier.

(viii) The bridge and viaduct structures shall be designed to satisfy for aesthetics requirement by following REAM - GL 1/1999: Guidelines on Bridge Aesthetics.

(ix) Footbridge design shall follow BD 29/04: Design Criteria for Footbridges

1.4.2 Durability

The bridge and viaduct structural elements shall be designed for enhance durability (if applicable) in accordance to The Highways Agency, UK BA 57/01 : Design For Durability. Reinforcement cover: in designing concrete members, nominal cover derived from BS5400: Part 4 Table 13, shall be increased by 10mm in accordance to BD 57/01 in the case of the bridge or structural elements of the bridge are subjected to abrasive chloride attack.

1.4.3 Design crack widths for reinforced concrete shall be in accordance to BS5400 part 4 and/or EN 1992-2 or as directed by JKR.

1.4.4 Earthquake loading

Earthquake loading for long-span lifeline bridges or bridges that required to be designed with seismic loading as directed by JKR, shall be taken as 1.0 in ULS and in Load Combination 4 only. The Peak Ground Acceleration (PGA) value depends on the project location and shall be taken as follow:

a) Peninsular Malaysia and Sarawak: 0.08g
b) Sabah : 0.17g

In considering earthquake loading no relieving effects from bearing friction will be considered.

1.4.5 Drainage: drainage facility for the bridge deck shall be suitably provided and the bridge deck shall have a minimum cross fall of 2.5%.

1.4.6 Reinforced earth wall shall be designed to Department of Transport Highways and Traffic Departmental Standard BD 3/78 (Revised 1987) Reinforced and Anchored Earth Retaining Walls and Bridge Abutments for Embankments. Reinforced earth structures shall have a design life of 120 years.

1.4.7 Approach embankment

Approach embankment for viaducts and structures shall conform to Geotechnical Design Criteria for Road Work to minimize any differential settlement at abutments.

Embankment must be designed with zero differential settlement at the connecting point to the bridge abutment and gradual settlement of **1 in 500** within 50m away from the abutment towards the toe of the approach embankment. Appropriate soil treatment must be provided in the case of SPT of the underlying soil is less than 5. Consultant must provide detail calculation of expected differential settlement with respect to the proposed type of soil improvement at the embankment area.

1.4.9 Surface finishes: the surfacing designed thickness shall be taken as 100 mm thick asphaltic concrete.

1.4.10 Bridge Clearances

(i) For bridge over river the freeboard and horizontal clearance shall be in accordance to DJ 1/2001 requirements and approved by Jabatan Pengairan dan Saliran (JPS), Jabatan Laut or relevant authorities;

(ii) For bridge over Keretapi Tanah Melayu Berhad (KTMB) railway lines the bridge vertical and horizontal clearance shall be approved by KTMB;

(iii) For bridge over road the vertical and horizontal clearance shall be approved by the relevant Road Authority.

1.4.11 Prestressing anchorages shall not be located at top flange face of T-beams or any other beams.

1.4.12 Half joint shall only be allowed as the temporary seating of precast beams onto the integral in situ crossheads.

1.4.13 Elastomeric bridge bearings shall be of natural rubber and shall be in accordance with the specification proposed by the Committee on Natural Rubber in Construction, Rubber Research Institute, Malaysia. Bridge bearing shall be designed with adequate stability in all directions during the beam launching and placement prior to deck slab casting.

1.4.14 Coating

The detail mix design and application of protective surface coating system for exposed concrete surfaces or areas where it deemed to be subjected to environmental condition attacks shall be in accordance to Section 9 (Concrete) Specification for Roadworks. Similar condition apply in the case of protective surface coating in combination with aesthetical surface coating. The minimum effective life of both protective systems shall be in excess of 20 years. Compulsory sample testing of paints is required.

1.4.15 Anti-corrosion protective system

The steel materials used for the bridge structures shall follow BS 5400: Part 6. A comprehensive anti-corrosion protective system in accordance with BS 5493 or equivalent shall be submitted and approval by JKR. The minimum effective life of such protective system shall be in excess of 20 years. Compulsory sample testing of paints is required.

1.4.16 Launching of precast elements

Utmost precautions shall be taken to eliminate any danger to workers and general public while launching precast elements. All lifting equipment shall be designed, such that if the primary lifting mechanism fails, a secondary mechanism will ensure that the precast element does not fall.

Upon erection, a fail-save method shall be used to temporarily secure the precast unit until the permanent fixing arrangements are implemented.

All precast unit must be braced adequately and maintained stable at all time. Bracing system must be designed to ensure stability of the precast unit prior to the fixed arrangement of the unit or structural members.

1.4.17 Temporary works

The risks for each case shall have to be considered and appropriate safety factors allowed in the design. The minimum safety factor at ULS shall be taken as 1.5 if the safety of the general public is at risk.

SESI SOAL JAWAB

SEKIAN TERIMA KASIH