



INSTITUT PENYELIDIKAN AIR KEBANGSAAN MALAYSIA (NAHRIM)  
KEMENTERIAN PERALIHAN TENAGA DAN TRANSFORMASI AIR (PETRA)

# NWICE 2024

National Water Innovation Conference & Exhibition 2024

**TRANSFORMASI AIR MENUJU KEMAMPAHAN SEJAGAT**

 PUSAT KONVENSYEN KUALA LUMPUR

 26-28 NOVEMBER 2024

## ***NON-DESTRUCTIVE TESTING (NDT) FOR HYDRAULIC STRUCTURES MONITORING***

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27 November 2024



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5. CONCLUSION/ WAY FORWARD



# 1.0 BACKGROUND



# 1.0 BACKGROUND

- Hydraulic structures are important components in irrigation engineering systems, flood control, water supply, navigation and hydroelectric generation
- There are three main categories of hydraulic structures based on their function namely:
  - Measurement structures such as overflow channels/ weirs
  - Control structures such as dams and sluices
  - Discharge structures such as spillways
- The construction and development of hydraulic structures need a huge funding and have an impact on property damage, infrastructure and lives if not properly monitored and repaired due to damage
- By using Non-Destructive Testing (NDT) techniques, engineers and inspectors can assess the condition of hydraulic structures, identify possible defects or weaknesses, and implement appropriate maintenance and repair measures to ensure safe and efficient operation

## 2.0 TYPES AND FUNCTIONS OF HYDRAULIC STRUCTURES



# TYPES AND FUNCTIONS OF HYDRAULIC STRUCTURES



Weir



Spillway



Dam



Bridge



Gate

# 1. WEIR



- A weir is a hydraulic structure built across a watercourse such as a river or canal to **control the level** and flow of water
- Usually weirs are designed with a flat top or a certain shape to allow water to flow in a controlled manner
- Important in the **water resources management and environmental protection**, ensuring efficient use of water and protection against natural disasters such as floods

# TYPES OF WEIR

| No. | Types of Spillway  | Characteristic and Functions                                                                                                                                            |
|-----|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.  | Sharp-Crested Weir | <ul style="list-style-type: none"><li>i. Has a sharp and thin top</li><li>ii. For the measurement of water flow in a laboratory or small river</li></ul>                |
| 2.  | Broad-Crested Weir | <ul style="list-style-type: none"><li>i. Has a wide and horizontal top</li><li>ii. Suitable for larger water flows and field applications</li></ul>                     |
| 3.  | V-Notch Weir       | <ul style="list-style-type: none"><li>i. Has a V-shaped opening at the top</li><li>ii. Used for lower water flow measurement with high accuracy</li></ul>               |
| 4.  | Rectangular Weir   | <ul style="list-style-type: none"><li>i. Has a rectangular opening</li><li>ii. Suitable for larger water flow measurements</li></ul>                                    |
| 5.  | Contracted Weir    | <ul style="list-style-type: none"><li>i. Having narrowed or contracted sides</li><li>ii. Helps to measure water flow in a more controlled and accurate manner</li></ul> |



Broad-Crested Weir  
Sumber: HydroCAD, 2024



V-Notch Weir  
Sumber: EncardioRite, 2024

## 2. SPILLWAY

- A spillway is a hydraulic structure built as part of a dam or dam to **drain excess water** from a reservoir or river downstream in a controlled manner.
- Designed to handle high water flows that may occur during heavy rains or floods to prevent uncontrolled overflow of water over the dam.
- A critical component in the design and management of dams to ensure excess water can be channeled safely to protect the dam structure and the surrounding area, especially the downstream area

# TYPES OF SPILLWAY

| No. | Types of Spillway      | Characteristic and Functions                                                                                                                                                                                                                                        |
|-----|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.  | Chute Spillway         | <ul style="list-style-type: none"><li>i. It consists of a sloping channel that drains water from the reservoir downstream</li><li>ii. Used for high and fast water flow and often equipped with an energy reducer at the base to reduce erosion</li></ul>           |
| 2.  | Morning Glory Spillway | <ul style="list-style-type: none"><li>i. Shaped like an inverted funnel on the surface of the reservoir that carries water to an underground channel</li><li>ii. Used in areas with limited space or where aesthetic design is required</li></ul>                   |
| 3.  | Saddle Spillway        | <ul style="list-style-type: none"><li>i. Built in the saddle or low area around the reservoir</li><li>ii. Usually used as an additional spillway</li><li>iii. Provides an additional path for overflow water, used when the main spillway is insufficient</li></ul> |
| 4.  | Shaft Spillway         | <ul style="list-style-type: none"><li>i. It consists of a vertical shaft or slope that carries water from the reservoir to an underground discharge channel</li><li>ii. Used in dams in hilly areas or limited space</li></ul>                                      |
| 5.  | Ogee Spillway          | <ul style="list-style-type: none"><li>i. Features a curved profile that follows the natural flow of water to minimize pressure and erosion.</li><li>ii. Commonly used in gravity dams and concrete dams</li></ul>                                                   |



*Chute Spillway*



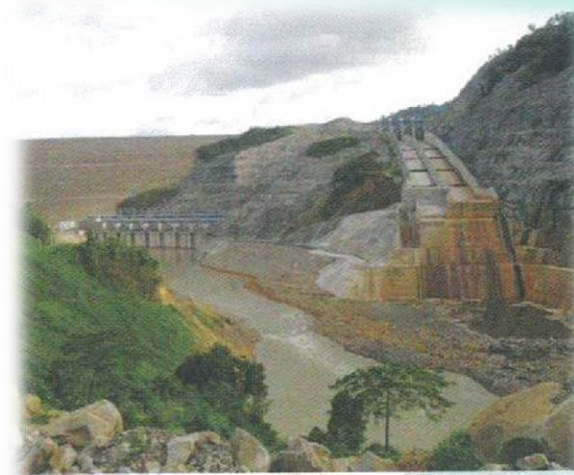
*Morning Glory Spillway*

### 3. *DAM*

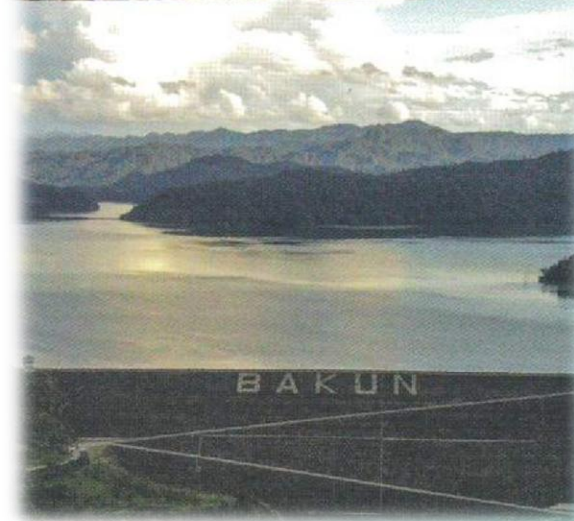
- A dam is a structure or area built in a river or watercourse to **maintain and store water** for the purpose of water supply, hydroelectricity and others
- An important structure in the management of water resources that has multiple functions for the benefit of humans, the environment, and sustainable development.

# TYPES OF DAM

| No. | Types of Dam             | Characteristic and Functions                                                                      |
|-----|--------------------------|---------------------------------------------------------------------------------------------------|
| 1.  | <b>Storage Dam</b>       | Storing water for various uses such as drinking water supply, irrigation, and hydroelectric power |
| 2.  | <b>Irrigation Dam</b>    | Specially designed to collect water for the purpose of irrigation of agricultural crops           |
| 3.  | <b>Temporary Dam</b>     | Built temporarily for construction purposes or to drain water temporarily                         |
| 4.  | <b>Flood Control Dam</b> | Designed to reduce the risk of flooding by retaining water during the rainy season                |
| 5.  | <b>Hydroelectric Dam</b> | Hydroelectric power generation through stored water reservoirs                                    |



**Storage Dam**  
**-Mengkuang Dam, Pulau Pinang**  
**Sumber: Kosmo, 2024**



**Hydroelectric Dam-Bakun Dam**  
**Sumber: Air dan Pembentungan, 2022**



**Irrigation Dam**  
**-Bekok Dam, Johor**  
**Sumber: Kosmo, 2024**

# INFRASTRUCTURE SABO



Sabo Infrastructure at Hokaido, Japan  
Source: Sabo & Landslide Technical  
Center, Japan (2019)



Open Infrastructure (Kitazato River Dam)  
Around Aso Mount, Japan  
Source: Sabo & Landslide Technical Center, Japan (2019)

- SABO originated from Japanese languages “Sa” and “Bo” which means erosion and sediment control works
- SABO means a reaction of rocks and sands which bringing the efforts of land and soil erosion control at mountainous areas
- Protecting humans and infrastructures at downstream from erosion and sedimentation disasters

# FUNCTION AND APPLICATION

## STATISTIC FROM JAPAN

- ✓ Sabo Dam was built since the 17<sup>th</sup> and 18<sup>th</sup> centuries
- ✓ Protect against landslides, snow avalanches, volcanic mud flows, lava flows and pyroclastic flows
- ✓ More than 50,000 Sabo facilities since 1897 with the introduction of the Sabo Act
- ✓ Overcome an average of 1,000 incidences of erosion and landslides each year



**a**

To trap erosion/ debris flow till discharge decreased

**b**

To decrease erosion/ debris flow rate

**c**

To serve as a *sediment settling* zone

**d**

To guide the flow in preventing the spread of erosion/ debris flow

**e**

To control erosion/ debris flow

Sabo infrastructure allows sediments to flow from upstream to downstream during normal conditions

When a large-scale of debris flow occurs, sediments/ rocks/ boulders will be trapped and temporarily hold at the back of Sabo infrastructure to avoid headwater or debris flow disaster at river downstream

# TYPES OF SABO STRUCTURES

Open Sabo (Segawe) located in Indonesia



OPEN SABO

- ✓ Water flow through holes or opening/slits and large pieces of soil/ rocks/ logs will be retained
- ✓ Slow down the flow of high volume water
- ✓ Typically constructed at upstream and mountainous area

Closed Sabo (Ashio) located in Japan



CLOSED SABO

- ✓ Water flow will flow through the top of the dam and trap the flow of erosion/ debris
- ✓ Will quickly be filled with sediment and requires good maintenance
- ✓ Usually built at downstream areas



Location: Titi Hayun Recreational Forest, Gunung Jerai, Kedah

## 4. GATE

- A sluice is a hydraulic structure that can be opened or closed **to control the flow of water** in irrigation systems, dams, canals, and water treatment plants.
- Usually made of concrete and **operated manually or automatically** using mechanical or electrical systems
- An essential component in water resource management and hydraulic systems, providing the flexibility and control needed to ensure safe and efficient operation

# TYPES OF GATE

| No. | Types of Gate | Characteristic and Functions                                                                                                                    |
|-----|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.  | Tilt Gate     | Open or close in an upward or downward slant                                                                                                    |
| 2.  | Lift Gate     | Open or close by going up or down vertically                                                                                                    |
| 3.  | Swing Gate    | Open or close by rotating on a certain axis                                                                                                     |
| 4.  | Roller Gate   | Open or close by rolling or pulling horizontally                                                                                                |
| 5.  | Sluice Gate   | It usually consists of a large portion of a metal plate or panel that can be moved vertically in a slot attached to the water channel structure |



**Tilt Gate**  
Source: HC Waterbeheersing, 2024



**Example of Sluice Gate**  
Source: Malaysiakini, 2021

## 5. *BRIDGE*

A bridge is a structure built to cross a gap or obstacle such as a river, railway or road. It is built to allow the passage of pedestrians, motorists or trains over the barrier.



Terengganu Drawbridge, Terengganu  
Source: MAPEI, 2024



Tower Bridge, London, UK  
Source: Etsy, 2024



Seri Wawasan Bridge, Putrajaya  
Source: Trip Advisor, 2024

# TYPES OF BRIDGE



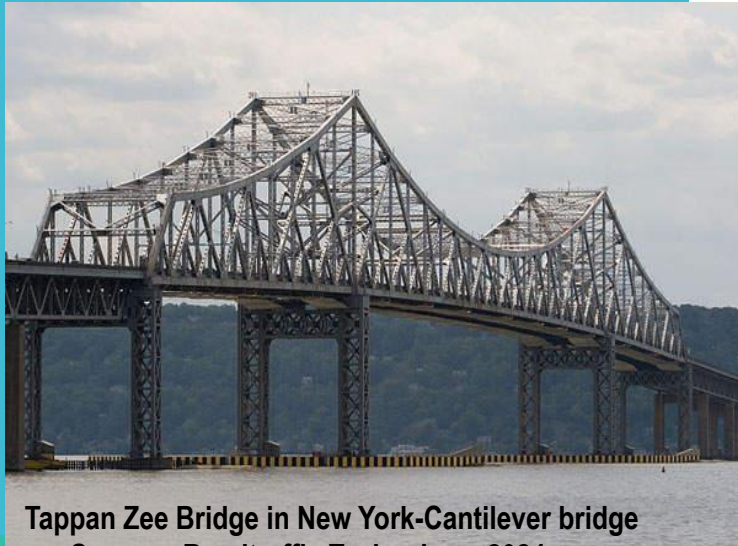
**Taaylor-Southgate Bridge, Ohio and Kentucky, US-Truss Bridge**

Source: Scott Lewis, 2024



**Golden Gate Bridge, San Francisco, US-Suspension Bridge**

Source: Britannica, 2024



**Tappan Zee Bridge in New York-Cantilever bridge**

Source: Roadtraffic Technology, 2024



**Penang Bridge, Malaysia- Cable-stayed Bridge**

Source: Wikimedia, 2024

- Log bridge
- Beam bridge
- Truss bridge
- Compression arch bridge
- Suspension bridge
- Cable-stayed bridge
- Cantilever bridge
- Moveable bridge

## 3.0 TREATS AND STRUCTURAL DETERIORATION



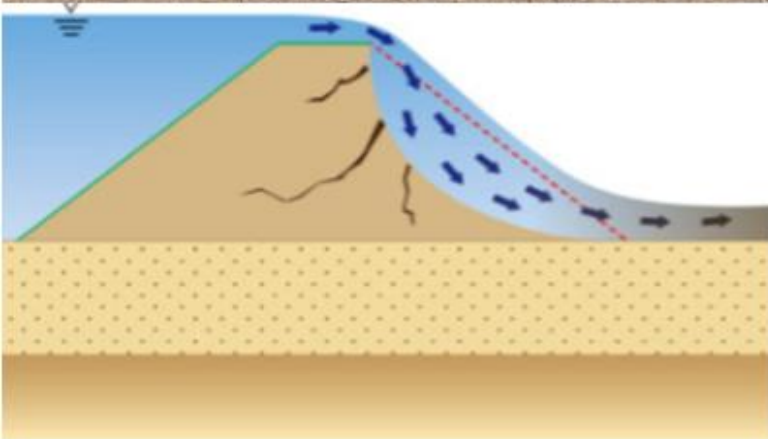
# 3.0 TREATS AND STRUCTURAL DETERIORATION

## *1.Overtopping*

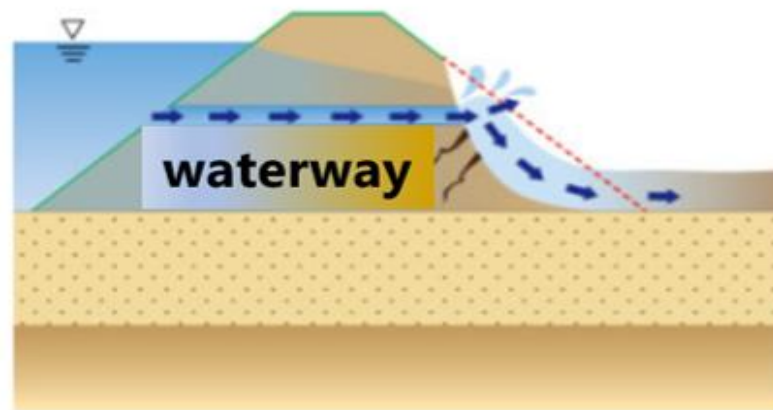
- ❑ The capacity of the channel is insufficient causing overflow/ overtopping occurs
- ❑ Insufficient free board to accommodate storms and flood events will result in overflow at the top of the dam body and the bank walls around the reservoir
- ❑ Dams at risk of overtopping hazard are Batu Dam, Timah Tasoh, Bekok and Sembrong (Syed Hashim et al., 2019)
- ❑ The height of the crest level is likely to be lowered in the event of other failures such as seismic movement and internal erosion

Sequence of critical dam with overtopping hazard  
(Syed Hashim et al., 2019)

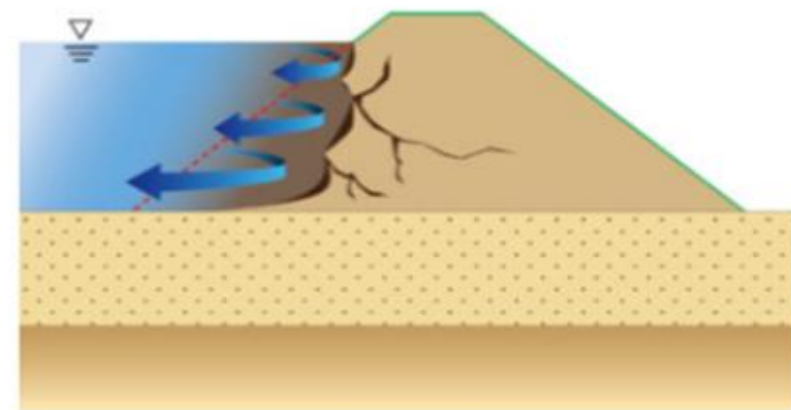
| No. | Dam         | Crest Elevation (m)/<br>years |
|-----|-------------|-------------------------------|
| 1.  | Batu        | 109 (35 years)                |
| 2.  | Timah Tasoh | 32 (30 years)                 |
| 3.  | Bekok       | 23 (32 years)                 |
| 4.  | Sembrong    | 15 (38 years)                 |



**Overtopping failure**



**Permeation failure**



**Erosion failure**



Normal Condition



Normal Condition



Overtopping due to floods  
(13 August 2003)

*Vertical Sluice Gate at Bukit Kemboja, Langkawi*



Overtopping due to floods  
(13 August 2003)

*Radial Sluice Gate at Padang Matsirat, Langkawi*

## 2. Seepage failure

- ❑ Seepage failure - due to water moving slowly through the dam and/or percolating slowly over a long period of time through the base of the hydraulic structure
- ❑ Will result in embankment, or foundation, or damage to the concrete structure
- ❑ If not properly controlled, seepage can gradually erode the soil from the embankment or at its base, resulting in dam failure
- ❑ A steady or sudden drop in normal lake levels is another indication that seepage is occurring
- ❑ Higher water levels can lead to extreme danger and risk when hydraulic structures such as dams occur, especially to residents in downstream areas



Issues of sediment build-up, dam seepage, major structural integrity and soil erosion

### Isu keselamatan Empangan Bakun telah ditangani – Sarawak Energy

📍 Bernama 📅 Oktober 4, 2023 📍 SARAWAK, UTAMA ⌚ 7:59 am

[Facebook](#) [Twitter](#) [LinkedIn](#) [WhatsApp](#) [Telegram](#)

KUCHING: Sarawak Energy Berhad, pemilik dan pengendali Empangan Bakun, berkata pihaknya telah pun menangani isu yang dibangkitkan oleh badan Dam Safety Flying Squad berhubung keadaan keselamatan empangan yang terletak di daerah Belaga di pedalaman Sarawak.

Dalam kenyataan hari ini, syarikat bekalan tenaga milik kerajaan negeri itu berkata isu pembentukan pemendapan, keadaan instrumen, resapan empangan, integriti struktur utama dan hakisan tanah, semuanya telah diperbetulkan selepas lawatan skuad berkenaan ke empangan itu pada bulan Oktober tahun lepas.

# 3. Aging/ Failure of Hydraulic Infrastructure

## Ageing dam infrastructure: More water disruptions expected, says SPAN

By Jason Yeo | 23/10/2023 | in Mainstream , Top



NATIONAL Water Services Commission (SPAN) chairman Charles Santiago has warned Malaysians that further piped water supply disruptions are likely due to the country's outdated dam infrastructure.

Santiago said according to the Dam Water Levels and Dam Water Supplies Risk Assessment Report, there were seven dams in Malaysia that have been identified as high risk.

"These are the Pedu, Muda, Durian Tunggal, Asahan, Mengkuang, Jus, and Linggui dams," Santiago told a press conference at the SPAN office in Cyberjaya today (Oct 23).

"Overall, a total 16 out of 55 dams in Peninsular Malaysia that are used for water consumption are more than 50 years old."

According to Santiago, there was a need to reevaluate their design and safety and conduct an assessment of both active and dead storage due to their old age.

- As of 2023, a total of 16 out of 55 Dams in Peninsular Malaysia (Water Supply) have exceeded 50 years
- Floods and other extreme environmental events are becoming more frequent and severe, which can exceed the design limits of dams and accelerate their aging process and risk structural failure
- Water supply disruption - Reduction of reservoir capacity (Sedimentation problem)
- Risk to the people in the downstream part of the river

# A beautiful day that turned tragic

Jetty collapse deaths a harsh lesson in human negligence

Incidents

4 Dec 2021 [+2 more](#) By PAUL GABRIEL paulnews@thestar.com.my

IT was a beautiful, sunny Sunday morning in Butterworth and July 31, 1988, was to be a very special day for Penang.

The Buddhist Guan Yin (Goddess of Mercy) festival was taking place in George Town on the island, with the annual St Anne's Feast being celebrated in Bukit Mertajam on the mainland.

The Guan Yin procession was touted as a once-in-60-years event, with tourists coming from as far as Hong Kong, Taiwan and Singapore.

I was The Star's Butterworth correspondent and the district was known

back then for sensational crimes.

About a year after setting up base there, I had already covered murders, shoot-outs, accidents, fires and even the hijacking of a tour bus with passengers in it.

But none would prepare me for the tragedy to befall the port town that afternoon. It was the unthinkable – the Pengkalan Sultan Abdul Halim jetty platform had collapsed under the overload of thousands of passengers scrambling to board ferries to get across to the island.

The horrific event killed 32 people and injured more than 1,000 others.

Running a one-man bureau then, I



**What happened:** On Sept 21, 1989, a 200-page report of the rci which was made public concluded that overloading of passengers in the waiting area of the terminal caused the platform to collapse, and that the Ppc's operations department had pleaded ignorance on the maximum number of passengers allowed there.

Source: TheStar, 2021

Jetty at Pangkalan Sultan Abdul Halim collapsed at Butterworth, Penang, Malaysia on Sunday, 4.40pm, 31 July 1988

32 deaths and 1,674 injured

## Factors of structural failure:

- The Sultan Abdul Halim platform built in 1956 was unable to accommodate 10,000 passengers (over loading)
- The iron girder of the terminal bridge is bent and broken. The wooden floors also collapsed. Iron walls and roofs fell down.



**Fatal wait:** Passengers were jostling to board the Pulau Langkawi ferry when the platform gave way, crushing the motorists and motorcyclists below.



Source: <https://suhaimiomar.blogspot.com/>. 2013

## Sequence of critical dam with structural failure hazard

| No. | Dam         | Age (year) |
|-----|-------------|------------|
| 1.  | Batu        | 35         |
| 2.  | Timah Tasoh | 30         |
| 3.  | Bekok       | 32         |
| 4.  | Sembrong    | 38         |

Source: Syarifah Intan Najla Syed Hashim et al., (2023). An Overview on the Potential dam hazard and pre-qualitative analysis on the selected critical dam in Malaysia. IOP Conference Series: Earth Environmental Science.1205 012019

## Eight dams found damaged, need repair, says ministry

NATION

Monday, 02 Oct 2023

6:22 PM MYT



Filepic: Water being released from Bakun Dam.

PUTRAJAYA: The dam safety flying squad in its inspection from 2021 to 2022 found that eight dams have damaged and could pose a threat to residents and property in the event of failure.

The eight dams are Muda and Ahning Dams in Kedah, Jor and Mahang Dams in Perak, Sultan Abu Bakar Dam in Pahang, Babagon Dam in Sabah, Bakun Dam in Sarawak and Kenyir Dam in Terengganu.

The Natural Resources, Environment and Climate Change Ministry said the results of the inspection found high sediment formation in the reservoir, damage to instrumentation and water control equipment, seepage, damage to the integrity of concrete structures, soil erosion and the signs of collapse.

Source: TheStar, 2 Oct 2023

## Sungai Musah bridge in Kapit, Sarawak closed to public

SABAH & SARAWAK

Friday, 22 Sep 2023

11:34 AM MYT



KAPIT: The Sungai Musah bridge on Jalan Tekait-Musah, about 21km from Song town, has been closed to the public due to damage caused by soil erosion in the area.

The damage to the 166 metre-long bridge was detected at about 9.30pm on Thursday (Sept 21).

Source: TheStar, 23 August 2024

## Flood: Slim Village Bridge Collapses

🕒 23/08/2024 11:54 PM



Credit: Pejabat exco dan awam

IPOH, Aug 23 (Bernama) -- The Slim Village bridge, a World War II historical site where the battle of Slim River was fought, collapsed at 8 pm tonight due to flooding caused by continuous rain since the afternoon.

Perak Infrastructure, Energy, Water and Public Transport Committee chairman Datuk Seri Mohammad Nizar Jamaluddin said a four-metre stretch was affected and that it only involved a single state road.

"The Public Works Department (JKR) are identifying other roads to see if only state roads or PLB roads are affected," he said in a statement tonight.

Source: Bernama, 23 August 2024

## Kuala Kubu Dam/ Ampang Pecah

- ❑ On October 24, 1883, the Kuala Kubu Dam broke and caused a major flood which submerged the entire town of Kuala Kubu and the surrounding area
- ❑ The collapsed dam was about 1.6 km long and over 91.4m wide
- ❑ It is made of wooden trunks and embanked with earth across Sungai Kubu, tributary of Sungai Selangor
- ❑ This incident has caused loss of lives and property
- ❑ 33 people including the District Officer and an English Magistrate-Cecil Ranking were also killed
- ❑ 38 houses were washed away and the only source of livelihood for the people of this area, which is ore trays, was also affected

Source: SMK Empang Pecah Bestari, 2001



Image of Drone at Ampangan Pecah  
Source: Fb Hulu Selangor, 2024



# 4. Scouring and Erosion

- Erosion of channel bottoms and edges due to rapid water flow or bottom erosion downstream of hydraulic structures or turbulent flow and eddy currents (*arus pusar*) is called scour

## Scouring at the Foot of the Dam

- The formation of large holes in the river bed near the dam due to the rapid flow of water, which can affect the stability of the dam structure

## Bridge Scouring

- Strong water flow around bridge piers or abutments can cause localized erosion that weakens bridge supports

## Spillway Scouring

- Heavy water flow through the spillway can cause erosion that damages the spillway structure and potentially causes failure

### SAMPAI DAH NAMPAK CERUCUK JAMBATAN

BY KORPORAT / WEDNESDAY, 31 JULY 2019 / PUBLISHED IN ARKIB, BERITA



KUALA KETIL – Dua operasi kuari dikenal pasti punca hakisan pasir sehingga menampakkan struktur cerucuk Jambatan Kampung Besah di sini.

Penduduk, Rozimah Ayub, 45, berkata, beberapa batang cerucuk di dua bahagian tiang jambatan berkenaan kelihatan jelas kerana hakisan pasir.

Source: Lembaga Sumber Air Negeri Kedah, 2019

### Iboi flood: Three bridges collapse, riverbank erosion forced Bailey bridge closure

By Ahmad Mukhsin Mukhtar - September 28, 2023 @ 1:57pm



One of the bridges connecting residents of Kampung Iboi and Kampung Padang Empang along Sungai Kupang collapsed due to intense flash floods last night. - NSTP/AHMAD MUKHSEIN MUKHTAR

### Kegagalan lapisan tanah punca struktur jambatan runtuh

Oleh SYAJARATULHUDA MOHD ROSLI / 04 Disember 2020 12:20pm / Masa membaca: 4 minit



One of the steel-reinforced concrete pillar structures (piers) of the Batu Kawan Bridge construction project across the Jejawi River to Batu Musang Jetty-cracked due to soil erosion

Sumber: Sinar Harian, 2020

BALING: Three bridges connecting Kampung Iboi and Kampung Padang Empang residents along Sungai Kupang here have collapsed due to flash floods last night.

Last night's flood incident also resulted in the closure of the Bailey bridge in Lata Chelai, Kampung Iboi, due to river bank erosion.

Kampung Iboi Village Development and Security Committee secretary Nor Mohamad Che Husain said that the Bailey bridge in the village had to be closed at 11pm after swift currents led to the erosion.

"Heavy rain since 4pm yesterday caused the river to overflow during sunset. I started receiving calls from residents after the Maghrib prayer, reporting that their homes were flooded, and at that moment, the electricity supply was cut off.

Source: NewStraits Times, 2023

## 5. Earthquake



*Service spillway structure  
Empangan Timah Tasoh, Perlis (DID, 2001)*

- Earthquakes are the **main threat** and influence the dams, especially old dams
- An earthquake is expected to cause the **dam failure**
- For example: The **Timah Tasoh Dam crack** in Perlis, Malaysia occurred due to earthquake in Timah Tasoh (Ismail, N., 2014)
- In Peninsular Malaysia there have also been several earthquakes with the local epicenter at Bukit Tinggi in Pahang, Kenyir Dam in Terengganu, Kuala Pilah in Negeri Sembilan as well as Manjung and Temenggor in Perak with a strength range between 1.6 to 4.6 on the Richter scale that occurred in 1984, 1985, 1987, 2007, 2009, 2010 and 2013 (Astro Awani, 2023)

1. Ismail, N. (2014). Issues and Problems towards the Sustainable Dam Management System in Malaysia. International Journal of Innovation, Management and Technology, Vol. 5, No. 6, December 2014.
2. Astro Awani (2023, April 19). *Ada kebarangkalian gempa bumi berlaku di Malaysia*. Retrieved 15 May, 2024.

## 6. Climate Change

- Climate change is a **global threat** that will affect the function and safety of hydraulic structures in Malaysia
- Malaysia receives high rainfall which always leads to flooding and causes the **failure of water control structures** such as dams, barrages and flood control bulls
- **Rising sea levels** and stronger coastal storms create challenges for states with coastlines and communities living near the sea.

### UNJURAN IMPAK PERUBAHAN IKLIM MALAYSIA



#### Suhu Permukaan Tahunan

Semenanjung Malaysia  
[2050] 1.29 - 1.37°C  
[2100] 1.85 - 1.93°C

Sarawak  
[2050] 1.35 - 1.43°C  
[2100] 1.94 - 2.05°C

Sabah  
[2050] 1.33 - 1.43°C  
[2100] 1.95 - 2.08°C

#### Hujan Tahunan

Semenanjung Malaysia  
[2050] +291mm (11%)  
[2100] +364mm (14%)

Sarawak  
[2050] +420mm (12%)  
[2100] +567mm (16%)

Sabah  
[2050] +616mm (19%)  
[2100] +813mm (25%)

#### Kenaikan Aras Laut

Semenanjung Malaysia  
[2100] +0.71 m

Sarawak  
[2100] +0.72 m

Sabah  
[2100] +0.74 m

Nota: Berdasarkan unjuran IPCC AR5 untuk Malaysia (NAHRIM, 2019)

## Too little water

### Water at Perlis dam enough for only 3 months

By Aizat Sharif - August 14, 2024 @ 3:20pm



The water level at Timah Tasoh dam in Beseri, which stands at 38.5 per cent, will last for only three more months if the dry spell in Perlis continues, said the state Irrigation and Drainage Department (DID).- NSTP/AIZAT SHARIF

KANGAR: The water level at Timah Tasoh dam in Beseri, which stands at 38.5 per cent, will last for only three more months if the dry spell in Perlis continues, said the state Irrigation and Drainage Department (DID).

Source: NewStraitsTimes, 14 August 2024

## Too much water

### Floods: 500 residents from four villages cut off after bridge collapses

Bernama  
18/12/2023 08:00 MYT



The bridge near Chenulang have been cut off a 25-metre bridge collapsed due to the recent floods. - BERNAMA

KUALA KRAI: About 500 residents from four villages - Pasir Jering, Dusun Bari, Dusun Bunut, and Batu Pagar - near Chenulang have been cut off a 25-metre bridge collapsed due to the recent floods.

Villager Mohd Mahdam Abdullah, 30, from Kampung Pasir Jering, said he learnt of the incident at 1pm yesterday when the floodwaters started to recede.

Source: AwanInternational, 18 December 2023

## Dabong-Gua Musang bridge closed due to damages caused by heavy rain

October 3, 2015 @ 8:37am



A temporary access bridge connecting Dabong to Gua Musang had to be closed due to several damages caused by heavy rain on Thursday. Pix by Ramli Ibrahim

**GUA MUSANG:** Due to continuous rain and overflow of Sungai Nenggiri, a temporary access bridge connecting Dabong to Gua Musang had to be closed to all vehicles.

Motorists from either place could not use the bridge near Kampung Pulau Setelu which was built after the worst flood in June, since Thursday early morning.

Source: NewStraitsTimes, 3 October 2015



Petugas Keretapi Tanah Melayu (KTM) berusaha membaikpulih landasan yang musnah akibat banjir di Bandar Segamat, Khamis.

**JOHOR BAHRU:** Sebelas batang jalan di empat daerah di Johor masih terputus hubungan berikutan banjir setakat 12 tengah hari ini, kata Pengerusi Jawatankuasa Kesihatan dan Alam Sekitar negeri Datuk Ayub Rahmat.

Source: mStar, 26 Januari 2017



**Struktur jambatan lama yang telah runtuh**

MiLo SuaM facebook

# 4.0 TYPES AND POTENTIAL OF NDT IN HYDRAULIC STRUCTURE MANAGEMENT



# 4.0 TYPES AND POTENTIAL OF NDT IN HYDRAULIC STRUCTURE MANAGEMENT

## Types of NDT

Non-Destructive Testing (NDT) - A technique used to inspect materials and structures without damaging or destroying them

| No. | Types of NDT                                            | Functions                                                                                                                                                                                           |
|-----|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.  | Ultrasonic Testing (UT)/<br>Sonic Pulse<br>Transmission | Using ultrasonic waves to detect defects such as cracks, wall thickness, or the presence of foreign materials in hydraulic structures                                                               |
| 2.  | Gamma Radiography<br>Testing                            | Using gamma rays to obtain images of materials that cannot be seen with the naked eye, such as the presence of cracks or corrosion in water lines                                                   |
| 3.  | Visual Testing (VT)                                     | Direct Testing using the naked eye or visual equipment to detect signs of damage such as cracks, erosion or loss of material on the hydraulic structure                                             |
| 4.  | Eddy Current Testing                                    | This technique involves the use of electromagnetic fields to detect changes in electrical concentration in materials that may be caused by the presence of defects such as cracks or erosion        |
| 5.  | Penetrant Inspection                                    | A process where a special liquid is used to fill cracks or defects on the surface of a structure, then this liquid is removed and a dye is applied to show the defect                               |
| 6.  | Radiography Testing<br>(RT)                             | Using X-rays or gamma rays to produce images of the internal structure of materials, allows detection of cracks, defects, or material thicknesses that cannot be seen directly                      |
| 7.  | Magnetic Particle<br>Testing                            | Using ferromagnetic particles placed on the surface of the structure. When a magnetic field is applied, the particles will gather around the crack or defect, indicating the location of the damage |

# POTENTIAL OF NDT IN HYDRAULIC STRUCTURE MANAGEMENT

## **Early Damage Detection**

NDT allows early detection of hydraulic structures' damage before they develop into more serious problems. This allows corrective action to be taken quickly to prevent further damage

## **Structural Integrity Assessment**

NDT enables comprehensive assessment of hydraulic structural integrity without damaging the structure itself. This is important to determine maintenance and upkeep requirements

## **Optimization of Maintenance and Operational Efficiency**

Through information from NDT testing, managers can optimize maintenance schedules, handling and operation of hydraulic structures, reducing costs associated with unnecessary maintenance.

## **Security Improvements**

Through early damage detection and integrity assessment, NDT helps improve the safety of hydraulic structures, reducing the risk of failure that can lead to accidents

## **Cost Savings**

By detecting early damage and proactively performing necessary maintenance, NDT helps reduce the costs associated with repairing and replacing affected hydraulic structures.



NDT by sonic transmission technique  
at Vakkileru Aqueduct, India



NDT by sonic transmission technique at  
Sardar Sarovar Dam, Gujarat, India.

- Some application of NDT was applied such as in India, Sonic Pulse transmission Technique is used to figure out weak zones comprising of voids, cracks, etc. in concrete and masonry structures like dams, Aqueduct, Canals and others thus, it is able to check the homogeneity of the material forming the structure.
- Since, ultrasonic pulse transmission technique has got limitation of penetration depth up to 5 meter, sonic pulse transmission technique is adopted for depth exceeding 5 meter .



- Non-destructive integrity testing (like ultrasonic or eddy current testing) for detecting cracks, leaks, and corrosion in asset components and structures.

- Using Drone in visual inspections

# Non-Destructive Testing of Bridge Decks (GPR-IRT-Video)



Penetradar has developed a method of using ground penetrating radar (GPR), infrared thermography (IRT) and video imaging for bridge deck surveys, which provides a cross correlation of the collected data, thus producing highly reliable results by detecting anomalies through the use of different technologies.



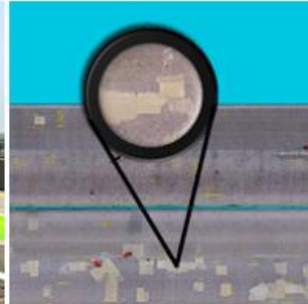
**Ground Penetrating Radar**

Penetradar's High Performance IRIS GPR Technology is unique in the industry and the only equipment available today that has the ability to cover an entire traffic lane width, while traveling at highway speeds and simultaneously collecting data at an ultra-high scan rate sufficient to identify small subsurface features such as delaminations in bridge decks.



**Infrared Thermography**

Penetradar's state of the art ThermalMap IRT inspection system utilizes the most advanced IR camera technology and records radiometric data for each pixel meaning better calibration and optimization in post processing by incorporating the correct temperature range that corresponds to delaminated locations and ultimately increased reliability of detections.



**Video Imaging**

Visual Plan-View maps of bridge decks are created from the high-resolution video capture which shows patching, marked out locations and other surface features. The zoomed in section shows the detail that the camera picked up by showing the dimensions and contours of the patches. This visual map is an integral asset to improving the GPR & IRT results.



GRP sled with multiple antennas  
reducing scanning time and costs



IPC's BridgeScan® goes beyond just GPR.  
This is a complete bridge deck and approach  
roadway assessment.

Source: Infrastructure Preservation Corporation (IPC), 2024

Source: Penetradar, 2024

# 5.0 CONCLUSION/ WAY FORWARD



1. **Non-destructive Testing (NDT)** has potential in the management of hydraulic structures where NDT provides added value for hydraulic structures monitoring, improve safety, efficiency and operational effectiveness, while reducing maintenance and repair costs.
2. **On-site Hydraulic Structure Safety/ Monitoring Teams** are beneficial to reduce structural failures and the use of NDT technology in managing the performance of hydraulic structure needs to be expanded.
3. Only dam structures are monitored such as Dam Inspection by the **Malaysian National Committee for Large Dams (MYCOLD)**
4. All relevant agencies involved play an **important role** in ensuring that hydraulic structures in Malaysia are regularly inspected and maintained using NDT methods to ensure the safety, reliability, and sustainability of the country's water resources.
5. Innovation development for **Green Hydraulic Structures** focuses on integrating environmental sustainability with current water management systems need to be explored further.



INSTITUT PENYELIDIKAN AIR KEBANGSAAN MALAYSIA (NAHRIM)  
KEMENTERIAN PERALIHAN TENAGA DAN TRANSFORMASI AIR (PETRA)

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# THANK YOU

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