



# Introduction of Maintenance Management for Bridge and Slope of National Freeway in Taiwan

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# Outline

1. Foreword

2. Introduction of Freeway Management System in Taiwan

3. Maintenance and Management for Bridges

4. Maintenance and Management for Slope

5. Closing Remarks

# 1. Foreword



# Bridges

- ◆ Bridges in Taiwan are in a typical multi-hazard situations:  
**Typhoons, Scouring, Earthquakes, Traffic Overloading, etc.**



- Inspection and maintenance of bridges need to be carried out in a very frequent manner
- Monitoring systems : **Scour monitoring system, early warning system, etc.**

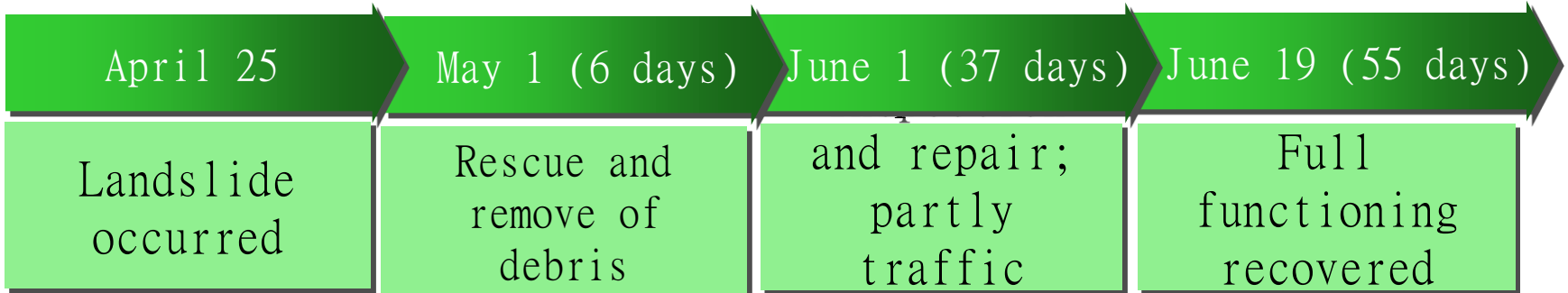
# Slopes

- Local landslides due to heavy rainfall or possibly over-saturated soil
- A large scale landslide occurred in northern Taiwan (3.1k) in April 2010
- Affecting area of over 22,800 m<sup>2</sup>, total mass of landslide over 20,000 m<sup>3</sup>



# Slopes (continued)

## Emergency recovery (2010)



2.

## Introduction of Freeway Management System in Taiwan



# Introduction of Taiwan Area National Freeway Bureau (TANFB)

- **Taiwan Area National Freeway Engineering Bureau Established in Jun 1970**
  - Operation of National Freeway #1 in Oct. 1978
  - Operation of National Freeway #3 in Jan. 2004
  - Operation of National Freeway #6 in Mar. 2009
- ◆ **National Freeway #7 under planning: one of the major recent new project**





# Maintenance Specifications and Manuals

Ministry of Transportation

**2011. 3. Update and amendment 「Highway Maintenance Specifications」**

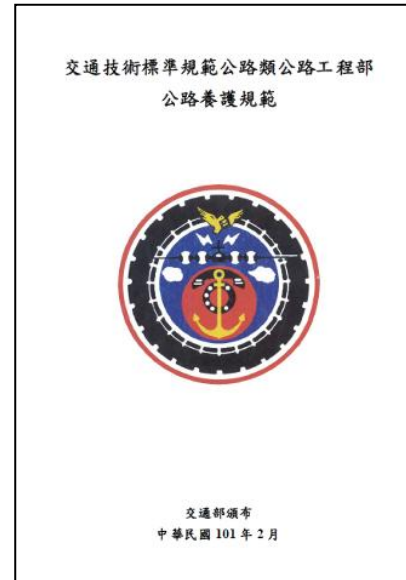
National Freeway Bureau

**2011.8 Amendment 「Expressway Maintenance Manuals」**

Chapter V of the "slope"

Chapter VII of the "bridge"

NEW



# 3 Maintenance and Management for Bridges



# Operations of Bridge Inspection

## Annual contract for inspection works:

1. Half-year Inspection
2. Periodic Inspection
3. Special Inspection
4. Detailed Inspection
5. Non-destructive testing
6. Riverbed cross-section measurements



# Bridge Inspection



Box girder internal



Viscous dampers



Expansion joints



Box girder internal



Supporting bear



Riverbed cross-section measurements

# Bridge Inspection



Pier crack



Substructure



Pier base erosion



Expansion joints



Concrete crack



Groundsill works

# The Highest Piers in Taiwan (h=68m) No.6 National Freeway-Kuohsing Viaduct



# The Practice of Bridge Monitoring

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## **Flood Disaster Prevention**

- ◆ **Regular Inspection and Maintenance Operations**
  - ◆ **River Cross-Section Measurements**
  - ◆ **Coordination between the Bridge Authority and the River Authority**
  - ◆ **Research Projects and Training**
-

# The Practice of Bridge Monitoring

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## Research projects and training

- ◆ Study on I-Lan Bridge Management and Maintenance System (2010~2011)
  - ◆ Experimental Study on an Innovative Bridge Monitoring System (2009~2012)
  - ◆ Establishment of Historical Database of the Scoured National Freeway Bridges (2009~2011)
  - ◆ Research on Scouring Depth Monitoring of Choshui River Bridge on National Freeway No.3 (2009~2010)
  - ◆ Research on Continued Scouring Depth Monitoring of Choshui River Bridge on National Freeway 3 (2011)
-



# Bridge Maintenance



**Number expansion joints**



**Grouting in bridge concrete slab**



**Repair expansion joint**



**Bridge railing replacement**



**Beam repair**



**Additional maintenance ladder**

# Bridge Maintenance



**Pier maintenance**



**Expansion joint replacement**



**Scuppers cleaning**



**Safety net setting**



**Pier steel plate paint**



**Shock rod Repair**

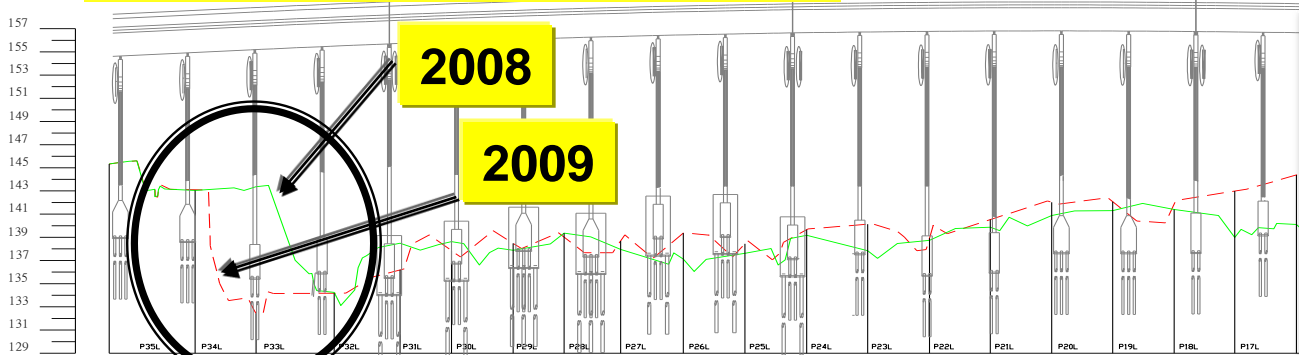
# Emergency repair cases : Choshui River Bridge on National Freeway #3



**Before the flood season in 2009**



**Pier base erosion**



濁水溪橋:4號斷面 (L4-R4)

H-SCALE = 1/3500 V-SCALE = 1/350

**Riverbed cross-section measurements**

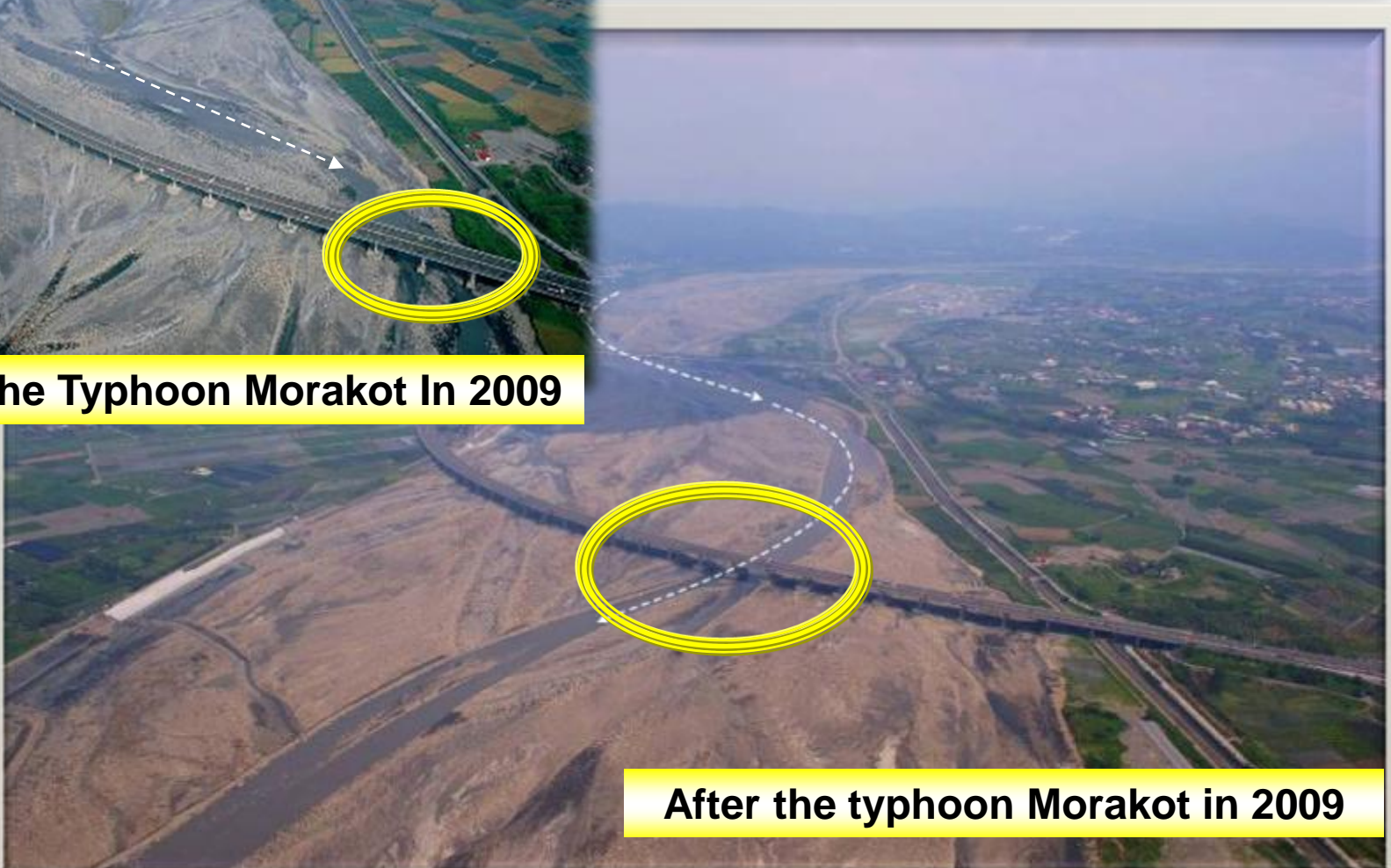


98年度 : - - - - -  
97年度 : \_\_\_\_\_

# Shift of the Watercourse of Choshui River



**Before the Typhoon Morakot In 2009**



**After the typhoon Morakot in 2009**

# Emergency repair cases : Choshui River Bridge on National Freeway N0.3



Pre-construction (2008.12.9) Weaving laying (2009.7.1)



Block dipping



After construction (2009.7.28) Morakot struck (2009.8.9)



Morakot(2009.8.9)



After

# 3 Maintenance Management for Bridges

*Introduction of Bridge Management System*



# 1. General Information System

## ❖ Database

- Administration
- Geometry
- Structure
- Design
- Photos
- Misc

台灣地區橋梁管理系統(公路總局) - Microsoft Internet Explorer

網址: http://bms.ilot.gov.tw/bmstsc/IndexStart.asp

基本資料 > 資料編輯 > 橋梁

刪除這筆資料 列印 確定修改 新增檢測記錄 歷史檢測記錄 GIS

整體 照片簿

橋梁名稱: 橋子頭橋

管理資料

管理機關: 交通部公路總局	工程處: 公路總局第二區工程處	工務段: 彰化工務段	所在縣市: 彰化縣
所在區鄉: [ ]	道路等級: 縣道	路盤: I37線	里程樁號: 5K+405m
竣工年月: 84 / 3	造價: [ ]	合約編號: [ ]	設計單位: [ ]
施工單位: [ ]	跨越物體: [ ]	參考地標: [ ]	竣工圖說保存地點: [ ]
最近一次維修年/月: [ ] / [ ]			

幾何資料

橋梁總長: 6	最大淨寬: 6	最小淨寬: 6	最高橋墩高度: [ ]
橋版投影面積: 64	橋上淨高: [ ]	橋下淨高: [ ]	總橋孔數: 1
總車道數: 2	最大跨距: [ ]	其他跨距: [ ]	
橋頭GPS經度: [ ]	橋頭GPS緯度: [ ]	橋尾GPS經度: [ ]	橋尾GPS緯度: [ ]

結構資料

結構型式: 簡支	橋墩型式: 無橋墩構造	橋墩材質: [ ]	橋墩基礎型式: 直接基礎
主梁型式: 板梁	主梁材質: [ ]	橋台型式: 重力式	橋台基礎型式: 直接基礎
鋪面材質: AC	伸縮縫: [ ]	翼牆型式: 重力式	支承型式: 無支承墊

完成

# 2. Statistics and Analysis Module

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## ❖ Management Administration

- Historical records
- Locations
- General Inventory

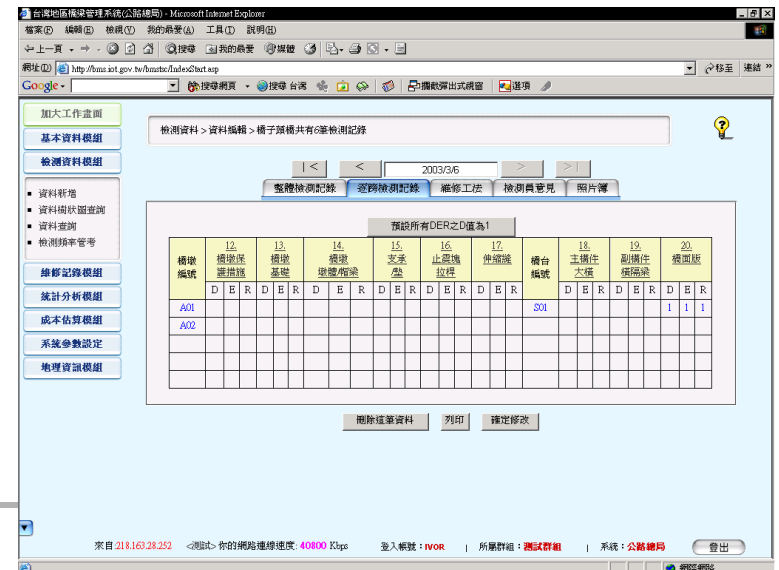
## ❖ Fundamental Database

- General Information
- Inspection records



# 3. Inspection Data Module

- ❖ General system
- ❖ Crew records
  - Operation
  - Deterioration observed
- ❖ Evaluation of design
  - Performance
  - Loading Capacity
- ❖ Traffic servicability
- ❖ Maintenance Strategy
- ❖ Cost and Budget System
- ❖ D.E.R. & U.



# 4. Repair Cost Estimation Module

- ❖ Requirements for full inspection
- ❖ Evaluation and priority
- ❖ Cost of repair and maintenance
- ❖ Repair methods selection and basic design

基本資料											檢測資料											地理資訊											統計分析											維修記錄											成本估算											整合決策										
估算範圍											花蓮縣											估算年度											89																																											
所有構件											急迫性(U=1)											急迫性(U=2)											急迫性(U=3)											急迫性(U=4)											急迫性(U=0)											重新選取										
選取	橋梁名稱	管理機關	工程處	工務段	縣市	檢測日期	檢測項目	維修項目	維修位置	維修單位																																																																		
<input checked="" type="radio"/>	正德橋	花蓮縣政府			花蓮縣	2000/9/17	欄杆及護欄	剝落混凝土修補	整體	M^3																																																																		
<input type="radio"/>	永吉橋	花蓮縣政府			花蓮縣	2000/9/8	主構件(大梁)	修補混凝土	S01	M^3																																																																		
<input type="radio"/>	永吉橋	花蓮縣政府			花蓮縣	2000/9/8	主構件(大梁)	修補混凝土	S02	M^3																																																																		
<input type="radio"/>	永吉橋	花蓮縣政府			花蓮縣	2000/9/8	橋面版	修補混凝土	S03	M^3																																																																		
<input type="radio"/>	永吉橋	花蓮縣政府			花蓮縣	2000/9/8	主構件(大梁)	修補混凝土	S05	M^3																																																																		
<input type="radio"/>	永吉橋	花蓮縣政府			花蓮縣	2000/9/8	副構件(橫隔梁)	修補混凝土	S10	M^3																																																																		
<input type="radio"/>	永吉橋	花蓮縣政府			花蓮縣	2000/9/8	引道護欄	其他	近端																																																																			
<input type="radio"/>	永吉橋	花蓮縣政府			花蓮縣	2000/9/8	引道護欄	其他	遠端																																																																			
<input type="radio"/>	永吉橋	花蓮縣政府			花蓮縣	2000/9/8	欄杆及護欄	金屬欄杆的防蝕保護	整體	M																																																																		
<input type="radio"/>	吾社橋	花蓮縣政府			花蓮縣	2000/9/26	引道護欄	整理保養	近端	M																																																																		
<input type="radio"/>	秀林一號橋	花蓮縣政府			花蓮縣	2000/9/14	河道	雜物清理	整體	M^3																																																																		
<input type="radio"/>	佳林五號橋	花蓮縣政府			花蓮縣	2000/9/17	伸縮縫	清除碎屑	A02	式																																																																		
<input type="radio"/>	佳林五號橋	花蓮縣政府			花蓮縣	2000/9/17	主構件(大梁)	修補混凝土	S01	M^3																																																																		
<input type="radio"/>	佳豐橋	花蓮縣政府			花蓮縣	2000/9/14	欄杆及護欄	剝落混凝土修補	整體	M^3																																																																		
<input type="radio"/>	尚志橋	花蓮縣政府			花蓮縣	2000/9/6	副構件(橫隔梁)	塗上保護塗料	S01	M^2																																																																		
<input type="radio"/>	尚志橋	花蓮縣政府			花蓮縣	2000/9/6	引道護欄	護欄換新	近端	M																																																																		

共計橋梁 11 座 構件 9 類 小計 NT\$84,946 元

# 5. Maintenance Records Module

## ❖ Major functions

- Tracking of maintenance and inspection works
- Life-time serviceability history
- Decision making for engineers

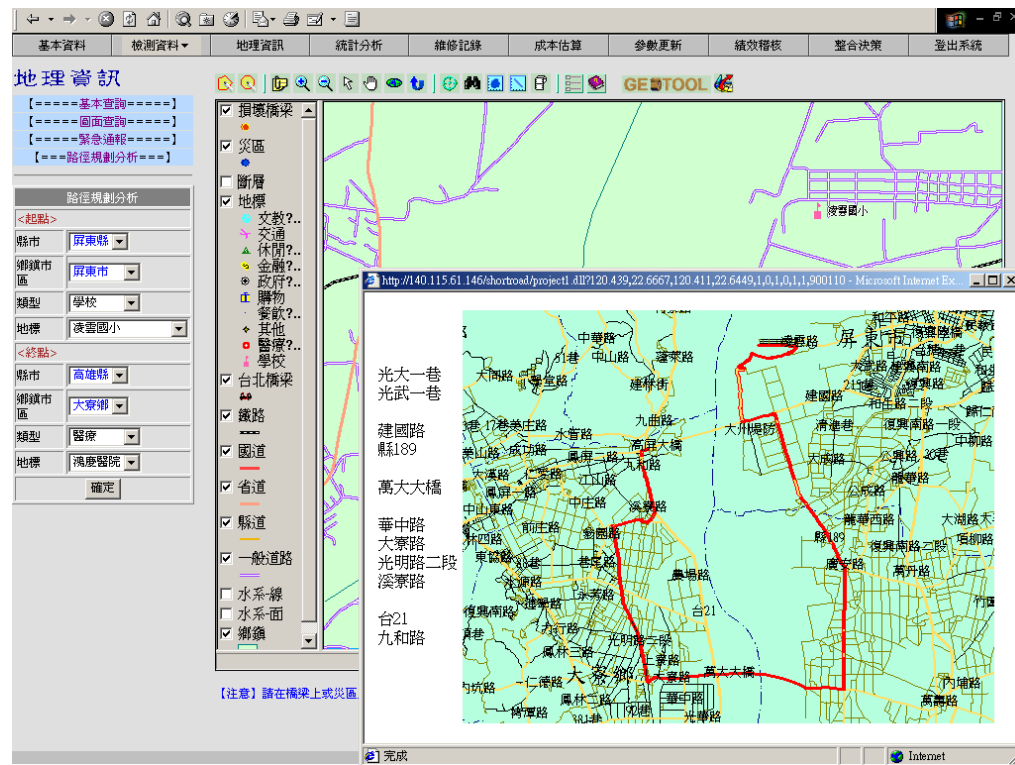
The screenshot shows a software interface for managing maintenance records. The interface is divided into several sections:

- Navigation Bar:** Includes tabs for '基本資料' (Basic Information), '檢測資料' (Inspection Data), '地理資訊' (Geographic Information), '統計分析' (Statistical Analysis), '維修記錄' (Maintenance Records), '成本估算' (Cost Estimation), '整合決策' (Integrated Decision), and '參數更新' (Parameter Update).
- Form Fields:** Contains fields for '橋梁名稱' (Bridge Name), '檢測單位' (Inspection Unit), '檢測員' (Inspector), and '檢測日期' (Inspection Date).
- Tree View:** A hierarchical tree view on the left lists various bridge components such as '引道護欄' (Approach Guardrail), '橋台基礎' (Abutment Foundation), and '橋墩基礎' (Pier Foundation).
- Form Fields (Right):** Includes '檢測項目' (Inspection Item), '維修項目' (Maintenance Item), '維修位置' (Maintenance Location), '維修數量' (Maintenance Quantity), '維修急迫性' (Maintenance Urgency), and '備註' (Remarks).
- Form Fields (Bottom):** Includes '承辦商名稱' (Contractor Name), '廠商統一編號' (Company ID), '實際維修數量' (Actual Maintenance Quantity), '實際維修金額' (Actual Maintenance Amount), '維修開工日期' (Maintenance Start Date), and '維修完成日期' (Maintenance Completion Date).

# 6. GIS Analysis Module

## ❖ Main function

- Map layout
- Bridge inquiry
- Emergency service
- Path planning
- Space analysis



# 4 Maintenance Management for Slopes



# Comprehensive Freeway Inspection and Monitoring

2010

(Monitoring)

- 202 sites of slope
- 912 monitoring sys. installed
- 3 million data per year



2010. July Installation of instruments at 32 sites of dip slope



**2010. Oct. Monitoring system developed**



**2010. Nov. SOP and practice manuals**

2011 (Inspection)

- 939 sites of slope
- Over 20,000 ground anchors



2011. June. Inspection of all rock anchors



2011. Dec. Safety evaluation of freeway slopes

2012 (Manag. system)

- Freeway Life-cycle maintenance and Management system
- 100 various types of monitoring equipment



2012. Jan. Integration of life-span management system

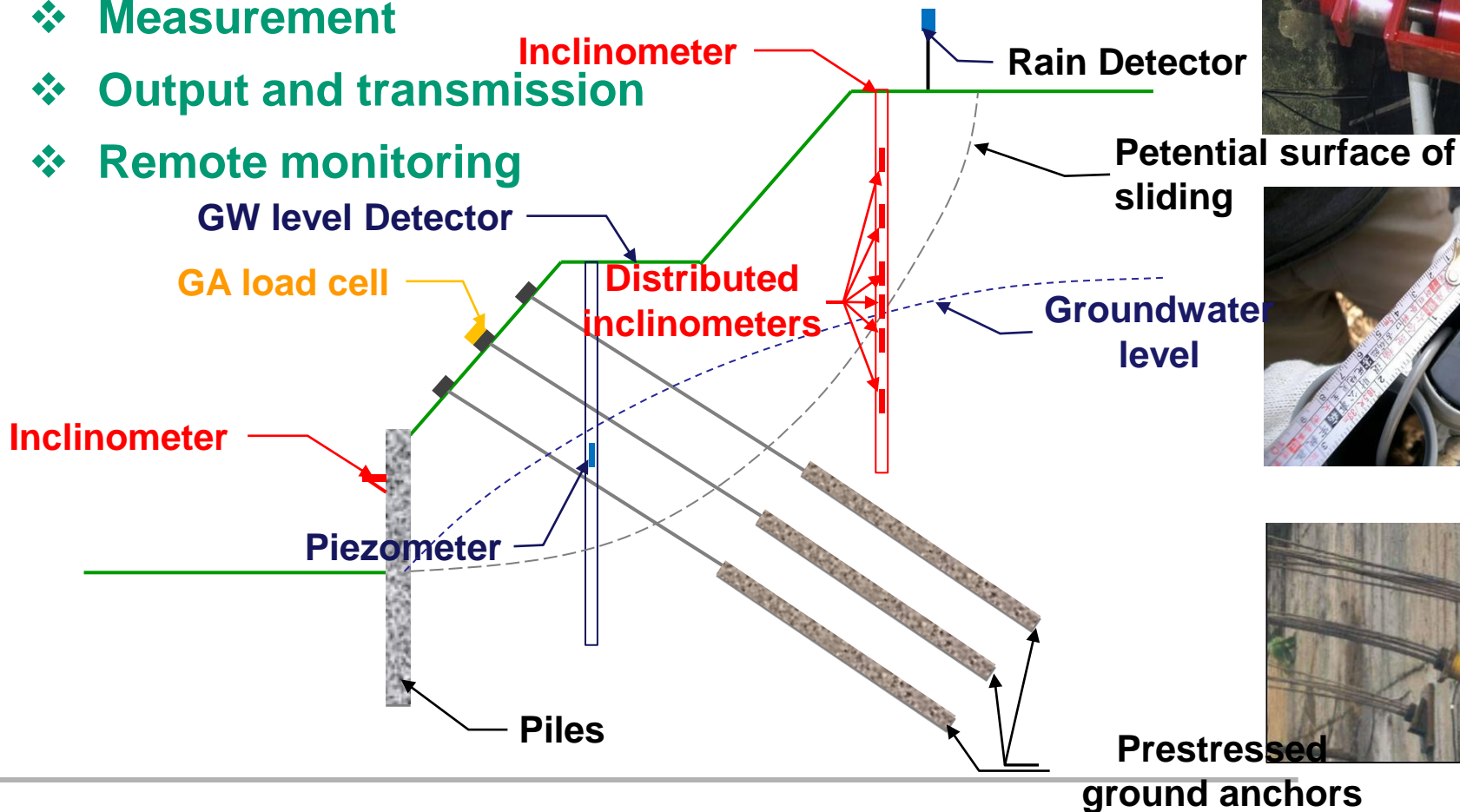


2012. May. Automation and standardization of slope monitoring and inspectio



# Standardization of Monitoring Operation of Freeway Slopes

- ❖ Specification
- ❖ Installation
- ❖ Measurement
- ❖ Output and transmission
- ❖ Remote monitoring





# 4 Maintenance Management for Slopes

*The Practice of Slope Maintenance*



# Evaluation and Ranking of Safety of Slopes

- Evaluation and ranking of slopes
  - Routine inspections
  - Periodic measurements
  - Ground anchor check-up

R	Characteristics	Response
A	Sig. unstable	Immed. action
B	Somewhat unstable	Intensive monit.
C	No sig. us observed	Routinely monitoring
D	Stable	Regular inspec.



**Rank B**



**Rank C**



**Rank D**

# Examples of Slope Repair



**Mini-piles**



**Intercepting Ditch**

# Examples of Slope Repair



All casing concrete piles



Rock anchors with shotcrete grids

# Examples of Slope Repair



**Retaining wall with piles**



**Berm ditch with mini-piles**

# 4 Maintenance Management for Freeway Slopes

*Introduction of Slope Management System*



# Full Life-span Management System of National Freeway Slopes

## ❖ Significance

- Comprehensive history and traceability system
- Automation of data processing and graphical interface
- Real-time monitoring



# Full Life-span Management System of National Freeway Slopes



交通部臺灣區國道高速公路局  
Taiwan Area National Freeway Bureau, MOTC

Systematic manag.

Slope inventory

Graphical interface

國道邊坡全生命週期  
維護管理系統



Traceability

Multiple alerts

Real-time monitoring



Mobile Inquiry System



Inteegration Platform





# Real-time Monitoring

## 3D Management System

The screenshot displays a web-based interface for a 3D Management System. The main title is "國道邊坡全生命週期 維護管理系統" (National Highway Slope Full Life Cycle Maintenance Management System). The interface includes a navigation menu with "功能列表" (Function List), "首頁" (Home), and "圖台" (Map). The central area shows a 3D topographic map of a highway slope with several green location markers. A red dashed circle highlights a specific area on the map. Three callout boxes provide detailed information:

- Real-time video:** A video player showing a live camera feed of the slope, with a "Google" logo and "© 2013 Google" text.
- Location indication:** A zoomed-in view of the highlighted area on the map, showing a yellow marker and "Google" text.
- Display and status:** A panel for "國道 1 號順" (National Highway 1, Normal) with elevation "8k247m~8k6". It features a "監測" (Monitoring) button and "巡檢" (Inspection) button. The status is shown with green circles: SIS傾度管 (2), TI傾斜計 (5), 水位觀測井 (2), and 地錨荷重計 (1).

# 4. Conclusions



# Closing Remarks

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- ◆ **Bridge and Slope Inspection and Maintenance Systems**
- ◆ **Establishment of Full Life-Span Management of the Bridge and Slope**
- ◆ **Automation and Real-time monitoring for Early Warning System**



***Thank for your attention***

