BRIDGE DESIGN TOWARD IMPROVED INSPECTION AND MAINTENANCE

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PIARC T.C. D.3 BRIDGES - WORKING GROUP 1

2016 – 2019 CYCLE

Kementerian Kerja Raya

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http://rivaspuede.org/?p=1276

Introduction

- Requirements of good bridge design:
  - Strength
  - Functionality
  - Aesthetics
  - Economics
- Practical, durable, sustainable, maintainable, etc.
- In achieving this, future inspections and maintenance must be considered upfront in the design
- Failure to do so, leads to impractical and costly future maintenance

http://www.flickr.com/photos/mickbab/3772025356/

Aim

- Assess *design and detailing practices and provisions* from various countries that are specifically directed *toward facilitating the undertaking of future inspections, maintenance and replacement of bridge elements*
- Achieved through a survey distributed to the members of T.C. D.3 Bridges of PIARC

https://brentwoodhomepage.com/lowest-rated-bridges-in-williamson-county-hills-oldhills/bridge-inspection-aid-climb-e1477683569325/

Methodology

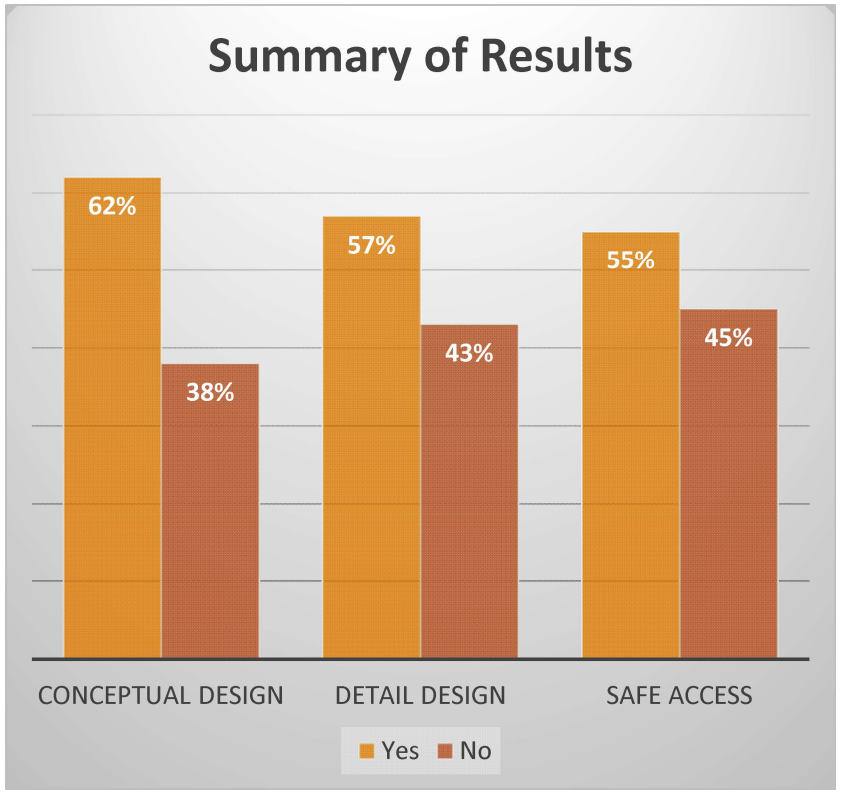
- Questionnaire
  - Conceptual design practices and provisions
  - Detail design practices and provisions
  - Safe access installations and provisions
- Case Study
  - Good examples
- Reviewed, compared and analysed responses
- Proposed a consolidated set of guidelines

Results and Analysis

- 17 responses to questionnaire
  - Austria
  - Belgium
  - Canada
  - China
  - Germany
  - Hungary
  - Japan
  - Norway
  - Portugal
  - Romania (2 responses)
  - South Africa
  - South Korea
  - Spain
  - Switzerland
  - USA (2 responses)

Results and Analysis

- Majority of responses indicate countries do take into account future inspections and maintenance in design and construction of bridges
- Majority of responses also indicate that provisions for design for this aspect are found in codes/standards/guidelines
- Minority (24%) indicate that it is left up to best practice/experience of individual design
- Most of the provisions were common to all countries
- The following slides present a consolidated set of best practice guidelines with regard to designing bridges for improved inspection and maintenance.

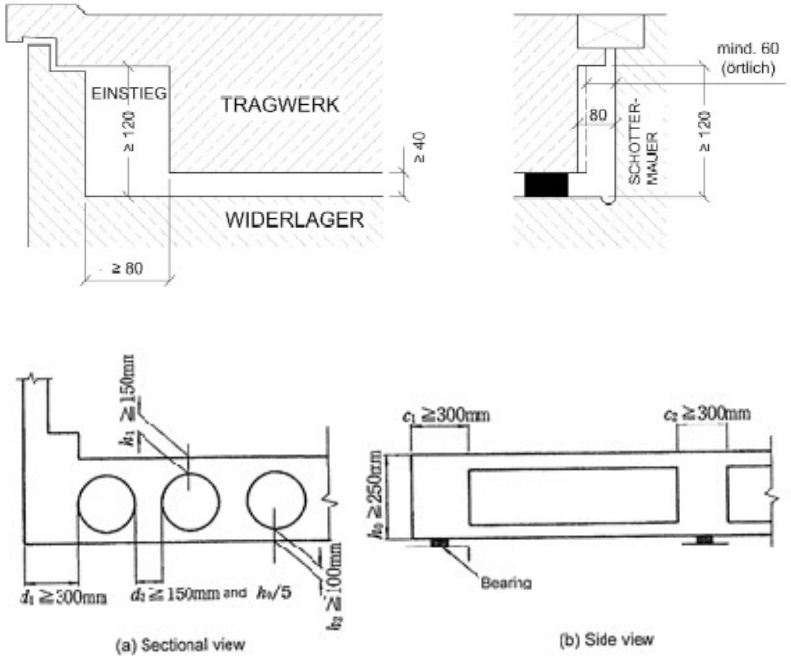


Conceptual Design

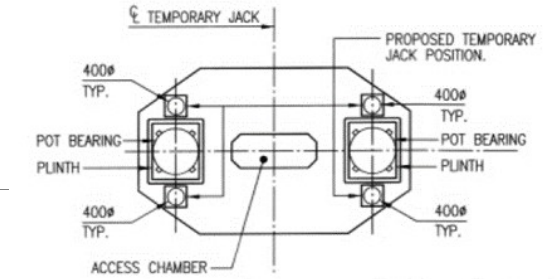
- Structural configurations (bridge typology)
  - Integral bridges, semi-integral or continuous deck slabs preferred
  - Voided slabs using permanently installed inaccessible void formers not favoured in some countries
- Material choice
  - Durability specifications, weathering steel, UHPC and fibre-reinforced concrete
  - Galvanised and stainless steel in decks and parapets
  - Protective coatings of steel elements

Conceptual Design

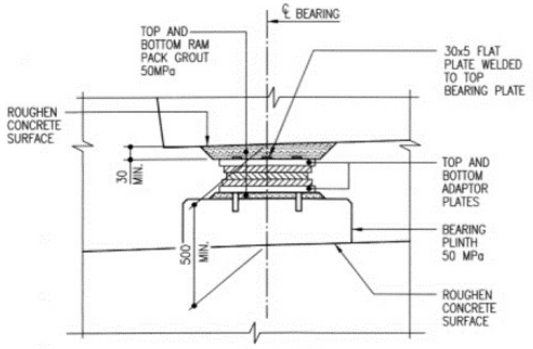
- Minimum dimensions and clearances
  - Min. clearance between top of substructure and soffit of superstructure
  - Min. dimensions of access gallery/chambers at abutments
  - Min. thickness of deck slabs
  - Min. thickness of steel plates
  - Min. sizes of openings, manholes, voids/hollow spaces (Health and Safety obligations)
  - Min. and max. height of parapets and barriers to suit required containment level and inspection equipment respectively (excluding noise/wind barriers)
- Bridge instrumentation
  - Limited use of bridge instrumentation such as structural health monitoring for inspections and maintenance
  - Mostly used for larger structures to monitor earthquake/wind effects and for research



Detail Design

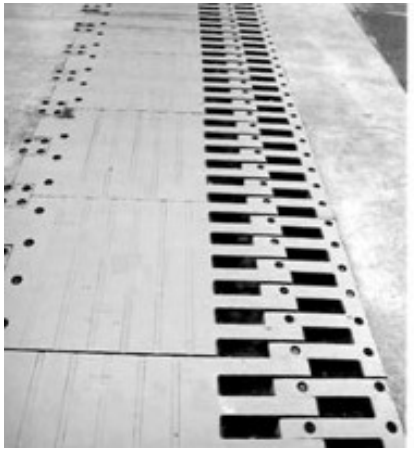


TYPICAL PLAN OF BEARING REPLACEMENT
ALL PIERS EXCEPT PIER 14
SCALE: 1:100



TYPICAL ELEVATION
BEARING DETAIL AT ABUTMENTS & PIERS
SCALE 1:20

- Bearings
  - Design details must consider bearing replacement
    - Adaptor plates
    - Provisions for jacking on top of bearing self and cross/transversal beam of diaphragm
    - Bearing plan and report to be undertaken for every design – design, installation, maintenance, replacement
- Expansion joints
  - Access galleries/chambers recommended for large bridges for inspection/maintenance of multi-element joints
  - Joint leakage must be catered for to protect substructure, prestressing anchorages
  - Joints installed in modular unit lengths to facilitate replacement



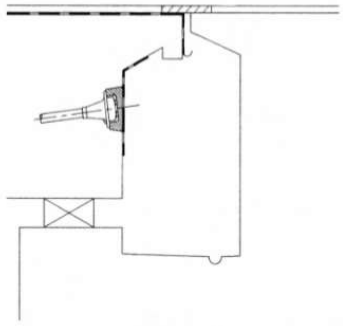
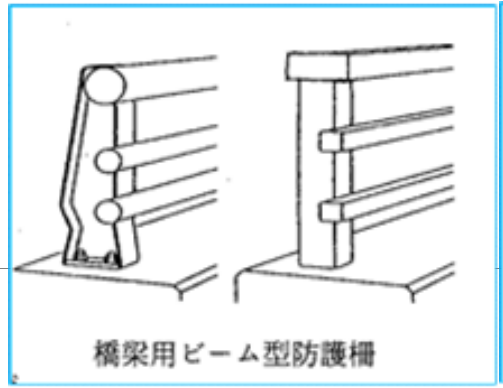
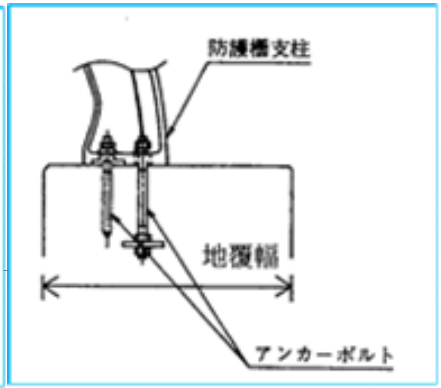


Fig.1.2 Buried anchorage for internal tendons at end of deck with abutment gallery, or beneath expansion joints, [7]

Detail Design



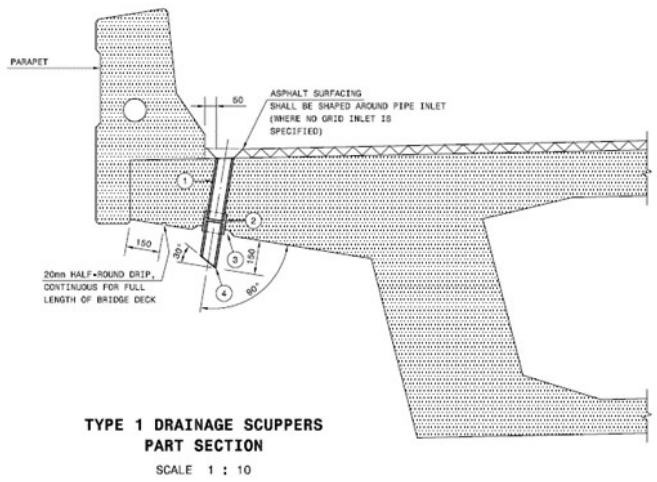


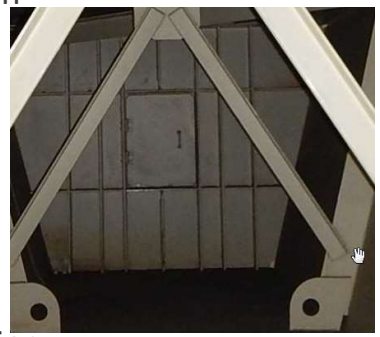
- Kerbs, parapets, railings
  - Anchor bolts for steel parapets shall fail in the case of impact and not the deck (ensure containment is satisfied)
  - High strength concrete (>50MPa) with high abrasion and delamination resistance for kerbs
  - Hydrophobic coatings recommended for kerbs where de-icing salts used
  - Where vandalism and theft are a risk, concrete parapets shall be used

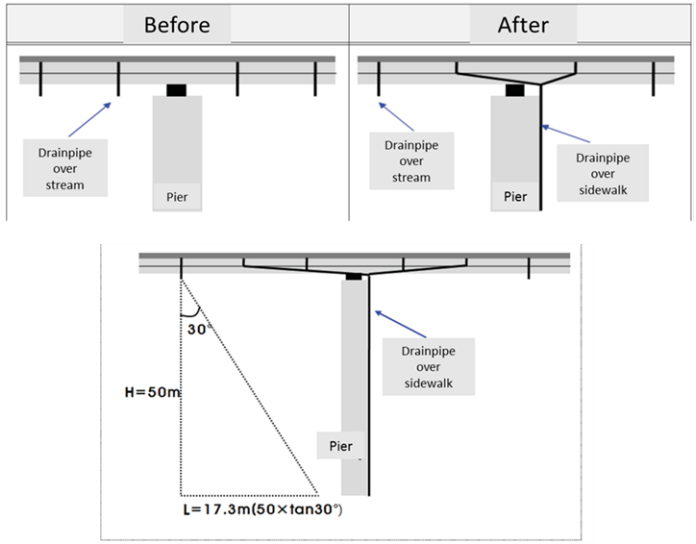
- Surfacing and waterproofing
  - Waterproofing membranes to be used where de-icing salts used
  - Modified mastic asphalt of latex modified concrete used for deck pavement which has increased service life
  - Paving machines to be used to float deck which improves riding surface and reduces low spots for ponding

Detail Design

- Drainage
  - Minimum size of scupper/downspouts to prevent blockage
  - Scupper to protrude beyond lowest level of deck/girder
  - Drainage between the interface of the pavement layer and top of deck to be catered for
  - Direct discharge (where environmental conditions permit) preferred over piped systems (except where to avoid spray on substructure faces)
  - Drip notches along all soffit edges
- Hollow-box girders, voids, hollow spaces
  - Voids must be accessible for inspection and maintenance
  - All voids must be drained especially composite box girders
  - Interior of voids painted white for improved lighting and easier identification of cracks







Detail Design

- Pre-stressing systems
  - Additional ducts shall be allowed for external post tensioning.
  - For non-grouted internal post tensioning, phased replacement of cables must be considered

- Other
  - In certain countries, where vandalism is a problem, areas under bridges in front of abutments to be protected and discourage activity
  - Street lighting to be placed in central reserve/median to facilitate the use of the bridge inspection vehicles

Safe Access

- Platforms, landings, walkways, catwalks
  - Connections for attachment of platforms to be considered
  - Permanently installed on large bridges
  - Permanently installed moveable platforms (be careful of long-term maintenance of this platform)
  - Including handrails, fall arrest systems, lugs, tie-off points
- Installations on inclined surfaces
  - Embankments
  - Arches
- Ladders, stairs, hoists, lifts
  - To be installed in tall hollow towers, piers or pylons





Safe Access

- Hatches, openings, ports, manholes
  - Doors to be made of fibre reinforced polymer plates which reduces the weight of doors and is better in corrosive areas
  - Doors to be designed to be anti-vandal
- Lighting
  - Installed in closed spaces
  - In some cases, the maintenance of lighting system itself becomes costly
- Ventilation
  - Installed in closed hollow spaces especially for steel box girders
- Other
  - Safe parking provided for inspector on road
  - Security personnel to accompany inspector in dangerous areas

Conclusion

- Cost of implementing some of the practices mentioned may add to initial capital cost
- However, where access is difficult, the efficiency of the inspector is impaired and future maintenance is costly
- Future costs far exceed initial capital investment of taking into account inspections and maintenance
- Other costs:
  - Social costs
  - Delays
  - Economic costs
- Purpose of this work is to highlight the importance of considering inspections and maintenance in design

THANK YOU