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Universidad de los Andes

Dirección de Vialidad
Ministerio de Obras Públicas

# Seismic Analysis Of Abutments On Bridges Strengthened By The Method Of Tied-Arch

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# Contents

# 1. Introduction

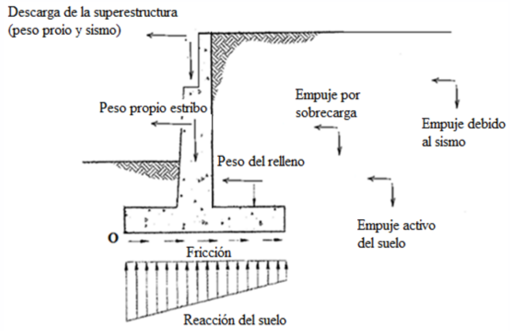
- Assessment of structures to strengthen using news methods.

- Tied arch method for strengthening bridges.

Fuente: Rongish (2011).

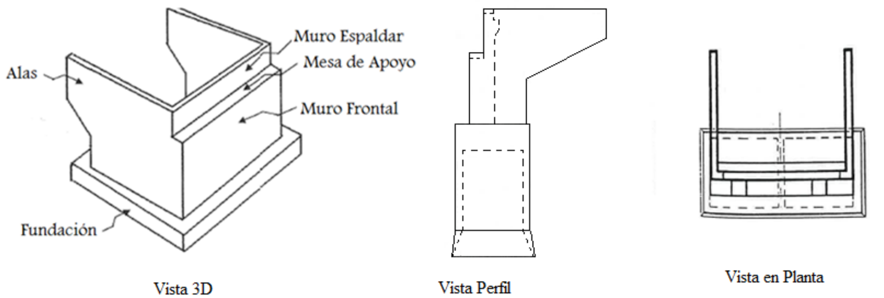
- Assessment of the seismic behavior of abutments

  a) Increased seismic earth pressure
  b) Download of the superstructure
  c) Inertial mass of the abutment due to earthquake.



# 2. Traditional Chilean bridges

- Full wall with wings on 90º - the most common design -.
- Reinforced concrete
- Foundation: Piles or footing




Fuente: Cosio (1990)

# 3. Case of Study: Puangue Bridge

Fuente: Aprovost (2010).

I. 3 continuous longitudinal beams
II. 3 piers at the intermediate spans
III. The intermediate piers and abutments are supported on piles type rail
IV. Cross section of the deck has a total width of 8.0 [m]
V. Total length: 70 meters

Design Assumptions:

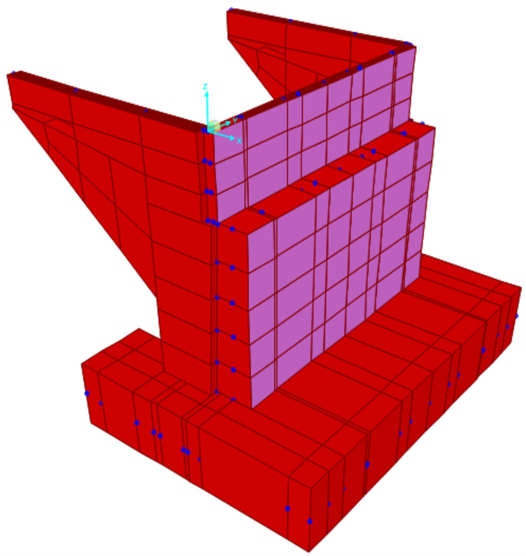
Service and seismic loads: Recommendations of Highway Handbook, Volume 3 (2012) and AASHTO (2004).

# 4. Modeling Assumptions

- Load state: dead loads and earthquake from Valenzuela (2012) and Rongish (2011)
- Filler compacted of sandy gravel
- Live Load: (HS20-44 + 20%)

Seismic Code: Highway Manual, Volume 3

- Seismic loads: Mononobe-Okabe
- Seismic zone of Chile (Zone 3), with a maximum effective acceleration of 0,40g.
- Modal spectral method (CQC)
- Directional combination of 100% in one direction and 30% in the other



# 5. Analysis of strengthened bridge abutment

Assessment:

I. Slippage safety factors
II. Overturning
III. Soil bearing capabilities
IV. Basal shear
V. Structural resistance

(I–III): Static and seismic case

# 5. Analysis of strengthened bridge abutment

Assessment:

I. **Slippage safety factors**
II. Overturning
III. Soil bearing capabilities
IV. Basal shear
V. Structural resistance

Static and seismic case (I–III)

Static and seismic safety factors for slippage are achieved

| Obtained | Acceptance |
|---|---|
| 4.83 | 1.5 |

| Obtained | Acceptance |
|---|---|
| 1.83 | 1.25 |

# 5. Analysis of strengthened bridge abutment

Assessment:

I. Slippage safety factors
**II. Overturning**
III. Soil bearing capabilities
IV. Basal shear
V. Structural resistance

(I–III:) Static and seismic case

Seismic and static case the safety factors for the overturn are achieved

| Obtained | Acceptance |
|---|---|
| 10.5 | 1.5 |

| Obtained | Acceptance |
|---|---|
| 2.69 | 1.96 |

# 5. Analysis of strengthened bridge abutment

Assessment:

I. Slippage safety factors
II. Overturning
**III. Soil bearing capabilities**
IV. Basal shear
V. Structural resistance

} Static and seismic case

foundation is completely compressed.

| | Static | Seismic |
|---|---|---|
| **σmin** [Ton / $m^2$] | 12.66 | 11.21 |
| σmax [Ton / $m^2$] | 33.52 | 35.37 |

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# 5. Analysis of strengthened bridge abutment

Assessment:

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**IV. Basal shear**
V. Structural resistance

(I–III:) Static and seismic case

| | Original | Strengthened |
|---|---|---|
| Shear V [Ton] | 86.1 | 109.0 |
| Shear Vmin [Ton] | 60.5 | 101.8 |

The baseline shear increased by **26%**

# 5. Analysis of strengthened bridge abutment

Assessment:

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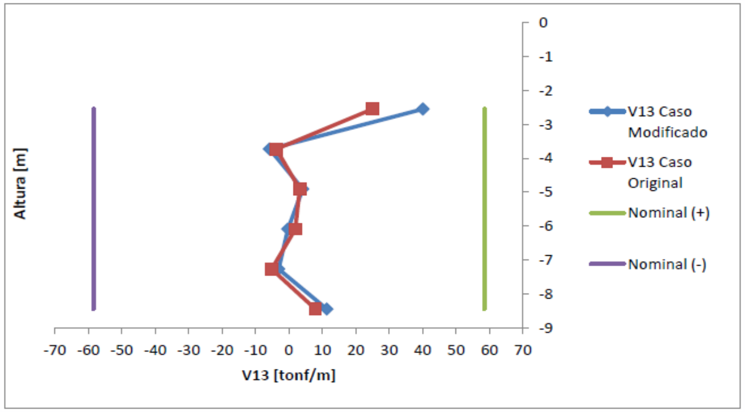
**V. Structural resistance**

(I–III:) Static and seismic case

Shear for the strengthened case of the abutment



# 5. Analysis of strengthened bridge abutment

Assessment:

I. Slippage safety factors
II. Overturning
III. Soil bearing capabilities
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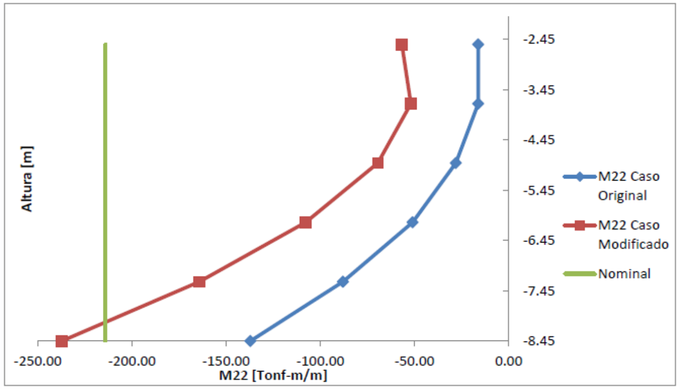
**V. Structural resistance**

(I–III) Static and seismic case

Front wall of the abutment is analyzed

The bending moment M22 increases by 73%

$\phi Mn \geq Mu$ is not achieved



# 5. Analysis of strengthened bridge abutment

Assessment:

I. Slippage safety factors
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IV. Basal shear
**V. Structural resistance**

(I–III:) Static and seismic case

Front wall of the abutment is analyzed

$\phi Mn \geq Mu$ is achieved

**A concrete screeding (thickness of 20 cm) using H30 and reinforcement A63-42H is proposed.**

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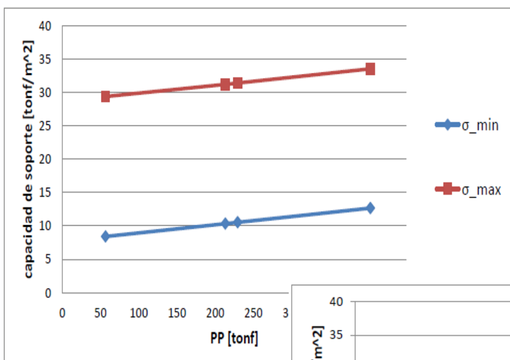
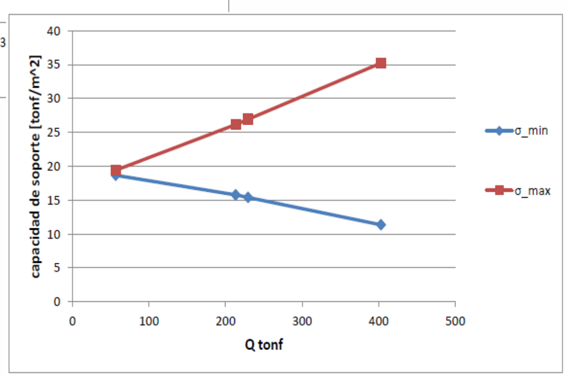
# 5. Parametric Analysis

Target: Capacity of the soil bearing in relation to the increased load

Final Stage: Completely strengthened bridge → Dead Load 402.9 (Ton)



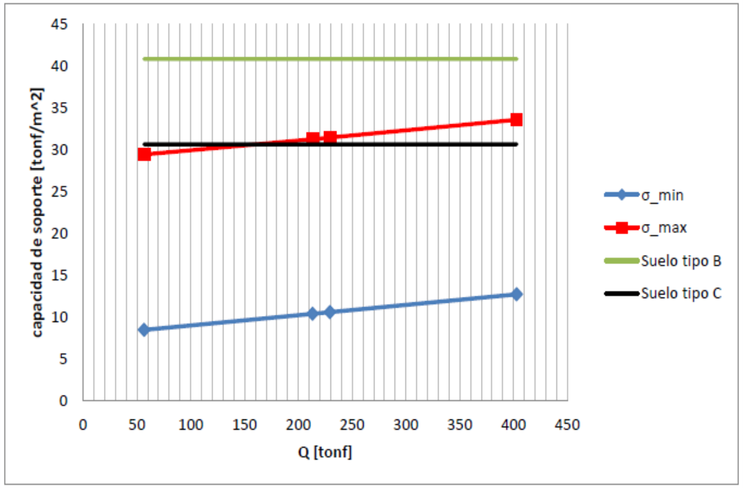

| Type | Description | Ultimate capacity (ton/m2) |
|---|---|---|
| A | Rock, cemented soil | 1020 |
| B | Soft or fractured rock, very dense or very firm ground | 41 |
| C | Soil dense or firm | 31 |

Increase between different construction phases is linear
Constant and variable (static – seismic)

# 5. Parametric Analysis

Target: Capacity of the soil bearing in relation to the increased load

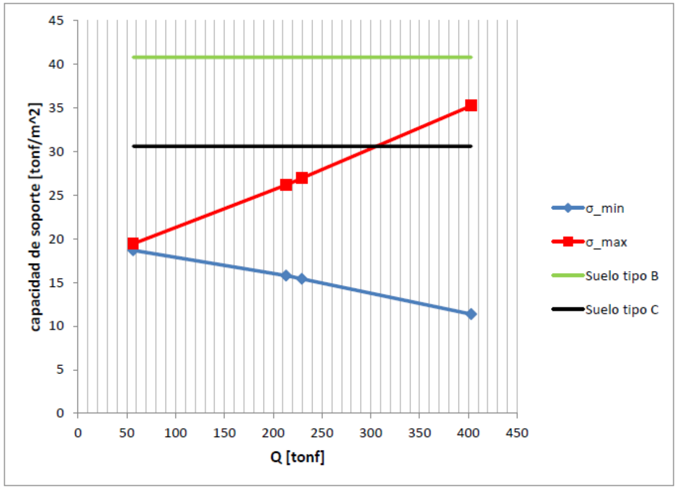
Bearing capacity: Static case




Type B ✓

Type C ✗

Bearing capacity seismic case




Type B ✓

Type C ✗ SD lesser than 0.05 ✓

# 6. Final Comments

1. Analyze background (or basic engineering).
2. Determine Loads.
3. Slippage, overturning and soil bearing capacity.
4. Preliminary assessment of the suitable soil bearing.
5. Identified different alternatives to increase this capacity.
6. Analyze the suitability of the foundation (SD).
7. Analyze the structural behavior of the abutment.

Santiago – CHILE
18 al 20 de Octubre de 2017
October 18 to 20, 2017

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**Venue – Santiago Chile**

**Technical Visit – Puerto Montt, Chile**
**Chacao Bridge Project**

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## Thank you

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