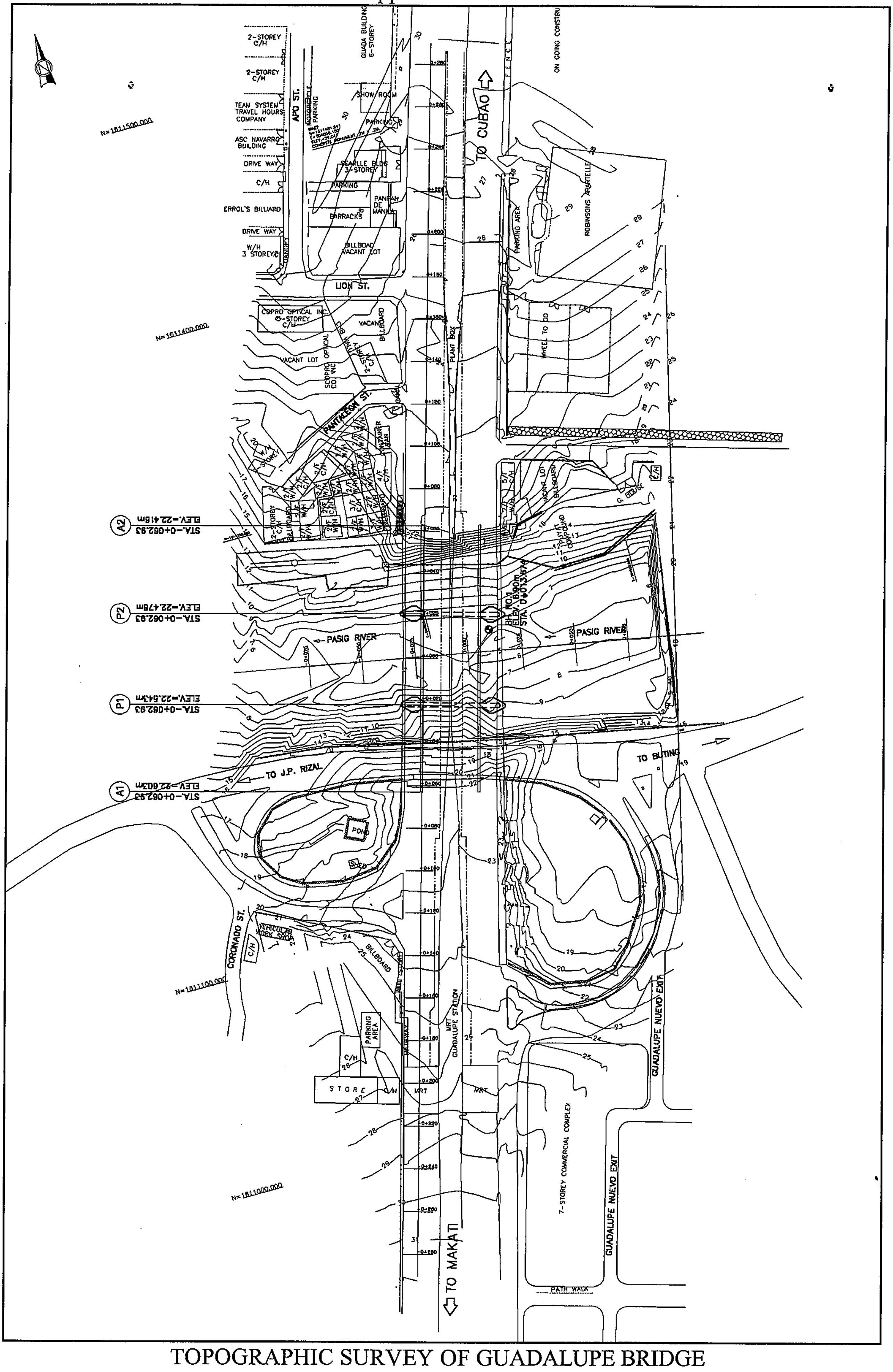
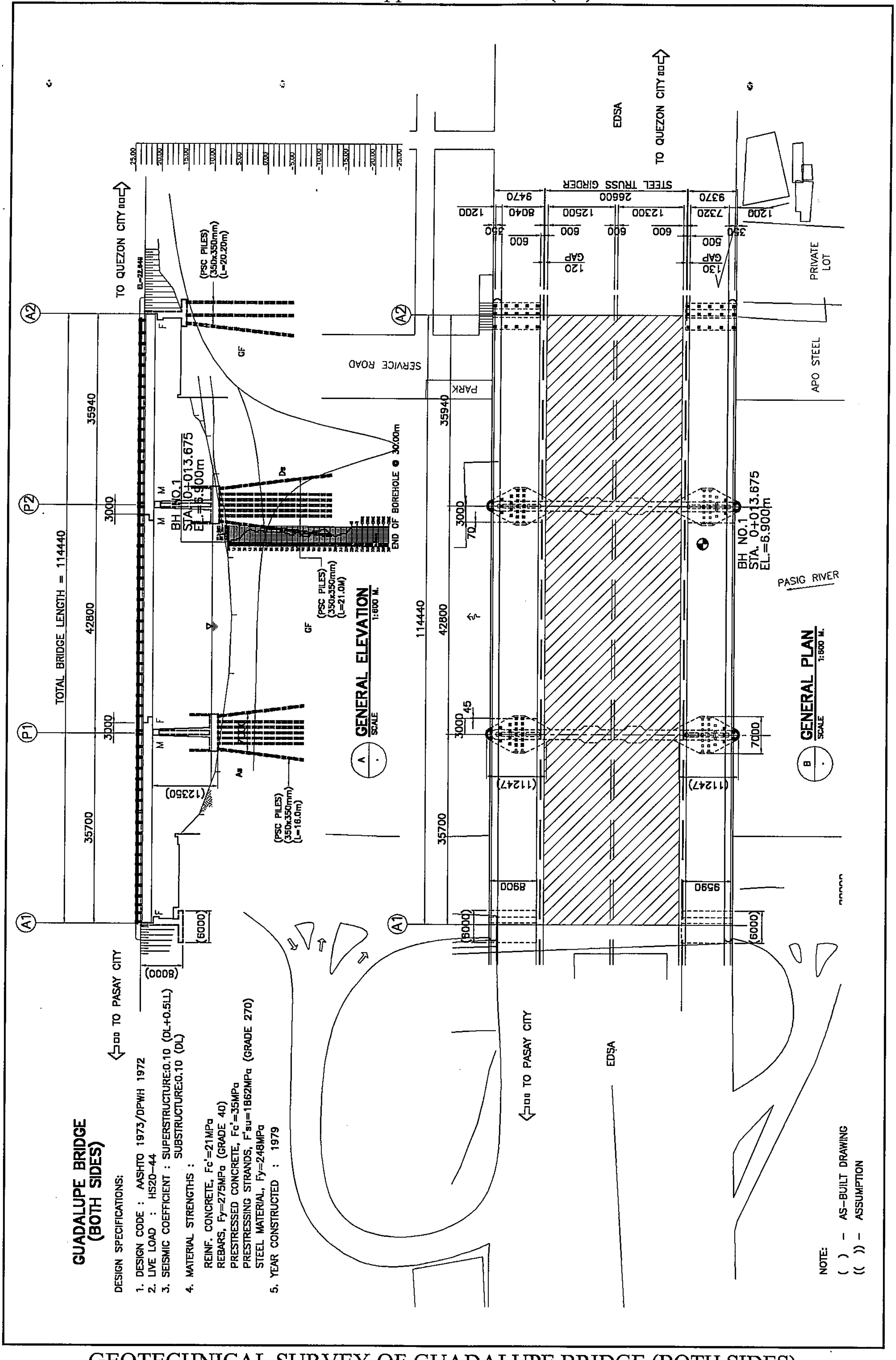
# CHAPTER 23

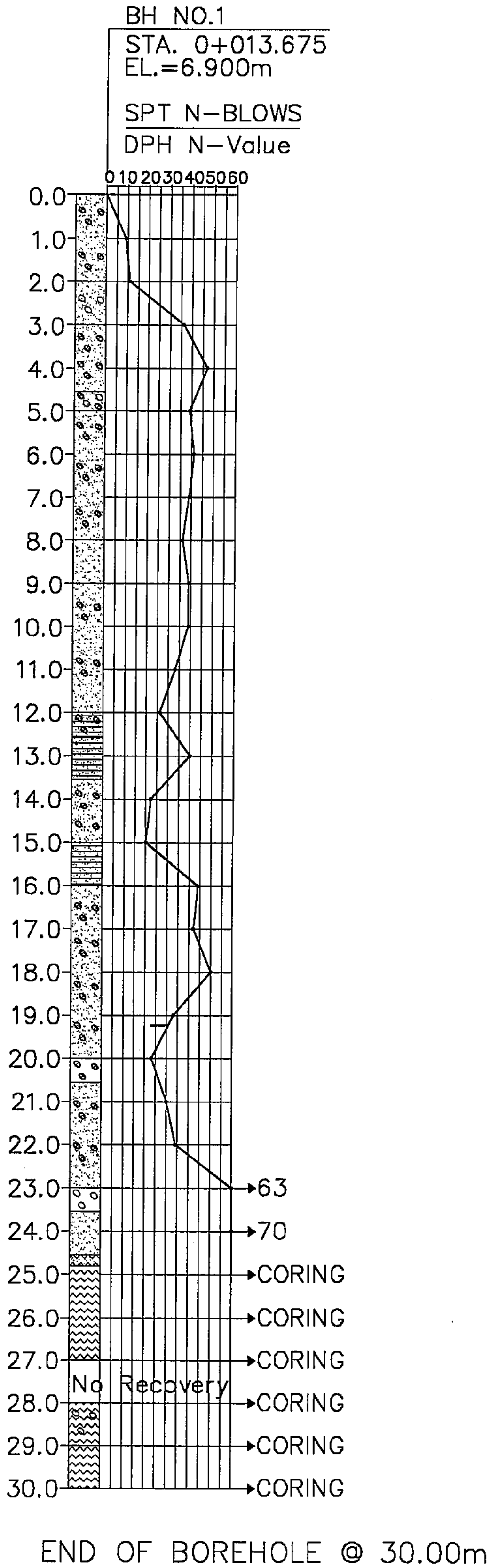
FEASIBILITY STUDY OF GUADALUPE BRIDGE
REHABILITATION PLAN

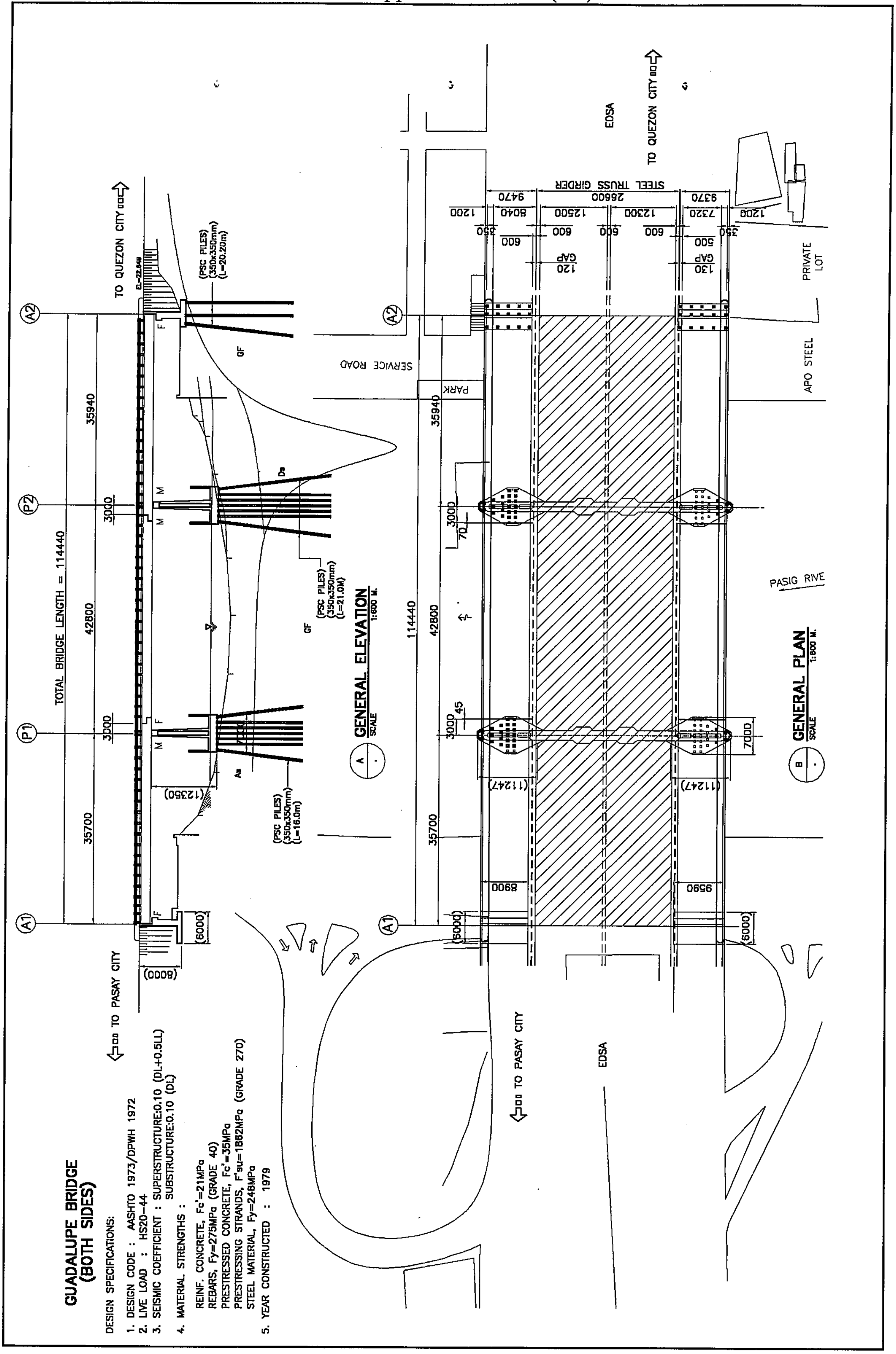



TOPOGRAPHIC SURVEY OF GUADALUPE BRIDGE

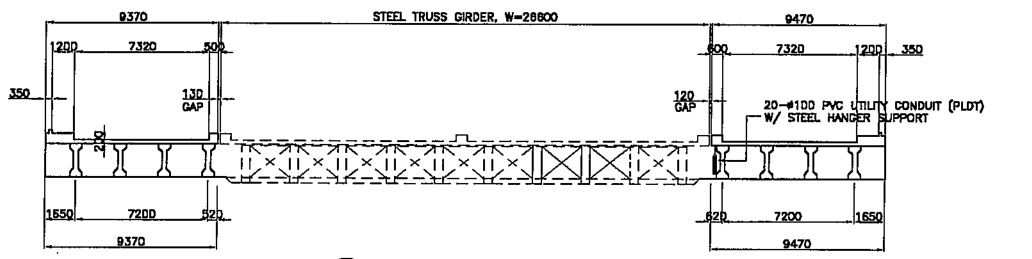



GEOTECHNICAL SURVEY OF GUADALUPE BRIDGE (BOTH SIDES)

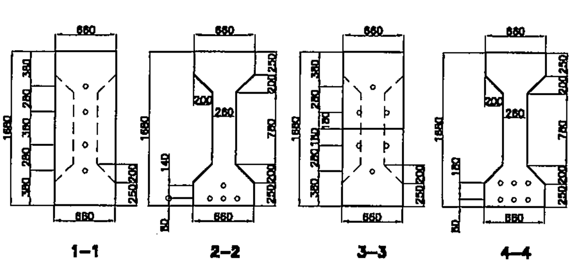

BH NO.1
STA. 0+013.675
EL.=6.900m
SPT N-BLOWS
DPH N-Value
0 10 20 30 40 50 60
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
63
70
CORING
CORING
CORING
CORING
CORING
CORING
No Recovery
END OF BOREHOLE @ 30.00m



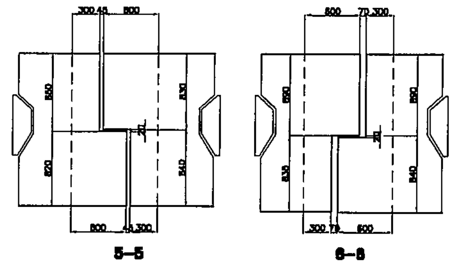

GENERAL PLAN AND ELEVATION OF GUADALUPE BRIDGE



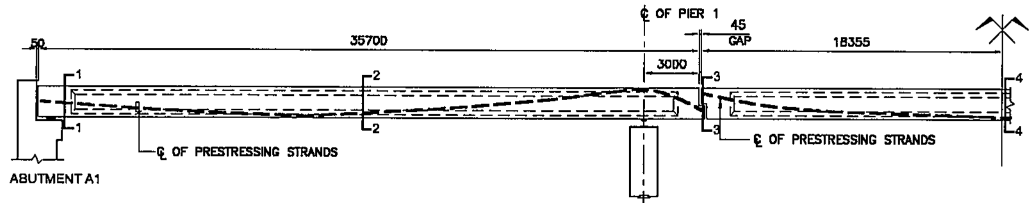

A BRIDGE CROSS SECTION
SCALE 1:250 M.



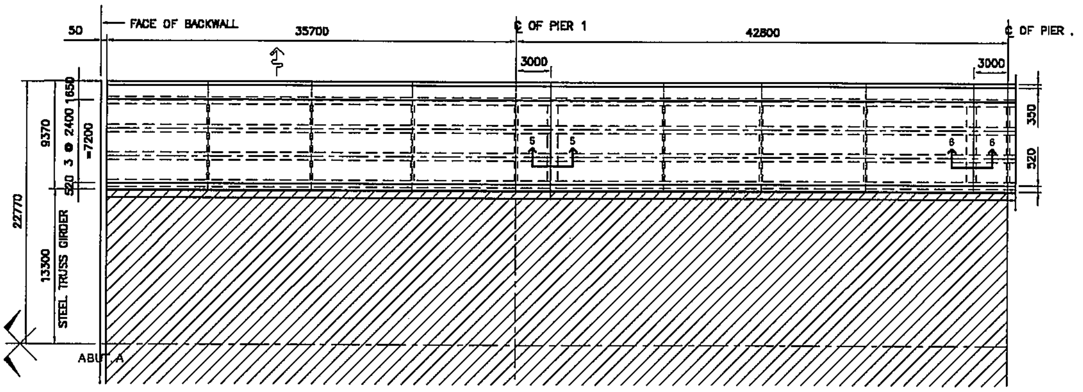

GIRDER SECTION
SCALE 1:50 M.




GERBER HINGE DETAIL
SCALE 1:50 M.

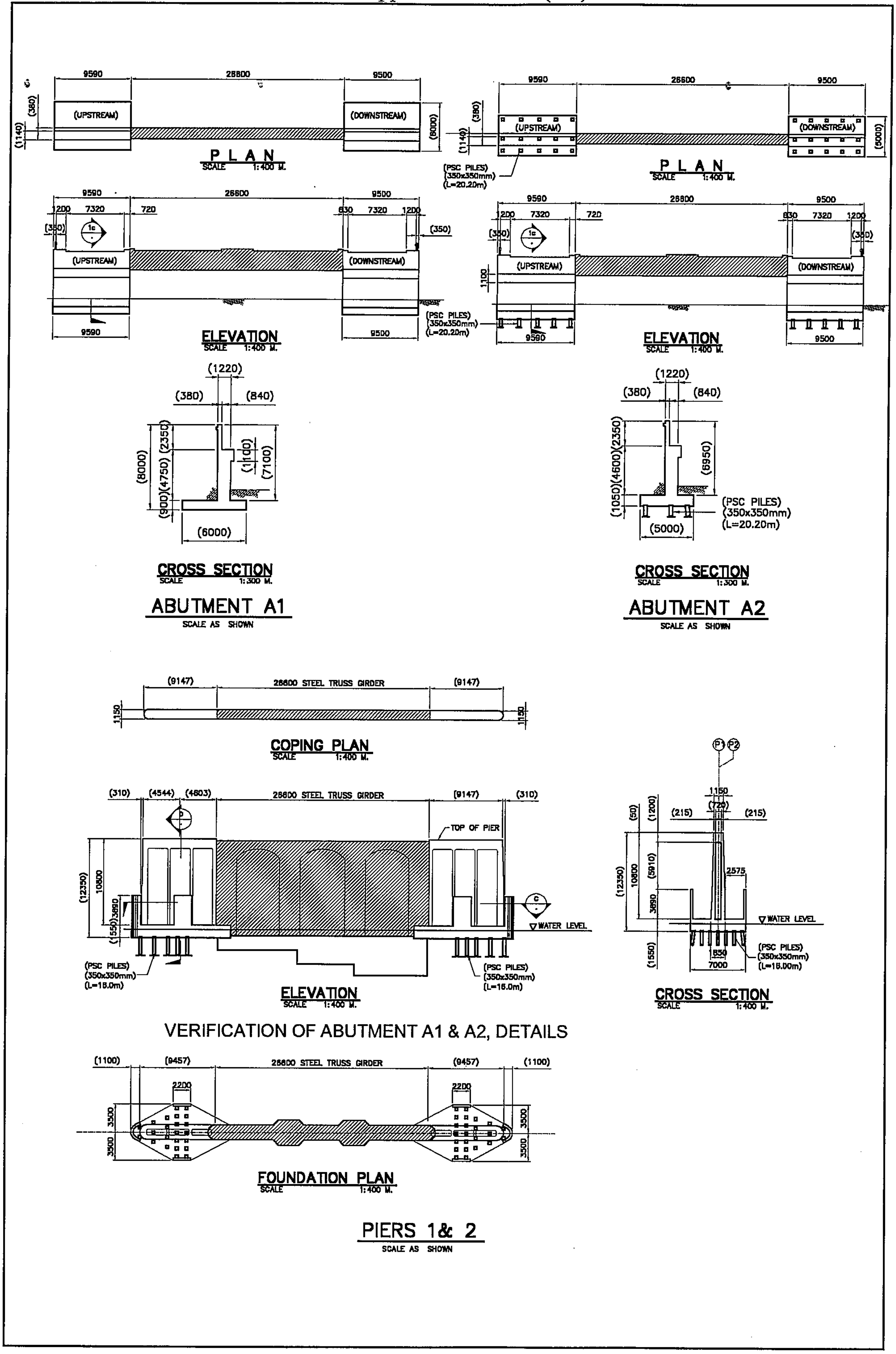



GIRDER ELEVATION
SCALE 1:250 M.

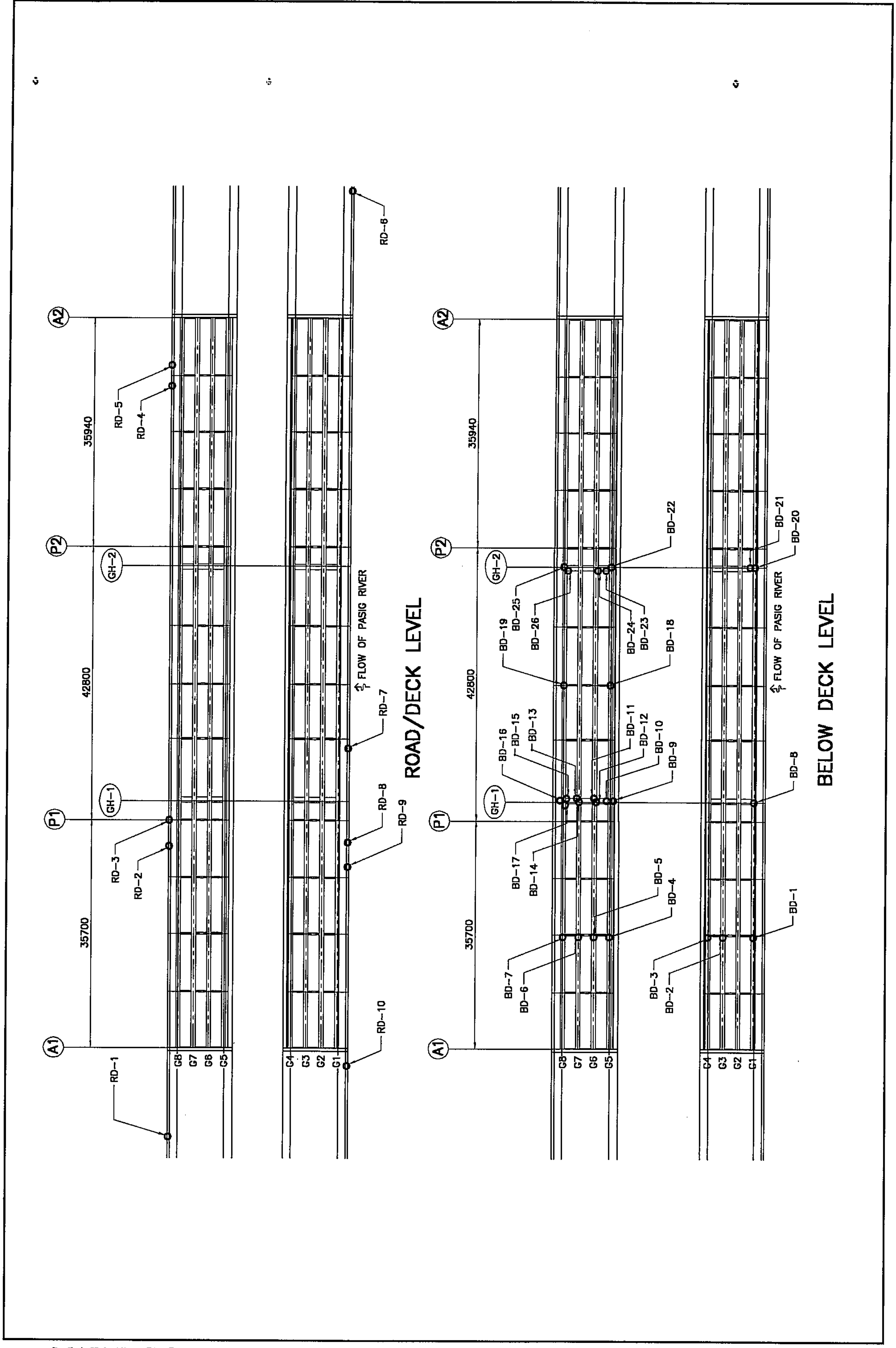



FRAMING PLAN
SCALE 1:400 M.

GIRDER SECTION & GERBER HINGE DETAILS,
GIRDER ELEVATION AND FRAMING PLAN

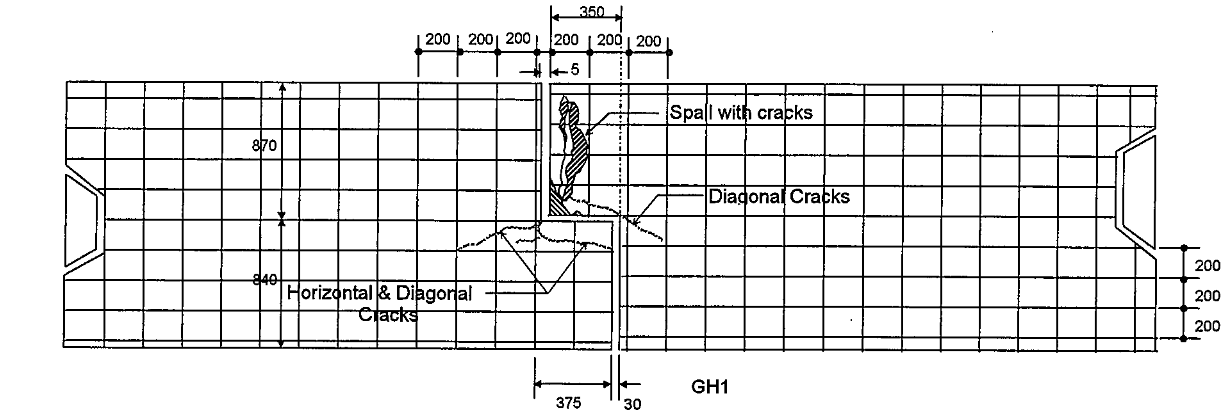



DETAILS OF ABUTMENT A1 & A2, DETAILS OF PIER 1 & 2

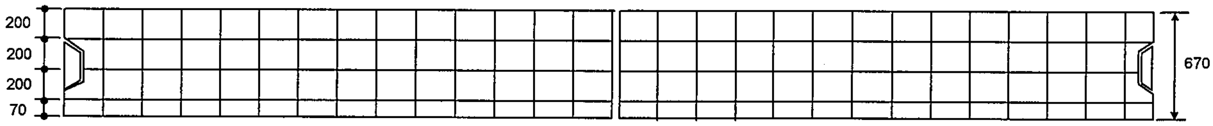



MAPPING OF DAMAGE ON ROAD / DECK LEVEL & BELOW DECK LEVEL

BRIDGE NAME : Guadalupe Bridge (Both Sides)
GIRDER : Interior [ ] Exterior [X]
GERBER HINGE NO. : GH1
GIRDER NO. : 1

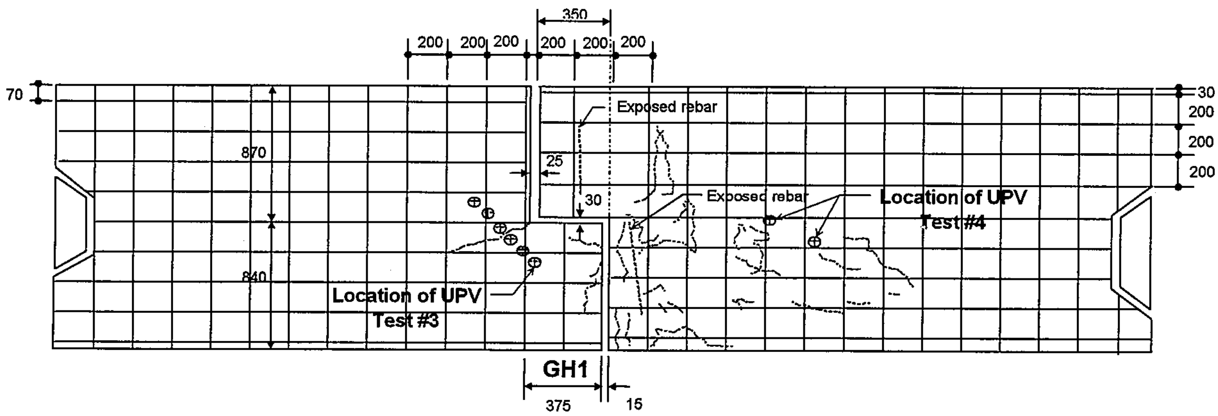



**Elevation of Girder**

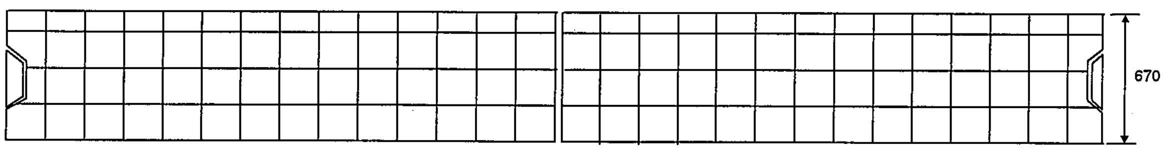



**Bottom of Girder**

BRIDGE NAME : Guadalupe Bridge (Both Sides)
GIRDER : Interior [ ] Exterior [X]
GERBER HINGE NO. : GH1
GIRDER NO. : 5




**Elevation of Girder**



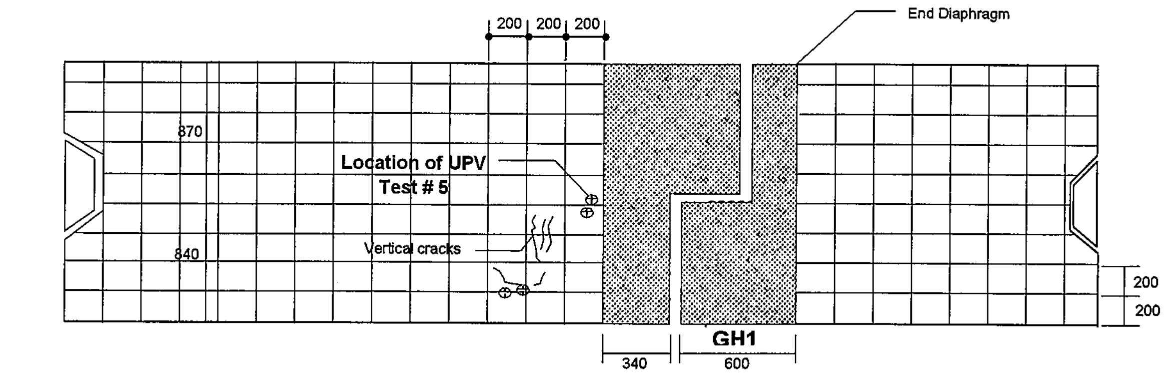

**Bottom of Girder**

Legend :
- = Vertical Crack
- = Horizontal Crack
- = Diagonal Crack

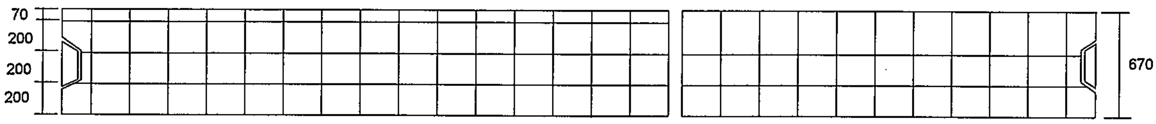
Note : All Dimensions are in mm.

MAPPING OF DAMAGE OF MAIN GIRDER/GERBER HINGE

**BRIDGE NAME :** Guadalupe Bridge (Both Sides)
**GIRDER :** Interior [X] Exterior [ ]
**GERBER HINGE NO. :** GHI (Facing East)
**GIRDER NO. :** 6

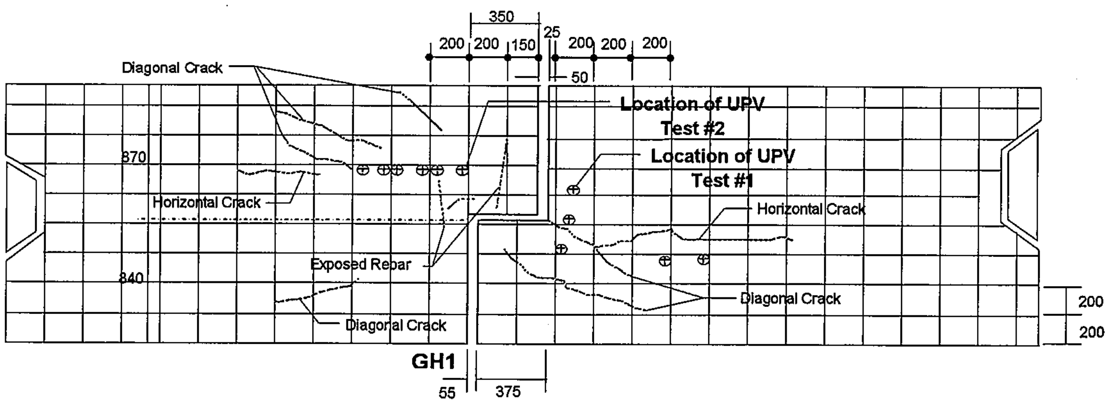



**Elevation of Girder**

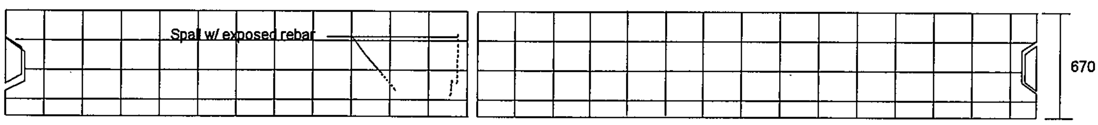



**Bottom of Girder**

**BRIDGE NAME :** Guadalupe Bridge (Both Sides)
**GIRDER :** Interior [ ] Exterior [X]
**GERBER HINGE NO. :** GHI (Facing East)
**GIRDER NO. :** 8




**Elevation of Girder**

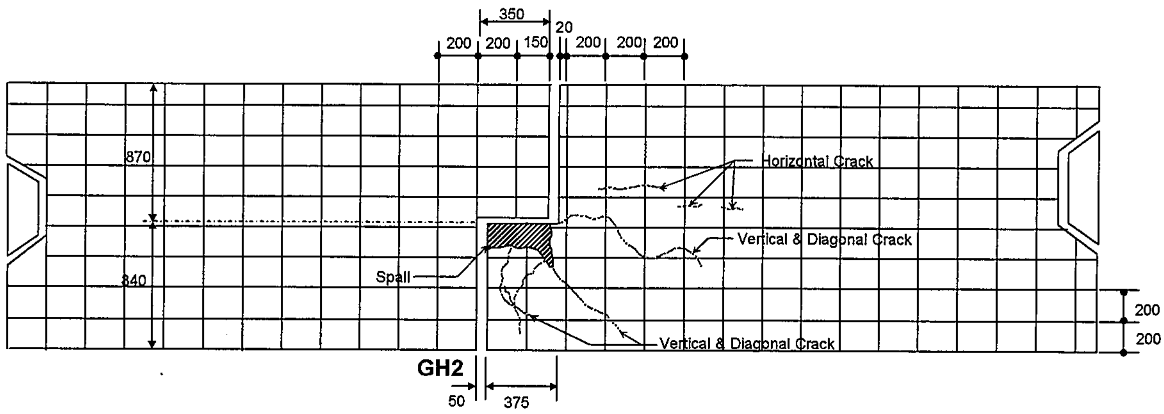



**Bottom of Girder**

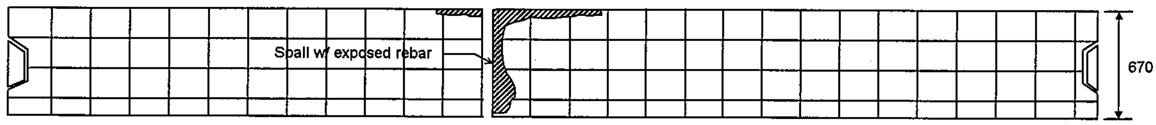
Note : All Dimensions are in mm.

MAPPING OF DAMAGE OF MAIN GIRDER/GERBER HINGE

**BRIDGE NAME :** Guadalupe Bridge (Both Sides)
**GIRDER :** Interior [ ] Exterior [X]
**GERBER HINGE NO. :** GH2
**GIRDER NO :** 1

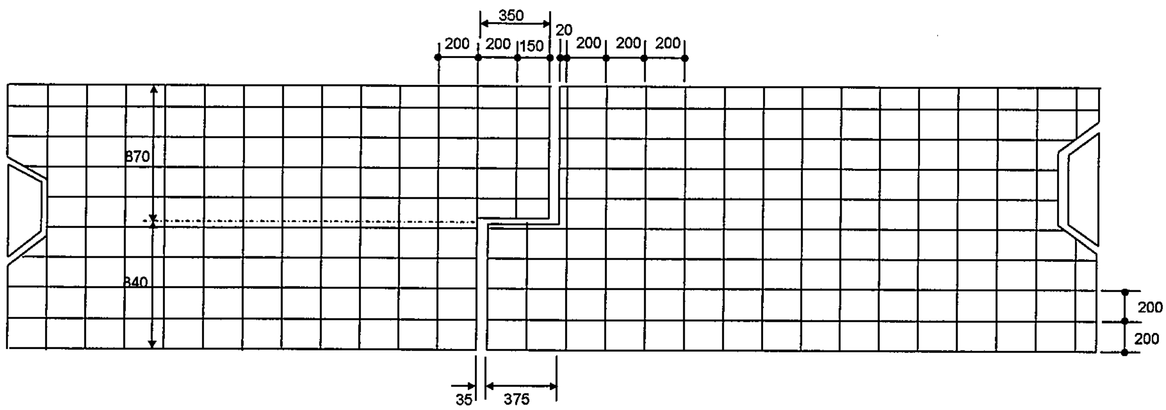



**Elevation of Girder**

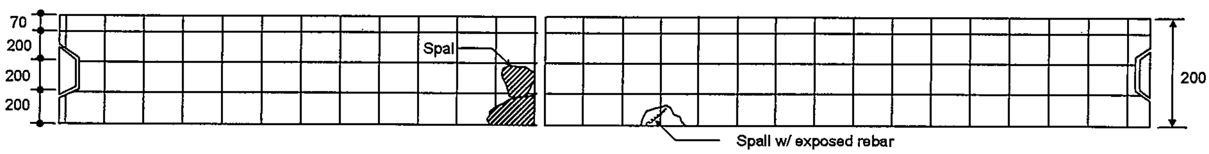



**Bottom of Girder**

**BRIDGE NAME :** Guadalupe Bridge (Both Sides)
**GIRDER :** Interior [X] Exterior [ ]
**GERBER HINGE NO. :** GH2
**GIRDER NO. :** 2




**Elevation of Girder**

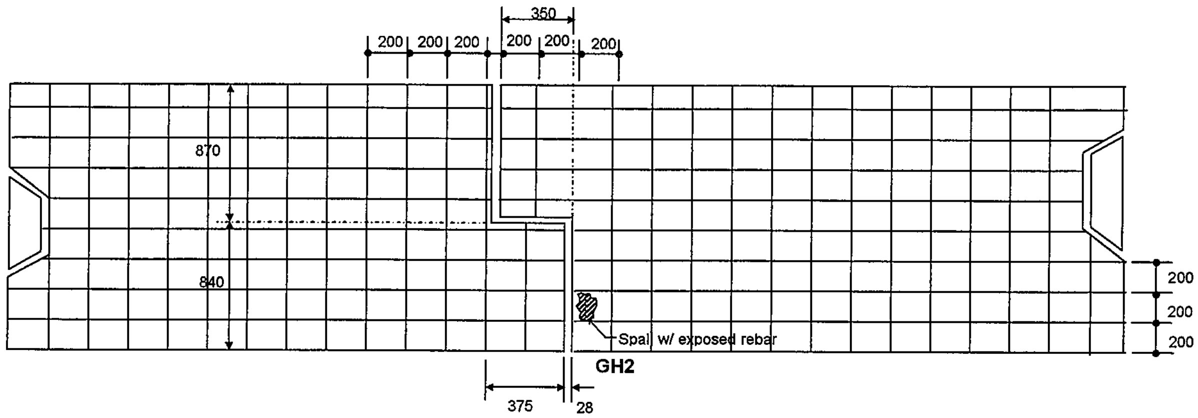



**Bottom of Girder**

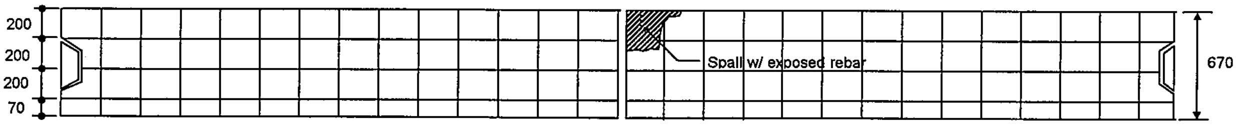
Note : All Dimensions are in mm.

MAPPING OF DAMAGE OF MAIN GIRDER/GERBER HINGE

BRIDGE NAME : Guadalupe Bridge (Both Sides)
GIRDER : Interior [ ] Exterior [X]
GERBER HINGE NO. : GH2 (Facing East)
GIRDER NO : 4

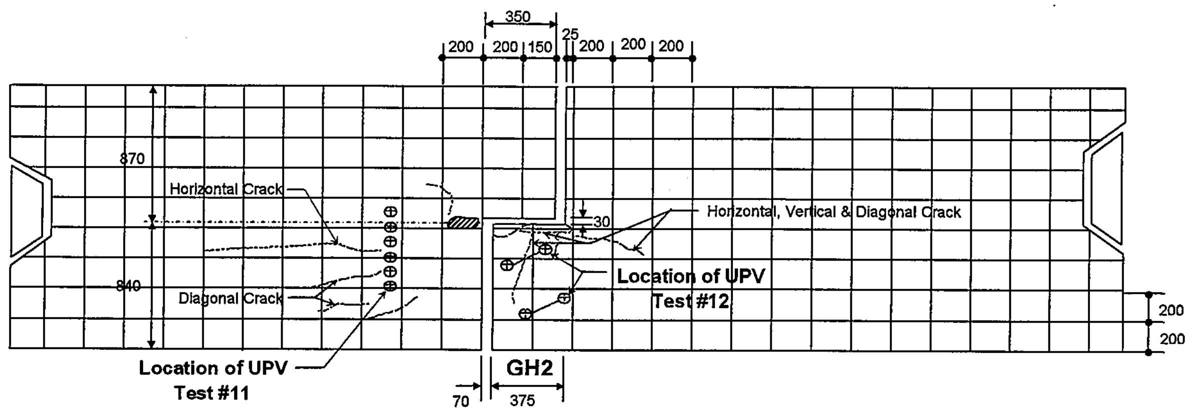



Elevation of Girder

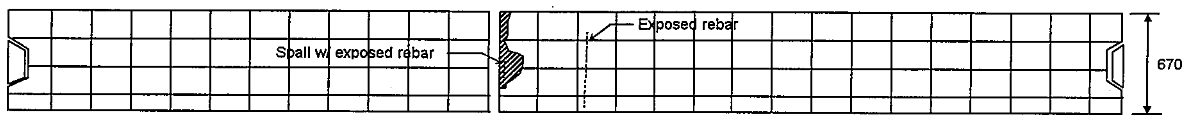



Bottom of Girder

BRIDGE NAME : Guadalupe Bridge (Both Sides)
GIRDER : Interior [ ] Exterior [X]
GERBER HINGE NO. : GH2
GIRDER NO : 5




Elevation of Girder

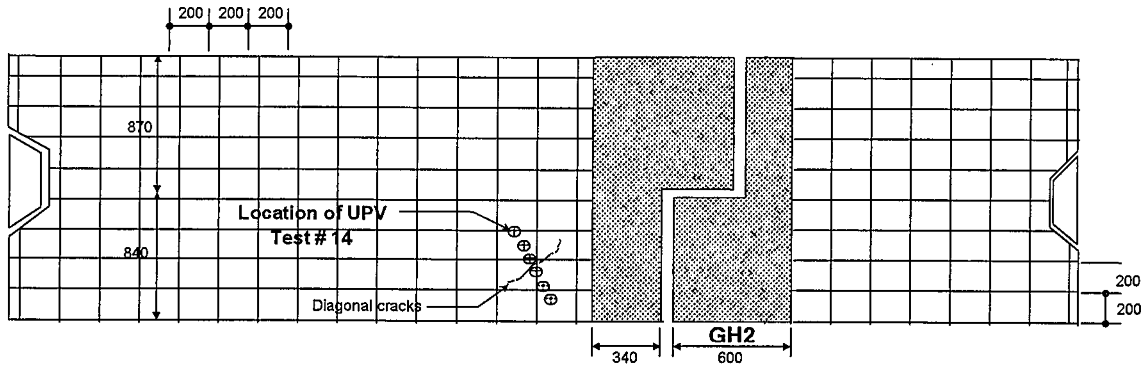



Bottom of Girder

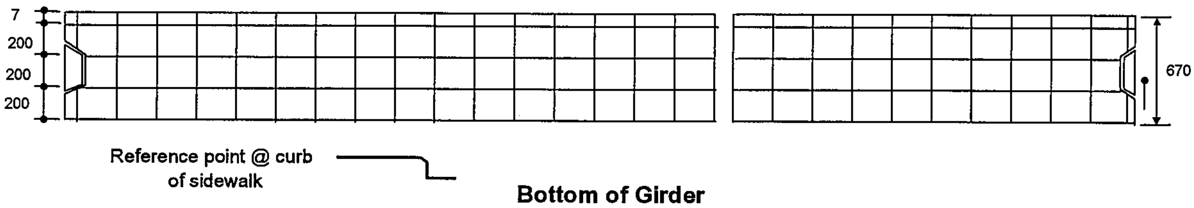
Note : All Dimensions are in mm.

MAPING OF DAMAGE OF MAIN GIRDER/GERBER HINGE

BRIDGE NAME : Guadalupe Bridge (Both Sides)
GIRDER : Interior [X] Exterior [ ]
GERBER HINGE NO. : GH2
GIRDER NO : 6

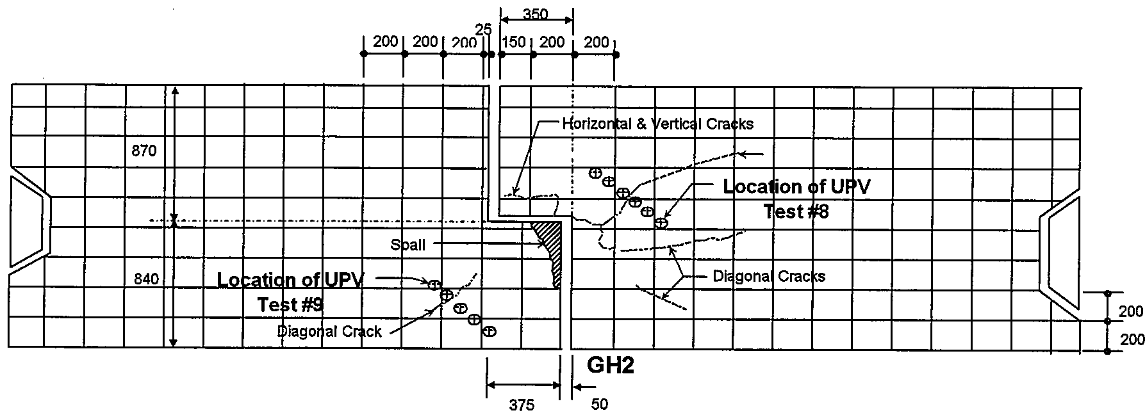



**Elevation of Girder**

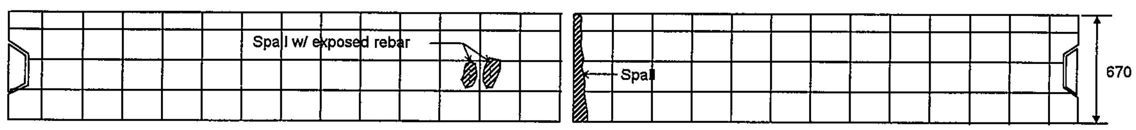



**Bottom of Girder**

BRIDGE NAME : Guadalupe Bridge (Both Sides)
GIRDER : Interior [ ] Exterior [X]
GERBER HINGE NO. : GH2 (Facing East)
GIRDER NO : 8




**Elevation of Girder**

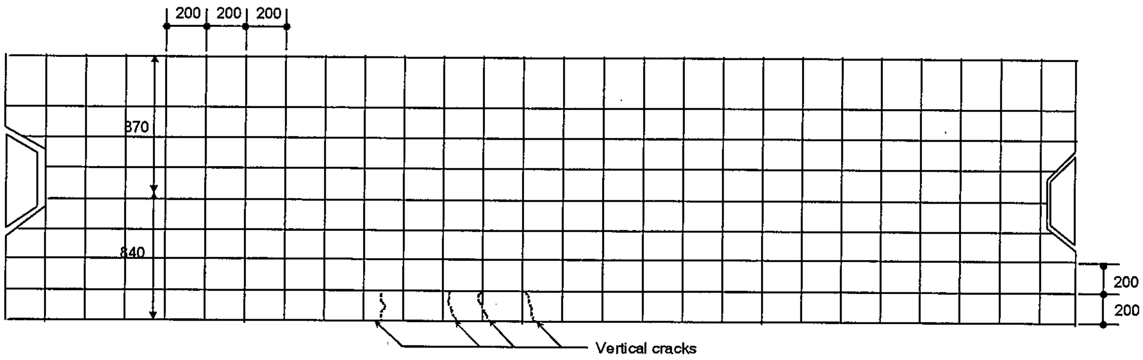



**Bottom of Girder**

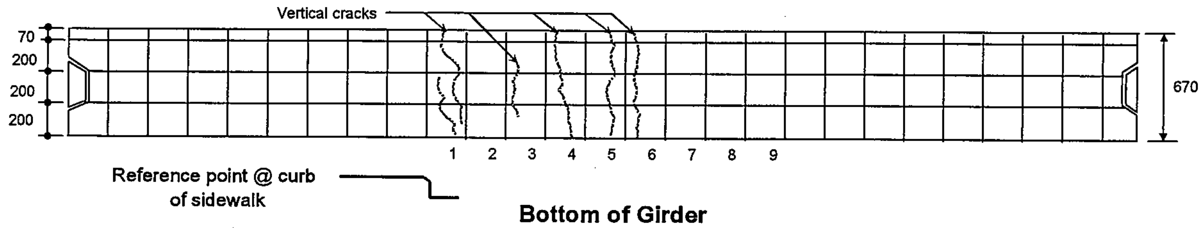
Note : All Dimensions are in mm.

MAPPING OF DAMAGE OF MAIN GIRDER/GERBER HINGE

BRIDGE NAME : Guadalupe Bridge (Both Sides)
GIRDER : Interior [ ] Exterior [X]
LOCATION : Span 2 @ Middle
GIRDER NO : 8



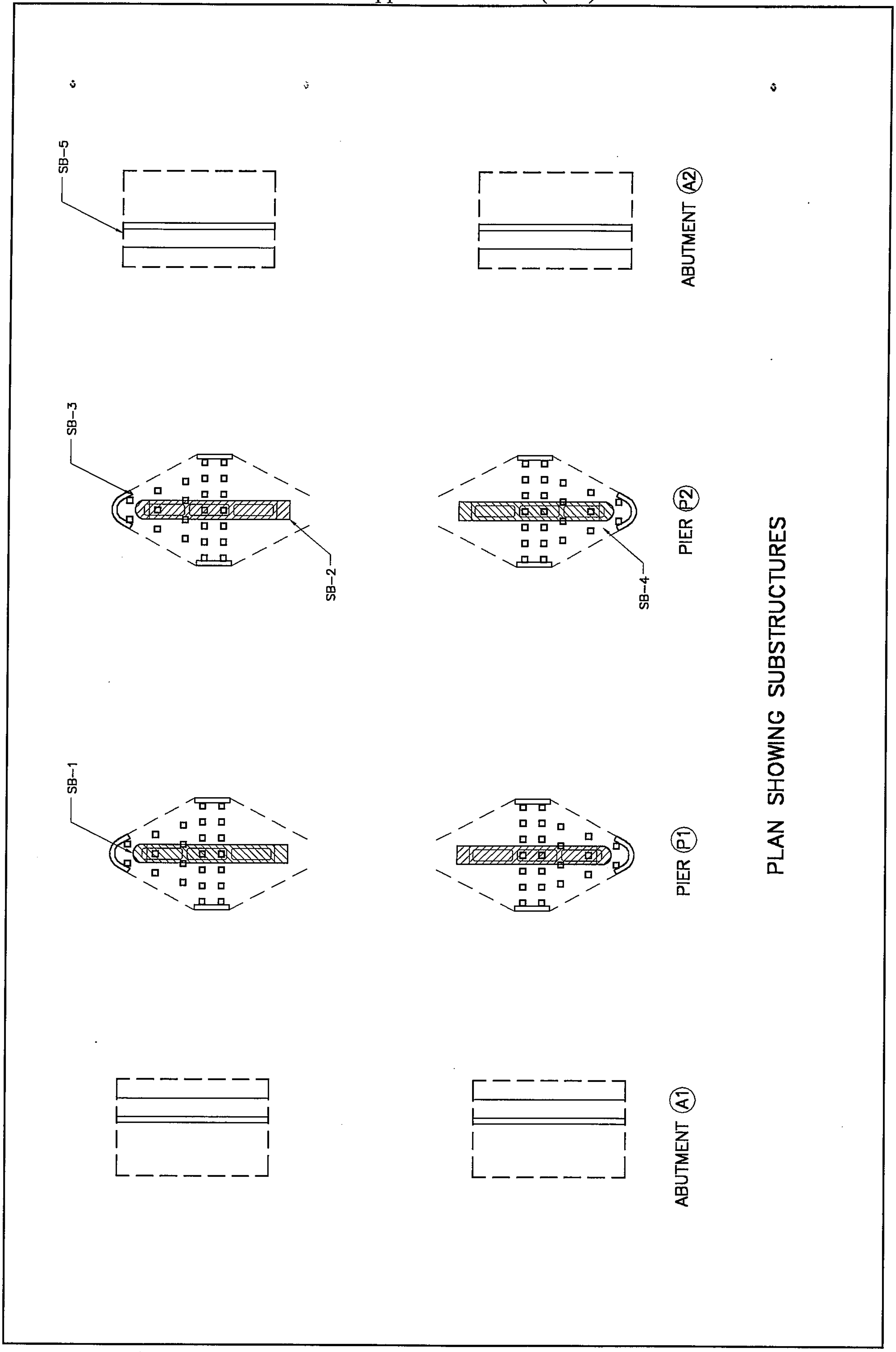

**Elevation of Girder**



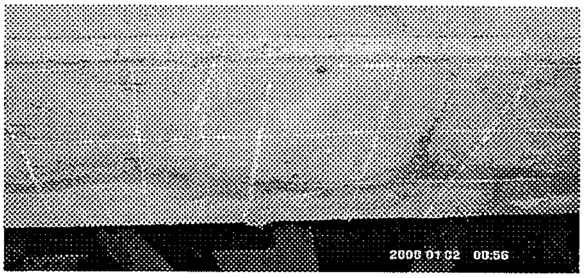

**Bottom of Girder**

Note : All Dimensions are in mm.

MAPPING OF DAMAGE OF MAIN GIRDER/GERBER HINGE



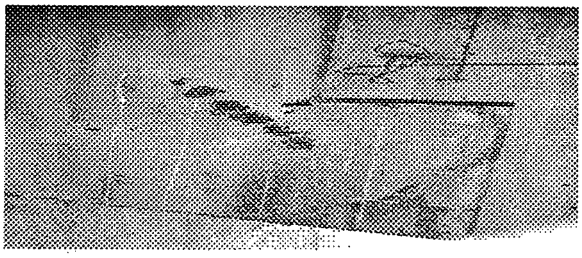

MAPPING OF DAMAGE ON SUBSTRUCTURES AND BEARINGS



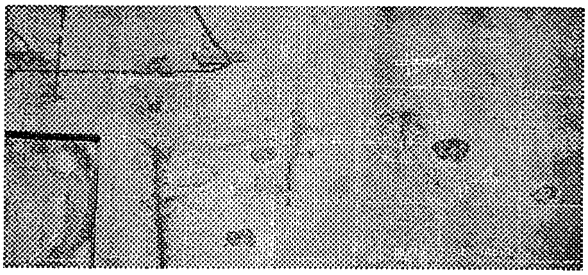

| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | MEDIUM |
| | | Z | HIGH |
| | RATING | III | |
| | DAMAGE CONDITION | w = 0.10 mm., spacing < 50 cm | |
| GIRDER | VIEW | PHOTO FILENAME | |
| G-5 / SPAN 1/MID | UPSTREAM | DCP-7975.JPG | |

| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | wide cracks range form 0.50 mm depth cracks small spall w/ d=78mm,(UPV(19),exposed rebar A=0.10x0.60=0.06sq.m. | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GHIL, G-1 | DOWNSTREAM | DCP-7938.JPG | |

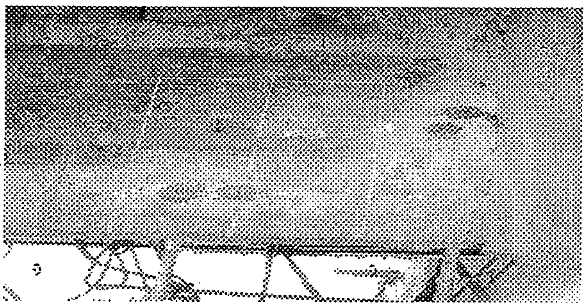
| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | wide 1.0 mm cracks, depth of cracks shallow spall w/ d=210mm (UPV 20) exposed rebars | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GHIR, G-1 | DOWNSTREAM | DCP-7939.JPG | |



| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACK | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | 3 wide cracks ranging form 1.5mm to 5mm | |
| GIRDER | VIEW | PHOTO FILENAME | |
| DHIL, G-5 | DOWNSTREAM | DCP-7807.JPG | |

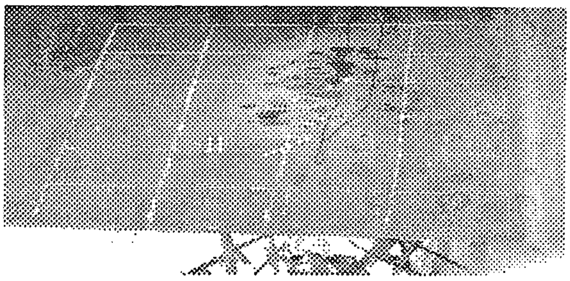


| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | WIDTH = 0.50mm | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GHIL, G-5 | DOWNSTREAM | DCP-7808.JPG | |

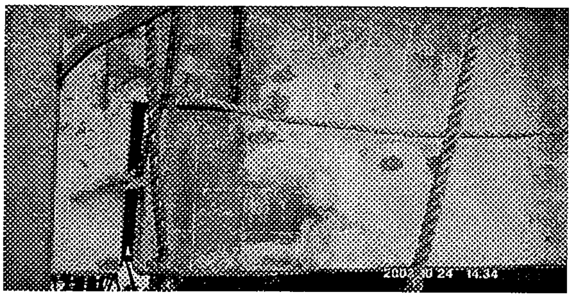


| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | WIDTH = 0.20 mm., SPACING < 50 cm. | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GHIR, G-6 | UPSTREAM | DCP-7806.JPG | |

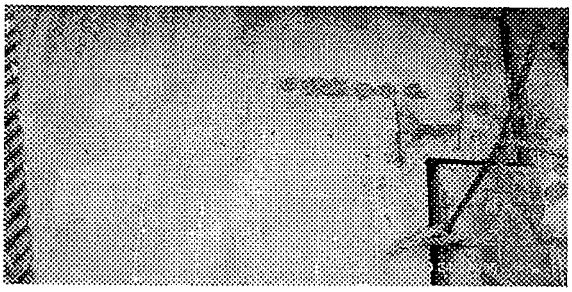
CLOSE-UP VISUAL INSPECTION OF DAMAGE (GUADALUPE BRIDGE)



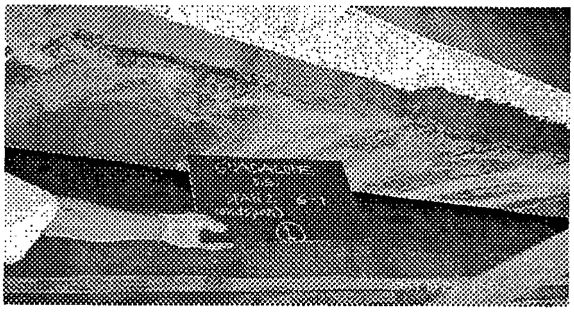
| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | LOW |
| | RATING | II | |
| | DAMAGE CONDITION | Width = 0.20 mm., One (1) Crack | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GH 1, G-7 | UPSTREAM | DCP-7871.JPG | |



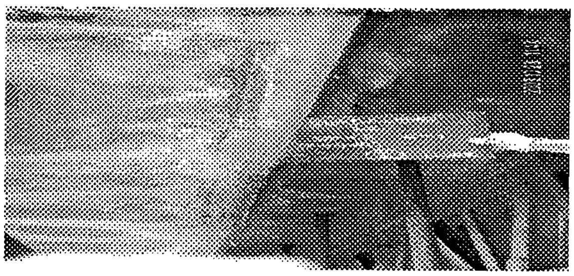
| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | - |
| | RATING | II | |
| | DAMAGE CONDITION | Two (2) Cracks, Width=2.00mm., Spacing < 0.50cm. | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GHIL, G-1 | DOWNSTREAM | DCP-7938.JPG | |



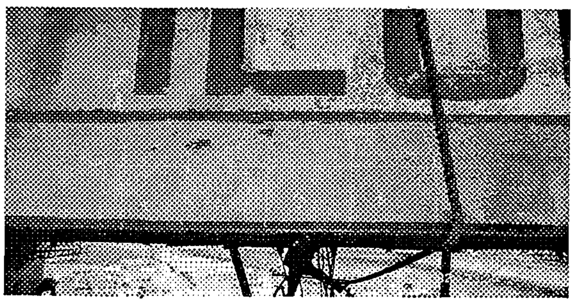
| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | One (1) Crack, Width = 1.50mm., Spacing < 50cm | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GHIL, G-8 | UPSTREAM | DCP-7804.JPG | |



| | | | |
|---|---|---|---|
| DAMAGE | TYPE | SPALLING/EXPOSED REBAR | |
| | EVALUATION | X | - |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | Spalling with Exposed Rebar @ bottom girder, A=0.10x1.75=0.175sq.m. | |
| GIRDER (BOTTOM) | VIEW | PHOTO FILENAME | |
| G-5/SPAN 2/MID | DOWNSTREAM | DCP-7768.JPG | |

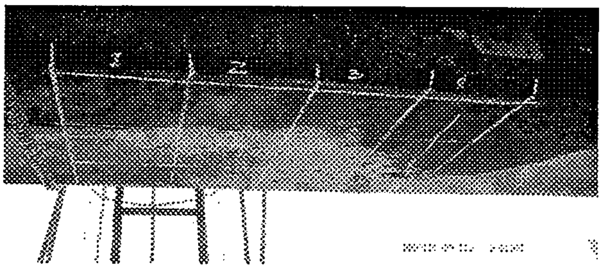


| | | | |
|---|---|---|---|
| DAMAGE | TYPE | | |
| | EVALUATION | X | |
| | | Y | |
| | | Z | |
| | RATING | | |
| | | | |
| GIRDER | VIEW | PHOTO FILENAME | |
| G-5/SPAN 2/MID | NORTH | DCP-7769.JPG | |

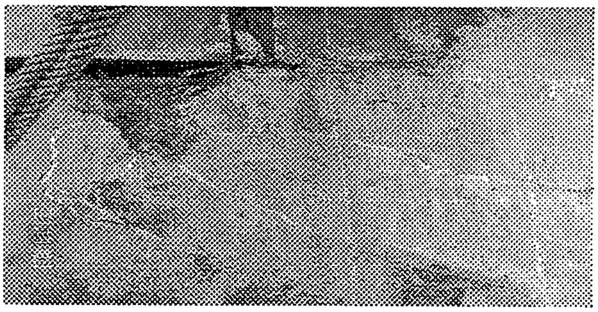


| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | MEDIUM |
| | | Z | HIGH |
| | RATING | III | |
| | DAMAGE CONDITION | WIDTH = 0.10 mm., SPACING < 50 cm. | |
| GIRDER | VIEW | PHOTO FILENAME | |
| G-8/SPAN 2/MID | UPSTREAM | DCP-7900.JPG | |

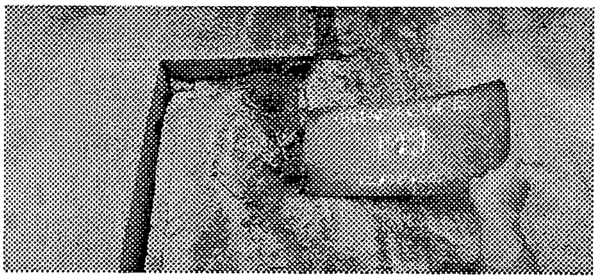
CLOSE-UP VISUAL INSPECTION OF DAMAGE (GUADALUPE BRIDGE)



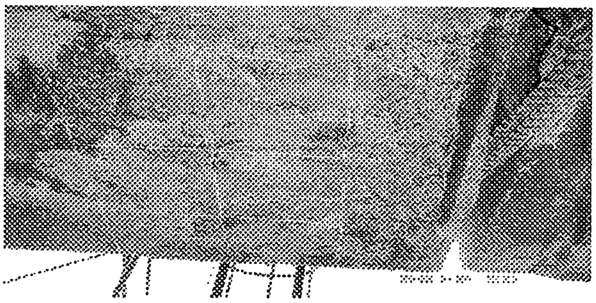
| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | MEDIUM |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | Width = 0.10 mm., Spacing < 50cm | |
| GIRDER (BOTTOM FLYOVER) | VIEW | PHOTO FILENAME | |
| G-8/SPAN 2/MID | UPSTREAM | DCP-7900.JPG | |



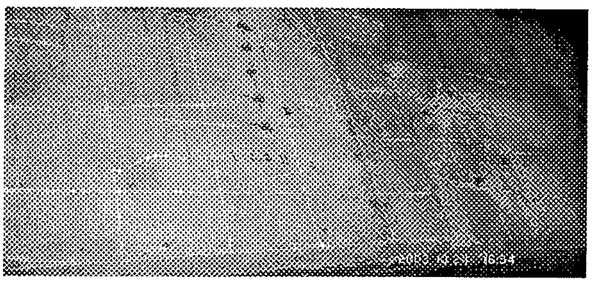
| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | MEDIUM |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | Many Cracks with thickness range from 0.10 mm. to 0.20 mm. depth of crack d=55m (UPV 15) | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GH2R, G-1 | UPSTREAM | DCP-7861.JPG | |



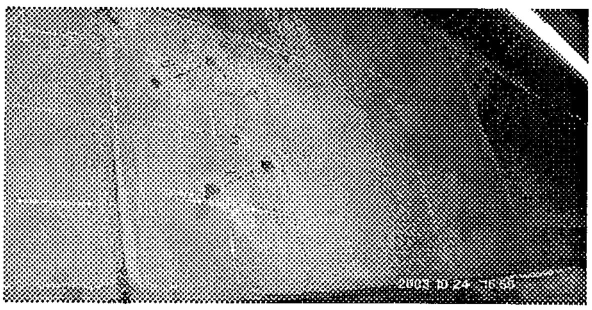
| | | | |
|---|---|---|---|
| DAMAGE | TYPE | | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | LOW |
| | RATING | II | |
| | DAMAGE CONDITION | One (1) crack w = 2.0 mm. (UPV 16) | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GH 2L, G-1 | WEST | DCP-0784.JPG | |



| | | | |
|---|---|---|---|
| DAMAGE | TYPE | SPALLING/EXPOSED REBAR | |
| | EVALUATION | X | - |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | Spalling at soffit of Diaphragm with exposed rebar A = 0.60x0.30=0.18sq.m. | |
| GIRDER (BOTTOM) | VIEW | PHOTO FILENAME | |
| GH2R, G-1 | UPSTREAM | DCP-7823.JPG | |

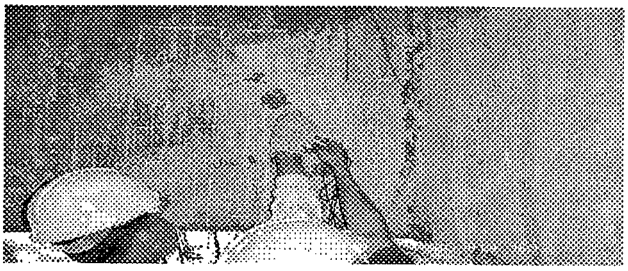


| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | II | |
| | DAMAGE CONDITION | Width = 1.00 mm., Spacing < 50 cm depth of crack d = 1065 mm (UPV 11) | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GH2L, G-5 | DOWNSTREAM | DCP-7834.JPG | |

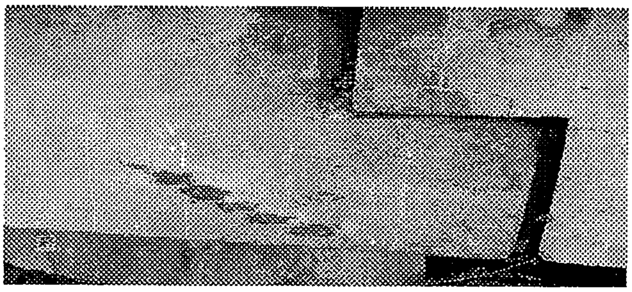


| | | | |
|---|---|---|---|
| DAMAGE | TYPE | CRACKS | |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | III | |
| | DAMAGE CONDITION | Width range from 2mm to 5mm, Spacing < 50cm depth of crack d = 1572mm (UPV 12) | |
| GIRDER | VIEW | PHOTO FILENAME | |
| GH2R, G-5 | DOWNSTREAM | DCP-7835.JPG | |

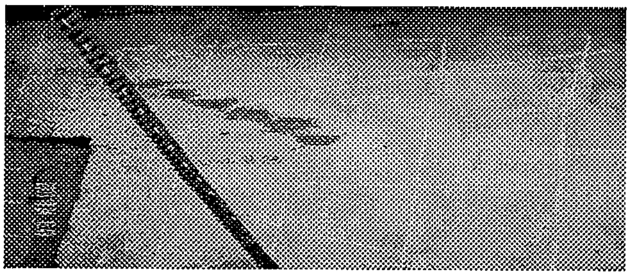
CLOSE-UP VISUAL INSPECTION OF DAMAGE (GUADALUPE BRIDGE)



| | | | |
|---|---|---|---|
| DAMAGE | TYPE | | CRACKS |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | | II |
| | DAMAGE CONDITION | | Width = 2.00mm, Spacing < 50cm depth of crack d = full depth (UPV 14) |
| GIRDER | VIEW | | PHOTO FILENAME |
| GH2L, G-6 | UPSTREAM | | DCP-7837.JPG |

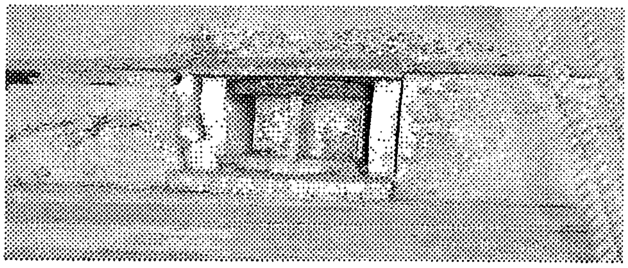


| | | | |
|---|---|---|---|
| DAMAGE | TYPE | | CRACKS |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | | II |
| | DAMAGE CONDITION | | Width = 3.00mm, Spacing < 50cm (3 cracks) depth of crack d = 660mm (UPV 9) |
| GIRDER | VIEW | | PHOTO FILENAME |
| GH2R, G-8 | UPSTREAM | | DCP-7832.JPG |

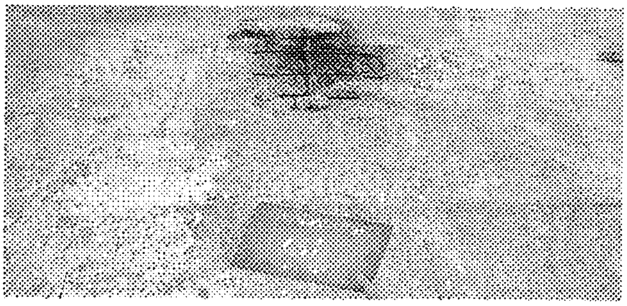


| | | | |
|---|---|---|---|
| DAMAGE | TYPE | | CRACKS |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | HIGH |
| | RATING | | II |
| | DAMAGE CONDITION | | Width range from 2mm, Spacing < 50cm (2 cracks) d = 55mm (UPV 8) |
| GIRDER | VIEW | | PHOTO FILENAME |
| GH 2L, G-8 | DOWNSTREAM | | DCP-7831.JPG |

| | | | |
|---|---|---|---|
| DAMAGE | TYPE | | CRACKS |
| | EVALUATION | X | HIGH |
| | | Y | HIGH |
| | | Z | LOW |
| | RATING | | II |
| | DAMAGE CONDITION | | Width = 1.00mm, Spacing < 50cm depth of crack d =730mm (UPV 10) |
| GIRDER | VIEW | | PHOTO FILENAME |
| GH 2L, G-8 | DOWNSTREAM | | DCP-7833.JPG |



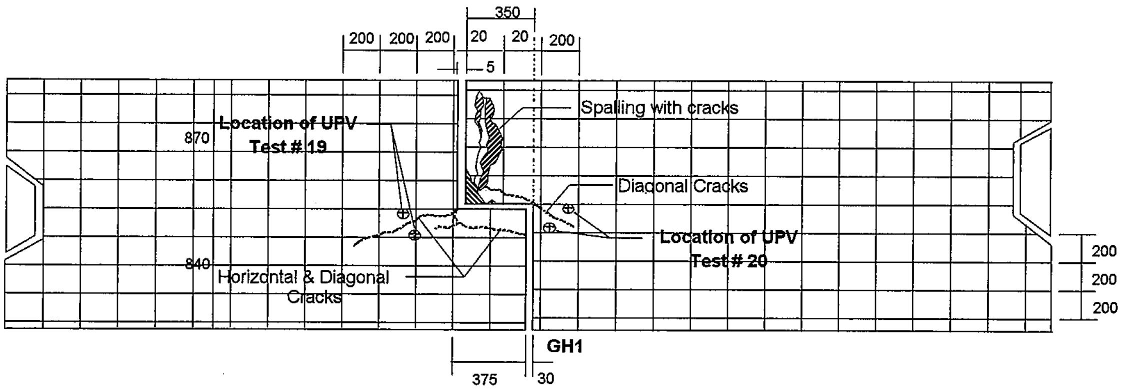
| | | | |
|---|---|---|---|
| DAMAGE | TYPE | | CORROSION |
| | EVALUATION | X | - |
| | | Y | LOW |
| | | Z | LOW |
| | RATING | | III |
| | DAMAGE CONDITION | | Moderate rust at bearing |
| BEARING | VIEW | | PHOTO FILENAME |
| G-5 / PIER 2 | WEST | | DCP-7828.JPG |



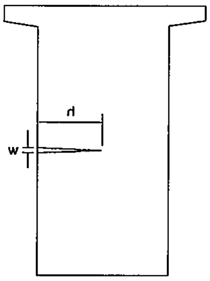
| | | | |
|---|---|---|---|
| DAMAGE | TYPE | | SPALLING/EXPOSED REBAR |
| | EVALUATION | X | - |
| | | Y | HIGH |
| | | Z | LOW |
| | RATING | | III |
| | DAMAGE CONDITION | | Spalling with Exposed Rebar at Pier Wall A = 0.30x0.30 = 0.09sq.m. |
| PIER (WALL) | VIEW | | PHOTO FILENAME |
| PIER 2, U/S | NORTH | | DCP-0581.JPG |

CLOSE-UP VISUAL INSPECTION OF DAMAGE (GUADALUPE BRIDGE)

**BRIDGE NAME : Guadalupe Bridge (Both Sides)**
**GIRDER : Interior [ ] Exterior [X]**
**GERBER HINGE NO : GH1**
**GIRDER NO : 1**

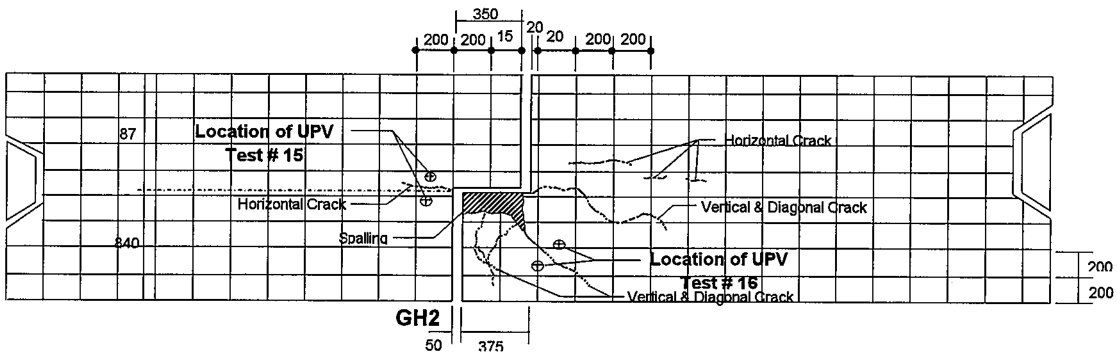



**Elevation of Girder**

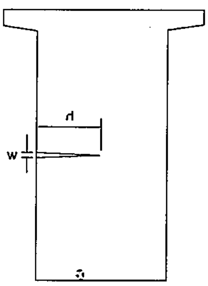



| Test Reference | Element | Face | Crack Orientation | Estimated Apparent Depth, d (mm) | Width of Crack w (mm) | Length of Crack L (mm) |
|---|---|---|---|---|---|---|
| UPV 19 | GH 1, G1 | OUTSIDE | HORIZONTAL | 78 | 0.5 | 700 |
| UPV 20 | GH 1, G1 | OUTSIDE | DIAGONAL | 210 | 1.0 | 600 |

**BRIDGE NAME : Guadalupe Bridge (Both Sides)**
**GIRDER : Exterior [ ] Interior [X]**
**GERBER HINGE NO : GH2**
**GIRDER NO : 1**



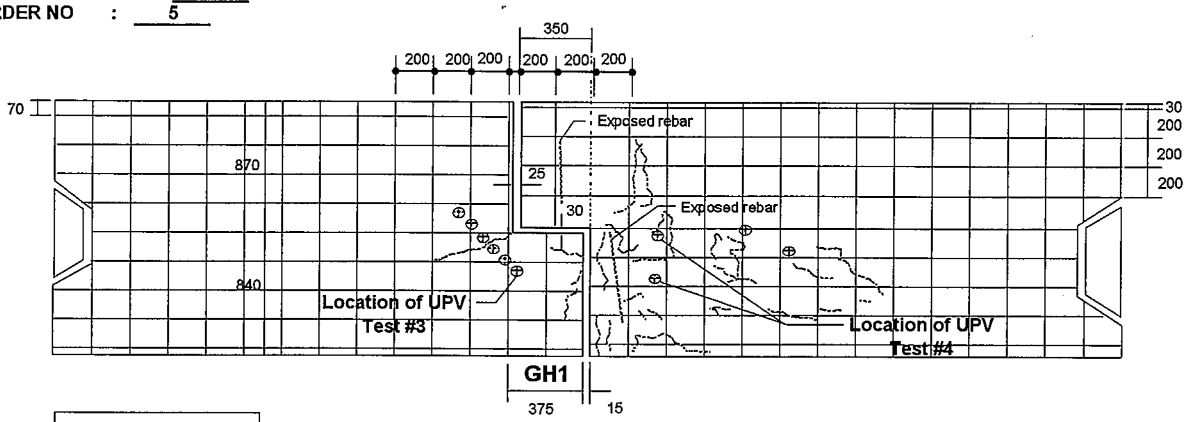

**Elevation of Girder**



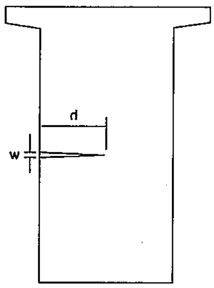

| Test Reference | Element | Face | Crack Orientation | Estimated Apparent Depth, d (mm) | Width of Crack w (mm) | Length of Crack L (mm) |
|---|---|---|---|---|---|---|
| UPV 15 | GH2, G1 | OUTSIDE | HORIZONTAL | 660 | 2.0 | 250 |
| UPV 16 | GH2, G1 | OUTSIDE | DIAGONAL | 55 | 0.2 | 800 |

SUMMARY OF RESULT FOR ULTRASONIC PULSE VELOCITY, GH1 & GH2

**BRIDGE NAME : Guadalupe Bridge (Both Sides)**
**GIRDER : Interior [ ] Exterior [X]**
**GERBER HINGE NO : GH1**
**GIRDER NO : 5**

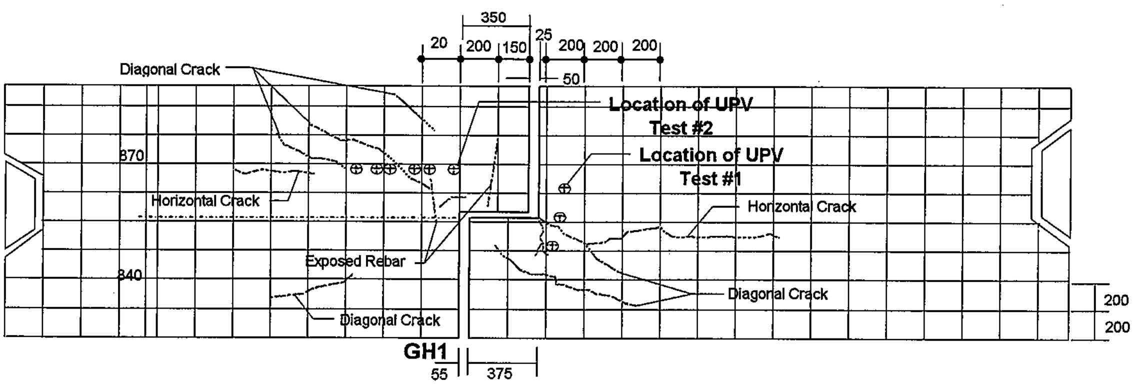



**Elevation of Girder**

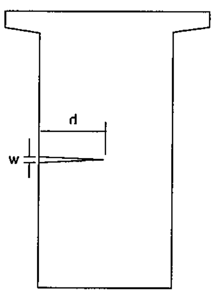



| Test Reference | Element | Face | Crack Orientation | Estimated Apparent Depth, d (mm) | Width of Crack w (mm) | Length of Crack L (mm) |
|---|---|---|---|---|---|---|
| UPV 3 | GH1,G5 | OUTSIDE | DIAGONAL | 660 | 1.5 | 400 |
| UPV 4 | GH1,G5 | OUTSIDE | DIAGONAL | 283 | 0.5 | 170 |

**BRIDGE NAME : Guadalupe Bridge (Both Sides)**
**GIRDER : Interior [ ] Exterior [X]**
**GERBER HINGE NO : GHI (Facing East)**
**GIRDER NO : 8**



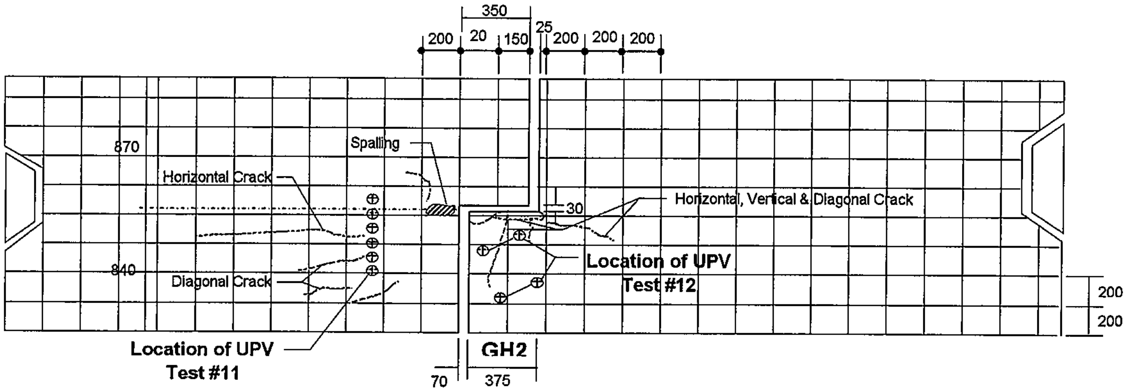

**Elevation of Girder**



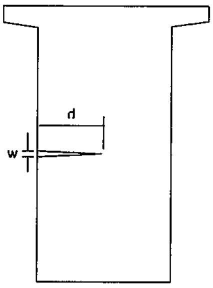

| Test Reference | Element | Face | Crack Orientation | Estimated Apparent Depth, d (mm) | Width of Crack w (mm) | Length of Crack L (mm) |
|---|---|---|---|---|---|---|
| UPV 1 | GH2,G8 | OUTSIDE | DIAGONAL | 660 | 2.0 | 700 |
| UPV 2 | GH2,G8 | OUTSIDE | DIAGONAL | 36 | 1.5 | 600 |

SUMMARY OF RESULT FOR ULTRASONIC PULSE VELOCITY, GH1

**BRIDGE NAME** : Guadalupe Bridge (Both Sides)
**GIRDER** : Interior [ ] Exterior [X]
**GERBER HINGE NO.** : GH2
**GIRDER NO** : 5

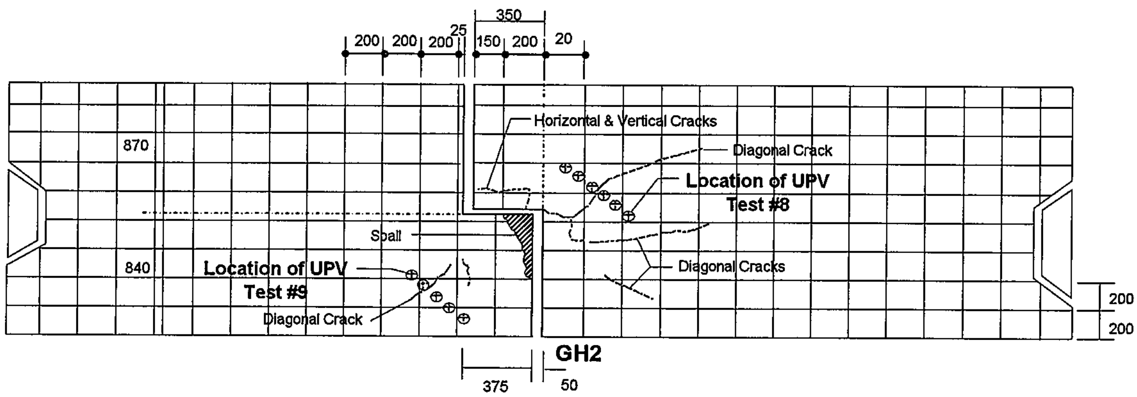



**Elevation of Girder**

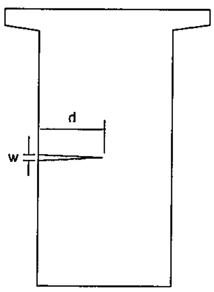



| Test Reference | Element | Face | Crack Orientation | Estimated Apparent Depth, d (mm) | Width of Crack w (mm) | Length of Crack L (mm) |
|---|---|---|---|---|---|---|
| UPV II | GH2, G5 | UPSTREAM | HORIZONTAL | 1065 | 2.0 | 250 |
| UPV I2 | GH2, G5 | UPSTREAM | VERTICAL | 1572 | 5.0 | 500 |

**BRIDGE NAME** : Guadalupe Bridge (Both Sides)
**GIRDER** : Interior [ ] Exterior [X]
**GERBER HINGE NO.**: GH2 (Facing East)
**GIRDER NO** : 8

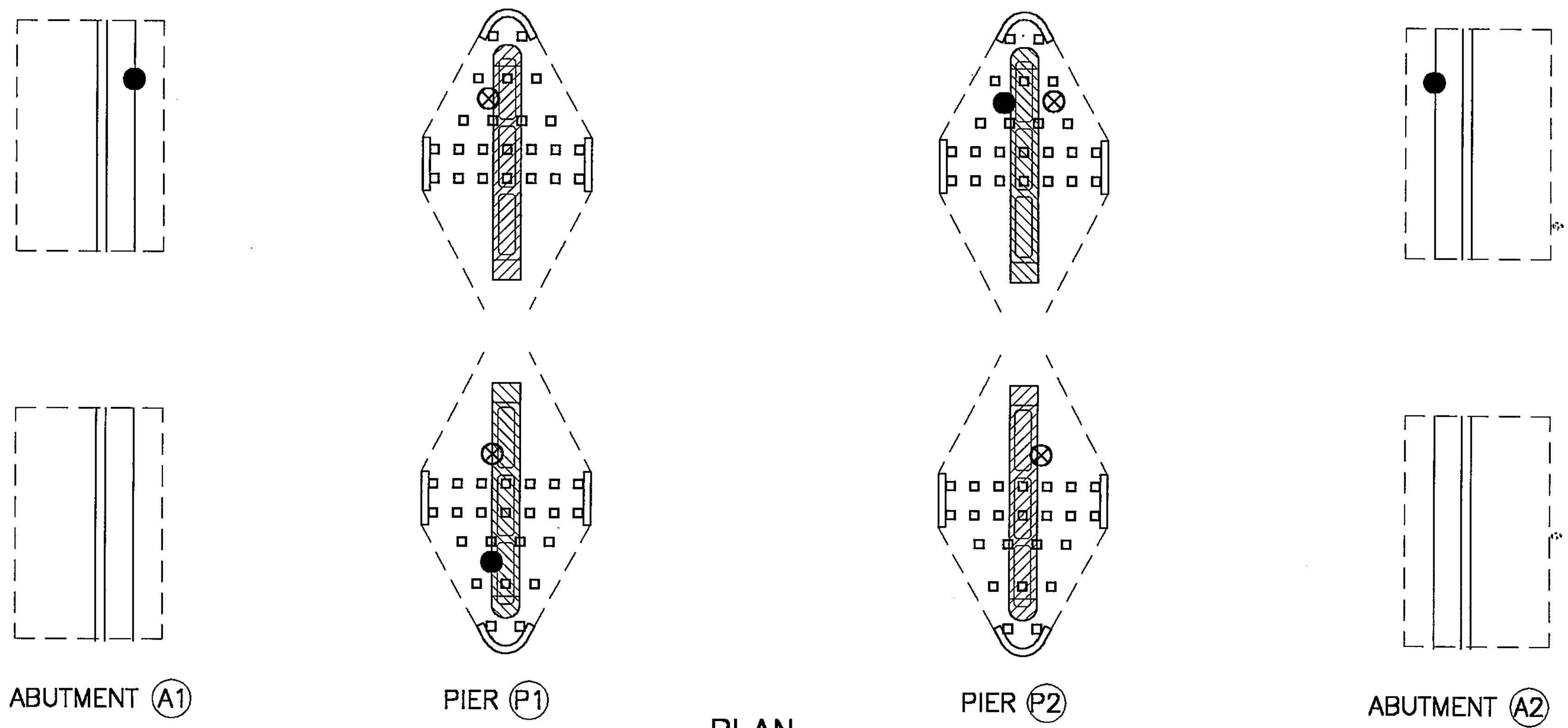



**Elevation of Girder**




| Test Reference | Element | Face | Crack Orientation | Estimated Apparent Depth, d (mm) | Width of Crack w (mm) | Length of Crack L (mm) |
|---|---|---|---|---|---|---|
| UPV 8 | GH2,G8 | DOWNSTREAM | DIAGONAL | 55 | 0.2 | 800 |
| UPV 9 | GH2,G8 | DOWNSTREAM | DIAGONAL | 660 | 0.2 | 250 |

SUMMARY OF RESULT FOR ULTRASONIC PULSE VELOCITY, GH2




PLAN

LEGEND :

⊗ CONCRETE CORE SAMPLE LOCATION

● SCHMIDT HAMMER TEST LOCATION

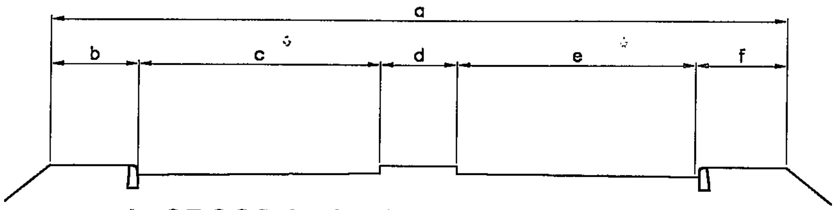
**IN-SITU NON-DESTRUCTIVE TEST OF CONCRETE**

| | TEST LOCATION | | | |
|---|---|---|---|---|
| | A1 | A2 | P1 | P2 |
| HAMMER ORIENTATION | H | H | H | H |
| REBOUND NUMBER, R | 42 | 38 | 42 | 42 |
| CALIBRATED COMPRESSIVE STRENGTH (MPa) 2 | 45 | 38 | 45 | 49 |
| CORE LENGTH (mm) | | | 400 | 410 |
| ORIENTATION 3 | | | H | H |
| CARBONATION DEPTH (mm) (PHENOLPHTHALEIN TEST) | | | 12 | 5 |

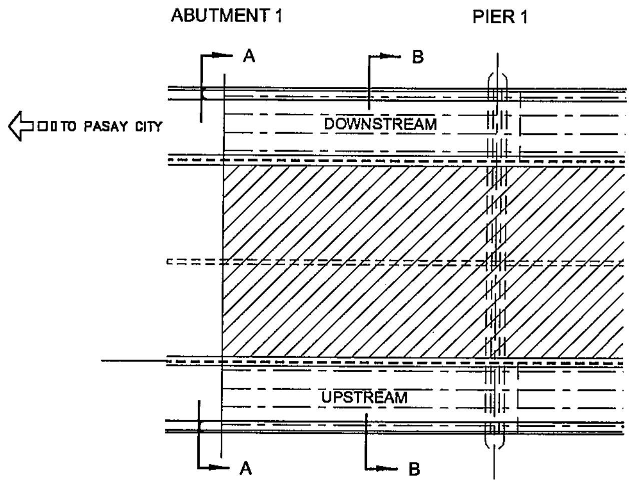
**LABORATORY TEST ON CONCRETE SAMPLE**

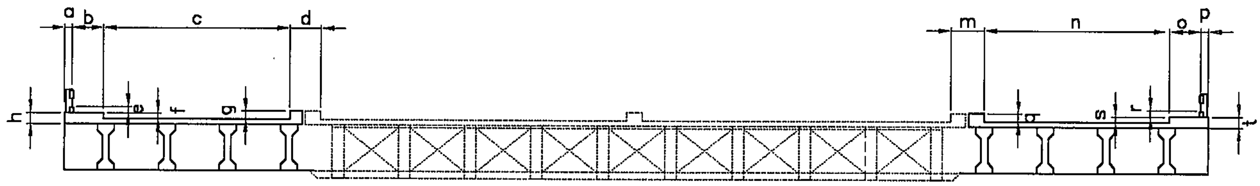
| | TEST LOCATION | | | |
|---|---|---|---|---|
| | A1 | A2 | P1 | P2 |
| COMPRESSIVE STRENGTH (MPa) | - | - | 30.7 | 21.1 |
| PETROGRAPHIC ANALYSIS | - | - | Good | Good |
| CHLORIDE CONTENT (CHLORIDE TEST) | - | - | None | None |

SUMMARY OF RESULTS FOR SUBSTUCTURES




A. CROSS SECTION OF APPROACH ROAD
( 8.50m. FROM ABUTMENT)




B. SECTION OF DECK

Table 1-1. Approach Road Dimensions

| | A-A |
|---|---|
| a | 45330 |
| b | 1150 |
| c | 20400 |
| d | 2770 |
| e | 19800 |
| f | 1210 |
| g | - |
| h | - |

Table 1-2. Deck Dimensions

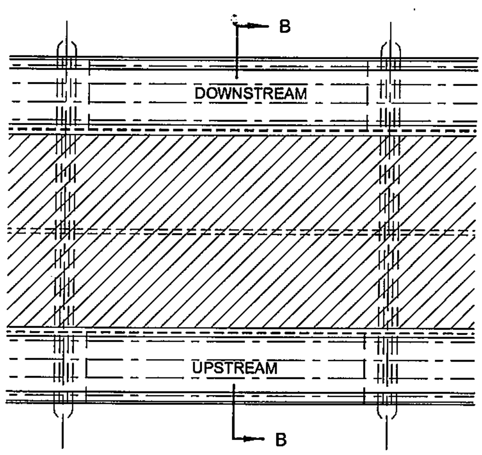
Downstream

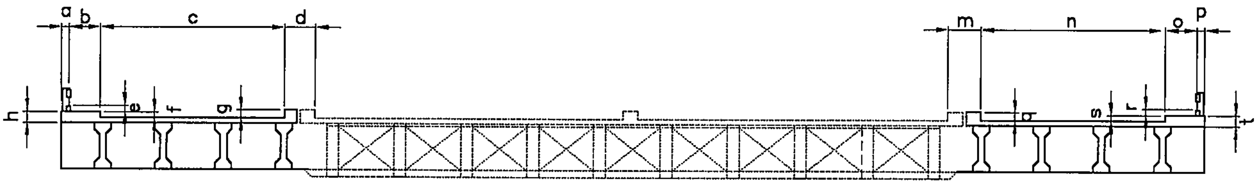
| | B-B |
|---|---|
| a | 350 |
| b | 1160 |
| c | 7290 |
| d | 460 |
| e | 200 |
| f | 240 |
| g | 210 |
| h | 200 |

Upstream

| | B-B |
|---|---|
| m | 455 |
| n | 7330 |
| o | 1190 |
| p | 350 |
| q | 210 |
| r | 210 |
| s | 230 |
| t | 200 |

SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)




B-B. SECTION OF BRIDGE DECK

Table 1-2. Deck Dimensions

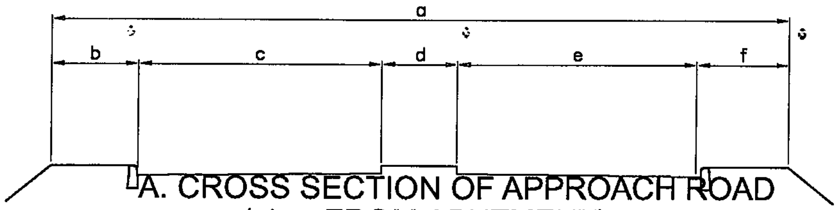
Downstream

| | B-B |
|---|---|
| a | 340 |
| b | 1150 |
| c | 7300 |
| d | 450 |
| e | 230 |
| f | 220 |
| g | 190 |
| h | 205 |

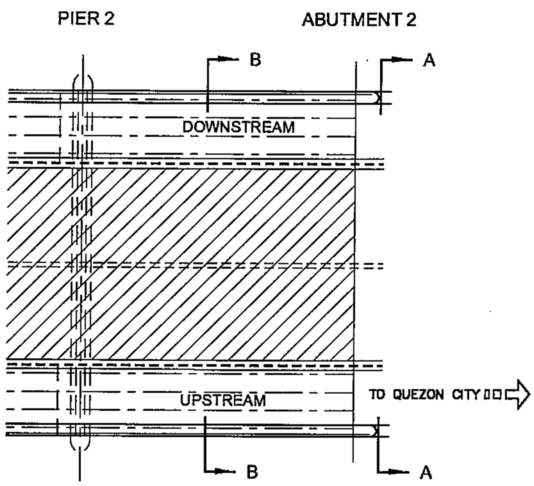
Upstream

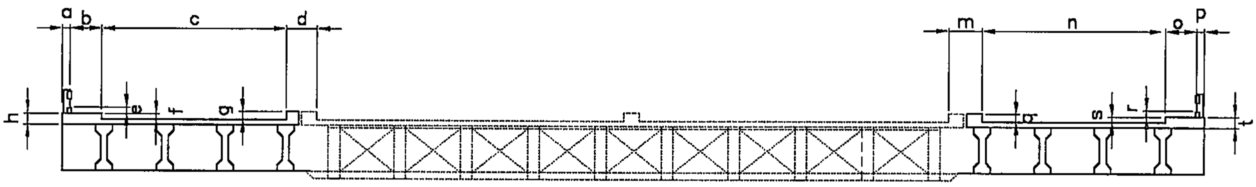
| | B-B |
|---|---|
| m | 460 |
| n | 7350 |
| o | 1180 |
| p | 360 |
| q | 190 |
| r | 190 |
| s | 220 |
| t | 195 |

SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)




A. CROSS SECTION OF APPROACH ROAD
( 1m. FROM ABUTMENT)




B. SECTION OF DECK

Table 1-1. Approach Road Dimensions

| | A-A |
|---|---|
| a | 45320 |
| b | 1180 |
| c | 19050 |
| d | 5290 |
| e | 18600 |
| f | 1200 |
| g | - |
| h | - |

Table 1-2. Deck Dimensions

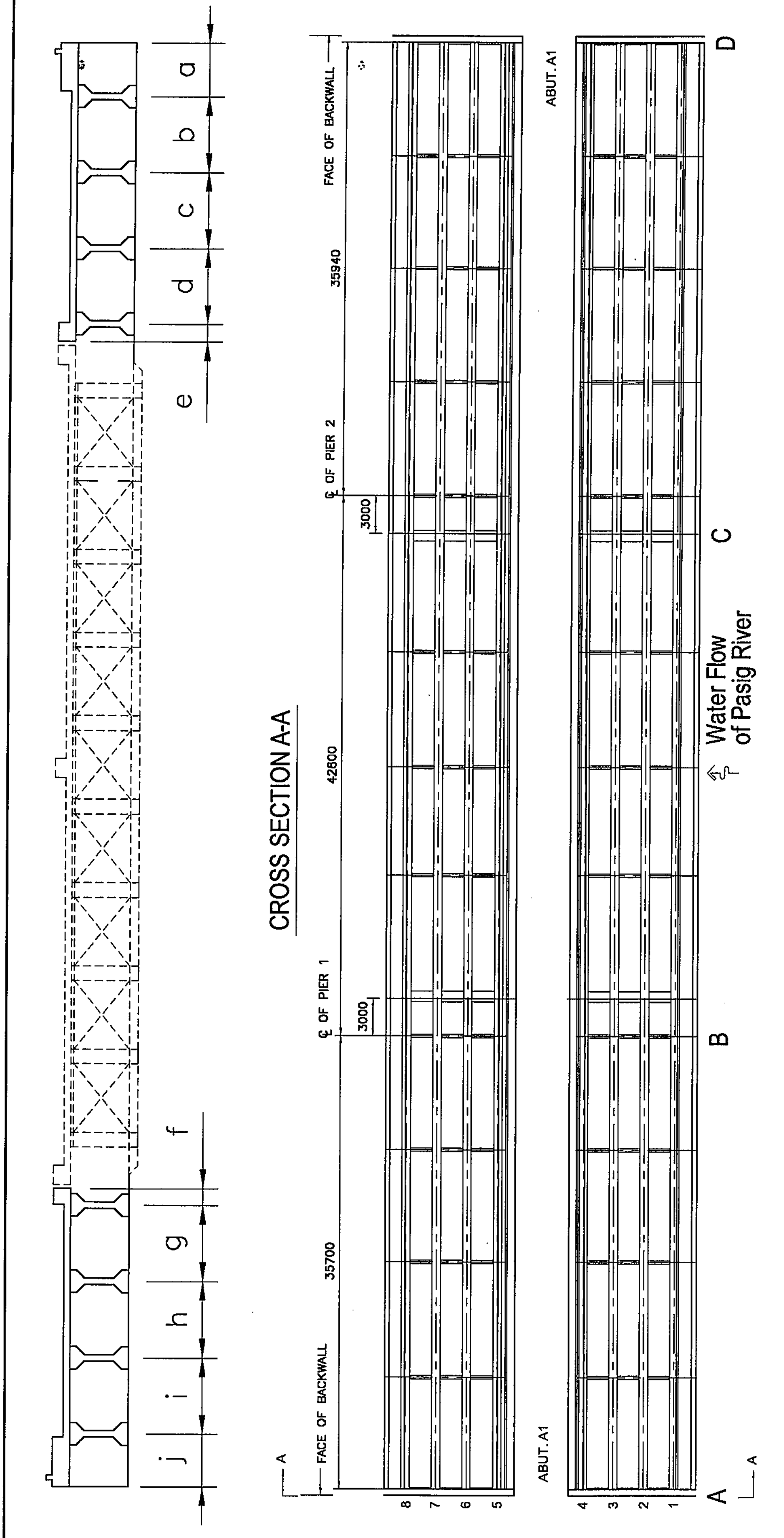
Downstream

| | B-B |
|---|---|
| a | 350 |
| b | 1170 |
| c | 7320 |
| d | 455 |
| e | 230 |
| f | 250 |
| g | 200 |
| h | 200 |

Upstream

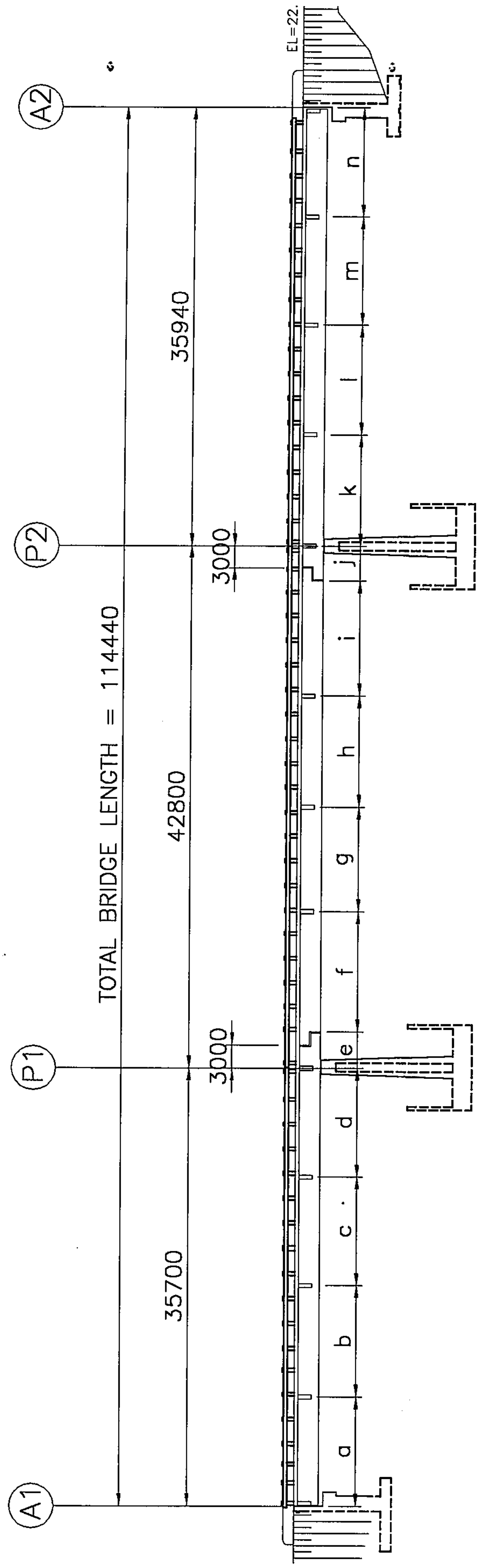
| | B-B |
|---|---|
| m | 460 |
| n | 7350 |
| o | 1160 |
| p | 370 |
| q | 200 |
| r | 210 |
| s | 240 |
| t | 200 |

SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)




| GRID | DIMENSION (mm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | j | i | h | g | f | e | d | c | b | a |
| A | 1640 | 2400 | 2430 | 2400 | 530 | 530 | 2400 | 2400 | 2400 | 1640 |
| B | 1640 | 2400 | 2400 | 2400 | 525 | 530 | 2400 | 2400 | 2420 | 1650 |
| C | 1640 | 2400 | 2400 | 2400 | 530 | 530 | 2400 | 2400 | 2400 | 1650 |
| D | 1640 | 2400 | 2400 | 2400 | 530 | 530 | 2400 | 2400 | 2400 | 1650 |

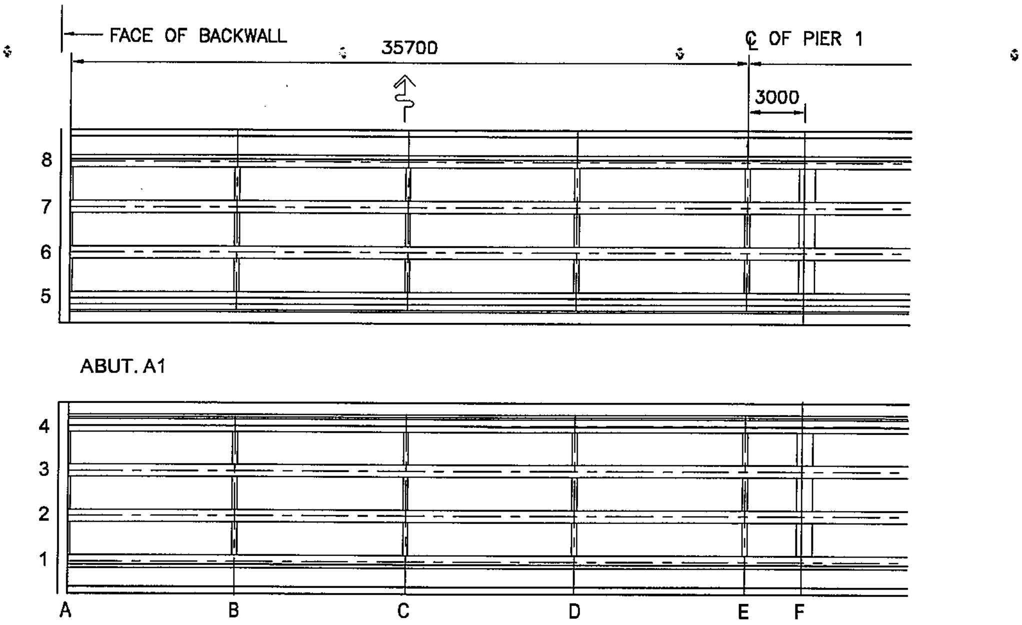
SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)

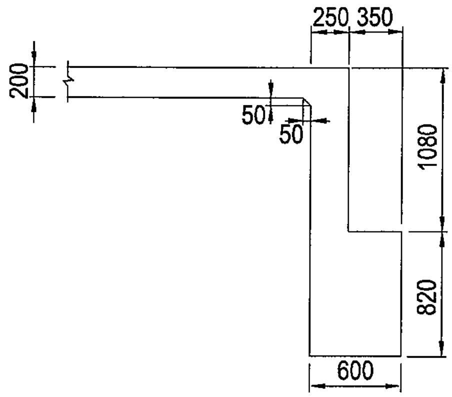



### Table of Diaphragm and Spacing

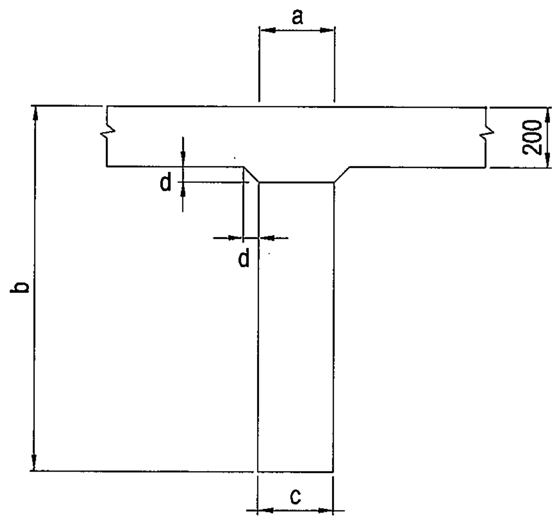
| | DIMENSION (mm) |
|---|---|
| a | 8800 |
| b | 9050 |
| c | 8850 |
| d | 9000 |
| e | 3360 |
| f | 9400 |
| g | 8540 |
| h | 9100 |
| i | 9050 |
| j | 3350 |
| k | 9050 |
| l | 9000 |
| m | 8850 |
| n | 9040 |

SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)



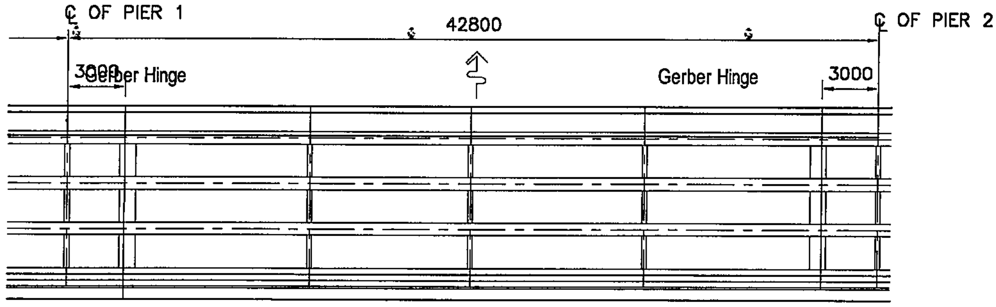

DETAIL OF GERBER HINGE (F)

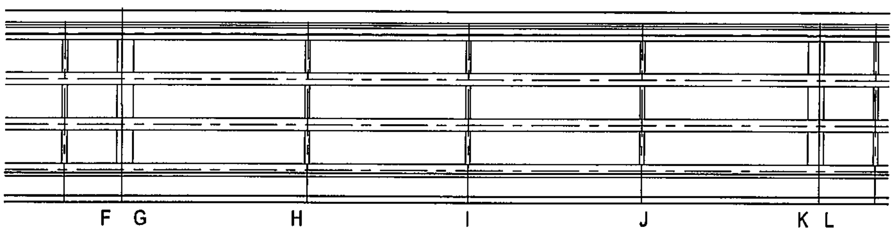


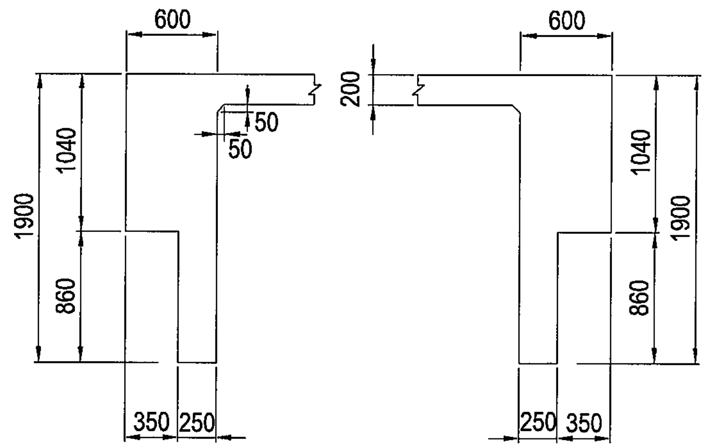

END / INTERMEDIATE DIAPHRAGM

| GRID | List of Diaphragm (mm) | | | |
|---|---|---|---|---|
| | a | b | c | d |
| A | 250 | 1060 | 250 | 50 |
| B | 250 | 1200 | 250 | 50 |
| C | 250 | 1200 | 250 | 50 |
| D | 250 | 1200 | 250 | 50 |
| E | 250 | 1200 | 250 | 50 |

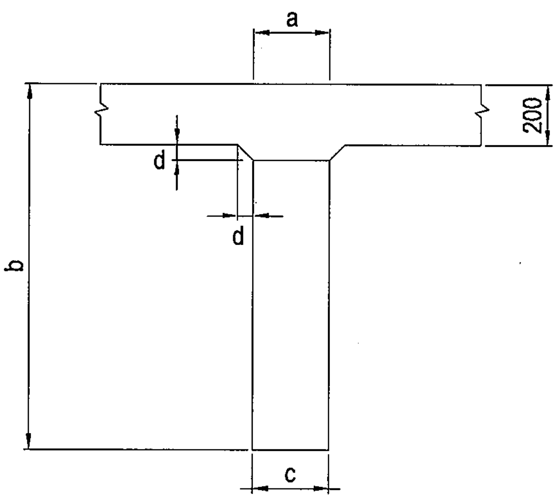
SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)



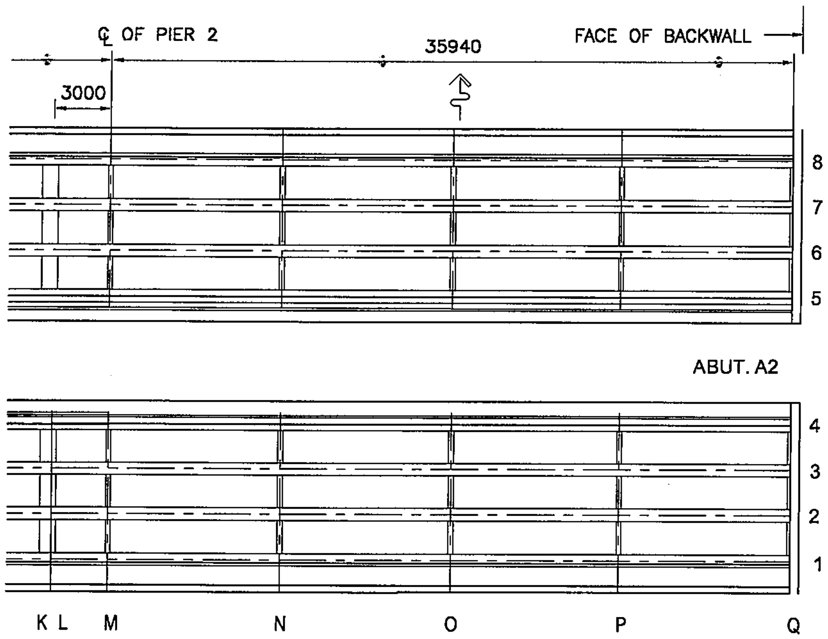

DETAIL OF GERBER HINGE (G & K)

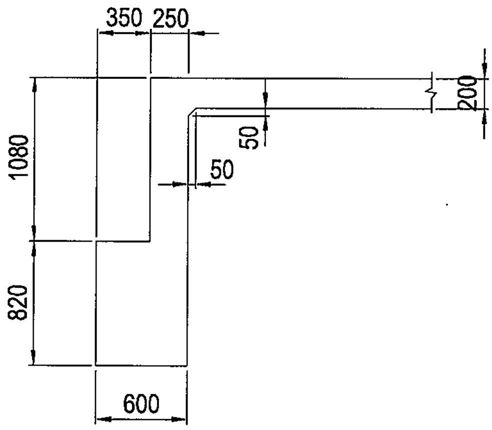



INTERMEDIATE DIAPHRAGM

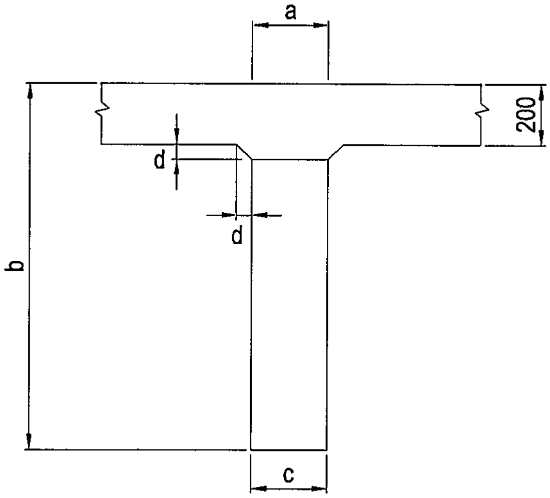
| GRID | DIMENSION (mm) | | | |
|---|---|---|---|---|
| | a | b | c | d |
| L | 250 | 1200 | 250 | 50 |
| M | 250 | 1200 | 250 | 50 |
| N | 250 | 1200 | 250 | 50 |

SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)



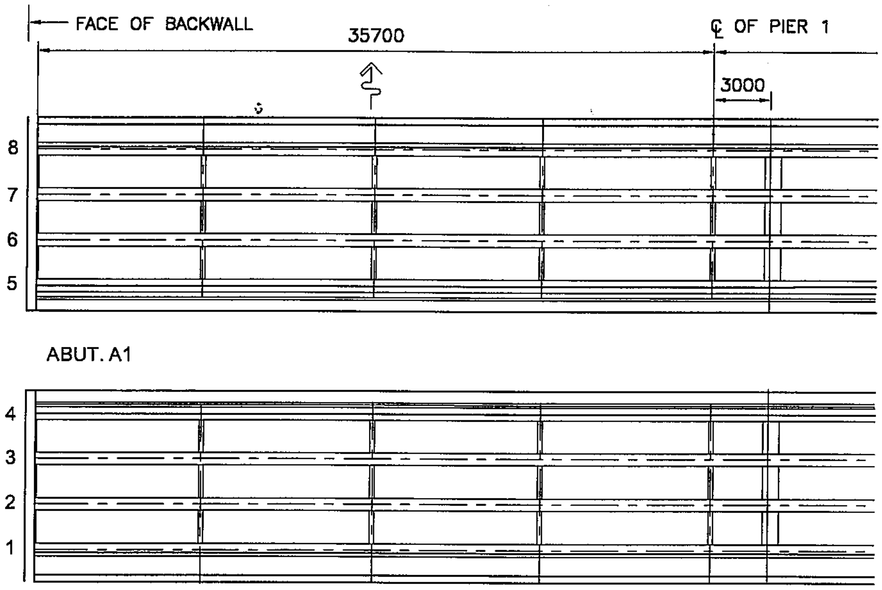

DETAIL OF GERBER HINGE (L)

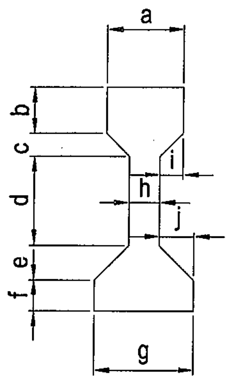



INTERMEDIATE DIAPHRAGM

| GRID | List of Diaphragm (mm) | | | |
|---|---|---|---|---|
| | a | b | c | d |
| M | 250 | 1200 | 250 | 50 |
| N | 250 | 1200 | 250 | 50 |
| O | 250 | 1200 | 250 | 50 |
| P | 250 | 1200 | 250 | 50 |
| Q | 250 | 1060 | 250 | 50 |

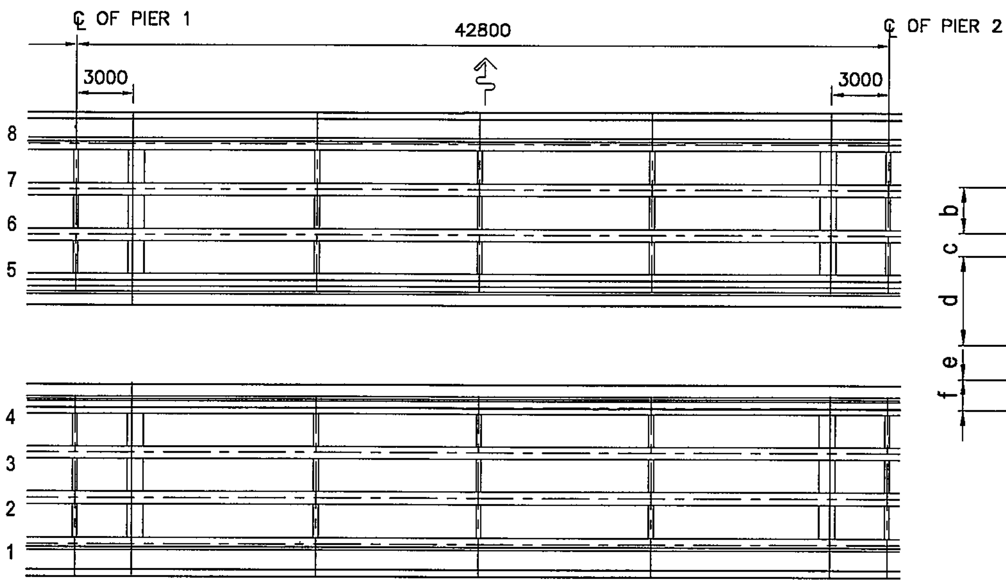
SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)

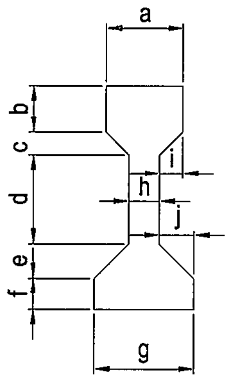



| GIRDER | a | b | c | d | e | f | g | h | i | j |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 670 | 250 | 210 | 800 | 210 | 250 | 670 | 265 | 200 | 200 |
| 7 | 660 | 260 | 200 | 760 | 200 | 260 | 660 | 250 | 175 | 175 |
| 6 | 670 | 260 | 200 | 760 | 200 | 260 | 670 | 270 | 185 | 185 |
| 5 | 670 | 250 | 210 | 800 | 210 | 250 | 670 | 255 | 200 | 200 |
| 4 | 665 | 250 | 195 | 830 | 195 | 250 | 665 | 260 | 180 | 180 |
| 3 | 670 | 260 | 200 | 760 | 200 | 260 | 670 | 250 | 180 | 180 |
| 2 | 670 | 260 | 200 | 760 | 200 | 260 | 670 | 260 | 190 | 190 |
| 1 | 660 | 250 | 205 | 810 | 205 | 250 | 660 | 260 | 175 | 175 |

CANTILEVER GIRDER

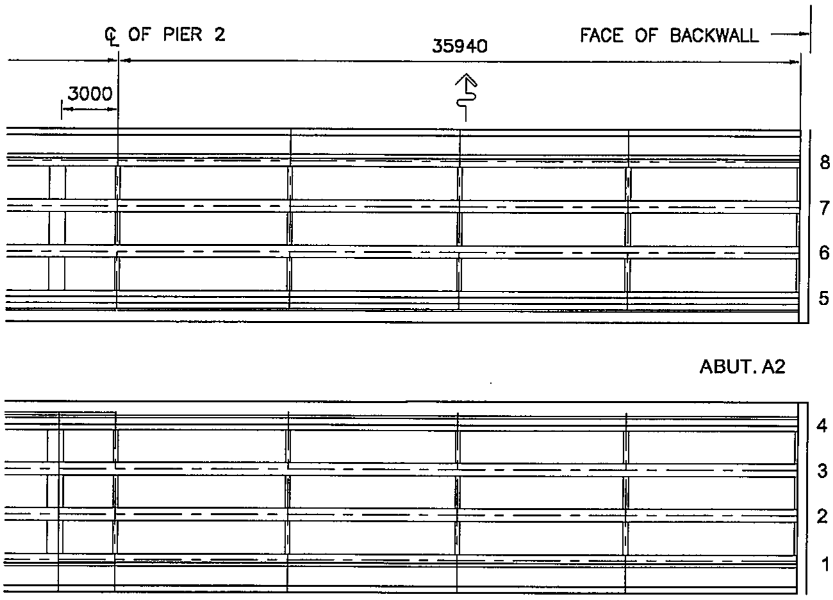


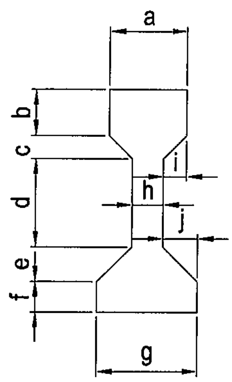




| GIRDER | a | b | c | d | e | f | g | h | i | j |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 670 | 250 | 200 | 820 | 200 | 250 | 670 | 250 | 200 | 200 |
| 7 | 670 | 260 | 210 | 740 | 210 | 260 | 670 | 255 | 200 | 200 |
| 6 | 665 | 260 | 200 | 760 | 200 | 260 | 665 | 260 | 190 | 190 |
| 5 | 660 | 250 | 210 | 800 | 210 | 250 | 660 | 270 | 180 | 180 |
| 4 | 670 | 250 | 210 | 800 | 210 | 250 | 670 | 250 | 190 | 190 |
| 3 | 665 | 260 | 200 | 760 | 200 | 260 | 665 | 250 | 200 | 200 |
| 2 | 670 | 260 | 200 | 760 | 200 | 260 | 670 | 260 | 180 | 180 |
| 1 | 660 | 250 | 210 | 800 | 210 | 250 | 660 | 250 | 190 | 190 |

SUSPENDED GIRDER

SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)

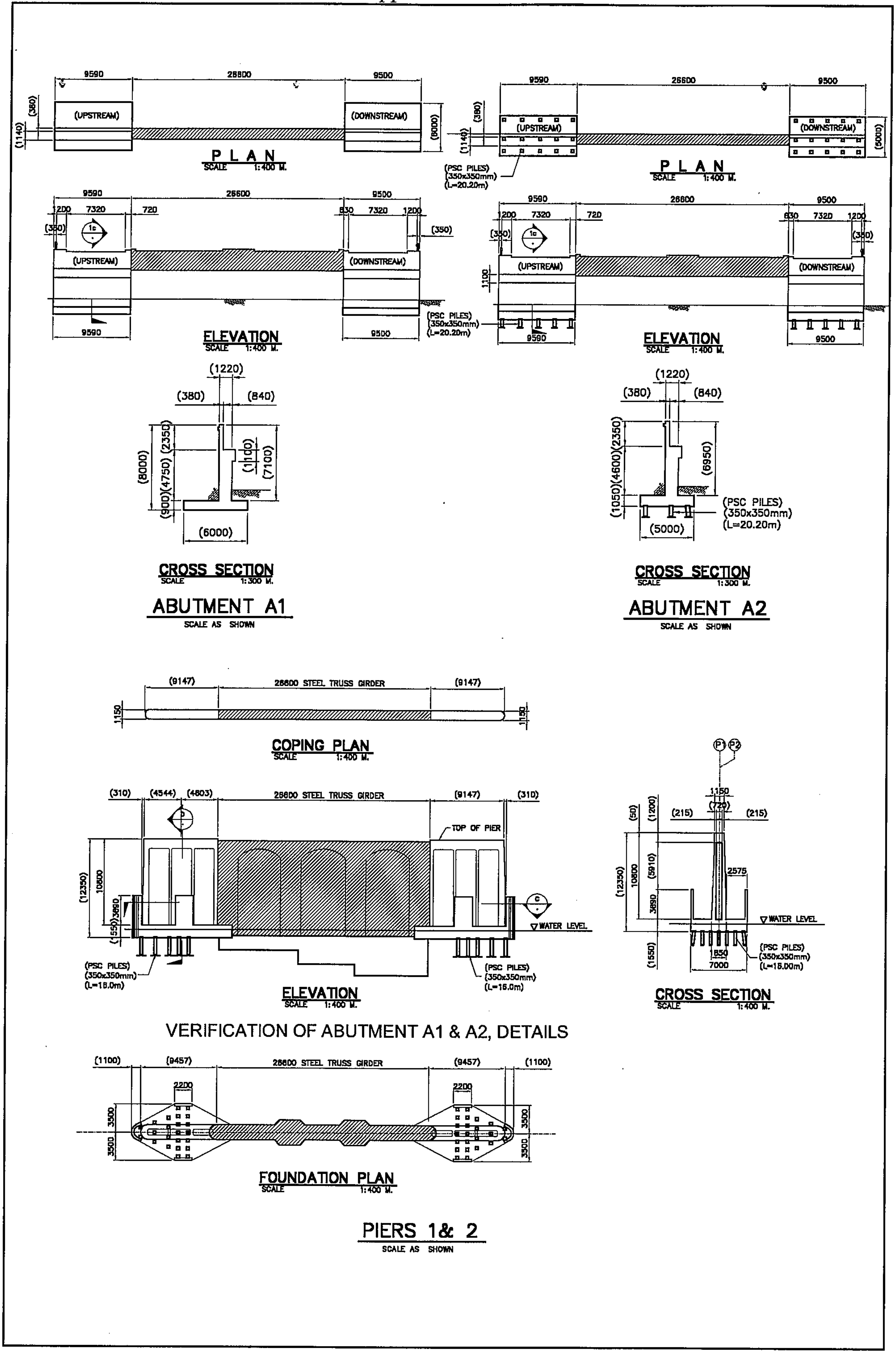



| GIRDER | a | b | c | d | e | f | g | h | i | j |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 670 | 250 | 210 | 800 | 210 | 250 | 670 | 265 | 200 | 200 |
| 7 | 660 | 260 | 200 | 760 | 200 | 260 | 660 | 250 | 175 | 175 |
| 6 | 670 | 260 | 200 | 760 | 200 | 260 | 670 | 270 | 185 | 185 |
| 5 | 670 | 250 | 210 | 800 | 210 | 250 | 670 | 255 | 200 | 200 |
| 4 | 665 | 250 | 195 | 830 | 195 | 250 | 665 | 260 | 180 | 180 |
| 3 | 670 | 260 | 200 | 760 | 200 | 260 | 670 | 250 | 180 | 180 |
| 2 | 670 | 260 | 200 | 760 | 200 | 260 | 670 | 260 | 190 | 190 |
| 1 | 660 | 250 | 205 | 810 | 205 | 250 | 660 | 260 | 175 | 175 |

CANTILEVER GIRDER

SHAPES AND DIMENSIONS (GUADALUPE BRIDGE)




SHAPES AND DIMENSIONS - SUBSTRUCTURE

# CALCULATION OF LOAD RATING - INTERIOR AND EXTERIOR GIRDER

**PROJECT TITLE: PASIG-MARIKINA RIVER BRIDGE INSPECTION, GUADALUPE BRIDGE (BOTH SIDES)**
**ITEM: ANALYTICAL ASSESMENT OF BRIDGE STRUCTURAL**

| RATING METHOD: ALLOWABLE STRESS AT INVENTORY LEVEL | | | | | |
|---|---|---|---|---|---|
| STRESSES | SECTION | | SPAN P1 TO P2 | SPAN A1 TO P1 / A2 TO P2 | SPAN A1 TO P1 / A2 TO P2 |
| | | | MIDSPAN | MIDSPAN | SUPPORT |
| TDL=PS+DL+SDL | TOP | Mpa | -12.41 | -7.52 | -7.90 |
| | BOTTOM | | -5.23 | -6.64 | -6.53 |
| LL (HS20) | TOP | Mpa | -2.87 | -2.72 | -1.11 |
| | BOTTOM | | 4.99 | 4.73 | 1.93 |
| Allowable Stress | Compression | Mpa | -21.00 | -21.00 | -21.00 |
| | Tension | | 2.96 | 2.96 | 2.96 |
| RATING FACTOR (RF=(Cap-TDL)/LL | TOP | | 2.99 | 4.96 | 11.82 |
| | BOTTOM | | 1.64 | 2.03 | 4.92 |
| Equivalent LL(HS20) | RF*(HS20) | tons | 52.44 | 64.89 | 157.38 |

| RATING METHOD: LOAD FACTOR | | | | |
|---|---|---|---|---|
| FORCES / SECTION | | SPAN P1 TO P2 | SPAN A1 TO P1 / A2 TO P2 | SPAN A1 TO P1 / A2 TO P2 |
| | | MIDSPAN | MIDSPAN | SUPPORT |
| Moment, DL+SDL | kN-m | 5988.00 | 4408.00 | 2058.00 |
| Moment, LL+I | kN-m | 2218.95 | 2101.71 | 857.14 |
| Width of Flange, b | mm | 2400.00 | 2400.00 | 2400.00 |
| Depth of Composite Section, d | mm | 1679.91 | 1679.91 | 1225.00 |
| Comp. Strength of Conc., $f_c'$ | Mpa | 35.00 | 35.00 | 35.00 |
| Ultimate Stress of PS Strands., $f_s'$ | Mpa | 1862.00 | 1862.00 | 1862.00 |
| Area of PS Strands, $A_s$* | $mm^2$ | 7106.40 | 4737.60 | 4737.60 |
| Steel Ratio, ρ* | | 0.0018 | 0.0012 | 0.0016 |
| $f_{su}$* | Mpa | 1774.70 | 1803.80 | 1782.19 |
| Neutral Axis, NA Bottom | mm | 1.07 | 1.07 | 1.07 |
| $R = \phi M_n = \phi A_s * f_{su} * d(1-0.6\rho * f_{su} */f_c')$ | kN-m | 20050.43 | 13834.33 | 9833.82 |
| **RATING FACTOR: INVENTORY LEVEL** RF=(R-1.3(DL+SDL))/1.3*1.67LL | | 2.55 | 1.78 | 3.61 |
| **RATING FACTOR: OPERATING LEVEL** RF=(R-1.3(DL+SDL))/1.3LL | | 4.25 | 2.97 | 6.02 |

## EVALUATION FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MODIFIED BRIDGE USING ALLOWABLE STRESS

**FOR SPAN P1 TO P2 - AT MIDSPAN**

**TABLE A: SECTION PROPERTIES**

| DESCRIPTION | Area ($m^2$) | Moment of Inertia ($m^4$) | Y Bottom of Girder (m) | Y Top of Girder (m) |
|---|---|---|---|---|
| Basic Section | | | | |
| PSCG Type IV | 0.717 | 0.228 | 0.84 | 0.84 |
| Deck Slab | 0.480 | N/A | N/A | N/A |
| Diaphragm | 2.67 | N/A | N/A | N/A |
| Composite Section | | | | |
| Suprimposed Loads | 1.214 | 0.474 | 1.067 | 0.613 |
| Live Load MS-18 | 1.214 | 0.474 | 1.067 | 0.613 |

**TABLE B: MOMENT DEMAND FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MODIFIED (D=1.680M; L=36.76M)**

| DESCRIPTION | MIDSPAN |
|---|---|
| Dead Load Moment per Girder (kN-m) | |
| Basic Section | |
| Due to Weight of Girder | 2902.00 |
| Due to Weight of Girder + Slab + Diaphragm | 5128.00 |
| Composite Section | |
| Due to Weight of Superimposed Loads (railing, sidewalk, median and wearing surface) | 860.00 |
| MS-18 Live Load Moment per Girder (kN-m) | |
| Without Impact *Distribution factor | 1849.13 |
| With Impact | 2218.95 |
| Load Combination at Service Condition | |
| DL + (LL+I) | 8206.95 |

Distribution Factor = S / 1.68 = 1.429
I = 100*(15.24 / L + 38) = 20 %

**TABLE C: STRESSES AT MIDSPAN FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV MODIFIED (D=1.680M; L=36.76M)**

Prestressing Force, Pf = 6618.62 kN (As-built: Pf = 1448 kips)

Eccentricity:

For Basic Section = 0.690 m

For Composite Section = 0.917 m (Superimposed Loads)

For Composite Section = 0.917 m (Live Loads)

After Transfer:

$f_c'$ = 35 MPa

Allowable Stress in Compression = 0.60 $f_c'$ = -21.00 MPa

Allowable Stress in Tension = 0.5 $\sqrt{f_c'}$ = 2.96 MPa

| LOAD DESCRIPTION | STRESSES (MPa) | | | |
|---|---|---|---|---|
| | Top Fiber | | Bottom Fiber | |
| Sresses due Dead Loads (Girder+Slab+Diaphragm Weight+Prestressing) | -11.30 | C | -7.16 | C |
| Sresses due to Superimposed Loads | -1.11 | C | 1.94 | T |
| Sresses due to all Live Load + Impact | -2.87 | C | 4.99 | T |

$$RF = \frac{\text{Allowable Stress - ( Stress due to Dead Loads + Stress due to Superimposed Loads )}}{\text{Stress due to Live Load + Impact}}$$

RF = 2.99 -At top fiber

RF = 1.64 -At bottom fiber

## EVALUATION FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MODIFIED BRIDGE USING ALLOWABLE STRESS

**FOR SPAN A1 TO P1 / A2 TO P2- AT MIDSPAN**

**TABLE A: SECTION PROPERTIES**

| DESCRIPTION | Area ($m^2$) | Moment of Inertia ($m^4$) | Y Bottom of Girder (m) | Y Top of Girder (m) |
|---|---|---|---|---|
| Basic Section | | | | |
| PSCG Type VI Modified | 0.717 | 0.228 | 0.84 | 0.84 |
| Deck Slab | 0.480 | N/A | N/A | N/A |
| Diaphragm | 2.67 | N/A | N/A | N/A |
| Composite Section | | | | |
| Suprimposed Loads | 1.214 | 0.474 | 1.067 | 0.613 |
| Live Load MS-18 | 1.214 | 0.474 | 1.067 | 0.613 |

**TABLE B: MOMENT DEMAND FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MODIFIED (D=1.680M; L=38.409M)**

| DESCRIPTION | MIDSPAN |
|---|---|
| Dead Load Moment per Girder (kN-m) | |
| Basic Section | |
| Due to Weight of Girder | 2136.00 |
| Due to Weight of Girder + Slab + Diaphragm | 3775.00 |
| Composite Section | |
| Due to Weight of Superimposed Loads (railing, sidewalk, median and wearing surface) | 633.00 |
| MS-18 Live Load Moment per Girder (kN-m) | |
| Without Impact *Distribution factor | 1751.43 |
| With Impact | 2101.71 |
| Load Combination at Service Condition | |
| DL + (LL+I) | 2734.71 |

Distribution Factor = S / 1.68 = 1.429
I = 100*(15.24 / L + 38) = 20 %

**TABLE C: STRESSES AT MIDSPAN FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IVB MODIFIED (D=1.680M; L=38.409M)**

Prestressing Force, P = 5293.12 kN (As-built: Pf = 1190 kips)

Eccentricity:

For Basic Section = 0.748 m

For Composite Section = 0.975 m (Superimposed Loads)

For Composite Section = 0.975 m (Live Loads)

After Transfer:

$f_c'$ = 35 MPa

Allowable Stress in Compression = 0.60 $f_c'$ = -21.00 MPa

Allowable Stress in Tension = 0.5 $\sqrt{f_c'}$ = 2.96 MPa

| LOAD DESCRIPTION | STRESSES (MPa) | | | |
|---|---|---|---|---|
| | Top Fiber | | Bottom Fiber | |
| Sresses due Dead Loads (Girder+Slab+Diaphragm Weight+Prestressing) | -6.70 | C | -8.06 | C |
| Sresses due to Superimposed Loads | -0.82 | C | 1.42 | T |
| Sresses due to all Live Load + Impact | -2.72 | C | 4.73 | T |

$$RF = \frac{\text{Allowable Stress - ( Stress due to Dead Loads + Stress due to Superimposed Loads )}}{\text{Stress due to Live Load + Impact}}$$

RF = 4.96 -At top fiber

RF = 2.03 -At bottom fiber

## EVALUATION FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MODIFIED BRIDGE USING ALLOWABLE STRESS

**FOR SPAN A1 TO P1 / A2 TO P2 - AT SUPPORT**

**TABLE A: SECTION PROPERTIES**

| DESCRIPTION | Area ($m^2$) | Moment of Inertia ($m^4$) | Y Bottom of Girder (m) | Y Top of Girder (m) |
|---|---|---|---|---|
| Basic Section | | | | |
| PSCG Type VI Modified | 0.717 | 0.228 | 0.84 | 0.84 |
| Deck Slab | 0.480 | N/A | N/A | N/A |
| Diaphragm | 2.67 | N/A | N/A | N/A |
| Composite Section | | | | |
| Suprimposed Loads | 1.214 | 0.474 | 1.067 | 0.613 |
| Live Load MS-18 | 1.214 | 0.474 | 1.067 | 0.613 |

**TABLE B: MOMENT DEMAND FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MODIFIED (D=1.680M; L=38.409M)**

| DESCRIPTION | SUPPORT |
|---|---|
| Dead Load Moment per Girder (kN-m) | |
| Basic Section | |
| Due to Weight of Girder | 1165.00 |
| Due to Weight of Girder + Slab + Diaphragm | 2058.00 |
| Composite Section | |
| Due to Weight of Superimposed Loads (railing, sidewalk, median and wearing surface) | 345.00 |
| MS-18 Live Load Moment per Girder (kN-m) | |
| Without Impact *Distribution factor | 714.29 |
| With Impact | 857.14 |
| Load Combination at Service Condition | |
| DL + (LL+I) | 1202.14 |

Distribution Factor = S / 1.68 = 1.429

I = 100*(15.24 / L + 38) = 20 %

**TABLE C: STRESSES AT SUPPORT FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE VI B MODIFIED (D=1.680M; L=38.409M)**

Prestressing Force, Pf = 5293.12 kN (As-built: Pf = 1190 kips)

Eccentricity:

For Basic Section = 0.385 m

For Composite Section = 0.158 m (Superimposed Loads)

For Composite Section = 0.158 m (Live Loads)

After Transfer:

$f_c'$ = 35 MPa

Allowable Stress in Compression = 0.60 $f_c'$ = -21.00 MPa

Allowable Stress in Tension = 0.5 $\sqrt{f_c'}$ = 2.96 MPa

| LOAD DESCRIPTION | STRESSES (MPa) | | | |
|---|---|---|---|---|
| | Bottom Fiber | | Top Fiber | |
| Sresses due Dead Loads (Girder+Slab+Diaphragm Weight+Prestressing) | -7.46 | C | -7.31 | C |
| Sresses due to Superimposed Loads | -0.45 | C | 0.78 | T |
| Sresses due to all Live Load + Impact | -1.11 | C | 1.93 | T |

$$RF = \frac{\text{Allowable Stress - ( Stress due to Dead Loads + Stress due to Superimposed Loads )}}{\text{Stress due to Live Load + Impact}}$$

RF = 11.82 -At bottom fiber

RF = 4.92 -At top fiber

## EVALUATION FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MODIFIED BRIDGE USING LOAD FACTOR

**FOR SPAN P1 TO P2 - AT MIDSPAN**

**TABLE A: SECTION PROPERTIES**

| DESCRIPTION | Area ($m^2$) | Moment of Inertia ($m^4$) | Y Bottom of Girder (m) | Y Top of Girder (m) |
|---|---|---|---|---|
| Basic Section | | | | |
| PSCG Type IV | 0.717 | 0.228 | 0.84 | 0.84 |
| Deck Slab | 0.480 | N/A | N/A | N/A |
| Diaphragm | 2.67 | N/A | N/A | N/A |
| Composite Section | | | | |
| Suprimposed Loads | 1.214 | 0.474 | 1.067 | 0.613 |
| Live Load MS-18 | 1.214 | 0.474 | 1.067 | 0.613 |

**TABLE B: MOMENT DEMAND FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MIDIFIED (D=1.680M; L=36.76M)**

| DESCRIPTION | MIDSPAN |
|---|---|
| Dead Load Moment per Girder (kN-m) | |
| Basic Section | |
| Due to Weight of Girder | 2902.00 |
| Due to Weight of Girder + Slab + Diaphragm | 5128.00 |
| Composite Section | |
| Due to Weight of Superimposed Loads (railing, sidewalk, median and wearing surface) | 860.00 |
| MS-18 Live Load Moment per Girder (kN-m) | |
| Without Impact | 1849.13 |
| With Impact | 2218.95 |
| Load Combination at Service Condition | |
| DL + (LL+I) | 8206.95 |

Distribution Factor = 1.429
I = 100*(15.24 / L + 38) = 20 %

**CALCULATION OF MOMENT CAPACITY AT MIDSPAN:**
CONSIDERING PRESTRESSING STEEL ONLY:

$A_S^* =$ 7106.40 mm² $f'_c =$ 35 MPa $f'_s =$ 1862.00 MPa b = 2400.00 mm d = 1679.91 mm
$\rho^* =$ 0.00176 $\gamma^* =$ 0.40 - for stress-relieved steel $\beta_1 =$ 0.80 - for f'c = 35.00 Mpa $\phi =$ 1.00

$f_{su}^* = f'_s \{ 1 - [ (\gamma^* / \beta_1) ( \rho^* f'_s / f'_c ) ] \}$
$f_{su}^* =$ 1774.7 MPa

$$\text{Compression Block} = \frac{A_S^* f_{su}}{0.85 f'_C b} = 176.6 \text{ mm} < t_{slab} = 200 \text{ mm}$$ -Consider rectangular section

$\phi M_n = \phi A_s^* f_{su}^* d \; [ 1 - ( 0.6 ( \rho^* f_{su}^* / f'_c ) ]$
$\phi M_n =$ 20050.4 kN

**LOAD RATING:**

$\gamma_D =$ 1.30 $\gamma_L =$ 2.17 (Inventory Level) D = 5988.00 kN LL + I = 2218.95 kN-m
$\gamma_L =$ 1.30 (Operating Level)

INVENTORY LEVEL:

$$RF = \frac{\phi M_n - \gamma_D D}{\gamma_L ( LL+I )} = 2.55$$

OPERATING LEVEL:

$$RF = \frac{\phi M_n - \gamma_D D}{\gamma_L ( LL+I )} = 4.25$$

## EVALUATION FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MODIFIED BRIDGE USING LOAD FACTOR

**FOR SPAN A1 TO P1 / A2 TO P2- AT MIDSPAN**

**TABLE A: SECTION PROPERTIES**

| DESCRIPTION | Area ($m^2$) | Moment of Inertia ($m^4$) | Y Bottom of Girder (m) | Y Top of Girder (m) |
|---|---|---|---|---|
| Basic Section | | | | |
| PSCG Type VI Modified | 0.717 | 0.228 | 0.84 | 0.84 |
| Deck Slab | 0.480 | N/A | N/A | N/A |
| Diaphragm | 2.67 | N/A | N/A | N/A |
| Composite Section | | | | |
| Suprimposed Loads | 1.214 | 0.474 | 1.067 | 0.613 |
| Live Load MS-18 | 1.214 | 0.474 | 1.067 | 0.613 |

**TABLE B: MOMENT DEMAND FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MIDIFIED (D=1.680M; L=38.409M)**

| DESCRIPTION | MIDSPAN |
|---|---|
| Dead Load Moment per Girder (kN-m) | |
| Basic Section | |
| Due to Weight of Girder | 2136.00 |
| Due to Weight of Girder + Slab + Diaphragm | 3775.00 |
| Composite Section | |
| Due to Weight of Superimposed Loads (railing, sidewalk, median and wearing surface) | 633.00 |
| MS-18 Live Load Moment per Girder (kN-m) | |
| Without Impact | 1751.43 |
| With Impact | 2101.71 |
| Load Combination at Service Condition | |
| DL + (LL+I) | 2734.71 |

Distribution Factor = S / 1.68 = 1.429
I = 100*(15.24 / L + 38) = 20 %

**CALCULATION OF MOMENT CAPACITY AT MIDSPAN:**
CONSIDERING PRESTRESSING STEEL ONLY:

$A_S^* =$ 4737.60 mm² $f'_c =$ 35 MPa $f'_s =$ 1862.00 MPa b = 2400.00 mm d = 1679.91 mm
$\rho^* =$ 0.00118 $\gamma^* =$ 0.40 - for stress-relieved steel $\beta_1 =$ 0.80 - for f'c = 35.00 Mpa $\phi =$ 1.00

$$f_{su}^* = f'_s \{1 - [(\gamma^* / \beta_1)(\rho^* f'_s / f'_c)]\}$$
$f_{su}^* =$ 1803.8 MPa

$$\text{Compression Block} = \frac{A_S^* f_{su}}{0.85 f'_C b} = 119.7 \text{ mm} < t_{slab} = 200 \text{ mm}$$ -Consider rectangular section

$$\phi M_n = \phi A_s^* f_{su}^* d \ [1 - (0.6 (\rho^* f_{su}^* / f'_c)]$$
$\phi M_n =$ 13834.3 kN

**LOAD RATING:** D = 4408.00 kN LL + I = 2101.71 kN-m

$\gamma_D =$ 1.30 $\gamma_L =$ 2.17 (Inventory Level)
$\gamma_L =$ 1.30 (Operating Level)

INVENTORY LEVEL:

$$RF = \frac{\phi M_n - \gamma_D D}{\gamma_L (LL+I)} = 1.78$$

OPERATING LEVEL:

$$RF = \frac{\phi M_n - \gamma_D D}{\gamma_L (LL+I)} = 2.97$$

## EVALUATION FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MODIFIED BRIDGE USING LOAD FACTOR

**FOR SPAN A1 TO P1 / A2 TO P2 - AT SUPPORT**

**TABLE A: SECTION PROPERTIES**

| DESCRIPTION | Area ($m^2$) | Moment of Inertia ($m^4$) | Y Bottom of Girder (m) | Y Top of Girder (m) |
|---|---|---|---|---|
| Basic Section | | | | |
| PSCG Type VI Modified | 0.717 | 0.228 | 0.84 | 0.84 |
| Deck Slab | 0.480 | N/A | N/A | N/A |
| Diaphragm | 2.67 | N/A | N/A | N/A |
| Composite Section | | | | |
| Suprimposed Loads | 1.214 | 0.474 | 1.067 | 0.613 |
| Live Load MS-18 | 1.214 | 0.474 | 1.067 | 0.613 |

**TABLE B: MOMENT DEMAND AT SUPPORT FOR SIMPLY SUPPORTED PRESTRESSED CONCRETE GIRDER TYPE IV B MIDIFIED (D=1.680M; L=38.409M)**

| DESCRIPTION | SUPPORT |
|---|---|
| Dead Load Moment per Girder (kN-m) | |
| Basic Section | |
| Due to Weight of Girder | 1165.00 |
| Due to Weight of Girder + Slab + Diaphragm | 2058.00 |
| Composite Section | |
| Due to Weight of Superimposed Loads (railing, sidewalk, median and wearing surface) | 345.00 |
| MS-18 Live Load Moment per Girder (kN-m) | |
| Without Impact | 714.29 |
| With Impact | 857.14 |
| Load Combination at Service Condition | |
| DL + (LL+I) | 1202.14 |

Distribution Factor = S / 1.68 = 1.429
I = 100*(15.24 / L + 38) = 20 %

**CALCULATION OF MOMENT CAPACITY AT SUPPORT:**
CONSIDERING PRESTRESSING STEEL ONLY:

$A_S^*$ = 4737.60 mm² $f'_c$ = 35 MPa $f'_s$ = 1862.00 MPa b = 2400.00 mm d = 1225.00 mm

$\rho^*$ = 0.00161 $\gamma^*$ = 0.40 - for stress-relieved steel $\beta_1$ = 0.80 - for f'c = 35.00 Mpa $\phi$ = 1.00

$$f_{su}^* = f'_s \ \{1 - [(\gamma^* / \beta_1)(\rho^* f'_s / f'_c)]\}$$

$f_{su}^*$ = 1782.19 MPa

$$\text{Compression Block} = \frac{A_S^* f_{su}}{0.85 f'_C b} = 118.3 \text{ mm} < t_{slab} = 200 \text{ mm}$$ -Consider rectangular section

$$\phi M_n = \phi A_s^* f_{su}^* d \ [1 - (0.6 (\rho^* f_{su}^* / f'_c)]$$

$\phi M_n$ = 9833.82 kN

**LOAD RATING:** D = 2403.00 kN LL + I = 857.14 kN-m

$\gamma_D$ = 1.30 $\gamma_L$ = 2.17 (Inventory Level)
$\gamma_L$ = 1.30 (Operating Level)

INVENTORY LEVEL:

$$RF = \frac{\phi M_n - \gamma_D D}{\gamma_L (LL+I)} = 3.61$$

OPERATING LEVEL:

$$RF = \frac{\phi M_n - \gamma_D D}{\gamma_L (LL+I)} = 6.02$$

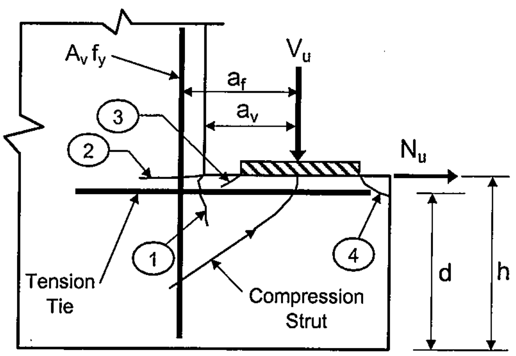
**PROJECT TITLE:** **PASIG-MARIKINA RIVER BRIDGE INSPECTION**
**GUADALUPE BRIDGE (BOTH SIDES)**

**ITEM: LIVE LOAD RATING**

## BEAM LEDGE CAPACITY INVESTIGATION (LOAD RATING) FOR GERBER HINGE

### 1. BEAM LEADGE FAILURE MECHANISM

Beam ledges have to be designed for overall member actions and local failure modes as follows:



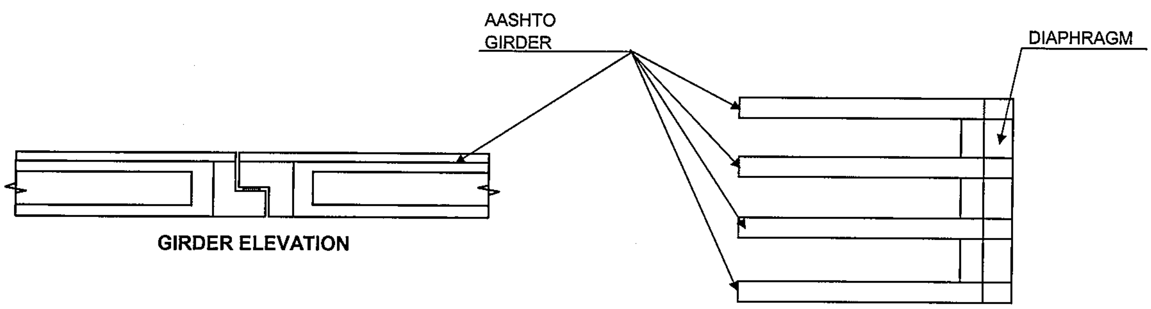

1. Flexural or shear failure mode
2. Separation necessitating hanger reinforcement
3. Punching shear failure
4. Local bearing; can be avoided by reducing the bearing stress or allowing more edge distance

**Failure Modes and Potential Cracks**

Forces and actions acting on the ledge includes shear (Vu), horizontal tensile force (Nuc), and moment (Mu):

| | | |
|---|---|---|
| Vu | = | Factored Shear (Dead load + Live load + Impact) |
| Nuc | ≥ | 0.2Vu, but less than 1.0Vu |
| Mu | = | Vu ($a_f$) + Nu (h-d) |
| $a_f$ | = | Flexural moment arm; distance from reaction centerline to centerline of hanger reinforcement |
| h - d | = | Moment arm for the horizontal load, Nuc |

### GERBER HINGE LAYOUT

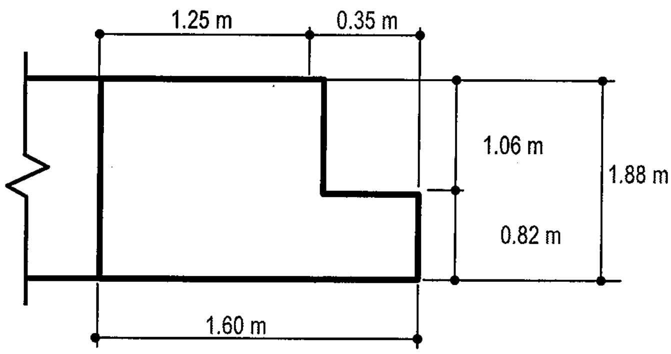


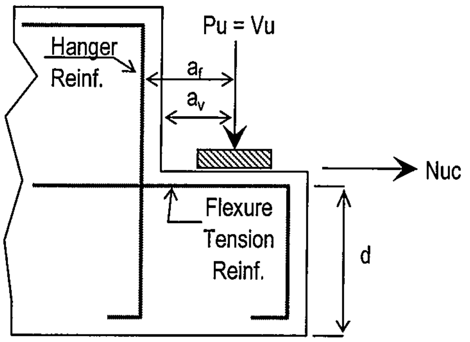

### 2. DIMENSION AND PROPERTIES OF LEDGE:

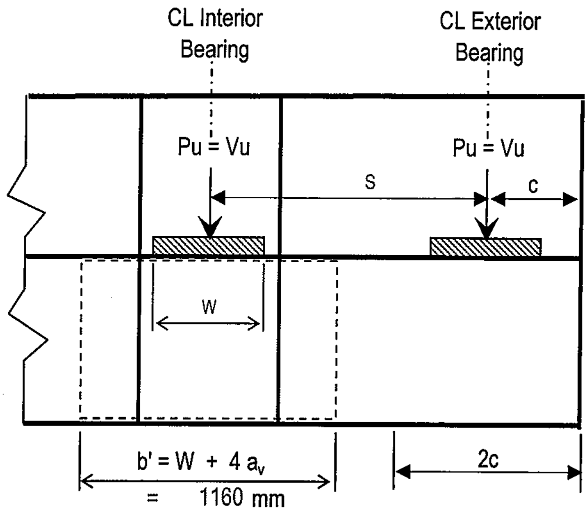
b = 1600 mm
D = 1880 mm
h = 820 mm

f'c = 35 Mpa
fys = 275 Mpa Reinforcing Steel
fyp = 1860 Mpa Prestressing Steel

concrete cover = 50 mm





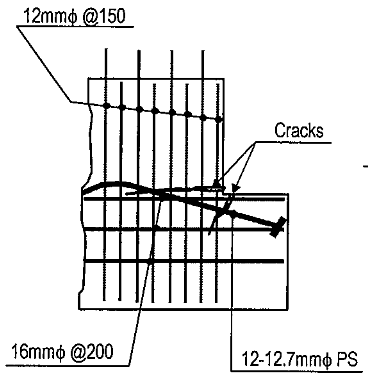



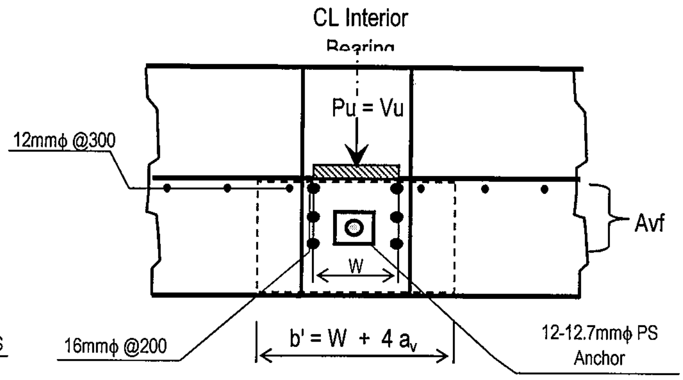

***Bearing Pad Dimensions :***

| | | | | | | |
|---|---|---|---|---|---|---|
| Width of bearing pad, W | = | 560 mm | $a_v$ | = | 150 | mm |
| Length of bearing pad, L | = | 200 mm | $a_f$ | = | 200 | mm |
| Width of Girder End Block | = | 660 mm | d | = | 770 | mm |
| Girder Spacing, S | = | 2400 mm (CL of bearing) | b | = | 660 | mm |
| Edge dist. of ext bearing,c | = | 330 mm | b' | = | 1160 | mm |

| Bearing Edage Width: | |
|---|---|
| 2c | = 660 mm |

## 3. SHEAR FRICTION




***Reinforcements Provided***

| Location | Bar Φ, mm | No. Pcs. | Area, mm² |
|---|---|---|---|
| Interior | 16 | 8.25 | 1658.8 |
| Exterior | 16 | 7.20 | 1447.6 |

$\mu$ = friction coefficient = 1.40

b' = $W+4a_b$ = 1160 mm

Contribution of Prestressing Tendons:

| | | | | |
|---|---|---|---|---|
| Prestress, As (12-d12.7) | = | 1184 | $mm^2$ | |
| Equiv. Rebar, As' | = | 7210 | $mm^2$ | |
| Effective Area of PS | = | 2652 | $mm^2$ | (2-tendons) |

$\theta$ = 10.6 deg

***Ledge Capacity Under Shear Friction:***

***For Interior Bearing:***

$a_v / d$ = 0.19 ≤ 1

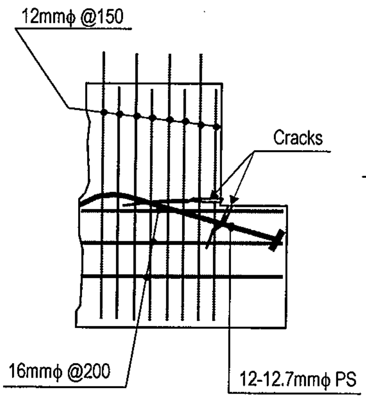
| | | | |
|---|---|---|---|
| Vu ≤ $\phi$ (0.2f'c) ($W+4a_v$) (d) | = | 5315 | kN |
| Vu ≤ $\phi\mu A_{vf}$ fy | = | 543 | kN |
| With Prestress, Vu | = | 1411 | kN |

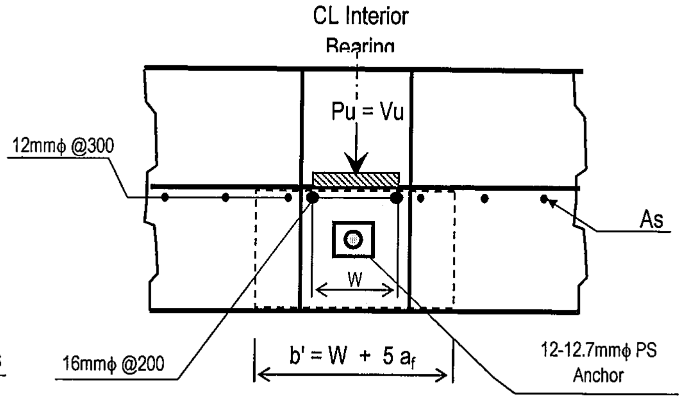
***For Exterior Bearing:***

$a_v / d$ = 0.19 ≤ 1

| | | | |
|---|---|---|---|
| Vu ≤ $\phi$ (0.2f'c) (K) (d) | = | 3024 | kN |
| Vu ≤ $\phi\mu A_{vf}$ fy | = | 474 | kN |
| With Prestress, Vu | = | 1342 | kN |
| K = 2c | = | 660 | mm |

## 4. FLEXURE




***Reinforcements Provided***

| Location | Bar Φ, mm | No. Pcs. | Area, mm² |
|---|---|---|---|
| Interior | 16 | 4.25 | 854.5 |
| Exterior | 16 | 3.20 | 643.4 |

Prestressing :

Ap = 12-ϕ12.7mm = 1184.4 mm²
Equiv. Rebar, As' 8010.9 mm²
Effective Area of PS = 7087 mm²
θ = 10.6 deg

$W + 5a_f$ = 1560 mm
2c = 660 mm

***Ledge Capacity Under Flexure:***

Reinforcing Bars Only

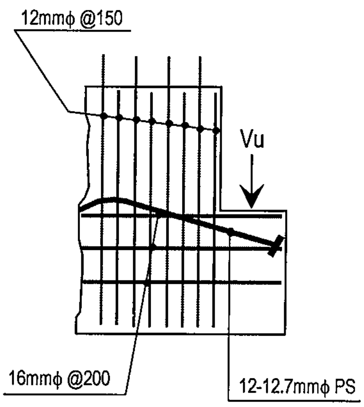
| Strength: $V_u \leq \phi A_f f_y jd / [a_f + 0.2(h-d)]$ | Interiror | = | 586 kN |
|---|---|---|---|
| | Exterior | = | 441 kN |

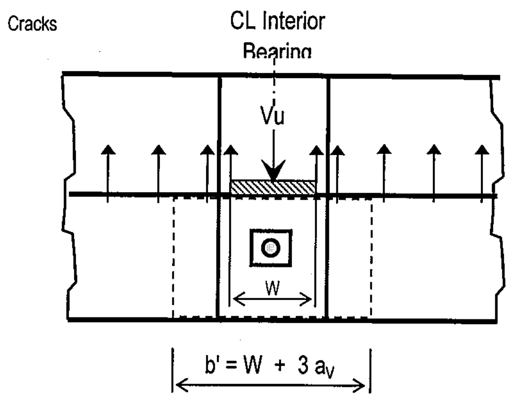
As ≥ $2(A_{vf})/3 + A_n$ = 1106 mm² NOT OK
As ≥ ρmin (W + 5af)(d) = 6115 mm² NOT OK
ρmin = 0.04(f'c/fy) = 0.0051

Reinforcing Bars Plus Prestressing Bars

| Strength: $V_u \leq \phi A_f f_y jd / [a_f + 0.2(h-d)]$ | Interiror | = | 5445 kN |
|---|---|---|---|
| | Exterior | = | 5300 kN |

## 5. HANGER REINFORCEMENT




***Reinforcements Provided***

| Location | Bar Φ, mm | No. Pcs. | Area, mm² |
|---|---|---|---|
| Interior | 12 | 16.00 | 1809.6 |
| Exterior | 12 | 15.00 | 1696.5 |

Contribution of Prestressing Tendons:

Prestress, As (12-d12.7) = 1184 mm²
Equiv. Rebar, As' = 7210 mm²
Effective Area of PS = 2652 mm³
θ = 10.6 deg

***Ledge Capacity Under Hanger Tension:***

**Reinforcing Bars Only**

Strength $V_u \leq \phi A_v f_y S / s$ Interior = 423 kN
Exterior = 397 kN

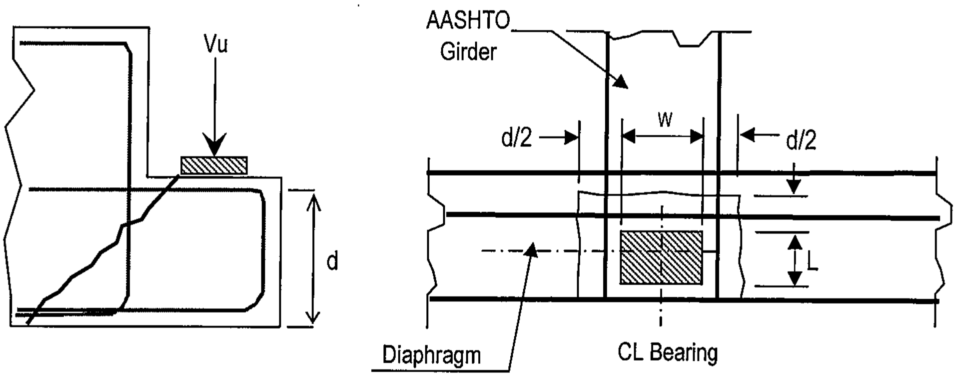
Serviceability Interior = 249 kN
$V \leq A_v (0.5 f_y)(W+3a)/s$ Exterior = 233 kN

**Reinforcing Bars Plus Prestressing Bars**

Strength $V_u \leq \phi A_v f_y S / s$ Interior = 1043 kN
Exterior = 1017 kN

Serviceability Interior = 614 kN
$V \leq A_v (0.5 f_y)(W+3a)/s$ Exterior = 598 kN

## 6. PUNCHING SHEAR



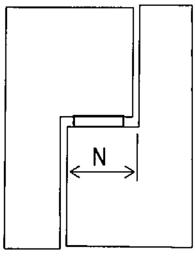

Allow. Tensile Strength for Puching = 0.33 √f'c = 1.95 MPa

***Ledge Capacity Under Punching Shear:***

Interior Bearing: Vu ≯ φ (0.33 √f'c)(W+2L'+2d)(d) = 2736 kN

Exterior Bearing: Vu ≯ φ (0.33 √f'c)(W+L'+d)(d) = 1663 kN

## 7. AVAILABLE SEAT WIDTH




From AASHTO 7.3.1 DIVISION 1A

N = ( 305 + 2.5L + 10H ) ( 1 + $0.000125S^2$ )

L = length in meters of the bridge deck to the adjacent expansion joint

S = angle of skew of support in degrees measured from a line normal to the span.

H = is the column or pier average height in meters

Seat width provided at gerber hinge = 350 mm

L = 38.7 m ( Total length of deck from expansion joint to the othe expansion )

S = 0 degrees

H = 8.2 m ( Average Height of Column at Main Bridge )

N = ( 305 + 2.5L + 10H ) ( 1 + $0.000125S^2$ )

N = 483.25 mm **> Provided Seat, NOT OK**

## 8. SUMMARY OF CAPACITY

***Demand / Reaction:***

Dead Load = 640.0 kN

Live Load = 192.4 kN (Including Impact)

| Load Factors | | |
|---|---|---|
| $\gamma_D$ Dead Load | = | 1.30 |
| $\gamma_L$ Inventory | = | 2.17 |
| $\gamma_L$ Operating | = | 1.30 |

***Calculated Capacity (Load Factor)***

| Girder Location | Shear Friction | | Flexure | | Hanger | | Punching Shear |
|---|---|---|---|---|---|---|---|
| | Rebar | W/ PS | Rebar | W/ PS | Rebar | W/ PS | |
| Interior | 543 | 1411 | 586 | 5445 | 423 | 1043 | 2736 |
| Exterior | 474 | 1342 | 441 | 5300 | 397 | 1017 | 1663 |

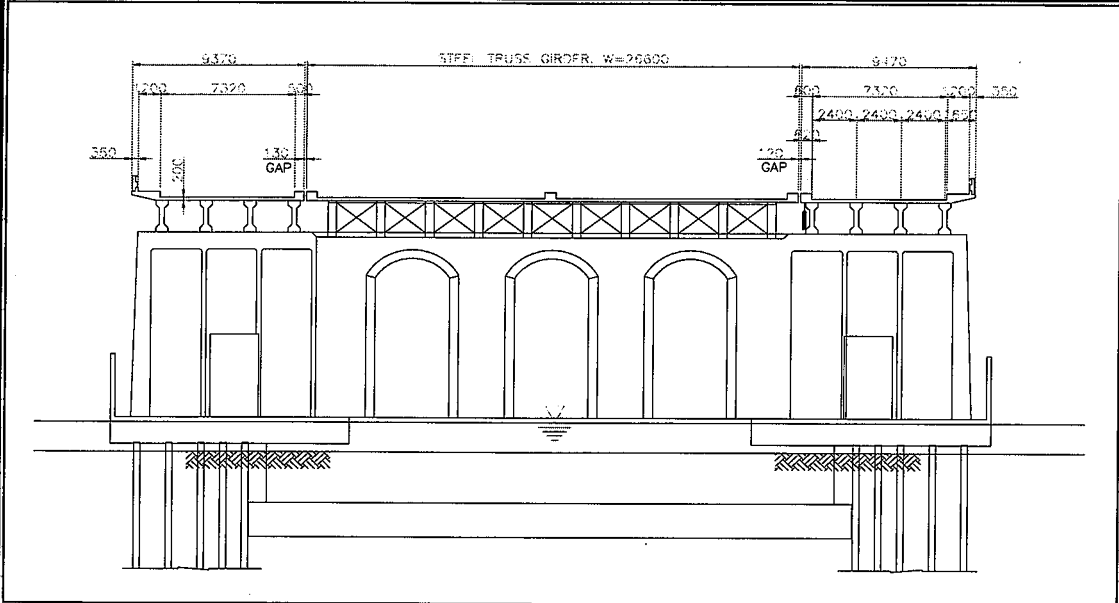
***Load Rating:***

By Load Factor Method:

| Girder Location | Considering Reinforcing Bars Only | | | | Reinforcing Bars Plus Prestress | | | |
|---|---|---|---|---|---|---|---|---|
| | Inventory | | Operatiing | | Inventory | | Operatiing | |
| | RF | $LL_{EQUIV}$ (HS20) | RF | $LL_{EQUIV}$ (HS20) | RF | $LL_{EQUIV}$ (HS20) | RF | $LL_{EQUIV}$ (HS20) |
| Interior | -0.98 | -32.0 tons | -1.64 | -53.5 tons | 0.51 | 16.5 tons | 0.84 | 27.6 tons |
| Exterior | -1.04 | -34.1 tons | -1.74 | -56.9 tons | 0.44 | 14.5 tons | 0.74 | 24.1 tons |

Appendix 23.1.4-4 ( 1/6 )
CALCULATION OF CAPACITY-DEMAND RATIO OF SUBSTRUCTURE

# CAPACITY/DEMAND RATIO FOR GUADALUPE BRIDGE



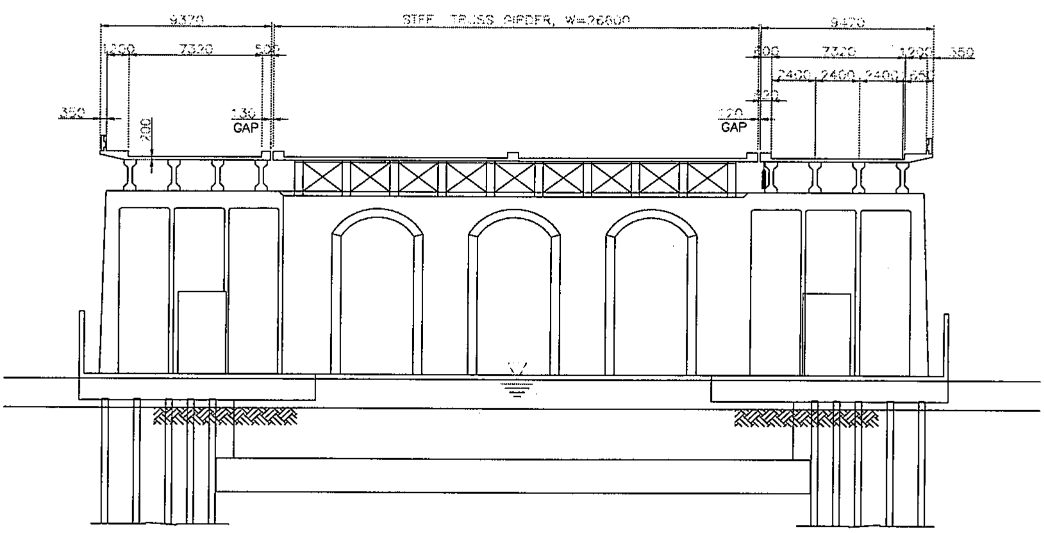

**Seismic Design Condition :**

| | | |
|---|---|---|
| Acceleration Coefficient, A | = | 0.22g |
| Seismic Performance Category, SPC | = | C |
| Importance Classification, IC (Essential Bridge) | = | I |
| Site Coefficient (Soil Profile Type II) | = | 1.20 |

| | Particular | | Longitudinal Direction | Transverse Direction | Unit |
|---|---|---|---|---|---|
| **Pier Walls 1 and 2** | Design Forces | $P_{max}$ | 7,751.58 | 7,808.05 | kN |
| | | $P_{min}$ | 7,698.70 | 7,642.23 | kN |
| | | $M_{DESIGN}$ | 17,840.16 | 11,247.73 | kN•m |
| | | $V_{DESIGN}$ | 3,146.64 | 2,543.78 | kN |
| | Number of Rebars | | 156 - ϕ25 | | |
| | Rebar Ratio | | 0.70% | | |
| | Flexural Capacity | $M_{CAPACITY}$ | 22,121.80 | 100,296.00 | kN•m |
| | C/D Ratio | | 1.24 | 8.92 | |
| | Displacement at Top of Column | | 57.47 | 56.00 | mm |
| **350mm x 350mm Precast Driven Pile** | Design Forces | $P_{max}$ | 7,751.58 | 7,890.94 | kN |
| | | $P_{min}$ | 7,698.70 | 7,559.34 | kN |
| | | $M_{DESIGN}$ | 27,184.26 | 42,866.00 | kN•m |
| | | $V_{DESIGN}$ | 6,291.65 | 5,087.00 | kN |
| | Number of Rebars | | NAD | | |
| | Rebar Ratio | | NAD | | |
| | Flexural Capacity | $M_{CAPACITY}$ | NAD | NAD | kN•m |
| | C/D Ratio | | | | |
| | Actual Pile Uplift | | 662.00 | 20.00 | kN |
| | Pile Uplift Capacity | | 301.00 | 301.00 | kN |
| | C/D Ratio | | 0.45 | 15.05 | |
| | Actual Pile Bearing | | 678.75 | 63.54 | kN |
| | Pile Bearing Capacity | | 805.00 | 805.00 | kN |
| | C/D Ratio | | 1.19 | 12.67 | |
| | Displacement at Top of Pile | | 31 | 21 | mm |

*NAD = No Available Data

# CAPACITY/DEMAND RATIO FOR GUADALUPE BRIDGE




**Seismic Design Condition :**

| | | |
|---|---|---|
| Acceleration Coefficient, A | = | 0.40 |
| Seismic Performance Category, SPC | = | D |
| Importance Classification, IC (Essential Bridge) | = | I |
| Site Coefficient (Soil Profile Type II) | = | 1.20 |

| | Particular | | Longitudinal Direction | Transverse Direction | Unit |
|---|---|---|---|---|---|
| **Pier Walls 1 and 2** | Design Forces | $P_{max}$ | 7,778.01 | 7,778.01 | kN |
| | | $P_{min}$ | 7,672.27 | 7,672.27 | kN |
| | | $M_{DESIGN}$ | 27,178.00 | 21,433.32 | kN•m |
| | | $V_{DESIGN}$ | 6,291.65 | 5,087.00 | kN |
| | Number of Rebars | | 156 - ϕ25 | | |
| | Rebar Ratio | | 0.70% | | |
| | Flexural Capacity | $M_{CAPACITY}$ | 23,222.00 | 105,750.00 | kN•m |
| | C/D Ratio | | 0.85 | 4.93 | |
| | Displacement at Top of Column | | 115 | 0.50 | mm |
| **350mm x 350mm Precast Driven Pile** | Design Forces | $P_{max}$ | 7,778.01 | 7,890.94 | kN |
| | | $P_{min}$ | 7,672.27 | 7,559.34 | kN |
| | | $M_{DESIGN}$ | 54,356.83 | 42,866.00 | kN•m |
| | | $V_{DESIGN}$ | 6,291.65 | 5,087.00 | kN |
| | Number of Rebars | | NAD | | |
| | Rebar Ratio | | NAD | | |
| | Flexural Capacity | $M_{CAPACITY}$ | NAD | NAD | kN•m |
| | C/D Ratio | | | | |
| | Actual Pile Uplift | | 1,348.00 | 56.00 | kN |
| | Pile Uplift Capacity | | 301.00 | 301.00 | kN |
| | C/D Ratio | | 0.22 | 5.38 | |
| | Actual Pile Bearing | | 1,330.00 | 102.00 | kN |
| | Pile Bearing Capacity | | 805.00 | 805.00 | kN |
| | C/D Ratio | | 0.61 | 7.89 | |
| | Displacement at Top of Pile | | 65 | 45 | mm |

*NAD = No Available Data

# ANALYSIS OF WALL-PIER MAIN REINFORCEMENT USING OLD CODE

## SEISMIC DESIGN CRITERIA

| | | |
|---|---|---|
| Acceleration Coefficient, A | = | 0.22 |
| Importance Classification, IC **(Essential Bridge)** | = | I (I or II) |
| Seismic Performance Category, SPC | = | C |
| Site Coefficient, S **(Soil Profile Type - II)** | = | 1.20 |

## ELASTIC SEISMIC FORCES

*From STAAD-III Multi-Modal Dynamic Analysis*

| LOADING | AXIAL (kN) | LONGITUDINAL DIRECTION SHEAR (kN) | LONGITUDINAL DIRECTION MOMENT (kN•m) | TRANSVERSE DIRECTION SHEAR (kN) | TRANSVERSE DIRECTION MOMENT (kN•m) |
|---|---|---|---|---|---|
| DEAD LOAD | 7,725.14 | 0.63 | 5.68 | 0.01 | 0.12 |
| LONG. EQ. | 1.72 | 3,054.21 | 26,427.30 | 21.21 | 179.70 |
| TRAN. EQ. | 82.39 | 20.88 | 181.48 | 2,358.25 | 19,786.04 |

***BOTTOM FORCES GOVERN***

## LOAD COMBINATION

Load Case 1 = 1.0 LONG. EQ. + 0.3 TRAN. EQ.
Load Case 2 = 0.3 LONG. EQ. + 1.0 TRAN. EQ.

| LOAD COMBINATION | AXIAL (kN) | LONGITUDINAL DIRECTION SHEAR (kN) | LONGITUDINAL DIRECTION MOMENT (kN•m) | TRANSVERSE DIRECTION SHEAR (kN) | TRANSVERSE DIRECTION MOMENT (kN•m) |
|---|---|---|---|---|---|
| Load Case 1 | 26.44 | 3,060.47 | 26,481.74 | 728.69 | 6,115.51 |
| Load Case 2 | 82.91 | 937.14 | 8,109.67 | 2,364.61 | 19,839.95 |

## GROUP LOADING OF DESIGN FORCES

Group Load = 1.0 (D + B + SF + E + EQ)

| LOAD COMBINATION | AXIAL Max (kN) | AXIAL Min (kN) | LONGITUDINAL DIRECTION SHEAR (kN) | LONGITUDINAL DIRECTION MOMENT (kN•m) | TRANSVERSE DIRECTION SHEAR (kN) | TRANSVERSE DIRECTION MOMENT (kN•m) |
|---|---|---|---|---|---|---|
| Load Case 1 | 7,751.58 | 7,698.70 | 3,061.10 | 26,487.42 | 728.70 | 6,115.63 |
| Load Case 2 | 7,808.05 | 7,642.23 | 937.77 | 8,115.35 | 2,364.62 | 19,840.07 |

## MODIFIED DESIGN FORCES

Group Load = 1.0 (D + EQ/R)
R = 1 (longitudinal direction)
R = 1 (transverse direction)

| LOAD COMBINATION | AXIAL Max (kN) | AXIAL Min (kN) | LONGITUDINAL DIRECTION SHEAR (kN) | LONGITUDINAL DIRECTION MOMENT (kN•m) | TRANSVERSE DIRECTION SHEAR (kN) | TRANSVERSE DIRECTION MOMENT (kN•m) |
|---|---|---|---|---|---|---|
| Load Case 1 | 7,751.58 | 7,698.70 | 3,061.10 | 26,487.42 | 728.70 | 6,115.63 |
| Load Case 2 | 7,808.05 | 7,642.23 | 937.77 | 8,115.35 | 2,364.62 | 19,840.07 |

***... MODIFIED DESIGN MOMENT OF Load Case 1 GOVERNS !***

## ELASTIC DESIGN FORCES

| | | | |
|---|---|---|---|
| $M_{DESIGN}$ | = | 27,184.27 | kN•m |
| $V_{DESIGN}$ | = | 3,146.64 | kN |
| $P_{max\ DESIGN}$ | = | 7,751.58 | kN |
| $P_{min\ DESIGN}$ | = | 7,698.70 | kN |

# DESIGN OF WALL-PIER MAIN REINFORCEMENT BARS

## MATERIAL SPECIFICATIONS

A) Concrete

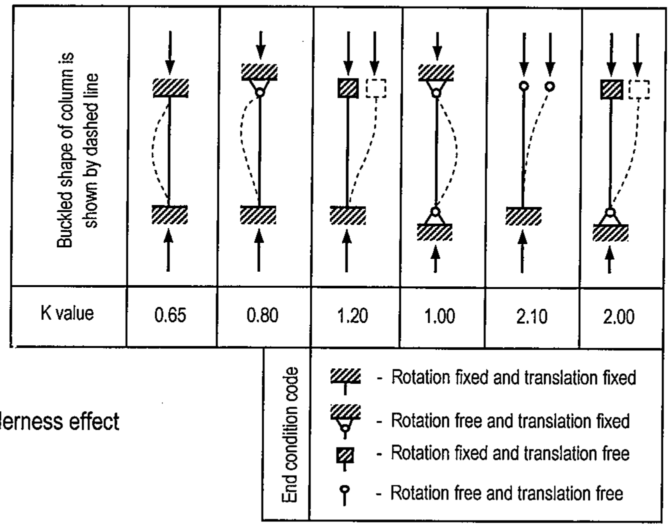
| | | |
|---|---|---|
| Compressive Strength of Concrete, $f'_c$ | = | 21.00 MPa |
| Modulus of Elasticity, $E_c$ = 4730 sqrt(f'( | = | 21,675.58 MPa |
| Concrete Cover, cc | = | 50 mm |

B) Reinforcing Steel

| | | |
|---|---|---|
| Tensile Strength, $f_y$ | = | 275.00 MPa |
| Modulus of Elasticity, $E_s$ | = | 200,000.00 MPa |
| Main Bar Diameter, $d_b$ | = | 25 mm |

## COLUMN PROPERTIES

| | | |
|---|---|---|
| Depth, D | = | 1.85 m |
| Unsupported Length, $L_u$ | = | 9.15 m |
| Clear Height, H | = | 8.15 m |
| Gross Area, $A_g = \pi D^2/4$ | = | 11.46 $m^2$ |
| Core Area, $A_c = \pi D_c^2/4$ | = | 9.74 $m^2$ |
| Moment of Inertia, $I_g = \pi D^4/64$ | = | 4.42 $m^4$ |
| Radius of Gyration, r = sqrt($I_g/A_g$) | = | 0.62 m |
| Effective Length Factor, k | = | 1.20 |




## SLENDERNESS EFFECT

a) 22.00 < $kL_u / r$ < 100.00
   22.00 > 17.68 < 100.00 ... neglect slenderness effect

b) $L_u / r$ < 35 / sqrt[$P_u$ / ($f'_c A_g$)]
   14.73 < 195.02

## MOMENT MAGNIFICATION

| | | |
|---|---|---|
| Maximum Dead Load Moment, $M_{DL}$ | = | 5.68 kN•m |
| Maximum Total Load Moment, $M_{max}$ | = | 27,184.27 kN•m |
| Ratio $\beta_d = M_{DL} / M_{max}$ | = | 0.00 |
| Flexural Stiffnes of Column, $EI = (E_c I_g/2.5)/(1+\beta_d)$ | = | 38,314.42 MN•m² |
| Factored Axial Load, $P_u = P_{max}$ | = | 7,751.58 kN |
| Buckling Load, $P_c = \pi^2 EI / (kL_u)^2$ | = | 3,136,587.16 kN |
| Spiral as Lateral Reinforcement, $\phi$ | = | 0.75 |
| Moment Magnification Factor not braced against sidesway, $\delta_s = 1 / [1-(\Sigma P_u / \phi \Sigma P_c)]$ | = | 1.00 $\geq$ 1.00 |
| Magnified Design Moment, $Mc = \delta_s M_{max}$ | = | 27,184.27 kN•m |

## MODIFIED STRENGTH REDUCTION FACTOR $\phi$

| | | |
|---|---|---|
| Maximum Axial Stress, $\sigma_{Pmax} = P_{max} / A_c$ | = | 795.85 kPa |
| 20% of Compressive Strength of Concrete, $0.20f'_c$ | = | 4,200.00 kPa |
| Approximate Balanced Axial Load, $\phi P_b = 0.20f'_c \cdot A_c$ | = | 40,908.00 kN |
| Modified Strength Reduction Factor, $\phi = 0.90 - 0.40 [\sigma_{Pmax} / (0.20f'_c)] \geq 0.50$ | = | 0.824 |

## MAGNIFIED ELASTIC DESIGN FORCES

| | | | |
|---|---|---|---|
| $M_{DESIGN}$ | = | 27184.27 | kN•m |
| $P_{max\ DESIGN}$ | = | 7751.58 | kN |
| $P_{min\ DESIGN}$ | = | 7698.70 | kN |

****** DESIGN COLUMN USING PCACOL PROGRAM ...***
****** NOTE : 0.01 < $A_s / A_g$ < 0.06***

## ULTIMATE (Nominal) DESIGN FORCES FOR COLUMN

| | | | |
|---|---|---|---|
| $M_{ULTIMATE}$ | = | 32982.42 | kN•m |
| $P_{max\ ULTIMATE}$ | = | 9404.92 | kN |
| $P_{min\ ULTIMATE}$ | = | 9340.76 | kN |

****** INVESTIGATE COLUMN PLASTIC CAPACITY FROM PCACOL INTERACTION DIAGRAM...***

## FORCES RESULTING FROM PLASTIC HINGING

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $P_{max\ DESIGN}$ | = | 7751.58 | kN | | $M_{NOMINAL\ CAPACITY}$ | = | 3265.40 | kN•m |
| $M_{PLASTIC}$ | = | 4245.02 | kN•m | < | $M_{ELASTIC}$ | = | 27184.27 | kN•m |

*Along Longitudinal Direction :*

| | | | |
|---|---|---|---|
| $V_{PLASTIC}$ | = | 463.94 | kN |
| $P_{max\ PLASTIC}$ | = | 7751.58 | kN |
| $P_{min\ PLASTIC}$ | = | 7698.70 | kN |

*Along Transverse Direction :*

| | | | |
|---|---|---|---|
| $V_{PLASTIC}$ | = | 1443.18 | kN |
| $P_{max\ PLASTIC}$ | = | 3903.84 | kN |
| $P_{min\ PLASTIC}$ | = | -201.06 | kN |

```
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=================================================================
Computer program for the Strength Design of Reinforced Concrete Sections
=================================================================

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General Information:
====================

File Name: C:\MSNAVAL\PASIG~~3\REPORT\GUADAL~1\APPENDIX\GUACOL.COL
Project: Guadalupe Bridge
Column: Pier Column — Engineer:
Code: ACI 318-95 — Units: Metric

Run Option: Investigation — Slenderness: Not considered
Run Axis: Biaxial — Column Type: Structural

Material Properties:
====================

f'c = 21 MPa — fy = 275 MPa
Ec = 21538.1 MPa — Es = 200000 MPa
fc = 17.85 MPa — Rupture strain = Infinity
Ultimate strain = 0.003 mm/mm
Beta1 = 0.85

Section:
========

Exterior Points

| No. | X (mm) | Y (mm) | No. | X (mm) | Y (mm) | No. | X (mm) | Y (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 4680 | 925 | 2 | -3542 | 925 | 3 | -3781 | 893 |
| 4 | -4004 | 801 | 5 | -4196 | 654 | 6 | -4343 | 463 |
| 7 | -4435 | 239 | 8 | -4467 | 0 | 9 | -4435 | -239 |
| 10 | -4343 | -463 | 11 | -4196 | -654 | 12 | -4004 | -801 |
| 13 | -3781 | -893 | 14 | -3542 | -925 | 15 | 4680 | -925 |

Interior Points

| No. | X (mm) | Y (mm) | No. | X (mm) | Y (mm) | No. | X (mm) | Y (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 4416 | 250 | 2 | 4316 | 350 | 3 | 2016 | 350 |
| 4 | 1916 | 250 | 5 | 1916 | 50 | 6 | 1616 | 50 |
| 7 | 1616 | 250 | 8 | 1516 | 350 | 9 | -642 | 350 |
| 10 | -742 | 250 | 11 | -742 | 50 | 12 | -1042 | 50 |
| 13 | -1042 | 250 | 14 | -1142 | 350 | 15 | -3442 | 350 |
| 16 | -3542 | 250 | 17 | -3542 | -250 | 18 | -3442 | -350 |
| 19 | -1142 | -350 | 20 | -1042 | -250 | 21 | -1042 | -50 |
| 22 | -742 | -50 | 23 | -742 | -250 | 24 | -642 | -350 |
| 25 | 1516 | -350 | 26 | 1616 | -250 | 27 | 1616 | -50 |
| 28 | 1916 | -50 | 29 | 1916 | -250 | 30 | 2016 | -350 |
| 31 | 4316 | -350 | 32 | 4416 | -250 | | | |

Gross section area, Ag = 1.13888e+007 mm^2
Ix = 4.41489e+012 mm^4 — Iy = 8.17555e+013 mm^4
Xo = 103.904 mm — Yo = 2.19514e-007 mm

Reinforcement:
==============

Rebar Database: ASTM A615

| Size | Diam (mm) | Area (mm^2) | Size | Diam (mm) | Area (mm^2) | Size | Diam (mm) | Area (mm^2) |
|---|---|---|---|---|---|---|---|---|
| # 3 | 10 | 71 | # 4 | 13 | 129 | # 5 | 16 | 200 |
| # 6 | 19 | 284 | # 7 | 22 | 387 | # 8 | 25 | 510 |
| # 9 | 29 | 645 | # 10 | 32 | 819 | # 11 | 36 | 1006 |
| # 14 | 43 | 1452 | # 18 | 57 | 2581 | | | |

Confinement: User-defined; #3 ties with #10 bars, #3 with larger bars.
phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.824

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Pattern: Irregular
Total steel area, As = 78560 mm^2 at 0.69%

| Area mm^2 | X (mm) | Y (mm) | Area mm^2 | X (mm) | Y (mm) | Area mm^2 | X (mm) | Y (mm) |
|---|---|---|---|---|---|---|---|---|
| 491 | -967 | -141 | 491 | -816 | -141 | 491 | 1842 | -141 |
| 491 | 1691 | -141 | 491 | 4606 | -141 | 491 | 4491 | -141 |
| 491 | 4548 | -141 | 491 | 4548 | 144 | 491 | 4491 | 144 |
| 491 | 4606 | 144 | 491 | 1691 | 144 | 491 | 1842 | 144 |
| 491 | -816 | 144 | 491 | -967 | 144 | 491 | -4375 | -141 |
| 491 | -4375 | 144 | 491 | -4106 | -141 | 491 | -4106 | 144 |
| 491 | -3616 | -141 | 491 | -3616 | 144 | 491 | -3878 | -141 |
| 491 | -3878 | 144 | 491 | 4606 | -849 | 491 | 4491 | -849 |
| 491 | 4548 | -849 | 491 | 4548 | -423 | 491 | 4491 | -423 |
| 491 | 4606 | -423 | 491 | 1842 | -849 | 491 | 1691 | -849 |
| 491 | 1691 | -423 | 491 | 1842 | -423 | 491 | 2136 | -849 |
| 491 | 2431 | -849 | 491 | 2725 | -849 | 491 | 3019 | -849 |
| 491 | 2725 | -849 | 491 | 3314 | -849 | 491 | 3608 | -849 |
| 491 | 3902 | -849 | 491 | 4197 | -849 | 491 | 4197 | -423 |
| 491 | 3902 | -423 | 491 | 3608 | -423 | 491 | 3314 | -423 |
| 491 | 2725 | -423 | 491 | 3019 | -423 | 491 | 2725 | -423 |
| 491 | 2431 | -423 | 491 | 2136 | -423 | 491 | -816 | -423 |
| 491 | -967 | -423 | 491 | -967 | -849 | 491 | -816 | -849 |
| 491 | -503 | -849 | 491 | -189 | -849 | 491 | 124 | -849 |
| 491 | 437 | -849 | 491 | 751 | -849 | 491 | 1064 | -849 |
| 491 | 1377 | -849 | 491 | 1377 | -423 | 491 | 1064 | -423 |
| 491 | 751 | -423 | 491 | 437 | -423 | 491 | 124 | -423 |
| 491 | -189 | -423 | 491 | -503 | -423 | 491 | -3616 | -846 |
| 491 | -1261 | -849 | 491 | -1556 | -849 | 491 | -1850 | -848 |
| 491 | -2144 | -848 | 491 | -2439 | -848 | 491 | -2733 | -847 |
| 491 | -3027 | -847 | 491 | -3322 | -846 | 491 | -3322 | -426 |
| 491 | -3027 | -426 | 491 | -2733 | -426 | 491 | -2439 | -425 |
| 491 | -2144 | -425 | 491 | -1850 | -424 | 491 | -1556 | -424 |
| 491 | -1261 | -424 | 491 | -4277 | -426 | 491 | -4106 | -635 |
| 491 | -3878 | -780 | 491 | -3616 | -426 | 491 | -3878 | -426 |
| 491 | -4106 | -426 | 491 | -4106 | 429 | 491 | -3878 | 429 |
| 491 | -3616 | 429 | 491 | -3878 | 782 | 491 | -4106 | 637 |
| 491 | -4277 | 429 | 491 | -1261 | 426 | 491 | -1556 | 426 |
| 491 | -1850 | 427 | 491 | -2144 | 427 | 491 | -2439 | 427 |
| 491 | -2733 | 428 | 491 | -3027 | 428 | 491 | -3322 | 429 |
| 491 | -3322 | 849 | 491 | -3027 | 849 | 491 | -2733 | 849 |
| 491 | -2439 | 850 | 491 | -2144 | 850 | 491 | -1850 | 851 |
| 491 | -1556 | 851 | 491 | -1261 | 851 | 491 | -3616 | 848 |
| 491 | -503 | 426 | 491 | -189 | 426 | 491 | 124 | 426 |
| 491 | 437 | 426 | 491 | 751 | 426 | 491 | 1064 | 426 |
| 491 | 1377 | 426 | 491 | 1377 | 852 | 491 | 1064 | 852 |
| 491 | 751 | 852 | 491 | 437 | 852 | 491 | 124 | 852 |
| 491 | -189 | 852 | 491 | -503 | 852 | 491 | -816 | 852 |
| 491 | -967 | 852 | 491 | -967 | 426 | 491 | -816 | 426 |
| 491 | 2136 | 426 | 491 | 2431 | 426 | 491 | 2725 | 426 |
| 491 | 3019 | 426 | 491 | 2725 | 426 | 491 | 3314 | 426 |
| 491 | 3608 | 426 | 491 | 3902 | 426 | 491 | 4197 | 426 |
| 491 | 4197 | 852 | 491 | 3902 | 852 | 491 | 3608 | 852 |
| 491 | 3314 | 852 | 491 | 2725 | 852 | 491 | 3019 | 852 |
| 491 | 2725 | 852 | 491 | 2431 | 852 | 491 | 2136 | 852 |
| 491 | 1842 | 426 | 491 | 1691 | 426 | 491 | 1691 | 852 |
| 491 | 1842 | 852 | 491 | 4606 | 426 | 491 | 4491 | 426 |
| 491 | 4548 | 426 | 491 | 4548 | 852 | 491 | 4491 | 852 |
| 491 | 4606 | 852 | | | | | | |

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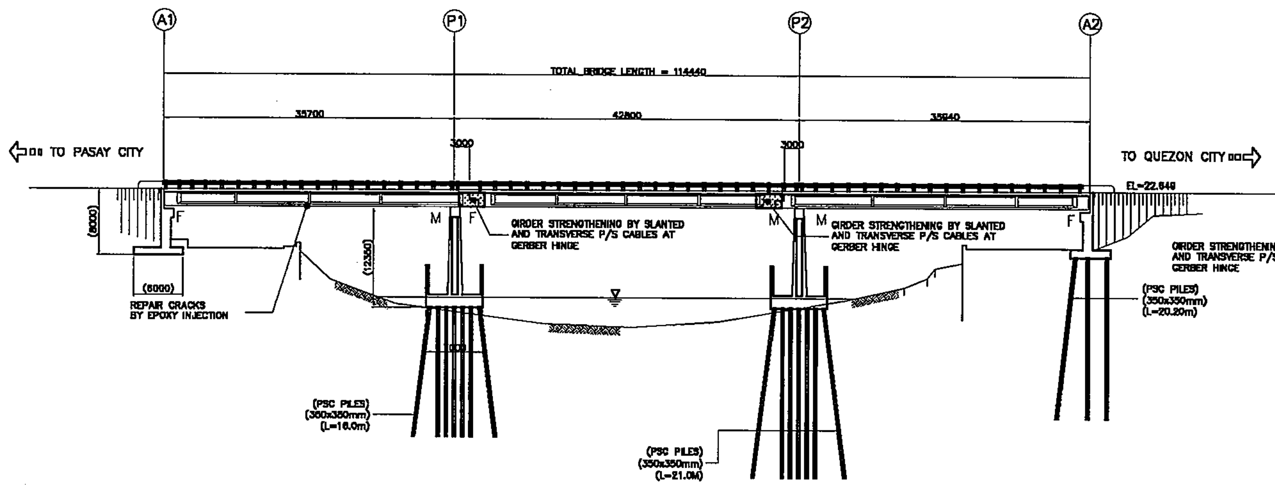
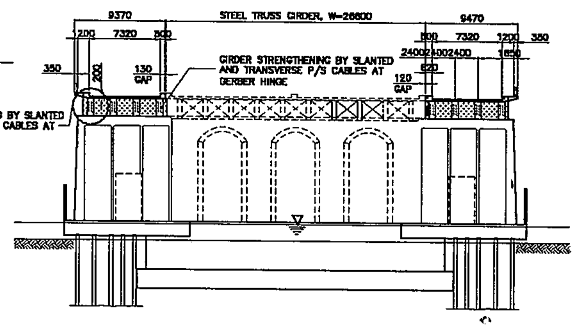
Factored Loads and Moments with Corresponding Capacities: (see user's manual for notation)

| No. | Pu kN | Mux kN-m | Muy kN-m | fMnx kN-m | fMny kN-m | fMn/Mu |
|---|---|---|---|---|---|---|
| 1 | 9439.9 | 32985.3 | 0.0 | 23927.1 | 28.0 | 0.725 |
| 2 | 9311.5 | 32985.3 | 0.0 | 23835.5 | -32.1 | 0.723 |
| 3 | 9439.9 | 0.0 | 0.0 | 23927.1 | 28.0 | 999.999 |
| 4 | 7751.6 | 13594.9 | 0.0 | 22719.3 | 31.7 | 1.671 |
| 5 | 7698.7 | 13594.9 | 0.0 | 22680.5 | -20.7 | 1.668 |
| 6 | 7751.6 | 0.0 | 0.0 | 22719.3 | 31.7 | 999.999 |

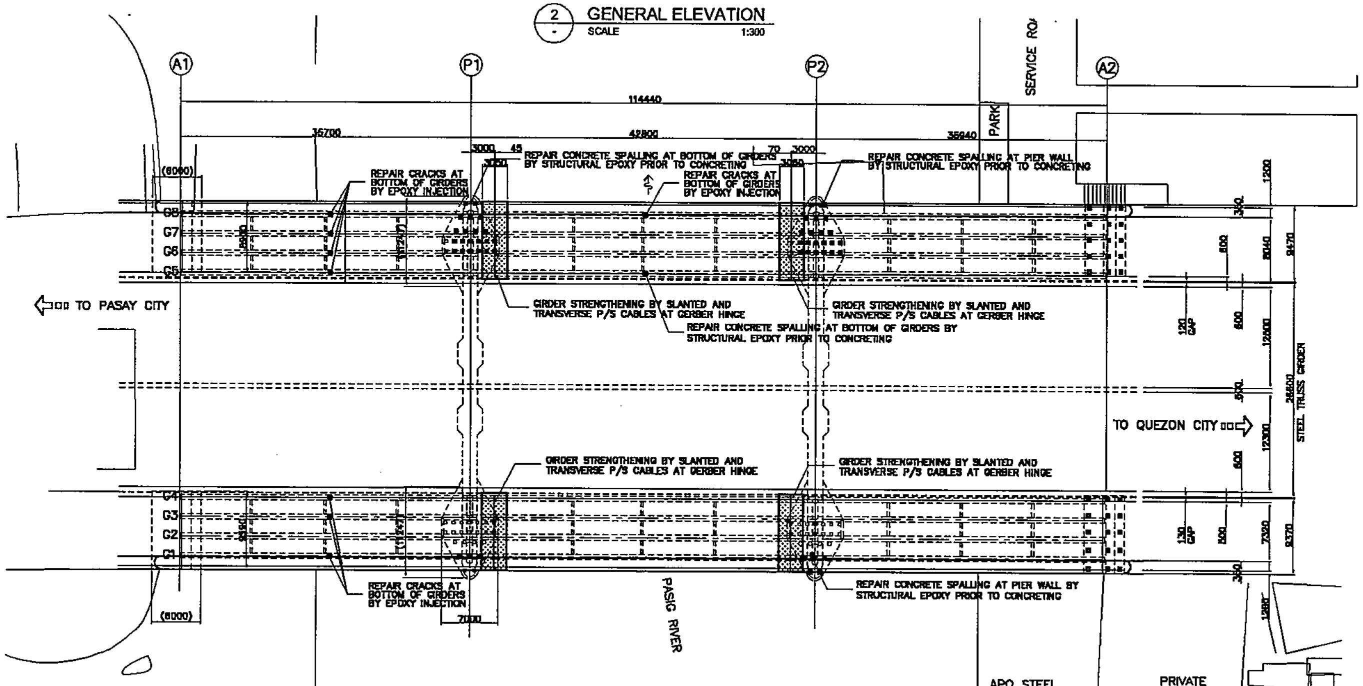
*** Program completed as requested! ***




2 GENERAL ELEVATION SCALE 1:300




3 CROSS SECTION @ PIER P1 SCALE 1:250




1 GENERAL PLAN SCALE 1:300

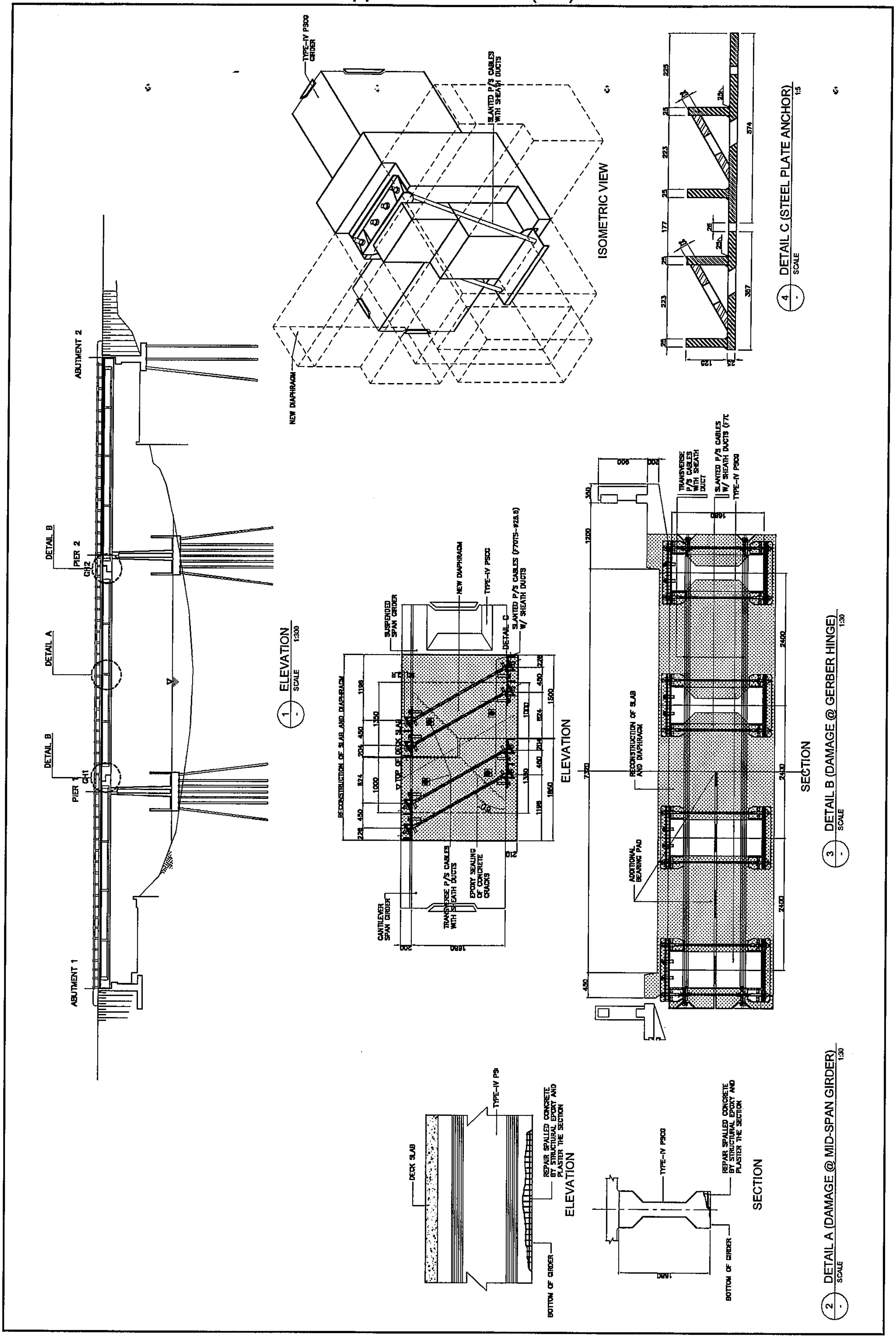
## SCOPE OF WORK

- REPAIR AND SEALING OF CONCRETE CRACKS, HONEYCOMB AND SPALLING.
- REHABILITATIONOF GERBER HINGE PORTION WITH SLANTED P/S CABLES.
- RECONSTRUCTION OF DIAPHRAGM AND PARTIAL RECONSTRUCTION OF DECK SLAB AT GERBER HINGE PORTION.
- ADDITIONAL ELASTOMERIC BEARING PADS AT DIAPHRAGM.
- INSTALLATION OF TRANSVERSE P/S CABLES AT DIAPHRAGM OF GERBER GERBER HINGE PORTION.

QUANTITY ESTIMATE

| ITEM NO. | DESCRIPTION | UNIT | QUANTITY |
|---|---|---|---|
| 1 | Epoxy Injection | l.s. | 1.00 |
| 2 | Replacement of New Concrete (Spalling w/ Exposed Rebars) | cu.m. | 30.00 |
| 3 | Removal of Concrete Slab | sq.m. | 83.00 |
| 4 | Removal of Concrete Diaphragm | sq.m. | 24.00 |
| 5 | Tack Coat | ton | 1.00 |
| 6 | Asphalt | ton | 9.00 |
| 7 | Structural Concrete for Slab | cu.m. | 16.00 |
| 8 | Structural Concrete for New Diaphragm | cu.m. | 117.00 |
| 9 | Reinforcing Steel Bars | kgs | 21,065.00 |
| 10 | Formworks | sq.m. | 201.00 |
| 11 | Prestressing Cables | kgs | 2,491.00 |
| | Reconstruction of Fender | l.m. | 13.00 |
| | Removal of Concrete Railing/Post | l.m. | 12.00 |
| | New Concrete Railing/Post | l.m. | 12.00 |
| | New Concrete Railing | l.m. | 3.00 |
| | New Concrete Post | each | 1.00 |
| | New Concrete Sidewalk | sq.m. | 2.00 |
| 12 | Gondola Falsework | l.s. | 1.00 |
| 13 | Traffic Management | l.s. | 1.00 |
| | Contingencies | l.s. | 1.00 |
| | Temporary Facilities | l.s. | 1.00 |
| | Mobilization/demobilization | l.s. | 1.00 |

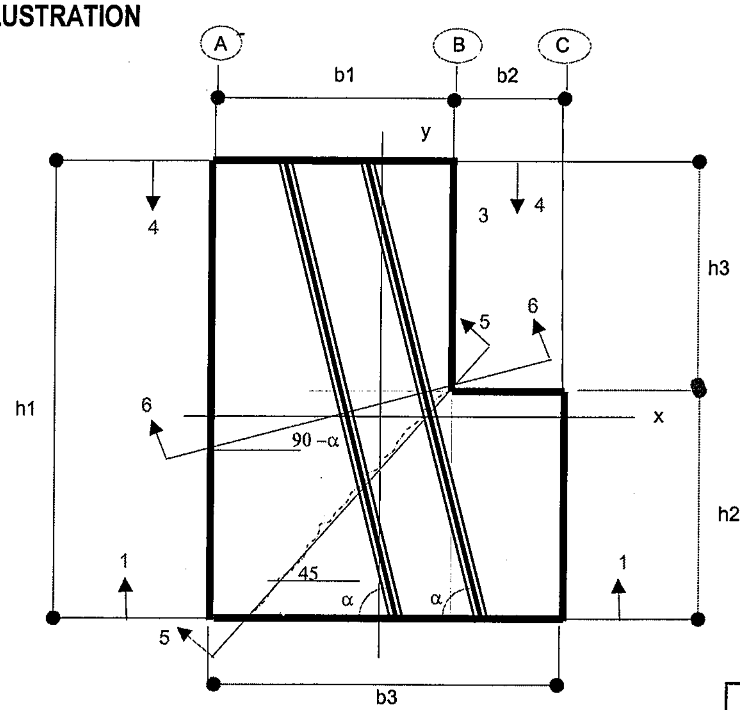
DRAWINGS DETAILS FOR REHABILITATION (GUADALUPE BRIDGE)



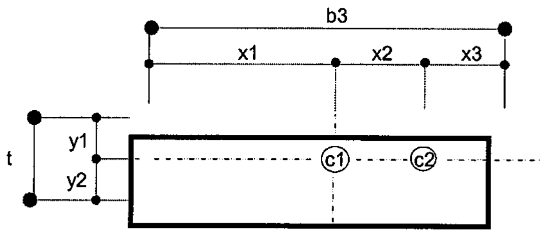

DRAWING DETAILS FOR REHABILITATION (GUADALUPE BRIDGE)

## ILLUSTRATION

**SECTION 5-6**

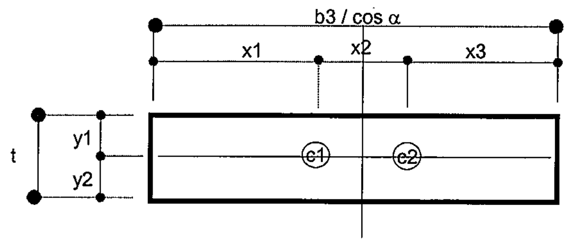



| | | |
|---|---|---|
| b1 = | 1.50 | m |
| b2 = | 0.35 | m |
| b3 = | 1.85 | m |
| h1 = | 1.68 | m |
| h2 = | 0.84 | m |
| h3 = | 0.84 | m |
| α = | 60.00 | deg |




SECTION

| Section | 1 | 4 | Unit |
|---|---|---|---|
| t = | 0.300 | 0.300 | m |
| y1 = | 0.150 | 0.150 | m |
| y2 = | 0.150 | 0.150 | m |
| x1 = | 1.100 | 0.130 | m |
| x2 = | 0.400 | 0.400 | m |
| x3 = | 0.150 | 0.770 | m |
| b3 or b1= | 1.650 | 1.300 | m |




SECTION

| Section | 5 | 6 | Unit |
|---|---|---|---|
| t = | 0.300 | 0.300 | m |
| y1 = | 0.150 | 0.150 | m |
| y2 = | 0.150 | 0.150 | m |
| x1 = | 0.556 | 0.918 | m |
| x2 = | 0.359 | 0.346 | m |
| x3 = | 0.245 | 0.237 | m |
| base, b = | 1.160 | 1.501 | m |

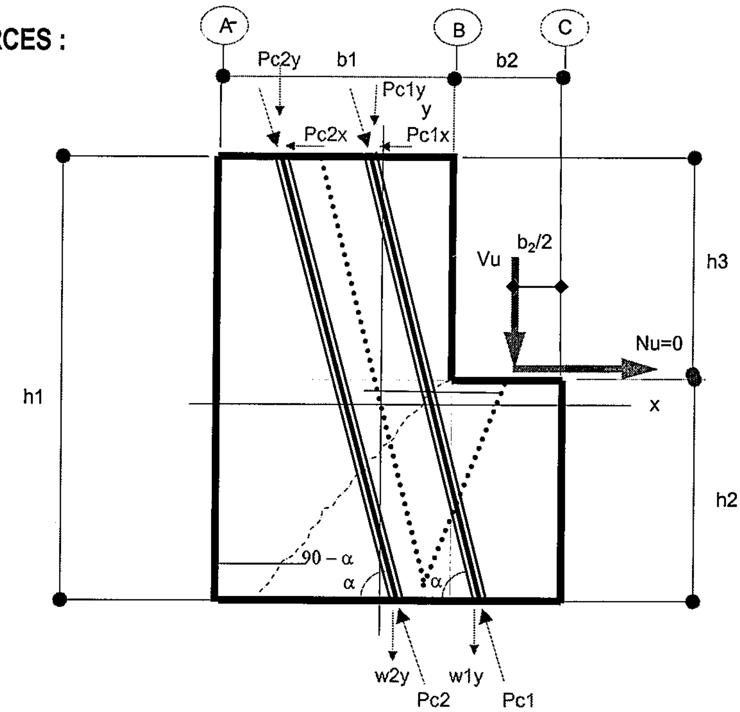
## SECTION PROPERTIES

| Section | 1 | 5 | 6 | 4 | Unit |
|---|---|---|---|---|---|
| Area, A | 0.495 | 0.348 | 0.450 | 0.390 | m² |
| Dist. from N.A. to edge a, Xa = | 0.825 | 0.580 | 0.751 | 0.650 | m |
| Dist. from N.A. to edge c, Xc = | 0.825 | 0.580 | 0.751 | 0.650 | m |
| Moment of Inertia, I = t * b^3/12 | 0.112 | 0.039 | 0.085 | 0.055 | $m^4$ |
| Section modulus @ a, Sa | 0.136 | 0.067 | 0.113 | 0.085 | m³ |
| Section modulus @ c, $S_c$ | 0.136 | 0.067 | 0.113 | 0.085 | m³ |

## MATERIAL SPECIFICATIONS

| | | | |
|---|---|---|---|
| Compressive strength of concrete : | | | |
| at time of initial prestress, f'ci | = | 22.40 | Mpa |
| at 28th day, $f'_c$ | = | 28.00 | Mpa |
| Ultimate strength of HTS, $f'_s$ | = | 1860.00 | Mpa |
| Elastic modulus of HTS, $E_S$ | = | 195000 | Mpa |
| Nominal area of HTS, $A_{ps}$ | = | 383.90 | mm² |
| Jacking stress, $0.70f'_s$ | = | 1302.00 | Mpa |
| Number of HTS, N | = | 1 | pcs |
| .70Pu | = | 499.84 | kN |
| Total number of Prestressing steel = | | 4 | pcs |

**FORCES :**




| Section | 1 | 5 | 6 | 4 | Unit |
|---|---|---|---|---|---|
| Shear reaction due to Dead Load, Wy = | 848.22 | 848.22 | 848.22 | 848.22 | kN |
| Shear reaction due to Live Load, Vll = | 188.38 | 188.38 | 188.38 | 188.38 | kN |
| Impact = (15.21 / 38.1 + L) = | 0.19 | 0.19 | 0.19 | 0.19 | |
| Wylocal = sin( 90-α ) * Wy due to DL | 734.58 | 734.58 | 734.58 | 734.58 | kN |
| Wxlocal = cos(90-α) * Wy due to DL | 424.11 | 424.11 | 424.11 | 424.11 | kN |
| Wylocal = sin( 90-α ) * Wy due to DL+LL+i | 928.39 | 928.39 | 928.39 | 928.39 | kN |
| Wxlocal = cos(90-α) * Wy due to DL+LL+i | 536.01 | 536.01 | 536.01 | 536.01 | kN |
| Effective 0.70Pu | 432.87 | 499.84 | 499.84 | 432.87 | kN |

Assumption :

1) Shear,V are carried equally by the oblique prestress cables since spacing is not far apart.
2) Favorable effects of internal prestress tendon in the girders are neglected.
3) Horizontal force, Nu is neglected due to cable restrainer/or slab made continuous, preventing the horizontal force from developing.

## ACTUAL ECCENTRICITY "e"

| Section | 1 | 5 | 6 | 4 | No. of HTS |
|---|---|---|---|---|---|
| Distance of c.g. of C1 from edge c = | 550 mm | 604 mm | 583 mm | 1170 mm | 1 |
| Distance of c.g. of C2 from edge c = | 150 mm | 245 mm | 237 mm | 770 mm | 1 |
| Ya of strands | 350 mm | 425 mm | 410 mm | 970 mm | Total = 2 |
| Eccentricity "e" | 475 mm | 156 mm | 341 mm | -320 mm | |

## LOSSES

### A) Friction and Anchorage Draw-In

| Section | 1 | 5 | 6 | 4 | Unit |
|---|---|---|---|---|---|
| Loss due to friction and anchorage draw-in, FS | 0.00 | 0.00 | 0.00 | 0.00 | Mpa |

Note :

-Live End device using SEE (Screw type).

-Tendon profile is straight.

### B) Elastic Shortening, ES

$$ES = \frac{0.50E_s f_{cir}}{E_{ci}}$$

where : $f_{cir}$ = Concrete stress at the center of gravity of the prestressing steel due to prestressing force and dead load of beam immediately after transfer, in mpa.

| Section | 1 | 5 | 6 | 4 | Unit |
|---|---|---|---|---|---|
| Eci, modulus of elasticity of concrete in mpa at transfer = | 22386.45 | 22386.45 | 22386.45 | 22386.45 | Mpa |
| Concrete stress, $f_{cir}$ | 3.49 | 3.49 | 3.59 | 3.83 | Mpa |
| Loss due to elastic shortening, ES | 15.19 | 15.21 | 15.64 | 16.70 | Mpa |

**C) Concrete Shrinkage, SH**

Mean annual ambient relative humidity in percent, RH = 80.00 %
Loss due to concrete shrinkage, SH = 0.80(117-1.03RH)
= 92.94 Mpa

**D) Creep of Concrete, $CR_C$**

$CR_C = 12f_{cir} - 7f_{cds}$

where : $f_{cds}$ = Concrete stress at center of gravity of the prestressing steel due to all dead loads except the dead load present at the time the prestressing force is applied, in Mpa.

| Section | 1 | 2 | 6 | 4 | Unit |
|---|---|---|---|---|---|
| Moment due to dead load (w/o beam weight) | 0.00 | 0.00 | 0.00 | 0.00 | kN-m |
| Concrete stress, $f_{cds}$ | 0.00 | 3.03 | 0.00 | 0.00 | Mpa |
| Loss due to creep of concrete, $CR_C$ | 41.86 | 20.71 | 43.09 | 46.01 | Mpa |

**E) Relaxation of Prestressing Steel, $CR_S$**

$CR_S = 138 - 0.30FR - 0.40ES - 0.20(SH+CR_C)$ *... for stress relieved strands*

| Section | 1 | 5 | 6 | 4 | Unit |
|---|---|---|---|---|---|
| Loss due to relaxation of prestressing steel, $CR_S$ | 104.96 | 109.19 | 104.54 | 103.53 | Mpa |

**F) Effective Prestress at Initial and Final Condition**

| Section | 1 | 5 | 6 | 4 | Unit |
|---|---|---|---|---|---|
| Initial losses, FR + ES | 15.19 | 15.21 | 15.64 | 16.70 | Mpa |
| **Effective prestress at initial condition** | **1286.81** | **1286.79** | **1286.36** | **1285.30** | **Mpa** |
| Final losses, FR + ES + SH + $CR_C$ + $CR_S$ | 254.96 | 238.04 | 163.27 | 166.24 | Mpa |
| **Effective prestress at final condition** | **1047.04** | **1063.96** | **1138.73** | **1135.76** | **Mpa** |

## CHECK STRESSES

**A) Only Prestress Force Acting.**

| Section | 1 | | 5 | | 6 | | 4 | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| Number of strands, N | 2 | | 2 | | 2 | | 2 | | pcs. |
| Effective jacking force @ intial condition, Pj | 855.64 | | 988.00 | | 987.67 | | 854.64 | | kN |
| Eccentricity, e | 0.475 | | 0.156 | | 0.341 | | -0.320 | | m |
| Stress at edge c, f c | 4.71 | C | 5.12 | C | 5.18 | C | -1.05 | T | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |
| Stress at edge a, f a | -1.26 | T | 0.87 | C | -0.79 | T | 5.43 | C | Mpa |
| Remarks | not safe | | safe! | | safe! | | safe! | | |

Allowable stresses : Compression = $0.55f'_{ci}$ = 12.32 Mpa
Tension = 1.40 Mpa or $0.25(f'_{ci})^{½}$ = -1.18 Mpa

**B) If All DL is Acting.**

| Section | 1 | | 5 | | 6 | | 4 | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| Axial Force due to dead load | -424.11 | | -367.29 | | -367.29 | | -424.11 | | kN |
| Number of strands, N | 2 | | 2 | | 2 | | 2 | | pcs. |
| Effective jacking force, Pj | 696.22 | | 816.90 | | 874.32 | | 755.21 | | kN |
| Eccentricity, e | 0.475 | | 0.156 | | 0.341 | | -0.320 | | m |
| Stress at edge c, f c | 1.50 | C | 2.33 | C | 2.66 | C | -0.40 | T | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |
| Stress at edge a, f a | -0.40 | T | 0.25 | C | -0.41 | T | 2.10 | C | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |

Allowable stresses : Compression = $0.40f'_c$ = 11.20 Mpa
Tension = $.50*( fc' )^{.5}$ = -2.65 Mpa

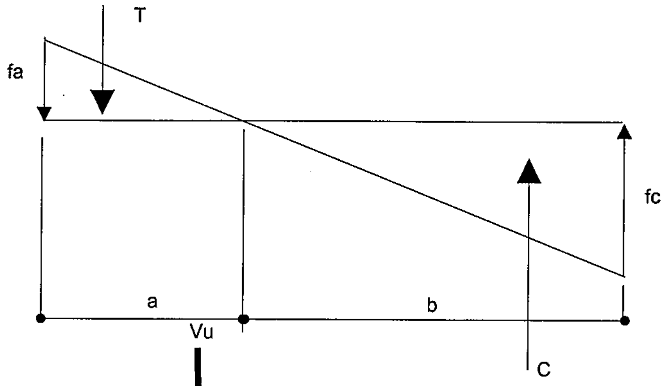
**C) Due to All Dead Load and Live Load Plus Impact (Service Condition)**

| Section | 1 | | 5 | | 6 | | 4 | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| Axial Force due to DL + LL+i | -518.30 | | -268.00 | | -268.00 | | -518.30 | | kN |
| Number of strands, N | 2 | | 2 | | 2 | | 2 | | pcs |
| Effective jacking force, Pj | 696.22 | | 816.90 | | 874.32 | | 755.21 | | kN |
| Eccentricity, e | 0.475 | | 0.156 | | 0.341 | | -0.320 | | m |
| Stress at edge c, f c | 0.980 | C | 2.846 | C | 3.179 | C | -0.290 | T | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |
| Stress at edge a, f a | -0.26 | T | 0.31 | C | -0.49 | T | 1.50 | C | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |

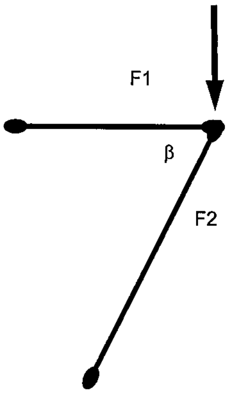
Allowable stresses : Compression = $0.40f'_c$ = 11.20 Mpa

Tension = $.50*(fc')^{.5}$ = -2.65 Mpa

**Reinforcement Bars :**



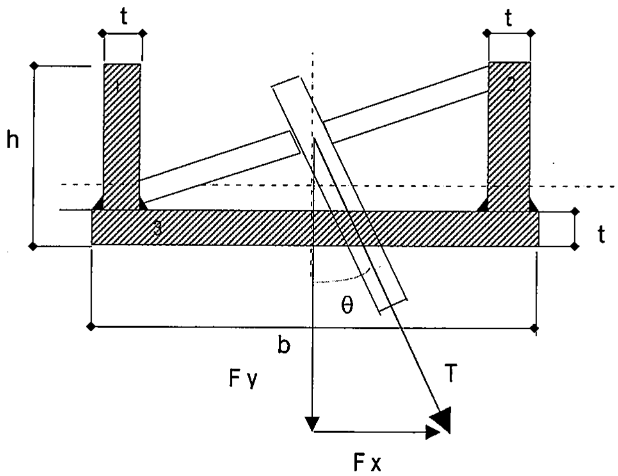

t = 0.30 m
a+b = 1.500 m
fa = 1.260 mpa
fc = 4.710 mpa
b = 1.183 m
a = 0.317 m
T = 59.83 kN
Fy = 414 mpa
As = T / .90 * Fy ;
As = 160.6 mm2
provide = 1 - 16 ; Ap = 201.0619 $mm^2$
cos ( 90 - $\alpha$ ) * T = 64.88 kN O.K!




$F_2$ = Vu * sin β ; $F_2$ = 1541.363 kN
$F_1$ = Vu / tan β ; $F_1$ = 396.07 kN ; As = F1 / (.90 * Fy)
β = 76 deg    Fy = 414 mpa
Vu = 1588.55 kN    As = 1062.99 $mm^2$
provide = 1 - 36 ; Ap = 1017.876 $mm^2$

**Dimension & Material Properties of steel channel anchorage::**

Specified minimum yield stress of structural steel, Fy = 245 mpa



# ANALYSIS OF GERBER HINGE REHABILITATION - GUADALUPE BRIDGE

| element | t (mm) | h (mm) | Area (mm2) | y (mm) | A*y (mm3) | Ix = bh3/3 (mm4) | A(Y-y)2 (mm4) |
|---|---|---|---|---|---|---|---|
| 1 | 22 | 125 | 2750 | 62.5 | 171875 | 14322916.67 | 1236645.978 |
| 2 | 22 | 125 | 2750 | 62.5 | 171875 | 14322916.67 | 1236645.978 |
| 3 | 22 | 175 | 3850 | 11 | 42350 | 621133.3333 | 3533274.221 |
| | | | 9350 | | 386100 | 29266966.67 | 6006566.176 |

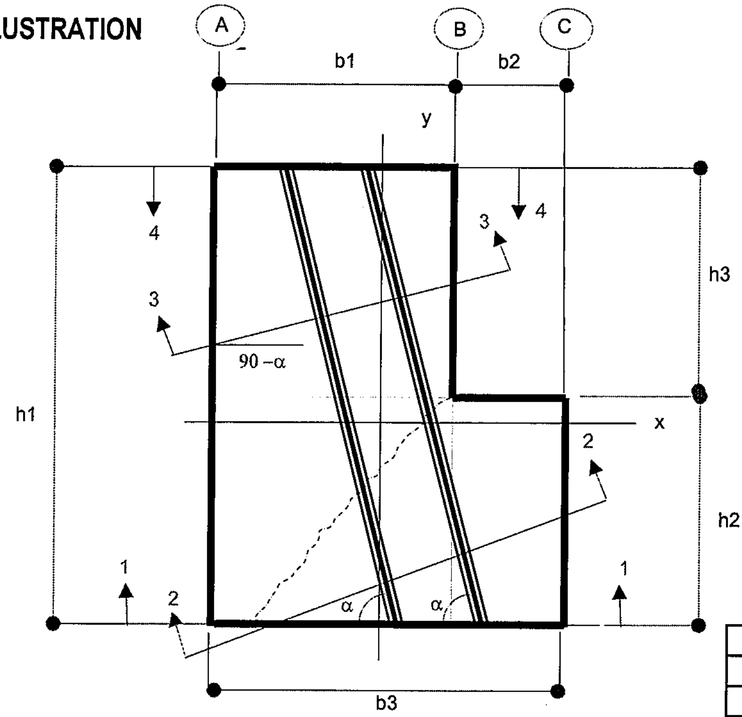
| | | |
|---|---|---|
| Y = | 41.29 | mm |
| Ix = | 35273532.84 | $mm^4$ |
| Sx = | 854202.36 | $mm^3$ |

**Check bending and shear stress :**

| | | | |
|---|---|---|---|
| F = | 499.84 | kN | |
| θ = | 30 | deg | |
| 0.70Puy = | 432.87 | kN | |
| 0.70Pux = | 249.92 | kN | |
| cantilever arm = | 0.15 | m | |
| moment = | 64.93 | kN-m | |
| .55Fy = | 134.75 | mpa | |
| fb = M/Sx = | 76.01 | mpa | OK! |
| Fv = .33Fy | 80.85 | mpa | |
| Fv = V / A | 78.70 | mpa | OK! |

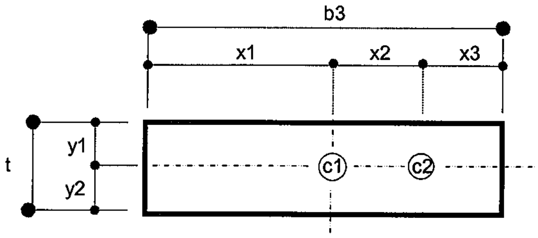
# ANALYSIS OF GERBER HINGE REHABILITATION - GUADALUPE BRIDGE

**ILLUSTRATION** **SECTION 2-3**



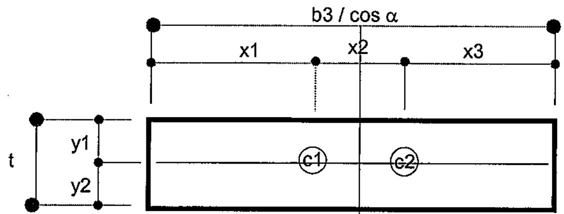

| | | |
|---|---|---|
| b1 = | 1.50 | m |
| b2 = | 0.35 | m |
| b3 = | 1.85 | m |
| h1 = | 1.68 | m |
| h2 = | 0.84 | m |
| h3 = | 0.84 | m |
| α = | 60.00 | deg |

| Section | 1 | 4 | Unit |
|---|---|---|---|
| t = | 0.300 | 0.300 | m |
| y1 = | 0.150 | 0.150 | m |
| y2 = | 0.150 | 0.150 | m |
| x1 = | 1.196 | 0.229 | m |
| x2 = | 0.450 | 0.450 | m |
| x3 = | 0.204 | 0.821 | m |
| b3 or b1= | 1.850 | 1.500 | m |




SECTION

| Section | 2 | 3 | Unit |
|---|---|---|---|
| t = | 0.300 | 0.300 | m |
| y1 = | 0.150 | 0.150 | m |
| y2 = | 0.150 | 0.150 | m |
| x1 = | 0.347 | 0.790 | m |
| x2 = | 0.390 | 0.390 | m |
| x3 = | 0.481 | 0.553 | m |
| b3/ cos(90 - α) = | 1.218 | 1.733 | m |




SECTION

## SECTION PROPERTIES

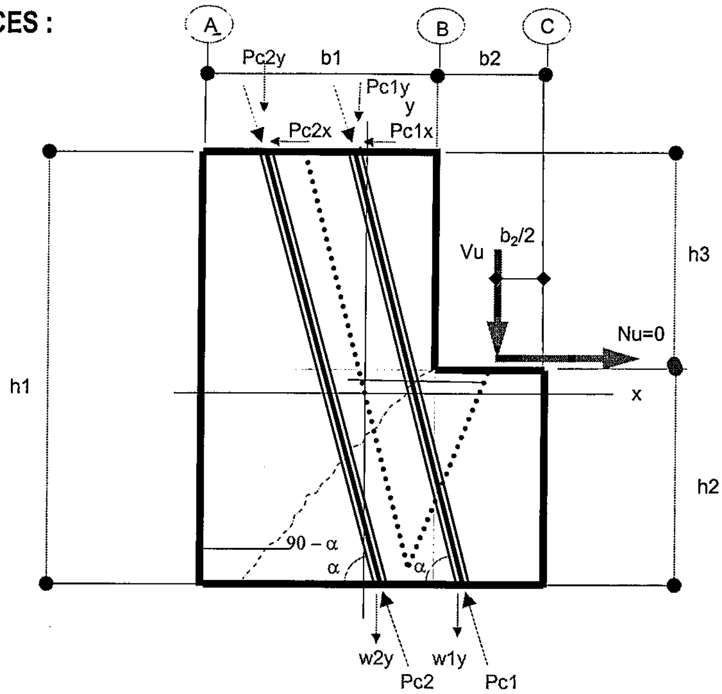
| Section | 1 | 2 | 3 | 4 | Unit |
|---|---|---|---|---|---|
| Area, A | 0.555 | 0.365 | 0.520 | 0.450 | $m^2$ |
| Dist. from N.A. to edge a, Xa = | 0.925 | 0.609 | 0.867 | 0.750 | m |
| Dist. from N.A. to edge c, Xc = | 0.925 | 0.609 | 0.867 | 0.750 | m |
| Moment of Inertia, I = t * b^3/12 | 0.158 | 0.045 | 0.130 | 0.084 | $m^4$ |
| Section modulus @ a, Sa | 0.171 | 0.074 | 0.150 | 0.113 | $m^3$ |
| Section modulus @ c, $S_c$ | 0.171 | 0.074 | 0.150 | 0.113 | $m^3$ |

## MATERIAL SPECIFICATIONS

Compressive strength of concrete :

| | | | |
|---|---|---|---|
| at time of initial prestress, f'ci | = | 22.40 | Mpa |
| at 28th day, $f'_c$ | = | 28.00 | Mpa |
| Ultimate strength of HTS, $f'_s$ | = | 1860.00 | Mpa |
| Elastic modulus of HTS, $E_S$ | = | 195000 | Mpa |
| Nominal area of HTS, $A_{ps}$ | = | 383.90 | $mm^2$ |
| Jacking stress, $0.70f'_s$ | = | 1302.00 | Mpa |
| Number of HTS, N | = | 1 | pcs |
| .70Pu | = | 499.84 | kN |
| Total number of Prestressing steel = | | 4 | pcs |

**FORCES :**




| Section | 1 | 2 | 3 | 4 | Unit |
|---|---|---|---|---|---|
| Shear reaction due to Dead Load, Wy = | 848.22 | 848.22 | 848.22 | 848.22 | kN |
| Shear reaction due to Live Load, Vll = | 188.38 | 188.38 | 188.38 | 188.38 | kN |
| Impact = (15.21 / 38.1 + L) = | 0.19 | 0.19 | 0.19 | 0.19 | |
| Wylocal = sin( 90-α ) * Wy due to DL | 734.58 | 734.58 | 734.58 | 734.58 | kN |
| Wxlocal = cos(90-α) * Wy due to DL | 424.11 | 424.11 | 424.11 | 424.11 | kN |
| Wylocal = sin( 90-α ) * Wy due to DL+LL+i | 928.39 | 928.39 | 928.39 | 928.39 | kN |
| Wxlocal = cos(90-α) * Wy due to DL+LL+i | 536.01 | 536.01 | 536.01 | 536.01 | kN |
| Effective 0.70Pu | 432.87 | 499.84 | 499.84 | 432.87 | kN |

Assumption :

1) Shear,V are carried equally by the oblique prestress cables since spacing is not far apart.
2) Favorable effects of internal prestress tendon in the girders are neglected.
3) Horizontal force, Nu is neglected due to cable restrainer/or slab made continuous, preventing the horizontal force from developing.

## ACTUAL ECCENTRICITY "e"

| Section | 1 | 2 | 3 | 4 | No. of HTS |
|---|---|---|---|---|---|
| Distance of c.g. of C1 from edge c = | 654 mm | 871 mm | 943 mm | 1271 mm | 1 |
| Distance of c.g. of C2 from edge c = | 204 mm | 481 mm | 553 mm | 821 mm | 1 |
| Ya of strands | 429 mm | 676 mm | 748 mm | 1046 mm | Total = 2 |
| Eccentricity "e" | 496 mm | -67 mm | 119 mm | -296 mm | |

## LOSSES

### A) Friction and Anchorage Draw-In

| Section | 1 | 2 | 3 | 4 | Unit |
|---|---|---|---|---|---|
| Loss due to friction and anchorage draw-in, FS | 0.00 | 0.00 | 0.00 | 0.00 | Mpa |

Note :

-Live End device using SEE (Screw type).
-Tendon profile is straight.

### B) Elastic Shortening, ES

$$ES = \frac{0.50 E_s f_{cir}}{E_{ci}}$$

where $f_{cir}$ = Concrete stress at the center of gravity of the prestressing steel due to prestressing force and dead load of beam immediately after transfer, in mpa.

| Section | 1 | 2 | 3 | 4 | Unit |
|---|---|---|---|---|---|
| Eci, modulus of elasticity of concrete in mpa at transfer = | 22386.45 | 22386.45 | 22386.45 | 22386.45 | Mpa |
| Concrete stress, $f_{cir}$ | 2.91 | 2.84 | 2.03 | 2.82 | Mpa |
| Loss due to elastic shortening, ES | 12.65 | 12.35 | 8.84 | 12.29 | Mpa |

**C) Concrete Shrinkage, SH**

Mean annual ambient relative humidity in percent, RH = 80.00 %
Loss due to concrete shrinkage, SH = 0.80(117-1.03RH)
= 92.94 Mpa

**D) Creep of Concrete, $CR_C$**

$CR_C = 12f_{cir} - 7f_{cds}$

where : $f_{cds}$ = Concrete stress at center of gravity of the prestressing steel due to all dead loads except the dead load present at the time the prestressing force is applied, in Mpa.

| Section | 1 | 2 | 3 | 4 | Unit |
|---|---|---|---|---|---|
| Moment due to dead load (w/o beam weight) | 0.00 | 0.00 | 0.00 | 0.00 | kN-m |
| Concrete stress, $f_{cds}$ | 0.00 | 2.67 | 0.00 | 0.00 | Mpa |
| Loss due to creep of concrete, $CR_C$ | 34.87 | 15.34 | 24.37 | 33.87 | Mpa |

**E) Relaxation of Prestressing Steel, $CR_S$**

$CR_S = 138 - 0.30FR - 0.40ES - 0.20(SH+CR_C)$ *... for stress relieved strands*

| Section | 1 | 2 | 3 | 4 | Unit |
|---|---|---|---|---|---|
| Loss due to relaxation of prestressing steel, $CR_S$ | 107.38 | 111.40 | 111.00 | 107.72 | Mpa |

**F) Effective Prestress at Initial and Final Condition**

| Section | 1 | 2 | 3 | 4 | Unit |
|---|---|---|---|---|---|
| Initial losses, FR + ES | 12.65 | 12.35 | 8.84 | 12.29 | Mpa |
| **Effective prestress at initial condition** | **1289.35** | **1289.65** | **1293.16** | **1289.71** | **Mpa** |
| Final losses, FR + ES + SH + $CR_C$ + $CR_S$ | 247.84 | 232.03 | 144.21 | 153.89 | Mpa |
| **Effective prestress at final condition** | **1054.16** | **1069.97** | **1157.79** | **1148.11** | **Mpa** |

## CHECK STRESSES

**A) Only Prestress Force Acting.**

| Section | 1 | | 2 | | 3 | | 4 | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| Number of strands, N | 2 | | 2 | | 2 | | 2 | | pcs. |
| Effective jacking force @ intial condition, Pj | 857.33 | | 990.19 | | 992.88 | | 857.57 | | kN |
| Eccentricity, e | 0.496 | | -0.067 | | 0.119 | | -0.296 | | m |
| Stress at edge c, f c | 4.03 | C | 1.82 | C | 2.69 | C | -0.35 | T | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |
| Stress at edge a, f a | -0.94 | T | 2.17 | C | 1.13 | C | 4.16 | C | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |

Allowable stresses : Compression = $0.55f'_{ci}$ = 12.32 Mpa
Tension = 1.40 Mpa or $0.25(f'_{ci})^{½}$ = -1.18 Mpa

**B) If All DL is Acting.**

| Section | 1 | | 2 | | 3 | | 4 | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| Axial Force due to dead load | -424.11 | | -367.29 | | -367.29 | | -424.11 | | kN |
| Number of strands, N | 2 | | 2 | | 2 | | 2 | | pcs. |
| Effective jacking force, Pj | 700.95 | | 821.52 | | 888.95 | | 763.42 | | kN |
| Eccentricity, e | 0.496 | | -0.067 | | 0.119 | | -0.296 | | m |
| Stress at edge c, f c | 1.30 | C | 0.83 | C | 1.42 | C | -0.14 | T | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |
| Stress at edge a, f a | -0.30 | T | 1.65 | C | 0.59 | C | 1.65 | C | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |

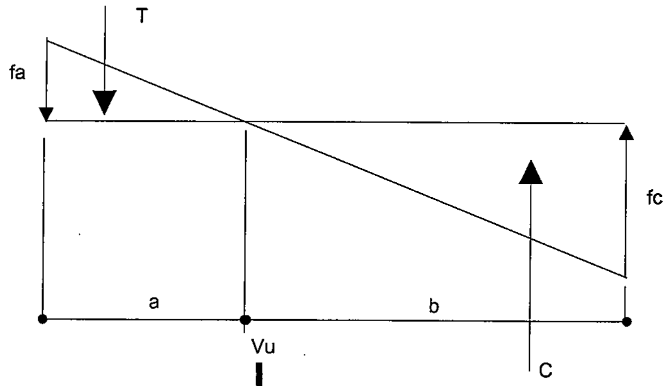
Allowable stresses : Compression = $0.40f'_c$ = 11.20 Mpa
Tension = $.50*(fc')^{.5}$ = -2.65 Mpa

**C) Due to All Dead Load and_Live Load Plus Impact (Service Condition)**

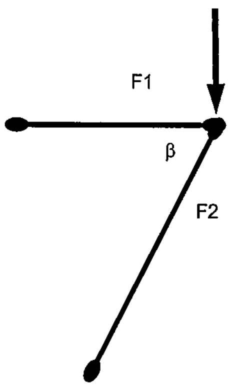
| Section | 1 | | 2 | | 3 | | 4 | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| Axial Force due to DL + LL+i | -518.30 | | -268.00 | | -268.00 | | -518.30 | | kN |
| Number of strands, N | 2 | | 2 | | 2 | | 2 | | pcs |
| Effective jacking force, Pj | 700.95 | | 821.52 | | 888.95 | | 763.42 | | kN |
| Eccentricity, e | 0.496 | | -0.067 | | 0.119 | | -0.296 | | m |
| Stress at edge c, f c | 0.858 | C | 1.015 | C | 1.684 | C | -0.100 | T | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |
| Stress at edge a, f a | -0.20 | T | 2.01 | C | 0.70 | C | 1.19 | C | Mpa |
| Remarks | safe! | | safe! | | safe! | | safe! | | |

Allowable stresses : Compression = $0.40f'_c$ = 11.20 Mpa
Tension = $.50*( fc' )^{.5}$ = -2.65 Mpa

**Reinforcement Bars :** (Not Applicable)




t = 0.30 m
a+b = 1.650 m
fa = 0.940 mpa
fc = 4.030 mpa
b = 1.338 m
a = 0.312 m
T = 44 kN
Fy = 275 mpa
As = T / .90 * Fy ;
As = 177.8 mm2
provide = 1 - 16 ; Ap = 201.0619 $mm^2$



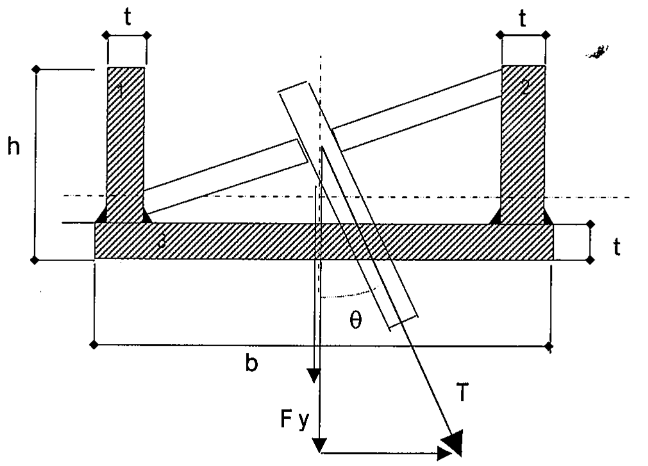

$F_2$ = Vu * sin β ; $F_2$ = 1541.363 kN
$F_1$ = Vu / tan β ; $F_1$ = 396.07 kN ; As = F1 / (.90 * Fy)
β = 76 deg Fy = 414 mpa
Vu = 1588.55 kN As = 1062.99 $mm^2$
provide = 2 - 28 ; Ap = 1231.504 $mm^2$

Check Shear at direction perpendicular to cables

| Section | 2 | 3 | Unit |
|---|---|---|---|
| Shear, Vu = | 397.14 | 397.14 | kN |
| Vci = | 308.73 | 349.61 | kN |
| Vcw = | 826.51 | 1071.77 | kN |
| Use Vc = | 308.73 | 349.61 | kN |
| Vs = (Vu / φ) - Vc | 132.53 | 91.66 | kN |
| fy = | 275 | 275 | Mpa |
| diameter,d = | 10 | 10 | mm |
| spacing, s = | 0.30 | 0.30 | m |
| Av = | 78.54 | 78.54 | mm2 |
| α = | 60.00 | 60.00 | deg |
| d = | 1.850 | 1.500 | m |
| Vs= Av * fy * (sin α ) * d / s | 230.69 | 187.05 | kN |
| Remarks | OK ! | OK ! | |

## Dimension & Material Properties of steel channel anchorage::

Specified minimum yield stress of structural steel, Fy = 245 mpa




| element | t (mm) | h (mm) | Area (mm2) | y (mm) | A*y (mm3) | Ix = bh3/3 (mm4) | A(Y-y)2 (mm4) |
|---|---|---|---|---|---|---|---|
| 1 | 22 | 125 | 2750 | 62.5 | 171875 | 14322916.67 | 1987325.789 |
| 2 | 22 | 125 | 2750 | 62.5 | 171875 | 14322916.67 | 1987325.789 |
| 3 | 22 | 273 | 6006 | 11 | 66066 | 968968 | 3639790.822 |
| | | | 11506 | | 409816 | 29614801.33 | 7614442.4 |

| | | |
|---|---|---|
| Y = | 35.62 | mm |
| .Ix = | 37229243.73 | $mm^4$ |
| Sx = | 1045248.79 | $mm^3$ |

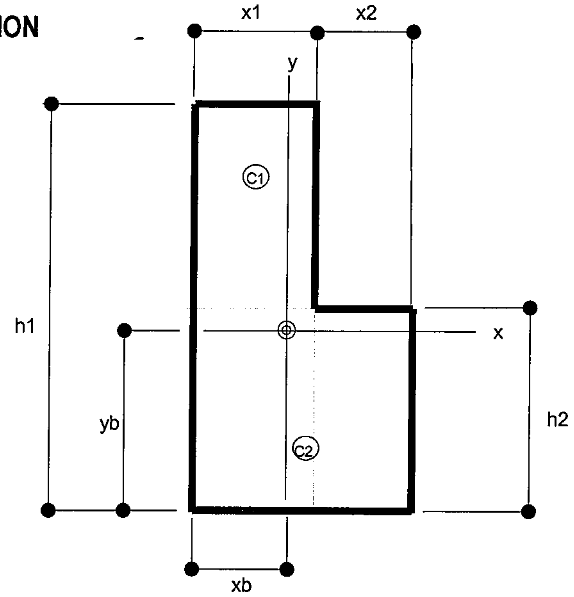
**Check bending and shear stress :**

| | | | |
|---|---|---|---|
| F = | 499.84 | kN | |
| θ = | 30 | deg | |
| 0.70Puy = | 432.87 | kN | |
| 0.70Pux = | 249.92 | kN | |
| cantilever arm = | 0.15 | m | |
| moment = | 64.93 | kN-m | |
| .55Fy = | 134.75 | mpa | |
| fb = M/Sx = | 62.12 | mpa | OK! |
| Fv = .33Fy | 80.85 | mpa | |
| Fv = V / A | 78.70 | mpa | OK! |

ANALYSIS OF GERBER HINGE REHABILITATION - GUADALUPE BRIDGE

**ILLUSTRATION**

**POST-TENSIONING OF DIAHPRAGM**




h1 = 1.68 m
h2 = 0.82 m
x1 = 1.00 m
x2 = 0.35 m

## SECTION PROPERTIES

| Section | jt. 17 | jt. 336 | Unit |
|---|---|---|---|
| Distance from face of support | 0.000 | 1.200 | m |
| Area, A | 1.967 | 1.967 | m² |
| Dist. from N.A. to top, $Y_{top}$ | 0.903 | 0.903 | m |
| Dist. from N.A. to bottom, $Y_{bot}$ | 0.777 | 0.777 | m |
| Moment of Inertia, I | 0.456 | 0.456 | $m^4$ |
| Section modulus at top, $S_{top}$ | 0.505 | 0.505 | m³ |
| Section modulus at bottom, $S_{bot}$ | 0.587 | 0.587 | m³ |

## MATERIAL SPECIFICATIONS

| Compressive strength of concrete : | | Value | Unit |
|---|---|---|---|
| at time of initial prestress, f'ci | = | 23.80 | Mpa |
| at 28th day, $f'_c$ | = | 28.00 | Mpa |
| Ultimate strength of HTS, $f'_s$ | = | 1860.00 | Mpa |
| Elastic modulus of HTS, $E_S$ | = | 195000 | Mpa |
| Nominal area of HTS, $A_{ps}$ | = | 383.90 | mm² |
| Jacking stress, 0.70f's | = | 1302.00 | Mpa |
| Number of HTS, N | = | 1 | pcs |

## MOMENTS

| Section | jt. 17 | jt. 336 | Unit |
|---|---|---|---|
| Moment due to selfweight only, $M_{SW}$ | -23.10 | 11.16 | kN-m |
| Moment due to all dead load (including selfweight), $M_{DL}$ | -166.10 | 154.16 | kN-m |
| Moment due to live load plus impact, $M_{LL+I}$ | -38.64 | 38.64 | kN-m |

## ACTUAL ECCENTRICITY "e"

| | jt. 17 | | jt. 336 | |
|---|---|---|---|---|
| Section | value | No. of HTS | value | No. of HTS |
| Distance of c.g. of C1 from bottom | 1430 mm | 1 | 1430 mm | 1 |
| Distance of c.g. of C2 from bottom | 315 mm | 1 | 315 mm | 1 |
| $Y_{bottom}$ of strands | 873 mm | Total = 2 | 873 mm | Total = 2 |
| Eccentricity "e" | 96 mm | | 96 mm | |

## LOSSES

**A) Friction and Anchorage Draw-In**

| Section | jt. 17 | jt. 336 | Unit |
|---|---|---|---|
| Loss due to friction and anchorage draw-in, FS | 0.00 | 0.00 | Mpa |

-Live End device using SEE (Screw type).
-Tendon profile is straight.

**B) Elastic Shortening, ES**

$$ES = \frac{0.50E_s f_{cir}}{E_{ci}}$$

where : $f_{cir}$ = Concrete stress at the center of gravity of the prestressing steel due to prestressing force and dead load of beam immediately after transfer, in Mpa.

| Section | jt. 17 | jt. 336 | Unit |
|---|---|---|---|
| Moment due to selfweight, $M_{sw}$ | -23.10 | 11.16 | kN-m |
| Concrete stress, $f_{cir}$ | 0.56 | 0.58 | Mpa |
| Loss due to elastic shortening, ES | 2.36 | 2.46 | Mpa |

**C) Concrete Shrinkage, SH**

Mean annual ambient relative humidity in percent, RH = 80.00 %
Loss due to concrete shrinkage, SH = 0.80(117-1.03RH)
= 92.94 Mpa

**D) Creep of Concrete, $CR_C$**

$CR_C = 12f_{cir} - 7f_{cds}$ where : $f_{cds}$ = Concrete stress at center of gravity of the prestressing steel due to all dead loads except the dead load present at the time the prestressing force id applied, in Mpa.

| Section | jt. 17 | jt. 336 | Unit |
|---|---|---|---|
| Moment due to dead load (w/o beam weight) | -143.00 | 143.00 | kN-m |
| Concrete stress, $f_{cds}$ | 0.32 | 0.23 | Mpa |
| Loss due to creep of concrete, $CR_C$ | 4.45 | 5.40 | Mpa |

**E) Relaxation of Prestressing Steel, $CR_S$**

$CR_S = 138 - 0.30FR - 0.40ES - 0.20(SH+CR_C)$ *... for stress relieved strands*

| Section | jt. 17 | jt. 336 | Unit |
|---|---|---|---|
| Loss due to relaxation of prestressing steel, $CR_S$ | 117.58 | 117.35 | Mpa |

**F) Effective Prestress at Initial and Final Condition**

| Section | jt. 17 | jt. 336 | Unit |
|---|---|---|---|
| Initial losses, FR + ES | 2.36 | 2.46 | Mpa |
| **Effective prestress at initial condition** | **1299.64** | **1299.54** | **Mpa** |
| Final losses, FR + ES + SH + $CR_C$ + $CR_S$ | 217.33 | 218.15 | Mpa |
| **Effective prestress at final condition** | **1084.67** | **1083.85** | **Mpa** |

## CHECK STRESSES

**A) Due to Selfweight Only**

| Section | jt. 17 | | jt. 336 | | Unit |
|---|---|---|---|---|---|
| Moment due to selfweight only, $M_{sw}$ | -23.10 | | 11.16 | | kN-m |
| Number of strands, N | 2 | | 2 | | |
| Effective jacking force @ intial condition, Pj | 997.87 | | 997.79 | | kN |
| Eccentricity, e | 0.096 | | 0.096 | | m |
| Stress at top, $f_{top}$ | 0.650 | C | 0.718 | C | Mpa |
| Remarks | safe | | safe | | |
| Stress at bottom, $f_{bot}$ | 0.384 | C | 0.326 | C | Mpa |
| Remarks | safe | | safe | | |

Allowable stresses : Compression = $0.55f'_{ci}$ = 13.09 Mpa
Tension = 1.40 Mpa or $0.25(f'_{ci})^{1/2}$ = -1.22 Mpa

**B) Due to All Dead Load (including selfweight)**

| Section | jt. 17 | | jt. 336 | | Unit |
|---|---|---|---|---|---|
| Moment due to all dead load, $M_{DL}$ | -166.10 | | 154.16 | | kN-m |
| Number of strands, N | 2 | | 2 | | |
| Effective jacking force, Pj | 832.81 | | 832.18 | | kN |
| Eccentricity, e | 0.096 | | 0.096 | | m |
| Stress at top, $f_{top}$ | 0.252 | C | 0.886 | C | Mpa |
| Remarks | safe | | safe | | |
| Stress at bottom, $f_{bot}$ | 0.571 | C | 0.025 | C | Mpa |
| Remarks | safe | | safe | | |

Allowable stresses : Compression = $0.40f'_c$ = 11.20 Mpa
Tension = $0.50(f'_{ci})^{1/2}$ = -2.44 Mpa

**C) Due to All Dead Load and Live Load Plus Impact (Service Condition)**

| Section | jt. 17 | | jt. 336 | | Unit |
|---|---|---|---|---|---|
| Moment due to $M_{DL}$ and $M_{LL+I}$, $M_{max}$ | -204.74 | | 192.80 | | kN-m |
| Number of strands, N | 2 | | 2 | | |
| Effective jacking force, Pj | 832.81 | | 832.18 | | kN |
| Eccentricity, e | 0.096 | | 0.096 | | m |
| Stress at top, $f_{top}$ | 0.175 | C | 0.962 | C | Mpa |
| Remarks | safe | | safe | | |
| Stress at bottom, $f_{bot}$ | 0.637 | C | -0.041 | T | Mpa |
| Remarks | safe | | safe | | |

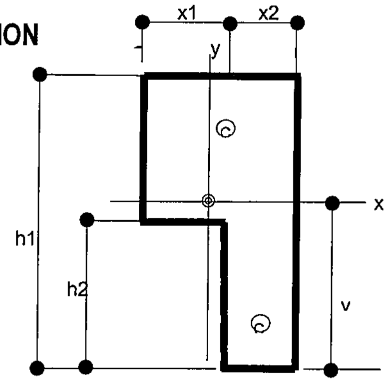
Allowable stresses : Compression = $0.40f'_c$ = 11.20 Mpa
Tension = $0.50(f'_{ci})^{½}$ = -2.44 Mpa

## ULTIMATE FLEXURAL STRENGTH

$\phi M_N = \phi [ A_s{}^*f_{su}{}^*d\,(1\text{-}0.60\rho^*f_{su}{}^*/f'_c) ]$ where : $\gamma^* = 0.40$ $\phi = 0.95$
$f_{su}{}^* = f'_s [ 1\text{-}(\gamma^*/\beta_1)(\rho^*f'_s/f'_c)]$ $\beta_1 = 0.75$

| Section | jt. 17 | jt. 336 | Unit |
|---|---|---|---|
| Width of section, b | 1000.00 | 1350.00 | mm |
| Effective depth of section, d | 872.50 | 998.50 | mm |
| Total area of prestressing strands, $A_s{}^*$ | 767.80 | 767.80 | mm² |
| Ratio of prestressing steel, $\rho^* = A_s{}^*/bd$ | 0.00088 | 0.00057 | |
| Average stress of prestressing steel at ultimate load, $f_{su}{}^*$ | 1802.01 | 1822.47 | Mpa |
| Moment capacity, $\phi M_N$ | 1107.85 | 1297.80 | kN-m |
| Ultimate moment, $M_U = 1.30\,(M_{DL} + 1.67M_{LL+I})$ | 299.82 | 284.30 | kN-m |
| Remarks | safe | safe | |

## ILLUSTRATION




## POST-TENSIONING OF DIAHPRAGM

h1 = 1.68 m
h2 = 0.82 m
x1 = 0.35 m
x2 = 1.00 m

## SECTION PROPERTIES

| Section | jt. 336 | jt. 44 | Unit |
|---|---|---|---|
| Distance from face of support | 0.000 | 2.400 | m |
| Area, A | 1.967 | 1.967 | m² |
| Dist. from N.A. to top, $Y_{top}$ | 0.777 | 0.777 | m |
| Dist. from N.A. to bottom, $Y_{bot}$ | 0.903 | 0.903 | m |
| Moment of Inertia, I | 0.456 | 0.456 | $m^4$ |
| Section modulus at top, $S_{top}$ | 0.587 | 0.587 | m³ |
| Section modulus at bottom, $S_{bot}$ | 0.505 | 0.505 | m³ |

## MATERIAL SPECIFICATIONS

| Compressive strength of concrete : | | Value | Unit |
|---|---|---|---|
| at time of initial prestress, f'ci | = | 23.80 | Mpa |
| at 28th day, $f'_c$ | = | 28.00 | Mpa |
| Ultimate strength of HTS, $f'_s$ | = | 1860.00 | Mpa |
| Elastic modulus of HTS, $E_S$ | = | 195000 | Mpa |
| Nominal area of HTS, $A_{ps}$ | = | 383.90 | mm² |
| Jacking stress, 0.70$f'_s$ | = | 1302.00 | Mpa |
| Number of HTS, N | = | 1 | pcs |

## MOMENTS

| Section | jt. 336 | jt. 44 | Unit |
|---|---|---|---|
| Moment due to selfweight only, $M_{sw}$ | -5.56 | -5.56 | kN-m |
| Moment due to all dead load (including selfweight), $M_{DL}$ | -452.56 | -125.56 | kN-m |
| Moment due to live load plus impact, $M_{LL+I}$ | -132.36 | -148.40 | kN-m |

## ACTUAL ECCENTRICITY "e"

| | jt. 336 | | jt. 44 | |
|---|---|---|---|---|
| Section | value | No. of HTS | value | No. of HTS |
| Distance of c.g. of C1 from bottom | 1430 mm | 1 | 1430 mm | 1 |
| Distance of c.g. of C2 from bottom | 315 mm | 1 | 315 mm | 1 |
| $Y_{bottom}$ of strands | 873 mm | Total = 2 | 873 mm | Total = 2 |
| Eccentricity "e" | -31 mm | | -31 mm | |

## LOSSES

### A) Friction and Anchorage Draw-In

| Section | jt. 336 | jt. 44 | Unit |
|---|---|---|---|
| Loss due to friction and anchorage draw-in, FS | 0.00 | 0.00 | Mpa |

-Live End device using SEE (Screw type).
-Tendon profile is straight.

### B) Elastic Shortening, ES

$ES = \frac{0.50 E_s f_{cir}}{E_{ci}}$ where : $f_{cir}$ = Concrete stress at the center of gravity of the prestressing steel due to prestressing force and dead load of beam immediately after transfer, in Mpa.

| Section | jt. 336 | jt. 44 | Unit |
|---|---|---|---|
| Moment due to selfweight, $M_{sw}$ | -5.56 | -5.56 | kN-m |
| Concrete stress, $f_{cir}$ | 0.47 | 0.47 | Mpa |
| Loss due to elastic shortening, ES | 1.98 | 1.98 | Mpa |

### C) Concrete Shrinkage, SH

Mean annual ambient relative humidity in percent, RH = 80.00 %
Loss due to concrete shrinkage, SH = 0.80(117-1.03RH)
= 92.94 Mpa

$CR_C = 12f_{cir} - 7f_{cds}$ where : $f_{cds}$ = Concrete stress at center of gravity of the prestressing steel due to all dead loads except the dead load present at the time the prestressing force id applied, in Mpa.

| Section | jt. 336 | jt. 44 | Unit |
|---|---|---|---|
| Moment due to dead load (w/o beam weight) | -447.00 | -120.00 | kN-m |
| Concrete stress, $f_{cds}$ | -0.28 | 0.30 | Mpa |
| Loss due to creep of concrete, $CR_C$ | 7.61 | 3.49 | Mpa |

**E) Relaxation of Prestressing Steel, $CR_S$**

$CR_S$ = 138 - 0.30FR - 0.40ES - 0.20(SH+$CR_C$) ... *for stress relieved strands*

| Section | jt. 336 | jt. 44 | Unit |
|---|---|---|---|
| Loss due to relaxation of prestressing steel, $CR_S$ | 117.10 | 117.92 | Mpa |

**F) Effective Prestress at Initial and Final Condition**

| Section | jt. 336 | jt. 44 | Unit |
|---|---|---|---|
| Initial losses, FR + ES | 1.98 | 1.98 | Mpa |
| **Effective prestress at initial condition** | **1300.02** | **1300.02** | **Mpa** |
| Final losses, FR + ES + SH + $CR_C$ + $CR_S$ | 219.63 | 216.33 | Mpa |
| **Effective prestress at final condition** | **1082.37** | **1085.67** | **Mpa** |

## CHECK STRESSES

**A) Due to Selfweight Only**

| Section | jt. 336 | | jt. 44 | | Unit |
|---|---|---|---|---|---|
| Moment due to selfweight only, $M_{sw}$ | -5.56 | | -5.56 | | kN-m |
| Number of strands, N | 2 | | 2 | | |
| Effective jacking force @ intial condition, Pj | 998.16 | | 998.16 | | kN |
| Eccentricity, e | -0.031 | | -0.031 | | m |
| Stress at top, $f_{top}$ | 0.446 | C | 0.446 | C | Mpa |
| Remarks | safe | | safe | | |
| Stress at bottom, $f_{bot}$ | 0.579 | C | 0.579 | C | Mpa |
| Remarks | safe | | safe | | |

Allowable stresses : Compression = $0.55f'_{ci}$ = 13.09 Mpa
Tension = 1.40 Mpa or $0.25(f'_{ci})^{½}$ = -1.22 Mpa

**B) Due to All Dead Load (including selfweight)**

| Section | jt. 336 | | jt. 44 | | Unit |
|---|---|---|---|---|---|
| Moment due to all dead load, $M_{DL}$ | -452.56 | | -125.56 | | kN-m |
| Number of strands, N | 2 | | 2 | | |
| Effective jacking force, Pj | 831.05 | | 833.57 | | kN |
| Eccentricity, e | -0.031 | | -0.031 | | m |
| Stress at top, $f_{top}$ | -0.392 | T | 0.167 | C | Mpa |
| Remarks | safe | | safe | | |
| Stress at bottom, $f_{bot}$ | 1.369 | C | 0.723 | C | Mpa |
| Remarks | safe | | safe | | |

Allowable stresses : Compression = $0.40f'_c$ = 11.20 Mpa
Tension = $0.50(f'_{ci})^{½}$ = -2.44 Mpa

**C) Due to All Dead Load and Live Load Plus Impact (Service Condition)**

| Section | jt. 336 | | jt. 44 | | Unit |
|---|---|---|---|---|---|
| Moment due to $M_{DL}$ and $M_{LL+I}$, $M_{max}$ | -584.92 | | -273.96 | | kN-m |
| Number of strands, N | 2 | | 2 | | |
| Effective jacking force, Pj | 831.05 | | 833.57 | | kN |
| Eccentricity, e | -0.031 | | -0.031 | | m |
| Stress at top, $f_{top}$ | -0.617 | T | -0.086 | T | Mpa |
| Remarks | safe | | safe | | |
| Stress at bottom, $f_{bot}$ | 1.631 | C | 1.017 | C | Mpa |
| Remarks | safe | | safe | | |

Allowable stresses : Compression = $0.40f'_c$ = 11.20 Mpa
Tension = $0.50(f'_{ci})^{½}$ = -2.44 Mpa

## ULTIMATE FLEXURAL STRENGTH

$\phi M_N = \phi [A_s{}^* f_{su}{}^* d (1-0.60\rho^* f_{su}{}^*/f'_c)]$ where : $\gamma^*$ = 0.40 $\phi$ = 0.95
$f_{su}{}^* = f'_s [1-(\gamma^*/\beta_1)(\rho^* f'_s/f'_c)]$ $\beta_1$ = 0.75

| Section | jt. 336 | jt. 44 | Unit |
|---|---|---|---|
| Width of section, b | 1350.00 | 1350.00 | mm |
| Effective depth of section, d | 872.50 | 746.50 | mm |
| Total area of prestressing strands, $A_s{}^*$ | 767.80 | 767.80 | mm² |
| Ratio of prestressing steel, $\rho^* = A_s{}^*/bd$ | 0.00065 | 0.00076 | |
| Average stress of prestressing steel at ultimate load, $f_{su}{}^*$ | 1817.04 | 1809.79 | Mpa |
| Moment capacity, $\phi M_N$ | 1127.04 | 956.32 | kN-m |
| Ultimate moment, $M_U = 1.30 (M_{DL} + 1.67M_{LL+I})$ | 875.68 | 485.41 | kN-m |
| Remarks | safe | safe | |

**SHEAR BOLT DESIGN**

Tux = 999.7 kN

use type HSL type as recommended, very good for shear loading.

HILTI HSL-TZ Heavy Duty Anchor

diameter = M24
$F_{30}$ = 81.00 kN (Non-cracked concrete)

Influence of Concrete Strength fb (using cube strength)

fb = 1 + 0.01 * ( 1 - $\alpha$ / 90 ) * ( fcc -30 ) ; (20 < fcc,act < 55)

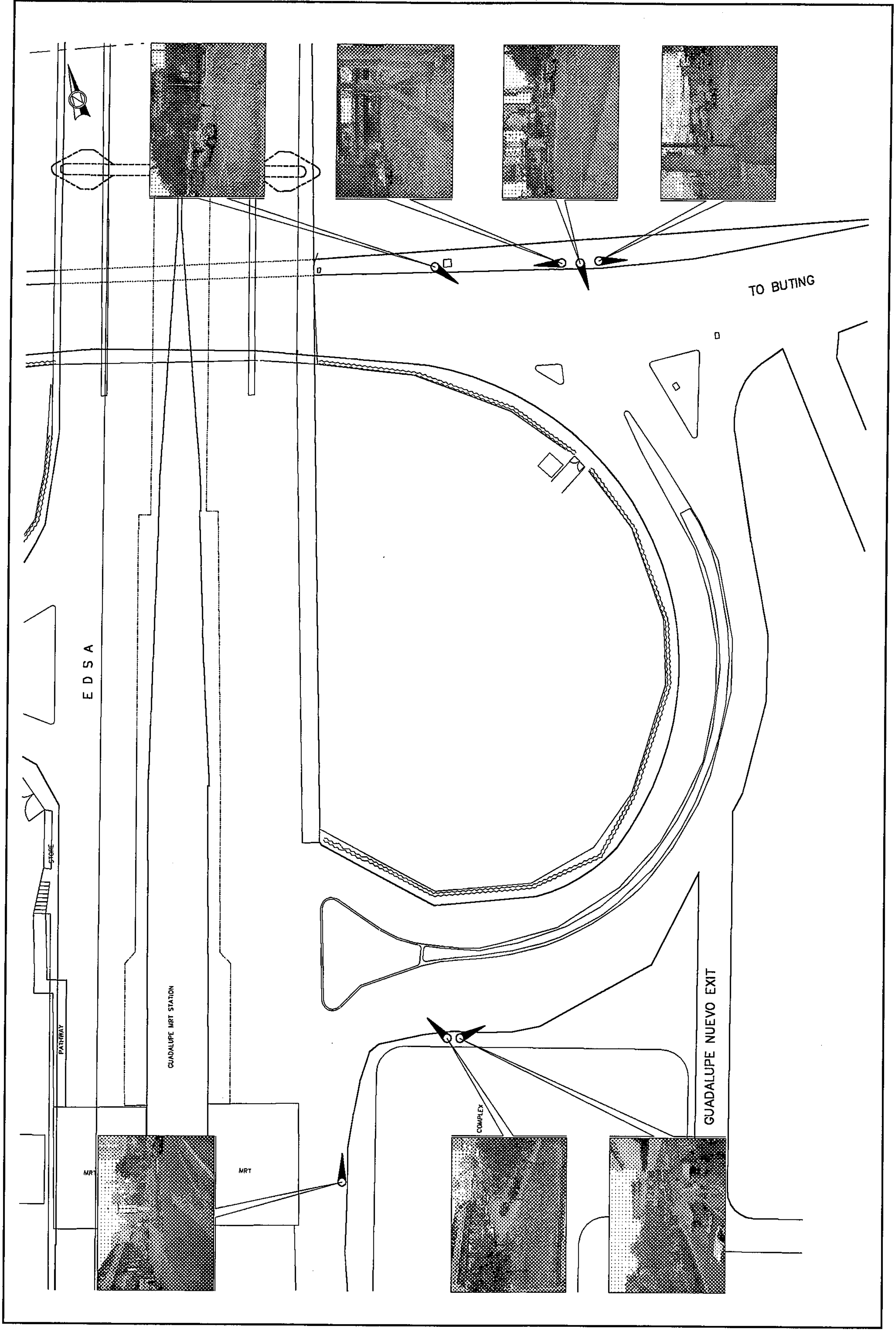
fcc = 35 N/mm2
$\alpha$ = 90
fb = 1.00

Influence of depth of embedment

ft = hact / hnom.
hact = 155 mm
hnom. = 155 mm
ff = 1.00

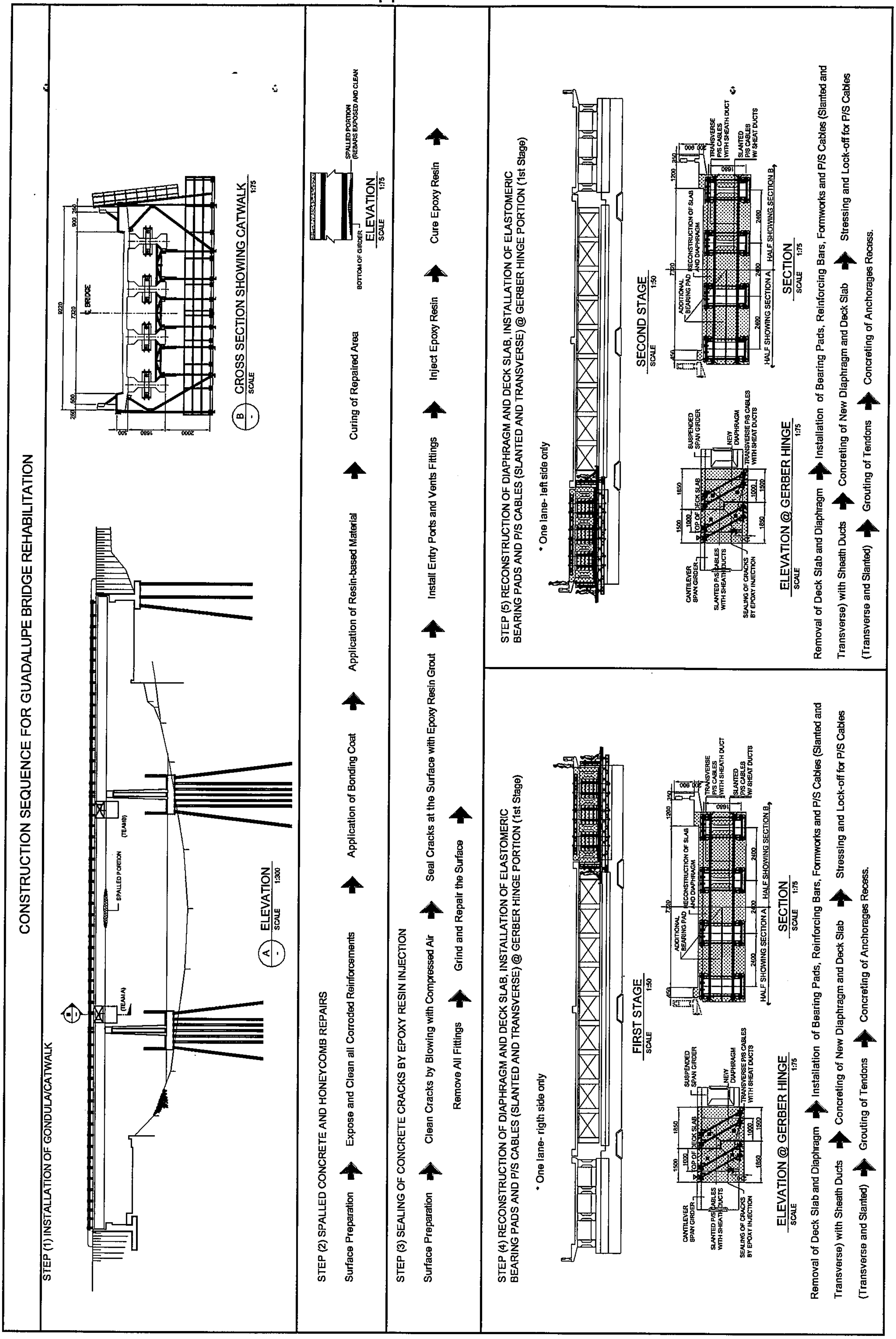
Influence of Anchor Spacing and edge distance fa , fr

s = 250 mm (anchor spacing)
fa = 0.79
fr = 1.00 (in the edge of concrete component, there must be reinforcement w/c can take up to 0.25 times the anchor load if edge distance is equal to or less than Ccr.
Frec = 63.99 kN
Number of bolts required = 16 - M24




APPROACH 1 SITE OCULAR INSPECTION (GUADALUPE BRIDGE)


APPROACH 2 SITE OCULAR INSPECTION (GUADALUPE BRIDGE)




CONSTRUCTION SEQUENCE FOR GUADALUPE BRIDGE REHABILITATION

Appendix 23.3.3-1
BREAKDOWN OF COSTS

## Annex I - Construction Cost for Retrofitting of Guadalupe Bridge

| Description | | Unit | Quantity | Unit Price | Cost | Components | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Foreign | Local | Taxes |
| **A. Repair/Sealing of Concrete Cracks** | | | | | | | | |
| SPL | Epoxy Injection | l.s. | 1.00 | 3,876,789.46 | 3,876,789.46 | 2,830,056.31 | 581,518.42 | 465,214.74 |
| SPL | Replacement of New Concrete (Spalling with Exposed Rebars) | l.s. | 1.00 | 583,269.69 | 583,269.69 | 379,125.30 | 145,817.42 | 58,326.97 |
| **B. New Diaphragm/Concrete Slab/Reconstruction of Fender** | | | | | | | | |
| 101(3) | Removal of Concrete Slab | sq.m. | 145.00 | 500.00 | 72,500.00 | 47,125.00 | 15,225.00 | 10,150.00 |
| 101(3)a | Removal of Concrete Diaphragm | cu.m. | 40.00 | 575.00 | 23,000.00 | 14,950.00 | 4,830.00 | 3,220.00 |
| 301(1) | Tack Coat | ton | 0.08 | 25,000.00 | 1,975.57 | 1,501.43 | 197.56 | 276.58 |
| 310 | Asphalt | ton | 14.00 | 3,100.00 | 43,400.00 | 32,984.00 | 4,340.00 | 6,076.00 |
| 405(1)a | Structural Concrete for Slab | cu.m. | 23.00 | 4,500.00 | 103,500.00 | 67,275.00 | 21,735.00 | 14,490.00 |
| 405(3) | Structural Concrete for New Diapahragm | cu.m. | 159.00 | 6,000.00 | 954,000.00 | 620,100.00 | 200,340.00 | 133,560.00 |
| 404 | Reinforcing Steel Bars | kgs | 25,322.00 | 50.00 | 1,266,100.00 | 822,965.00 | 265,881.00 | 177,254.00 |
| 416(1) | Prestressing Bar with Anchor | kgs | 2,384.00 | 604.27 | 1,440,589.22 | 936,382.99 | 302,523.74 | 201,682.49 |
| | Transverse P/S Cables | kgs | 1,280.00 | 604.27 | 773,470.72 | 502,755.97 | 162,428.85 | 108,285.90 |
| | Bearing Pads | each | 12.00 | 15,000.00 | 180,000.00 | 117,000.00 | 37,800.00 | 25,200.00 |
| **C. Guadrail Post** | | | | | | | | |
| | Removal of Concrete Railing/Post | l.m. | 42.91 | 150.00 | 6,436.80 | 4,183.92 | 1,351.73 | 901.15 |
| | Removal of Concrete Sidewalk | sq.m. | 18.55 | 160.00 | 2,968.00 | 1,929.20 | 623.28 | 415.52 |
| | New Concrete Railing/Post | l.m. | 42.91 | 3,500.00 | 150,192.00 | 97,624.80 | 31,540.32 | 21,026.88 |
| | New Concrete Railing | l.m. | 3.00 | 1,500.00 | 4,500.00 | 2,925.00 | 945.00 | 630.00 |
| | New Concrete Post | each | 10.00 | 2,000.00 | 20,000.00 | 13,000.00 | 4,200.00 | 2,800.00 |
| | New Concrete Sidewalk | sq.m. | 20.55 | 350.00 | 7,191.52 | 4,674.49 | 1,510.22 | 1,006.81 |
| **D. Gondola and Falsework** | | | | | | | | |
| SPL | Gondola and Falsework | l.s. | 1.00 | 5,149,532.35 | 5,149,532.35 | 3,501,682.00 | 926,915.82 | 720,934.53 |
| | | | | | | | | |
| **E. Traffic Management** | | | | | | | | |
| SPL | Traffic Management | l.s. | 1.00 | 1,500,000.00 | 1,500,000.00 | 1,065,000.00 | 225,000.00 | 210,000.00 |
| | | | | | | | | |
| **F. Contingencies** | | | | | | | | |
| | Contingencies | l.s. | 1.00 | 807,970.77 | 807,970.77 | 605,978.07 | 121,195.61 | 80,797.08 |
| | | | | | | | | |
| **G. Facilities** | | | | | | | | |
| | Temporary Facilities | l.s. | 1.00 | 2,960,034.00 | 2,960,034.00 | 1,924,022.10 | 621,607.14 | 414,404.76 |
| | | | | | | | | |
| **H. Mobilization/Demobilization** | | | | | | | | |
| | Mobilization/demobilization | l.s. | 1.00 | 484,782.46 | 484,782.46 | 363,586.84 | 72,717.37 | 48,478.25 |
| | | | | | | | | |
| | | | | **Total** | **20,412,202.55** | **13,956,827.42** | **3,750,243.48** | **2,705,131.65** |
| | | | | **% Component** | **100%** | **68%** | **18%** | **13%** |