Design a Steel Bridge at Prince Metib Service Roads Intersection with Railway In Dammam

SENIOR PROJECT SPRING 2017/2018 (FINAL-EXAM PRESENTATION)

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OUTLINE

- *Objectives*
- *Project Description*
- *Design Codes Used*
- *MOMRA Standards*
- *Design Constraints*
- *Preliminary & Structural Design*
- *CSiBridge Analysis & Design*
- *Geotechnical & Foundation Design*
- *Cost Estimation*
- *Acknowledgment*
- *Conclusion*

PROJECT OBJECTIVES

1

Structural design of the bridge following AASHTO & MOMRA Standards.

2

Geotechnical design for abutments, piers and foundation system.

3

Cost Estimation compared with the post-tensioned bridge.

PROJECT DESCRIPTION

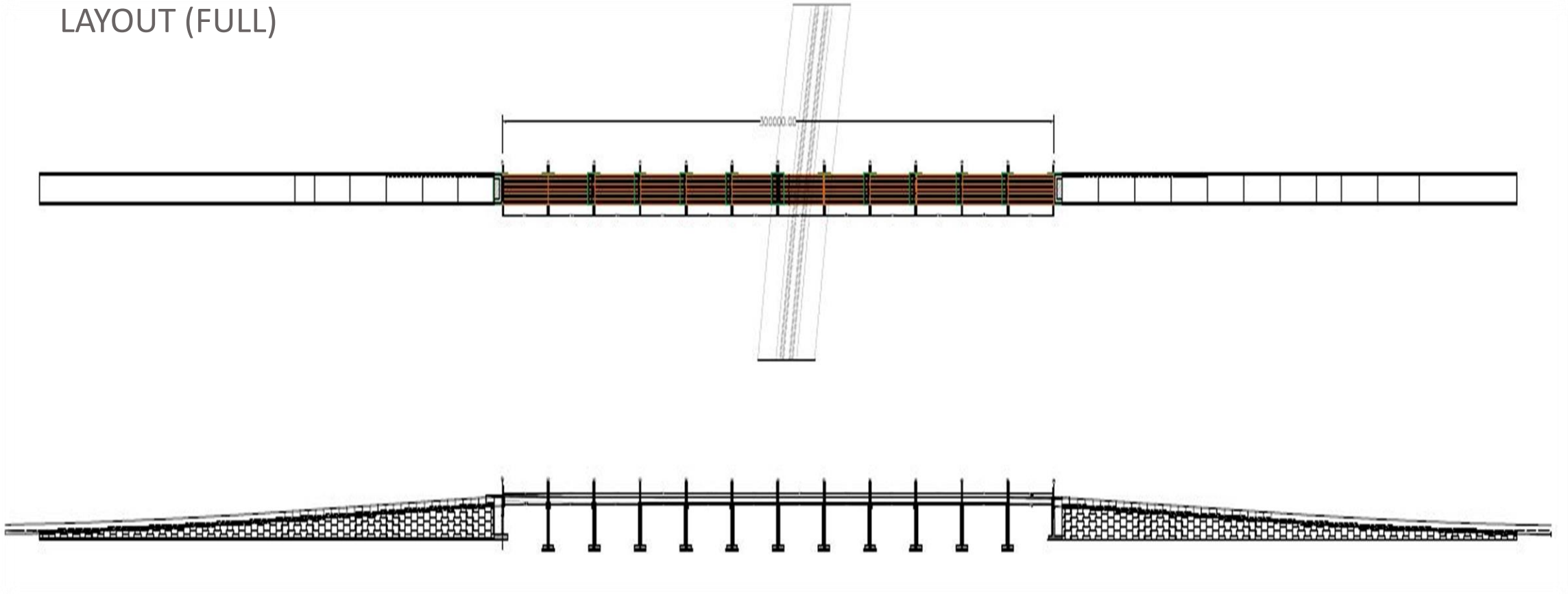
Location: Prince Metib Service Roads Intersection With Railway In Dammam

PROJECT DESCRIPTION (continue)

- Two traffic lanes
- 300 m length
  9.1 m width
- 12 simply supported spans with 25 m length
- 11 bent cap with height of 8.8 m

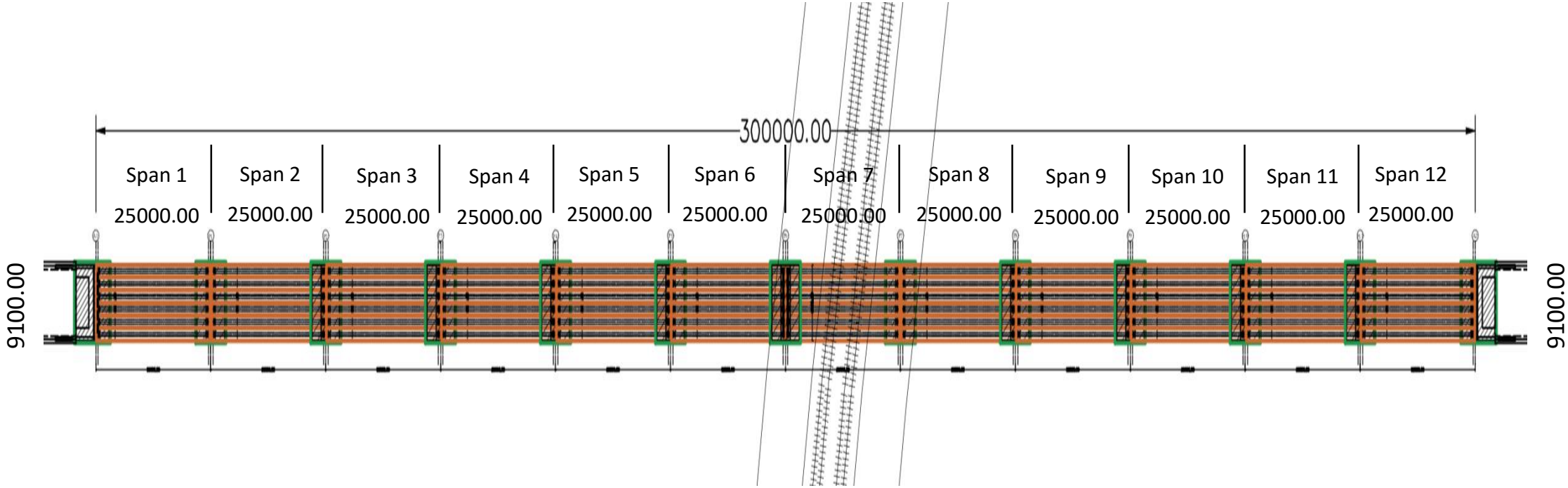
PROJECT DESCRIPTION *(continue)*

LAYOUT (FULL)



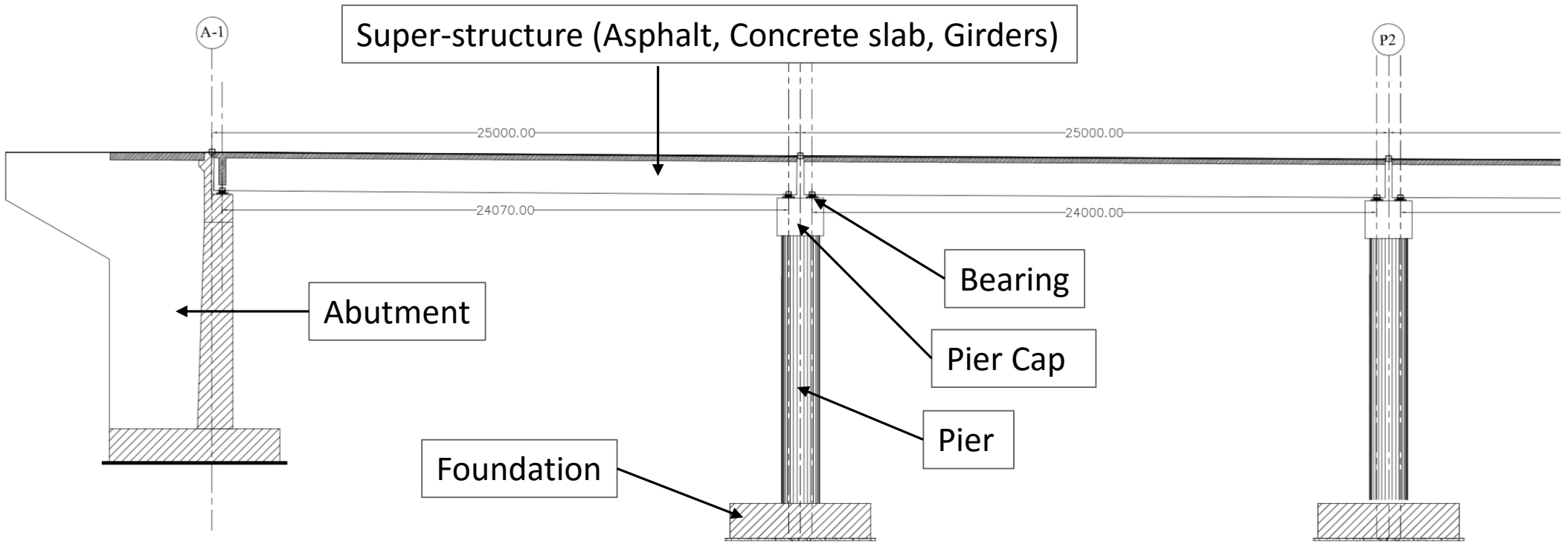
PROJECT DESCRIPTION (continue)

LAYOUT (TOP VIEW)



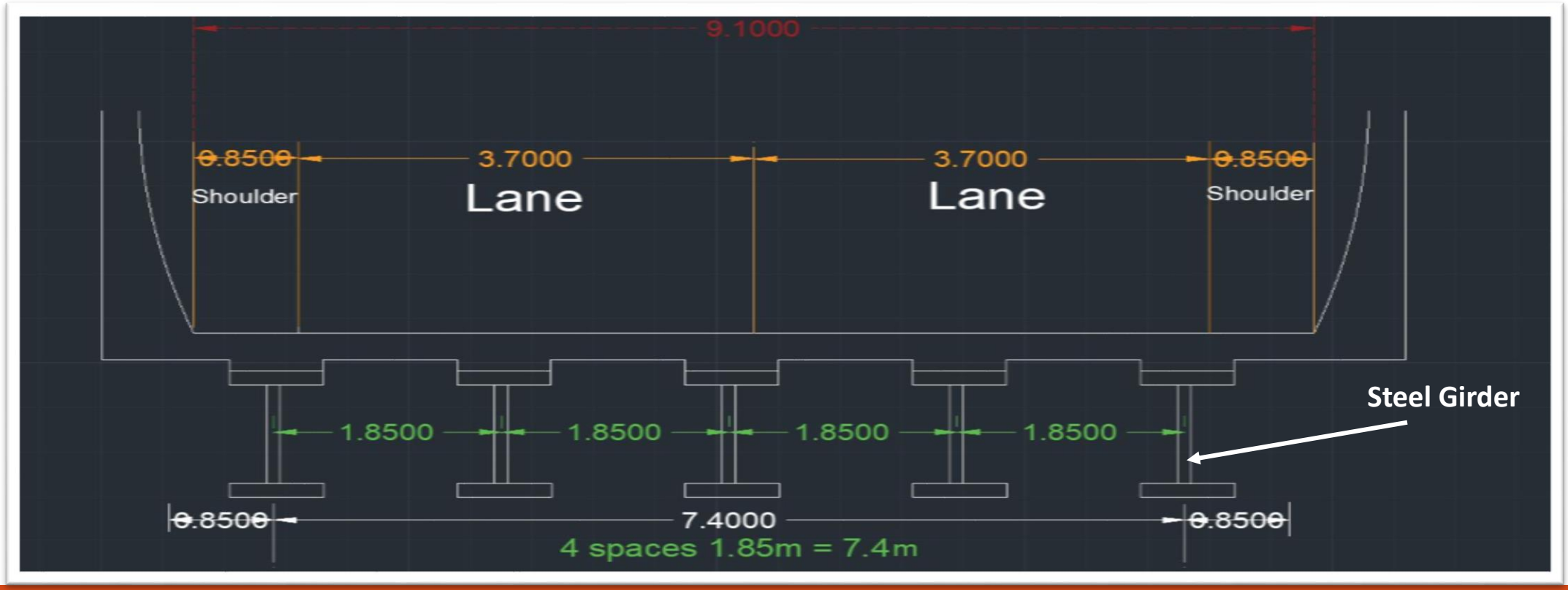
PROJECT DESCRIPTION *(continue)*

LAYOUT (SIDE VIEW)



PROJECT DESCRIPTION *(continue)*

CROSS SECTION



DESIGN CODES USED

(MOMRA) Ministry of Municipal and Rural Affairs.

(AASHTO) American Association of State Highway and Transportation Official.

(AISC) American Institute of Steel Construction.

(ACI) American Concrete Institute.

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Ministry of Municipal and Rural Affairs

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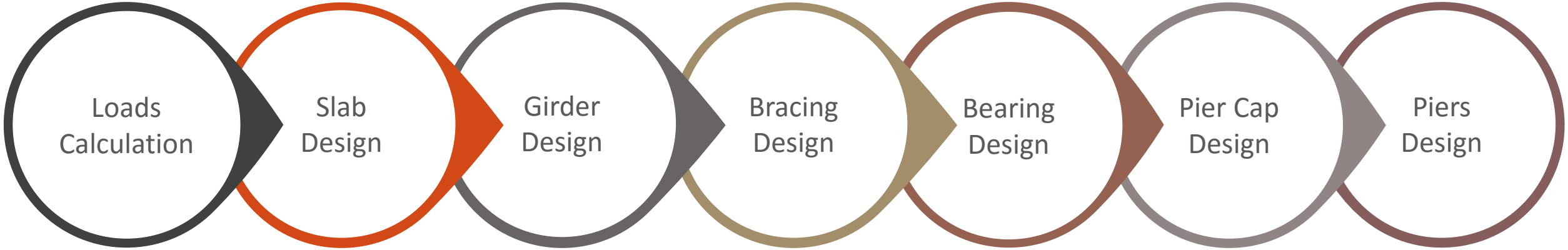
(MOMRA) *STANDARDS*

Standard	Limitation
Safety Factors	1.3 Dead 1.6 Live
Asphalt thickness	75 mm
Concrete slab thickness	175 mm
Traffic Parapet	$H = 810$ mm $W = 430$ mm
Deflection limit	$\frac{L}{800}$
Steel Girder Depth	$\geq 0.04L$
Compressive Strength of Concrete $f c'$	≥ 28 MPa
Yielding strength of steel $f y$	450 MPa

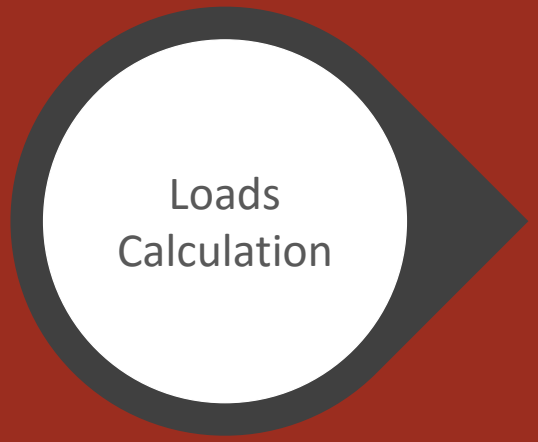
DESIGN CONSTRAINTS

Design Constraints	Project Application
Durability	Maintenance every five years
Economic	Economical limitations were established
Constructability	Being able to design a constructible bridge
Environmental	Avoid the corrosion by coating
Serviceability	Several factors considered such as stability and deflection limit
Safety	Several safety factors and precautions were taken into account in designing process.

PRELIMINARY & STRUCTURAL DESIGN



PRELIMINARY & STRUCTURAL DESIGN (continue)



Type of Load	Result
Dead Load	37.44 kN/m
Truck Load	263.88 kN
Lane Load	83.75 kN
Seismic Load	550 kN
Wind Load	22.24 kN

PRELIMINARY & STRUCTURAL DESIGN (continue)

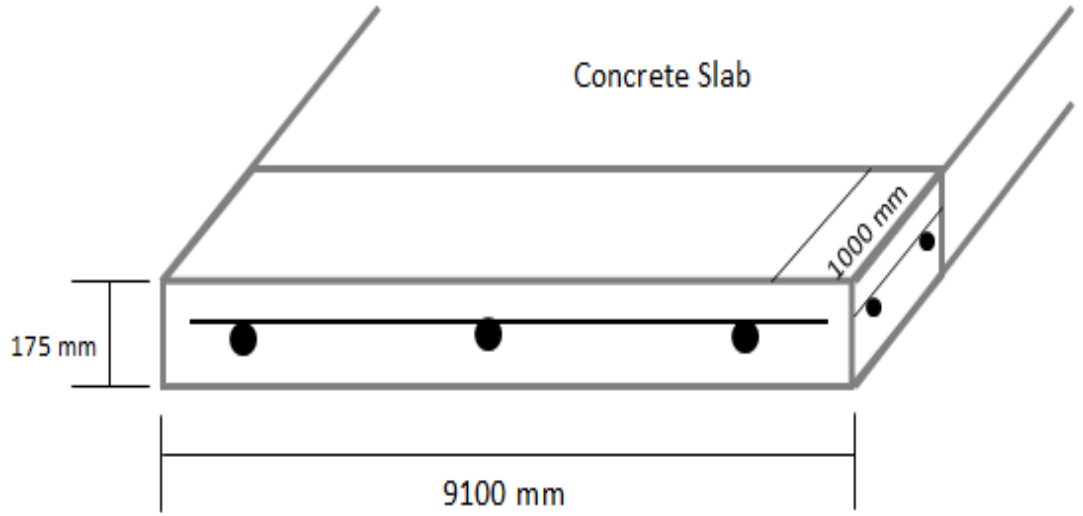
Slab Design

Reinforced Concrete Slab **(ACI)**

For each 1m use:

5 # 16 mm

Spacing ≈ 170 mm c/c

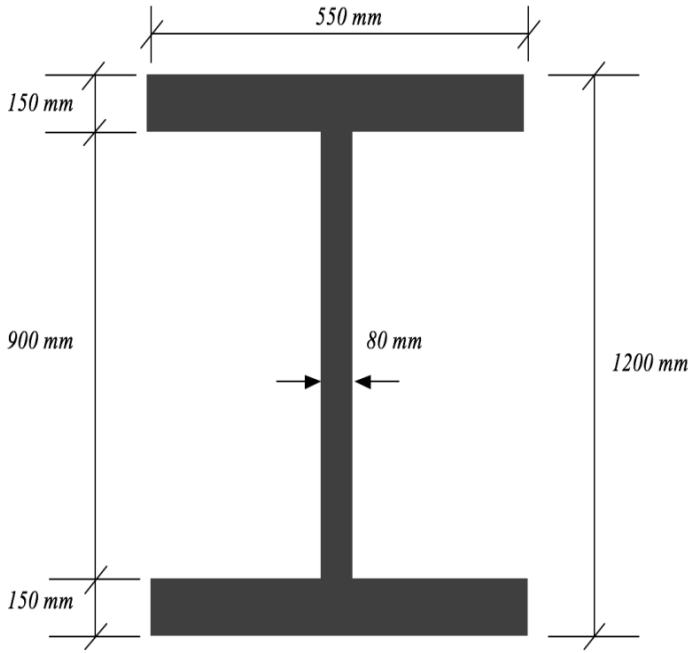


PRELIMINARY & STRUCTURAL DESIGN (continue)

Girder Design

Steel Girder W-Shape **(AISC)**

Shear	$V_u = 1{,}154.47\ \text{kN} < \emptyset V_n = 19{,}440\ \text{kN}$
Moment	$M_u = 7{,}055.63\ \text{kN} - \text{m} < \emptyset M = 40{,}500\ \text{kN} - \text{m}$
Deflection	$18.3\ \text{mm} < 31.3\ \text{mm}$
Depth of steel	$1.2\ \text{m} \geq 1\ \text{m}$
Moment of Inertia	$0.05065\ \text{m}^4 \geq 0.0298\ \text{m}^4$



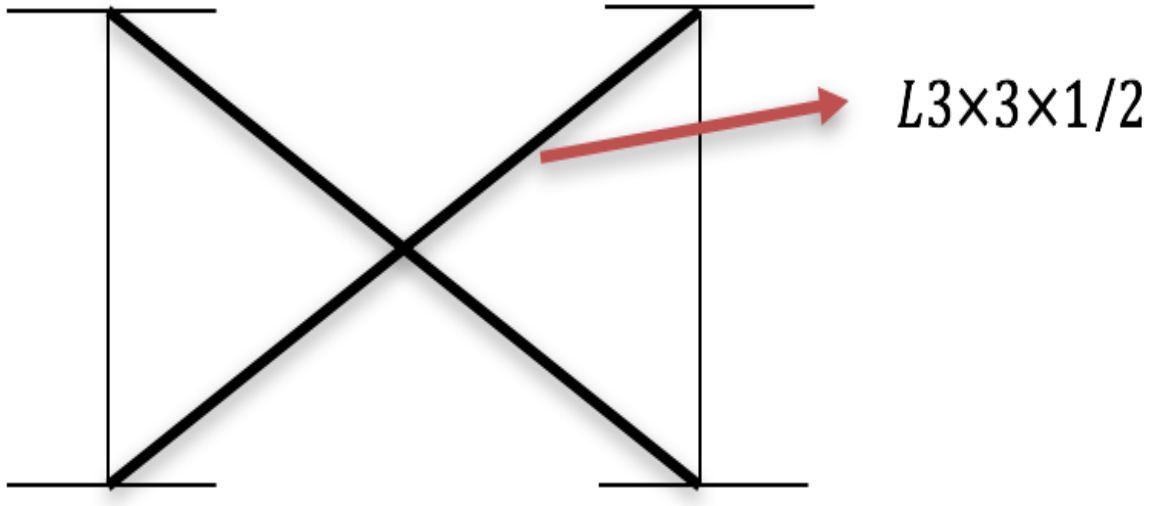
PRELIMINARY & STRUCTURAL DESIGN (continue)

Bracing Design

X Type Steel Bracing **(AISC) (AASHTO)**

Maximum unbraced length L_p = 5 m

Lateral Load = 30% of reaction

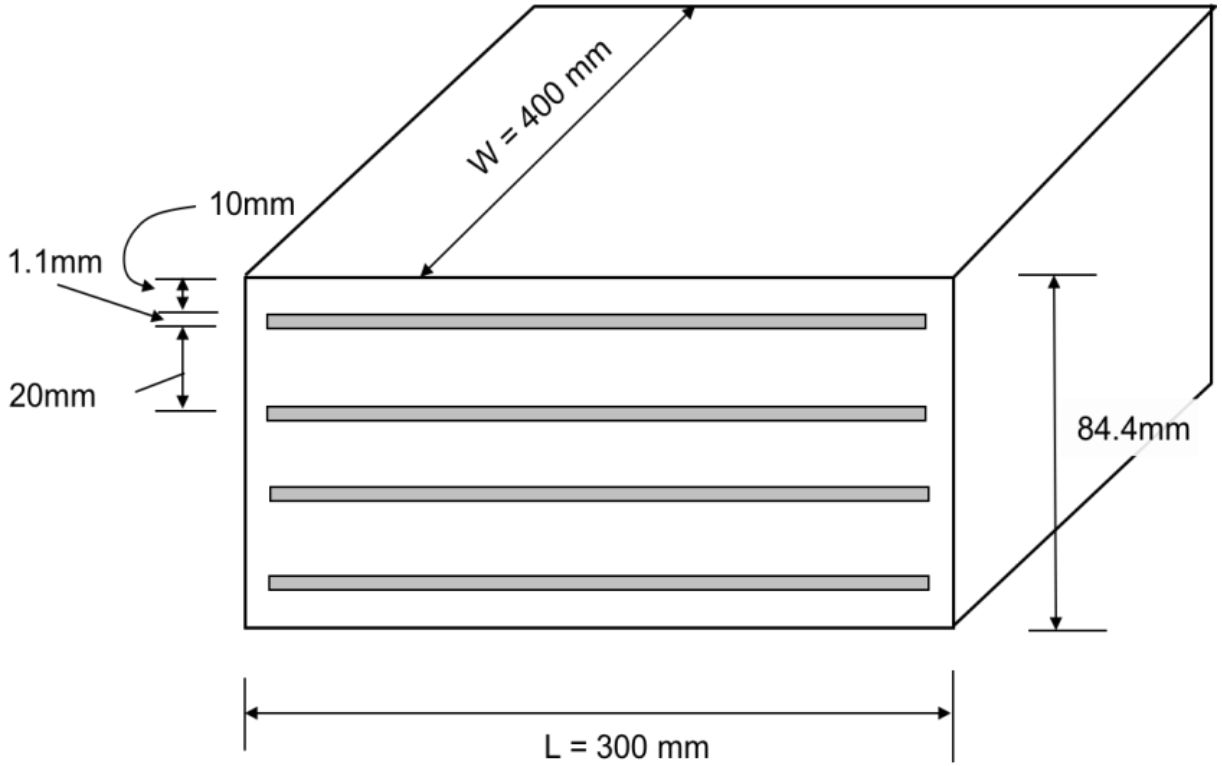


PRELIMINARY & STRUCTURAL DESIGN (continue)

Bearing Design

Steel-Reinforced Elastomeric Bearing **(AASHTO)**

$$\sigma_s = \frac{R}{LW} = \frac{754800}{(300)(400)} = 6.3\ \text{MPa} < 11\ \text{MPa}$$



PRELIMINARY & STRUCTURAL DESIGN (continue)

Pier Cap Design

Reinforced Concrete Pier Cap **(AASHTO) (ACI)**

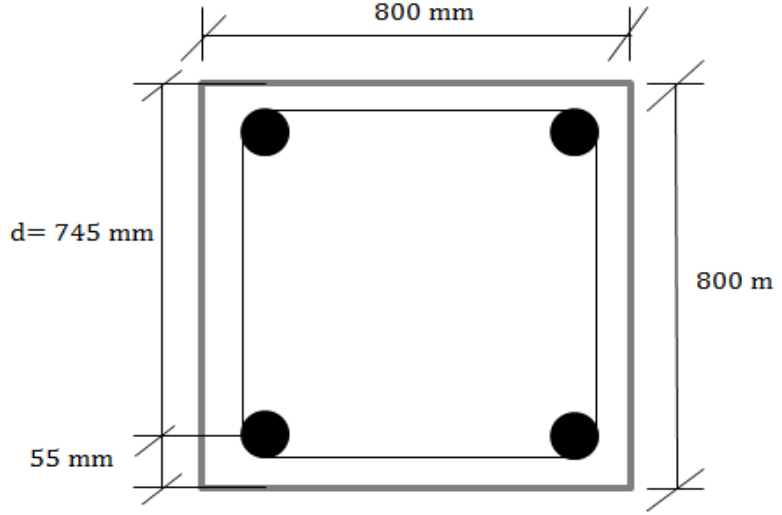
Thermal Expansion 4 in - 10 in = 101.6 mm - 152.4 mm

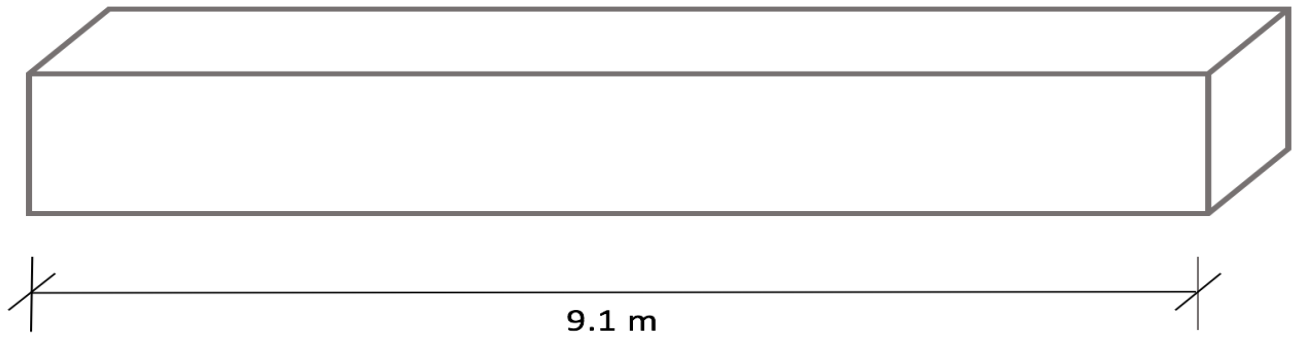
Top bars: 8 # 25 mm

Spacing ≈ 92 mm

Bottom bars: 6 # 25 mm

Spacing ≈ 118 mm





PRELIMINARY & STRUCTURAL DESIGN (continue)

Piers Design

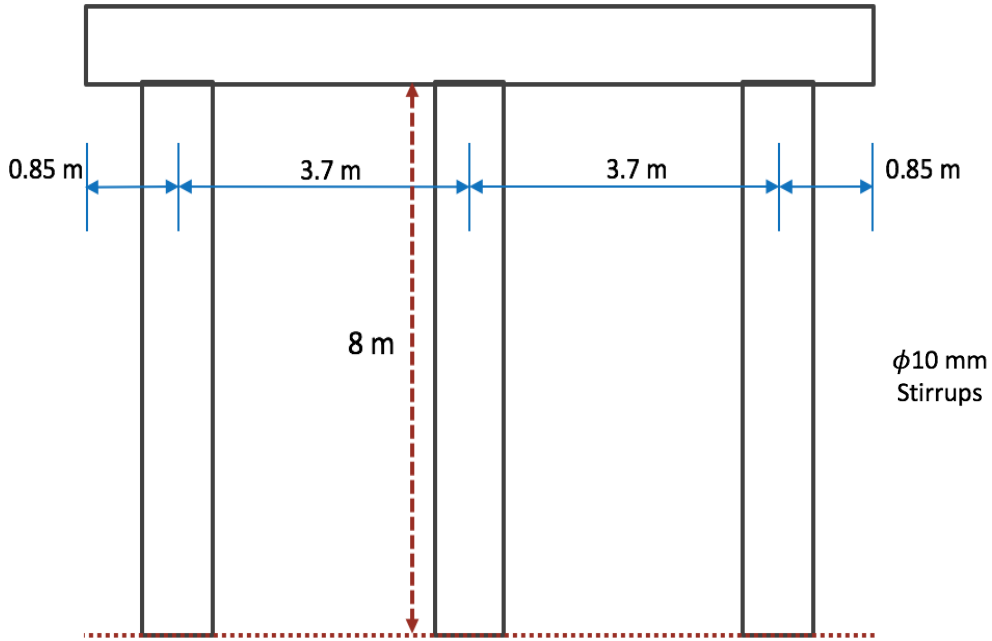
Reinforced Concrete Pier **(ACI)**

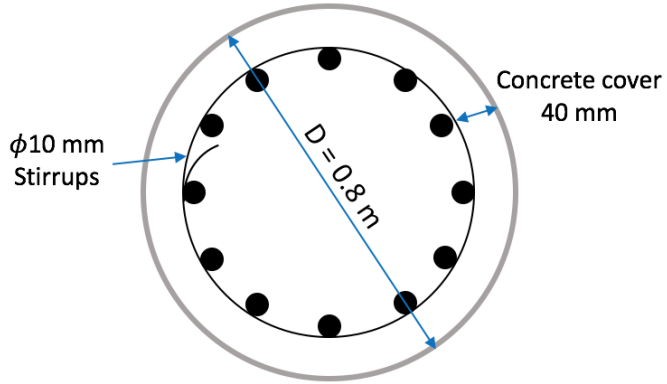
Axial Compression = 3667.11 KN (from SAP2000)

Moment = 4400 + 177.92 = 4577.92 KN-m

32 # 20 mm bars

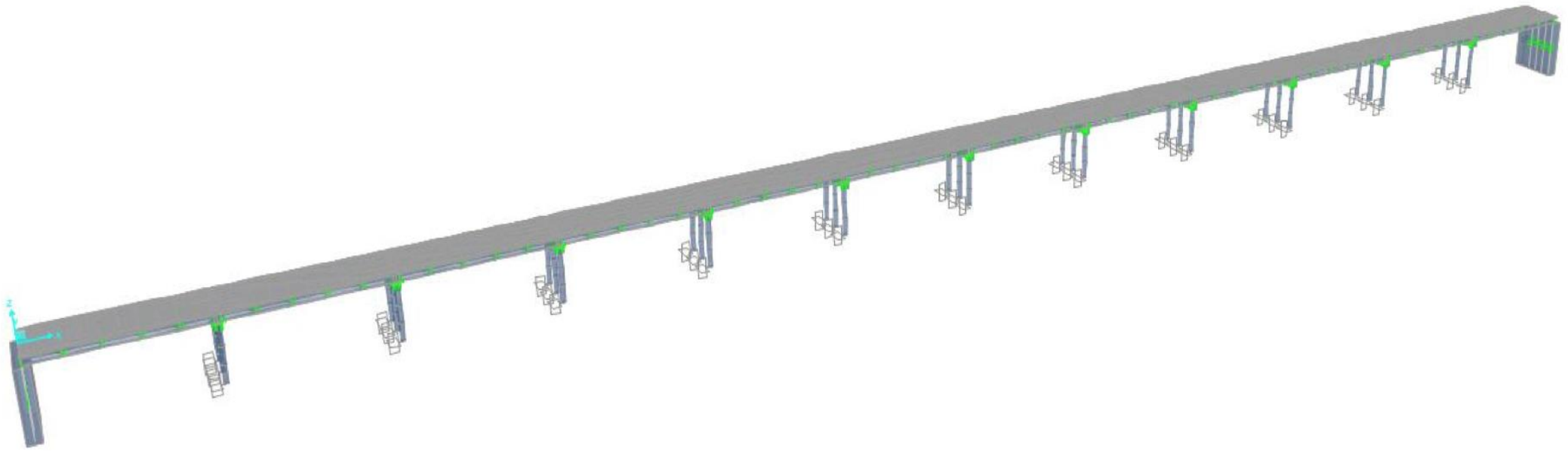
Spacing ≈ 54 mm





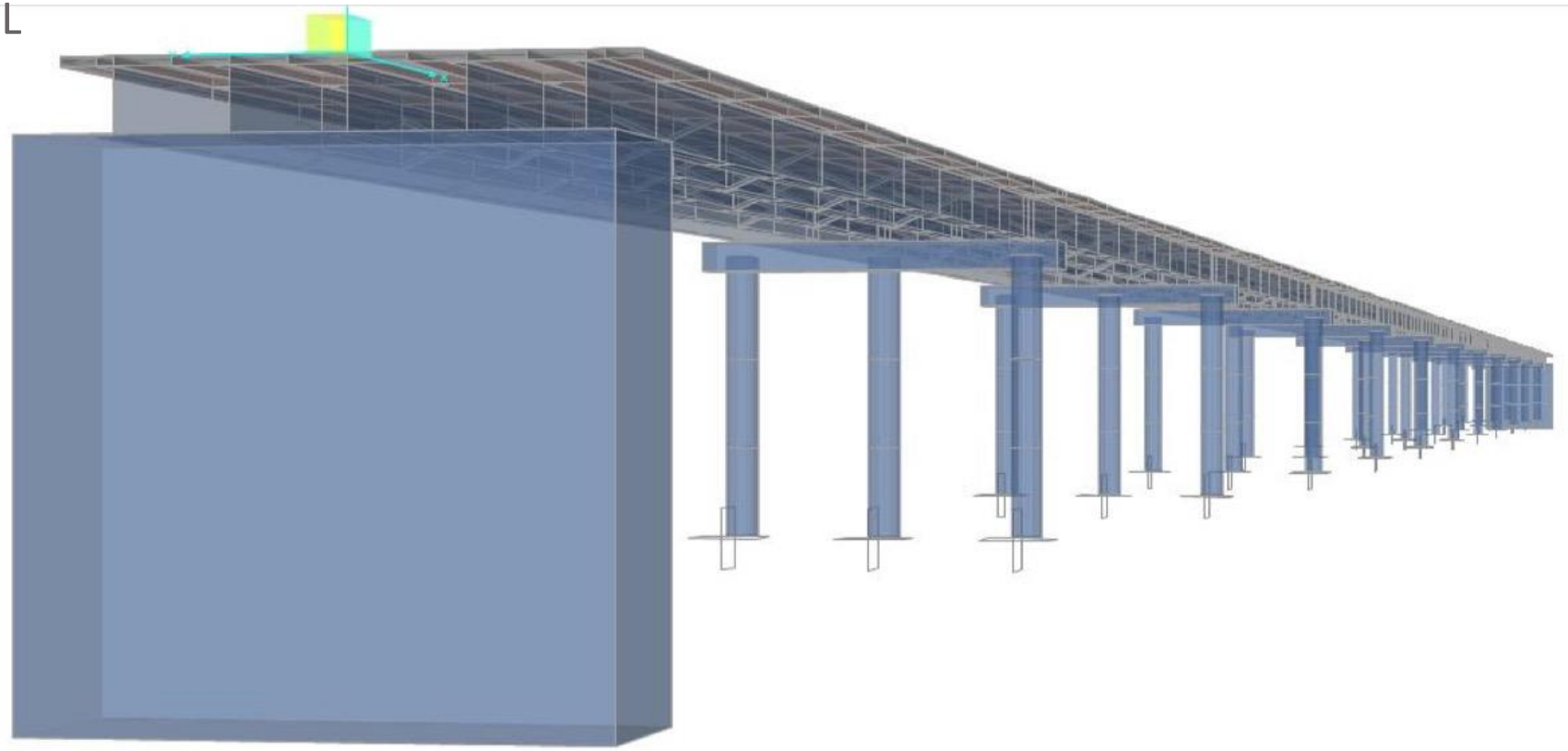
CSiBridge ANALYSIS & DESIGN

3D MODEL



CSiBridge ANALYSIS & DESIGN (continue)

3D MODEL

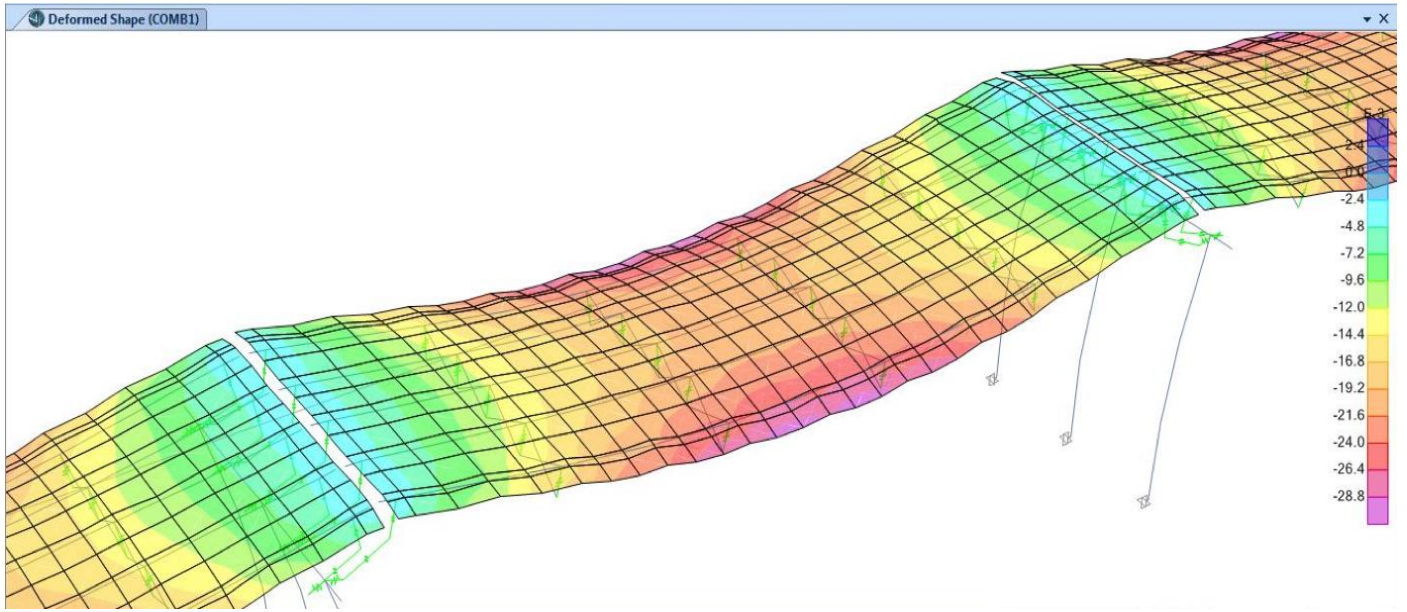


CSiBridge ANALYSIS & DESIGN (continue)

DEFLECTION

Allowable Deflection : $\frac{\mathrm{L}}{800} = 31.3$ mm (**MOMRA**)

Software Result = 29.8 mm

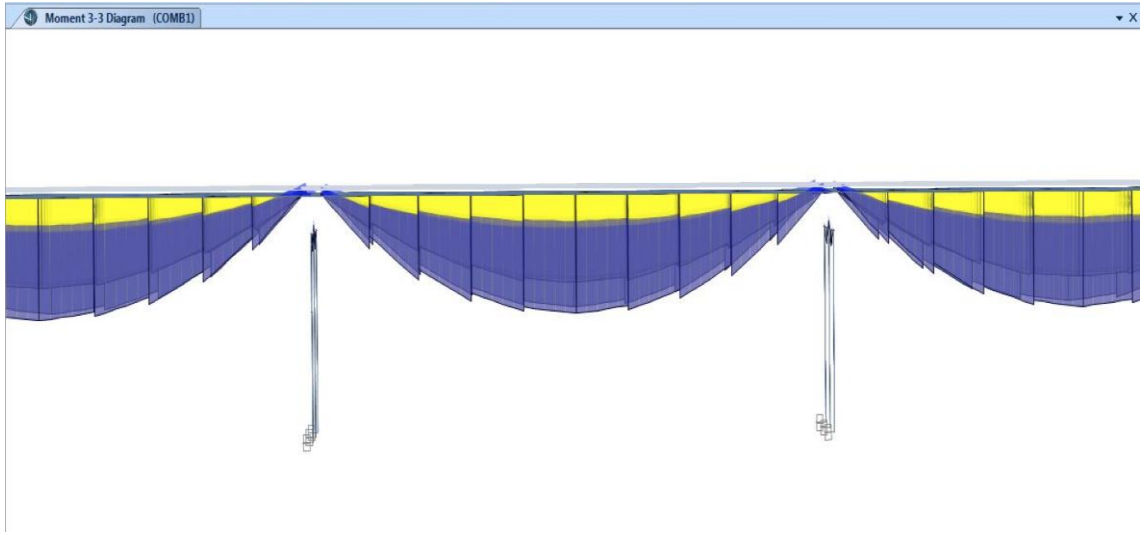


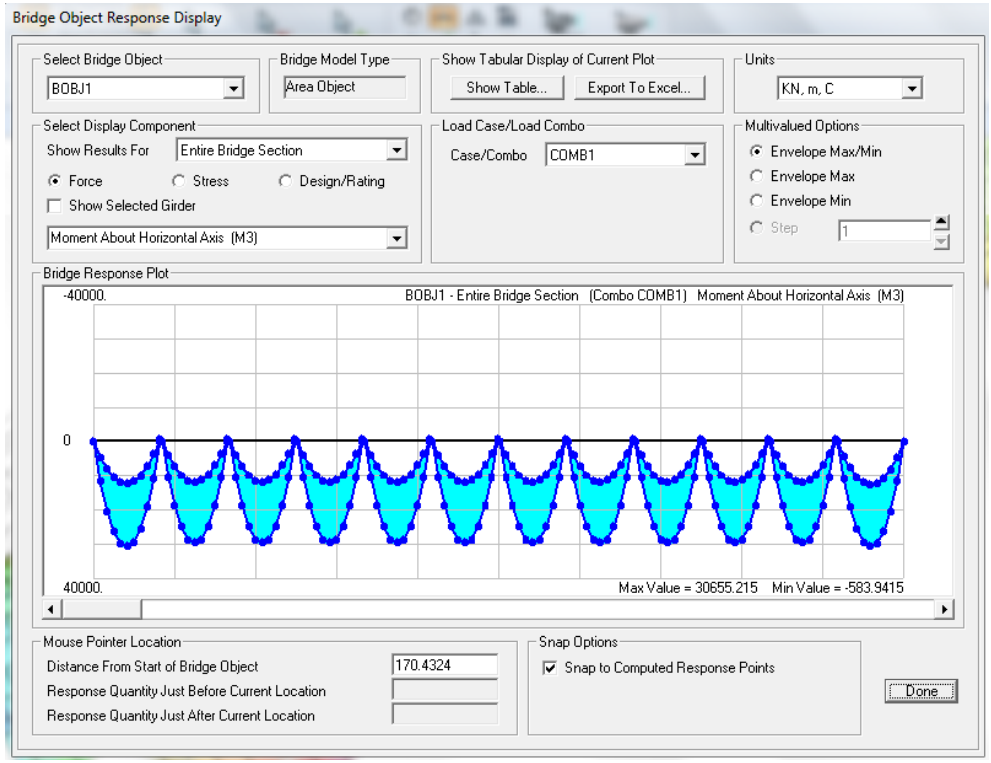
CSiBridge ANALYSIS & DESIGN (continue)

MOMENT

Maximum Moment = 40,500 kN-m (**AISC**)

Software Result = 30,655 kN-m



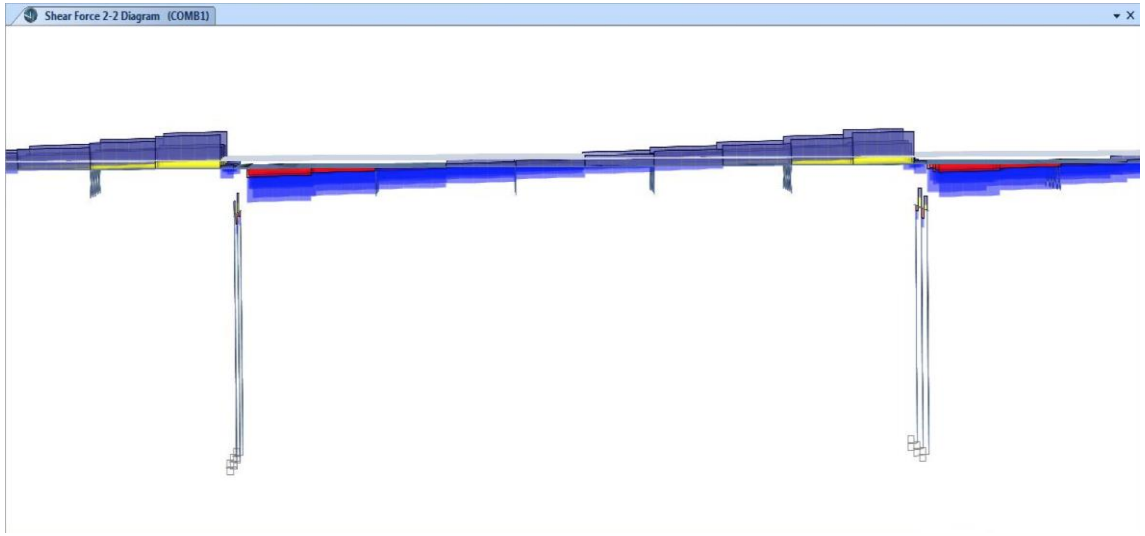


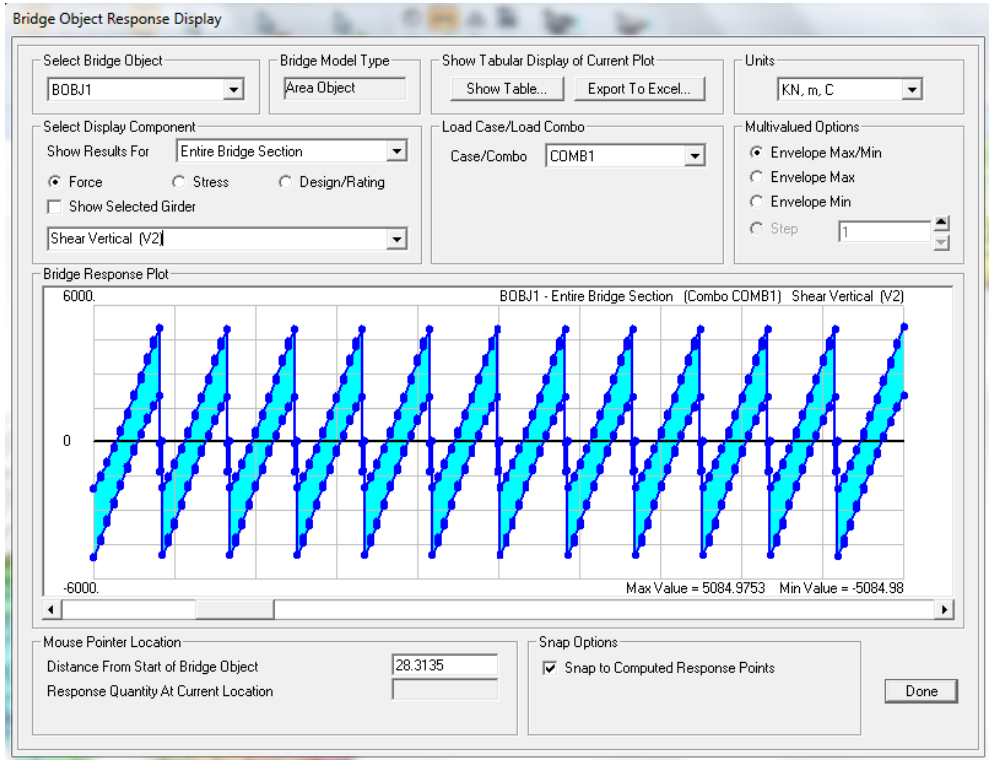
CSiBridge ANALYSIS & DESIGN (continue)

SHEAR

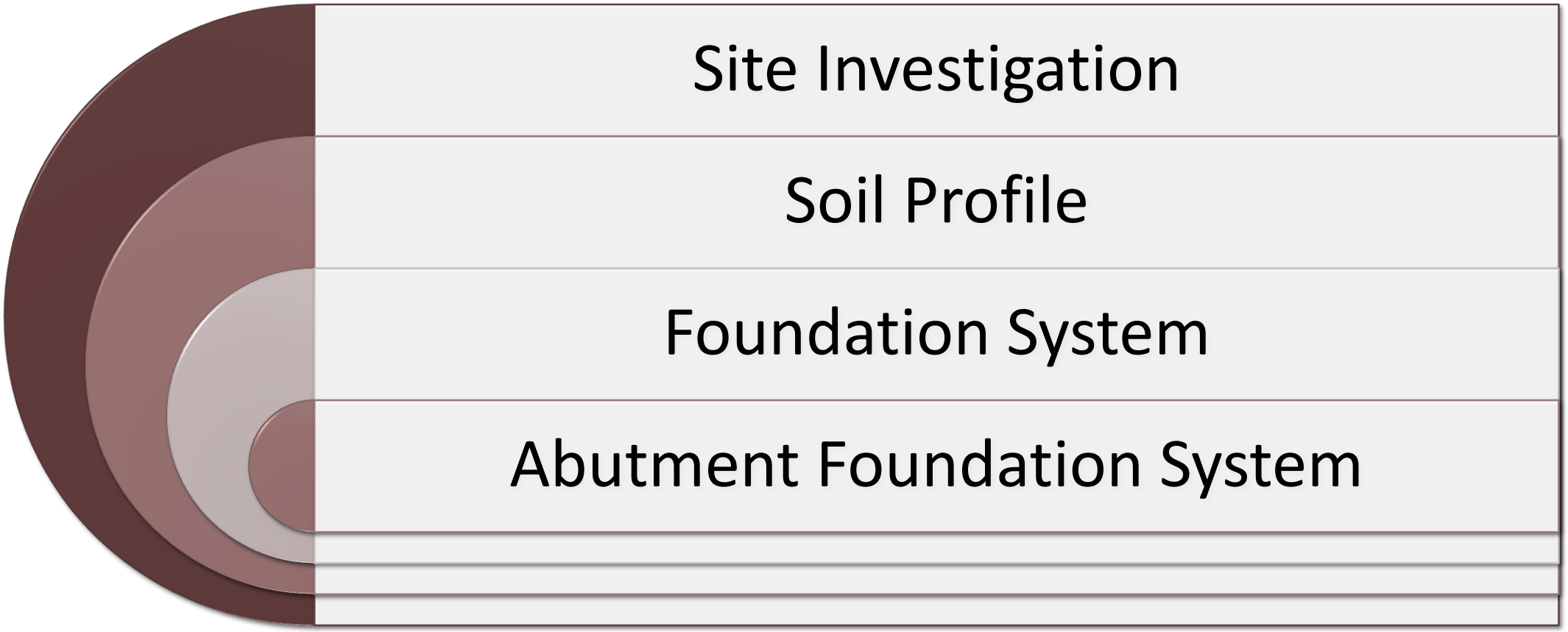
Maximum Shear = 19,440 kN (**AISC**)

Software Result = 5,085 kN



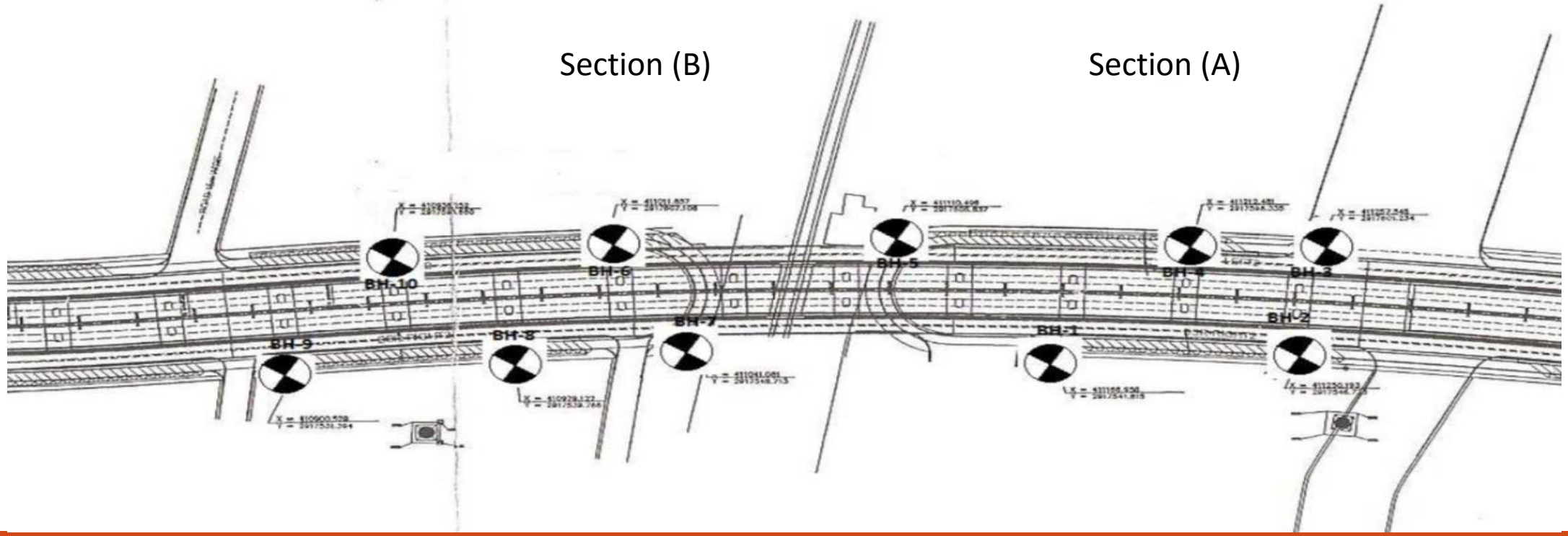


GEOTECHNICAL & FOUNDATION DESIGN



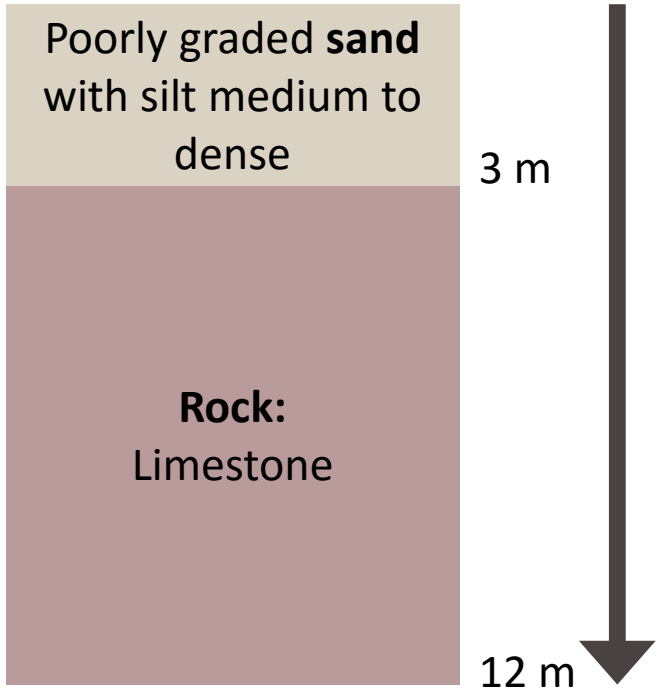
GEOTECHNICAL & FOUNDATION DESIGN (continue)

Site Investigation

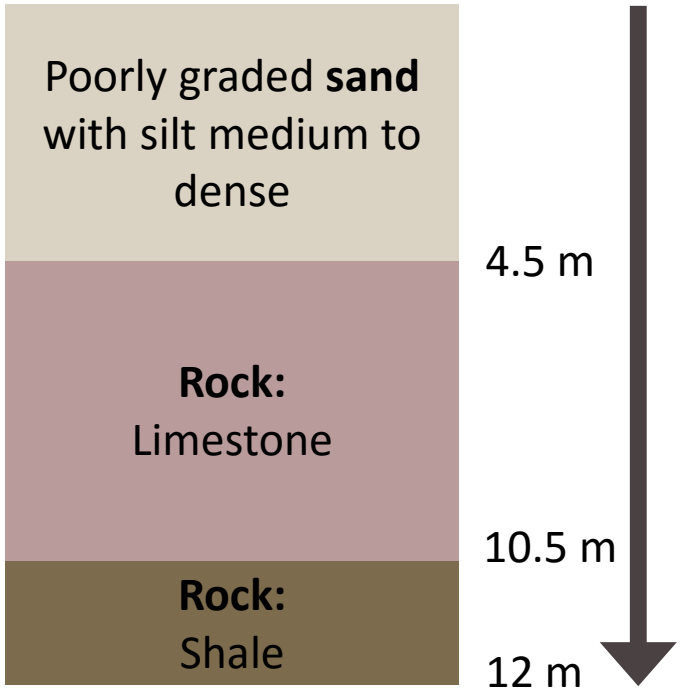


GEOTECHNICAL & FOUNDATION DESIGN (continue)

Soil Profile



Section (A)

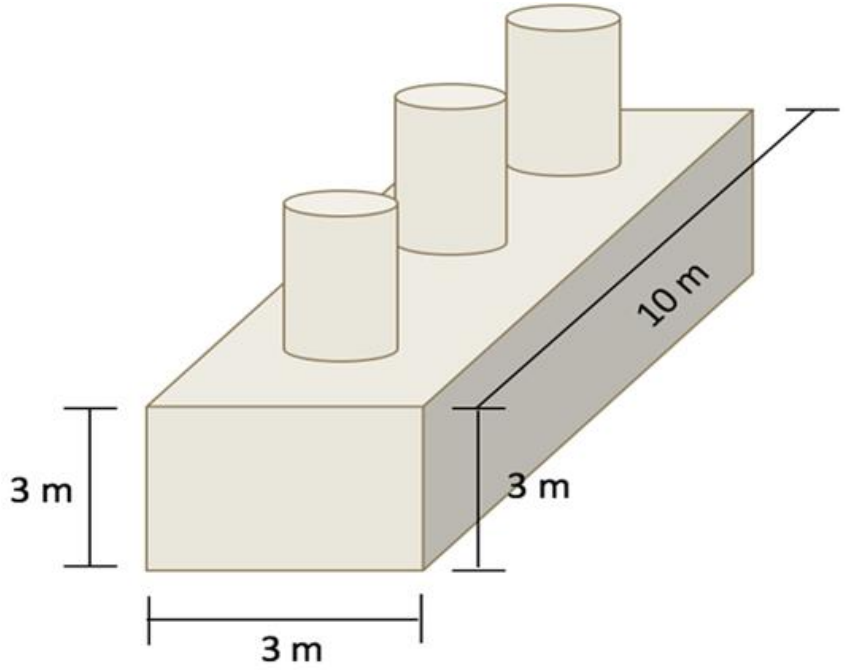


Section (B)

GEOTECHNICAL & FOUNDATION DESIGN (continue)

Foundation System **(Section A)**

Characteristics	Result
Formula used	Rock Formula
Rock Quality Designation (**R.Q.D**)	43.6 %
Rock Capacity (**RC**)	13.24 MPa
Factor of Safety (**FS**)	10
Allowable Bearing Capacity (q_{all})	461.80 kN/m^2
Maximum Bearing Capacity (q_{max})	246.22 kN/m^2
Settlement	None

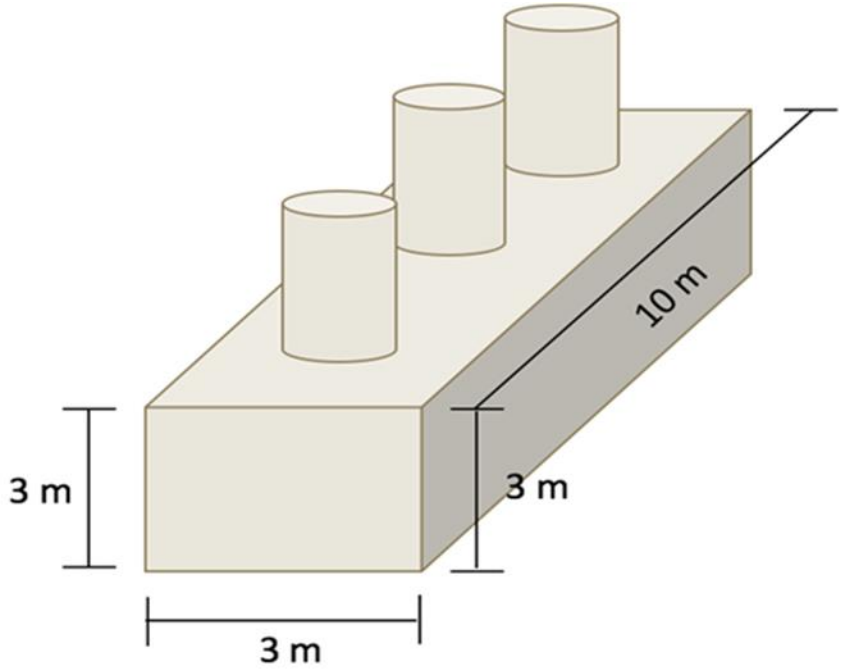


Final Design (strip footing)

GEOTECHNICAL & FOUNDATION DESIGN (continue)

Foundation System **(Section B)**

Characteristics	Result
Formula used	Meyerhof
Angle of friction (Ø)	35°
Unit weight (γ)	20 kN/m^3
Cohesion factor (**C**)	0
Factor of Safety (**FS**)	3
Allowable Bearing Capacity (q_{all})	421.70 kN/m^2
Maximum Bearing Capacity (q_{max})	246.22 kN/m^2
Settlement (S_e)	3.4 mm < **16 mm**

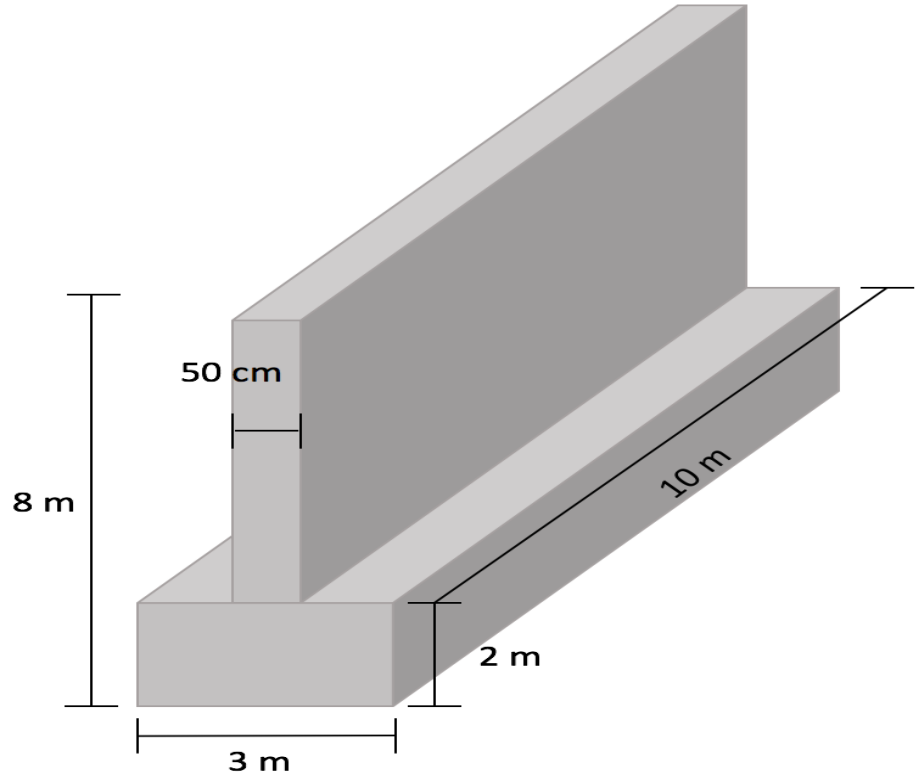


Final Design (strip footing)

GEOTECHNICAL & FOUNDATION DESIGN *(continue)*

Abutment Foundation System

Characteristics	Result
Formula used	Meyerhof
Angle of friction (Ø)	32°
Unit weight (γ)	17.5 kN/m^3
Cohesion factor (**C**)	0
Factor of Safety (**FS**)	3
Allowable Bearing Capacity (q_{all})	243.27 kN/m^2
Maximum Bearing Capacity (q_{max})	194.10 kN/m^2
Settlement (S_e)	9.43 mm < **16 mm**



Final Design (wall footing)

COST ESTIMATION

ANALOGOUS TECHNIQUE:

Similar Project

King Salman bridge intersection with Dammam Khobar highway

Data	Similar Project	Our Project
Cost (SAR)	82 Million SAR	Unknown
Area (m^2)	22800	2730
Start of Construction	Finished in 2010	Start in 2020
Interest Rate (i)	3.72 %	3.72 %
Location	Alkhobar	Dammam

COST ESTIMATION (continue)

ANALOGOUS TECHNIQUE:

Cost Of Our Project = (Cost Of The Similar Project × **S.F** × **A.F** × **L.F** × **T.F** × **Q.F**) + Overhead Risk

The total cost = 26,959,800 SAR

Factor	Result
Size (**S.F**)	0.833
Area (**A.F**)	0.12
Location (**L.F**)	0.923
Interest Rate (**T.F**)	2.0343
Quality (**Q.F**)	150%
Overhead Risk	5 Million

ACKNOWLEDGMENT

Eng. MOHD NAYEEMUDDIN
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Dr. TAHAR AYADAT
Advisor

Dr. ANDI ASIZ
Coordinator

ACKNOWLEDGMENT *(continue)*

Eng. DANISH AHMED
Consultant

Dr. ALAA SALMAN
Consultant

CONCLUSION

- Structural design of the bridge following AASHTO & MOMRA Standards.
- Geotechnical design for abutments, piers and foundation system.
- Modeling using CSiBridge software & analysis.
- Cost Estimation compared with the post-tensioned bridge.

REFERENCES

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- Civil Engineering. (2015, January 21). What Is a Girder Bridge? Retrieved February 2, 2018, from https://goo.gl/FYYK

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Thank You

Q&A