RAWALPINDI RING ROAD

STRUCTURE DESIGN REPORT

VOLUME III [ANNEX-A]

DECEMBER 2020

NESPAK (PVT.) LTD.

STRUCTURAL DESIGN REPORT

General

Bridges, flyovers, overpasses, culverts, underpasses etc. are different type structures used for crossing any obstruction beneath it while maneuvering over roads. This report summarizes the knowledge and skills that our design team has utilized for the design of all the structures that fall on the project alignment. The structural design, suitable design specifications and construction as per specifications are all important parameters to achieve the desired design life of structures.

The concept of influence line is used to analyses the moving track and tank load, which is then combined with other live loads and dead loads to come up with the entire shear force and bending moment envelope along the structural members. However, state of the art software like CSi Bridges, STAAD pro, ET Culvert and different Excel work sheets developed during course of time etc. will be used for analysis/design of relevant structures. Once all the design loads is determined, detailed computational analysis/designs is performed for all structural elements for highway structures in accordance with the applicable design standards.

Inventory of Structures and Design Approach

After geometric design, hydrology/hydraulics, geotechnical investigation of the project alignment, following list of structures has been prepared, comprising bridges, flyovers, underpasses, culverts etc. Detailed design of bridge at KM 36+225, underpass of size 10x5.1m, subway/cattle creep of size 4x3m and retaining wall of 5m height has been carried to explain the methodology and concept of design at this stage of project.

OVERPASSES/FLYOVERS						
Sr.#	CH.		No. of Spans	Span length	Deck Width	
					left	Right
1	0+050	A	4	25+40+40+25	12	
		B	4	25+40+40+25	12	
2	4+627		1	40	15.6	19.2
3	5+170		1	40	19.2	19.2
4	6+960		2	25	10.1	
5	8+100		2	25	10.1	
6	13+030		2	25	10.1	
7	13+524		2	25	10.1	10.1
8	15+535		2	25	10.1	
9	17+200		2	25	10.1	
10	23+865		1	40	24.8	15.6
11	29+250		2	30	15.6	19.2
12	29+802		2	30	19.2	20.3
13	31+585		2	25	10.1	
14	36+225		2	30	15.6	15.6
15	36+470		2	40+30	12	12
16	36+451 A		4	30	12	12
17	37+603		2	30	28.05	15.6
18	37+927		1	45	25.4	31
19	39+765		2	25	10.1	
20	43+265		2	30	10.1	
21	44+130		2	35	15.6	19.2
22	47+473		2	25	10.1	
23	51+735		4	25+30+30+25	15.6	12
24	51+740		1	30	12	
25	57+735		1	35	10.1	10.1
26	59+040		1	30	10.1	10.1
27	60+725	A	5	40+25+30+30+30	15.1	
		B	12	40	15.1	
28	62+750		2	30	15.1	15.1
29	63+400		1	35	15.1	15.1
30	65+580		4	20+40+40+20	11.5	11.5

Bridges (CANNAL / NULLAH)

Sr.#	CH.	No. of Spans	Span length	Deck Width	
				left	Right
1	2+465	4	45	15.6	15.6
2	22+050	14	40	15.6	15.6
3	25+610	5	40	15.6	15.6
4	30+810	2	40	15.6	15.6
5	33+435	4	35	15.6	15.6
6	45+160	2	45	15.6	15.6
7	52+175	1	30	15.6	15.6
8	52+800	1	25	15.6	15.6
9	64+645	3	30	15.1	15.1

LIST OF UNDERPASS

Sr.No.	CHAINAGE	# OF SPAN	WIDTH	HEIGHT	SKEW
1	0+196	1	10	5.5	0
2	1+350	1	10	5.5	0
3	20+420	1	10	5.5	23
4	35+590	1	10	5.5	0
5	44+685	1	10	5.5	31
6	50+810	1	10	5.5	25
7	64+980	1	10	5.5	23

LIST OF BOX CULVERT

Sr.No.	CHAINAGE	# OF SPAN	WIDTH	DEPTH	SKEW
1	0+490	1	2	2	0
2	0+820	2	2	2	0
3	0+975	2	2	2	0
4	2+750	2	2	2	0
5	3+150	1	4	4	0
6	3+350	4	2	2	0
7	3+525	1	2	2	0
8	4+150	2	2	2	0
9	4+770	2	2	2	0
10	6+225	1	2	2	0
11	6+825	6	2	2	0
12	7+825	7	3	2	60
13	8+640	9	3	2	0
14	8+803	5	3	2	0
15	10+550	4	2	2	0
16	10+903	3	3	2	0
17	11+900	8	2	2	0
18	12+300	3	2	2	0
19	13+975	2	2	2	0
20	14+650	2	2	2	0
21	16+750	2	2	2	0
22	17+600	1	2	2	0
23	17+700	2	2	2	0
24	18+250	4	2	2	0
25	18+450	2	2	2	0
26	20+0475	2	2	2	0
27	21+250	2	2	2	0
28	21+450	2	2	2	0
29	22+950	12	4	3	0
30	24+025	2	2	2	0
31	24+425	1	2	2	0
32	26+750	2	2	2	0
33	26+875	2	2	2	0
34	27+450	2	2	2	0
35	27+625	2	2	2	0

LIST OF BOX CULVERT					
Sr.No.	**CHAINAGE**	**# OF SPAN**	**WIDTH**	**DEPTH**	**SKEW**
36	28+000	2	2	2	0
37	28+650	3	2	2	0
38	28+820	3	2	2	0
39	29+375	1	2	2	0
40	30+475	5	2	2	21
41	31+025	3	2	2	0
42	31+325	1	2	2	30
43	32+675	1	2	2	0
44	33+020	5	2	2	0
45	33+552	1	2	2	44
46	35+750	8	3	2	0
47	36+600	1	4	4	0
48	36+825	1	4	4	0
49	37+700	4	2	2	0
50	38+000	4	2	2	0
51	38+350	1	3	2	0
52	39+023	6	3	2	0
53	39+475	2	2	2	0
54	40+150	5	2	2	0
55	41+150	2	3	2	0
56	41+350	8	4	2	0
57	42+510	2	2	2	0
58	44+150	2	3	2	45
59	45+925	1	2	2	2
60	47+578	2	2	2	20
61	47+860	2	2	2	0
62	48+750	1	2	2	0
63	49+450	2	2	2	0
64	51+300	1	4	4	0
65	52+800	2	4	4	0
66	53+155	2	2	2	0
67	60+395	3	4	4	0
68	62+610	1	1	2	19
69	63+335	2	2	2	44
70	63+975	1	3	2	0

LIST OF UTILITY DUCT					
Sr.No.	**CHAINAGE**	**# OF SPAN**	**WIDTH**	**DEPTH**	**SKEW**
1	0+925	1	1.5	1.5	0
2	2+030	1	1.5	1.5	0
3	4+025	1	1.5	1.5	0
4	5+800	1	1.5	1.5	5
5	7+200	1	1.5	1.5	0
6	8+475	1	1.5	1.5	0
7	9+330	1	1.5	1.5	0
8	10+225	1	1.5	1.5	0
9	10+860	1	1.5	1.5	0
10	12+250	1	1.5	1.5	0
11	12+970	1	1.5	1.5	0
12	14+100	1	1.5	1.5	0
13	15+000	1	1.5	1.5	0
14	15+835	1	1.5	1.5	0
15	16+600	1	1.5	1.5	0
16	18+025	1	1.5	1.5	2
17	19+420	1	1.5	1.5	0
18	21+380	1	1.5	1.5	33
19	32+500	1	1.5	1.5	0
20	34+000	1	1.5	1.5	0
21	39+350	1	1.5	1.5	0
22	40+500	1	1.5	1.5	0
23	42+950	1	1.5	1.5	3
24	46+400	1	1.5	1.5	0

LIST OF CATTLE CREEP					
Sr.No.	**CHAINAGE**	**# OF SPAN**	**WIDTH**	**DEPTH**	**SKEW**
1	1+850	1	4	3	0
2	3+860	1	4	3	0
3	7+625	1	4	3	0
4	10+950	1	4	3	0
5	11+642	1	4	3	0
6	12+630	1	4	3	0
7	14+735	1	4	3	0
8	18+175	1	4	3	0
9	18+800	1	4	3	0
10	20+085	1	4	3	0
11	23+010	1	4	3	0
12	27+130	1	4	3	0
13	27+724	1	4	3	25
14	36+840	1	4	3	0
15	40+425	1	4	3	2
16	41+525	1	4	3	0
17	42+415	1	4	3	33

Structural Design Criteria

The main purpose and the objective of the structural design criteria is to formulate and finalize technical data, design assumptions, codes of practice, methods and procedures to be adopted in the structural design of various structures of the Project.

The design assumptions and criteria enunciated herein will be used for the structural design of the flyover bridges, subways, culverts, reinforced earth retaining walls and related works.

Units of Measurement

The designs will be accomplished using International System (SI units).

Codes and Standards

AASHTO LRFD (2017)	-	Bridge Design Specifications The American Association of State Highway and Transportation Officials.
BCP (1986)	-	Building Code of Pakistan
WPCPHB (1967)	-	West Pakistan Code of Practice for Highway Bridges
ACI 318-08	-	Building Code Requirements for Reinforced Concrete. American Concrete Institute.
ASTM A-615	-	Specifications for Deformed and Plain Billet Steel Bars for Concrete Reinforcement.
ASTM C-150	-	Specifications for Portland Cement
ACI-350 R	-	Environmental Engineering Concrete Structures
ASTM C-33	-	Specifications for Concrete Aggregate
UBC 1997	-	Uniform Building Code of USA.

Loads

Structures designed will be capable of resisting the following main loads and forces:

- Dead Load
- Live Load
- Impact/ Dynamic Allowance
- Vehicle Collision Force
- Wind Load
- Longitudinal forces due to tractive/braking effort of vehicles
- Earth Pressure
- Earthquake Forces

Dead loads

Dead Loads will be computed from the unit weights of the materials as given in the Building Code of Pakistan.

Live loads

Vertical live loads as underneath, whichever results in the more severe forces will be considered for design.

- Class – "A" Truck-train loading as specified in Clause 2.4 of West Pakistan Code of Practice for Highways (WPCPHB-1967).
- Class - "AA" Military loading as specified in Section-4 of West Pakistan Code of Practice for Highways Bridges (WPCPHB-1967).
- Vehicular live loading on the roadways of bridges or incidental structures, designated HL-93, and will consist of a combination of the; Design truck or design tandem, and Design Lane Load.

Impact / dynamic allowance

Impact on live loads will be considered as specified in Clause 4.4 for 'Military Loading' and in Clause 2.9 for 'Truck Train Loading' of West Pakistan Code of Practice for Highway Bridges (WPCPHB-1967), as appropriate.

Abutments and piers located within a distance of 9000mm to the edge of roadway, or within a distance of 15000mm to the centerline of railway track, shall be designed for an equivalent static force of 180,000 N, which is assumed to act in any direction in horizontal plane, at a distance of 1200mm above ground as per clause 3.6.5.2 in AASHTO LRFD 2017 for "Vehicle and railway collision with structures".

Alternatively, Impact / dynamic allowance on HL-93 will be considered as specified in Clause 3.6.2 for design truck and design tandem of AASHTO LRFD 2017.

Wind load

Wind load will be computed according to UBC considering wind velocity of 160 km per hour or alternatively Wind load on structure and on live load will be computed according to the clause 3.8 of the AASHTO LRFD 2017.

Braking forces

Longitudinal forces due to tractive/braking effort will be equal to 30% of the weight of the vehicle considering that only one lane is occupied for Class 'A' Loading and 15% of weight of military vehicle for Class 'AA' Loading.

Alternatively, braking forces will be calculated as per clause 3.6.4 of AASHTO LRFD 2017.

The braking force will be taken as the greater of:

- 25 percent of the axle weights of the design truck or design tandem or,

- 5 percent of the design truck plus lane load or five percent of the design tandem plus lane load.

Earth pressures

Lateral earth pressures due to backfill will be computed by the classical theories taking into account the effect of submergence and seismicity of the area as per AASHTO LRFD 2017.

Earthquake forces

Earthquake forces will be considered using earthquake acceleration (pseudo-static) of 0.16g to 0.24g as specified by BCP (2007) under Seismic Zone-2B (Applicable for Rawalpindi). Seismic design will be carried out in accordance with the provisions of AASHTO LRFD 2017.

Loading combination

Loading combinations will be as per AASHTO LRFD 2017 Code.

Materials

For material specifications, the “General Specifications” (1998) by “National Highway Authority (NHA)” will be used. Special provisions will cover any deviation from these specifications. The following major materials will be used in the construction of the structures mentioned earlier.

Concrete:

Minimum compressive cylinder strength of concrete at 28 days for various structural works shall be as follows:

Substructure of bridge	280 Kg/cm^2 (4000 psi).
Deck slab and diaphragms of bridge	280 Kg/cm^2 (4000 psi).
Piles	280 Kg/cm^2 (4000 psi).
Cast in-situ “I”/ Box Girder	280 Kg/cm^2 (4000 psi).
Precast Pre stressed concrete	350 Kg/cm^2 (5000 psi).
Lean/Blinding concrete	100 Kg/cm^2 (1500 psi)
Substructure of culvert/underpass	280 Kg/cm^2 (4000 psi)
Superstructure of culvert/underpass	280 Kg/cm^2 (4000 psi)

Reinforcement

All reinforcing steel (deformed) to be used in reinforced concrete works will conform to ASTM A615 Grade 60 with minimum yield strength of 4250 kg/cm2 (60,000 psi) or AASHTO M-31 Grade 60.

All pre-stressing steel shall be normal relaxation strand conforming to AASHTO M203 (ASTM A-416), Grade 270 having minimum ultimate tensile strength of 19000 N/mm^2 (270 KSi).

Foundation parameters

The Geotechnical parameters relating to the bearing capacity, modulus of subgrade reaction, soil springs, pile capacity curves, lateral earth pressures, depth of foundations etc. will be based on the geotechnical investigations.

Stability Criteria

The following stability criteria will be used:

Factor of safety (Sliding)	=	1.50
Factor of safety (Overturning)	=	1.50
Bearing Pressure	=	The Resultant Force should lie within middle third of the base

Computer Software

Computer programs CSi Bridges/STAAD-Pro, ET Culverts will be used for the analysis and design of the project structures. Design of structural members will be based upon the results obtained after performing 3-D analysis of the structures.

DRAWINGS

All drawings have been prepared using AutoCAD.

DESIGN OF BRIDGE AT KM 36+225

INPUT FILE OF SUPER AND SUB STRUCTURE

Table: Analysis Options

Table: Analysis Options

Solver	SolverProc	Force32Bit	StiffCase	GeomMod	HingeOpt
Advanced	Auto	No	None	None	In Elements

Table: Area Section Properties, Part 1 of 4

Table: Area Section Properties, Part 1 of 4

Section	Material	MatAngle	AreaType	Type	DrillDOF	Thickness	BendThick	Arc
		Degrees				m	m	Degrees
ASEC1	4000Psi	0.	Shell	Shell-Thin	Yes	0.25	0.25	

Table: Area Section Properties, Part 2 of 4

Table: Area Section Properties, Part 2 of 4

Section	InComp	CoordSys	Color	TotalWt	TotalMass	F11Mod	F22Mod
				Tonf	Tonf-s2/m		
ASEC1			White	702.7413	71.66	1.	1.

Table: Area Section Properties, Part 3 of 4

Table: Area Section Properties, Part 3 of 4

Section	F12Mod	M11Mod	M22Mod	M12Mod	V13Mod	V23Mod	MMod	WMod
ASEC1	1.	1.	1.	1.	1.	1.	1.	1.

Table: Area Section Properties, Part 4 of 4

Table: Area Section Properties, Part 4 of 4

Section	GUID	Notes
ASEC1	95b726bf-0a6d-44b3-b5f8-8096c3ea8132	

Table: Auto Wind - AASHTO 2018, Part 1 of 2

Table: Auto Wind - AASHTO 2018, Part 1 of 2

LoadPat	LimitState	Superstructure	Substructure	Vertical	GrndElev	SuperZProg	SubZProg
					m		
Wind	Strength III	Yes	Yes	Yes	-10.5662	Yes	Yes

Table: Auto Wind - AASHTO 2018, Part 2 of 2

Table: Auto Wind - AASHTO 2018, Part 2 of 2

LoadPat	WindSpeed	ExpCat	G	CdSuper	CdSub
	mph				
Wind	110.	C	1.	1.3	1.6

Table: Auto Wind - Live Load

Table: Auto Wind - Live Load

LoadPat	RefLoadPat	Height
		m
Wind-live	Wind	6.

Table: Auto Wind Angles

Table: Auto Wind Angles

LoadPat	SymTran	SymLong	UserDef	Angle	TranCoeff	LongCoeff
				Degrees		
Wind	No	No	No	0.	1.	0.
Wind				15.	0.88	0.12
Wind				30.	0.82	0.24
Wind				45.	0.66	0.32
Wind				60.	0.34	0.38
Wind				90.	0.	0.45

Table: Auto Wind Exposure For Horizontal Diaphragms

Table: Auto Wind Exposure For Horizontal Diaphragms

LoadPat	Diaphragm	DiaphragmZ	X	Y	TribWidth	TribDepth	TribHeight
		m	m	m	m	m	m
Wind							

Table: Auto Wind Exposure For Horizontal Diaphragms

LoadPat	Diaphragm	DiaphragmZ	X	Y	TribWidth	TribDepth	TribHeight
		m	m	m	m	m	m
Wind-live							

Table: Bridge Abutment Definitions

Table: Bridge Abutment Definitions

Abutment	GirderSup	SubType	BeamSect	BeamLength	FSProp
				m	
Abutment	Bottom	Beam	Abutment	17.75	Fixed

Table: Bridge Bearing Definitions

Table: Bridge Bearing Definitions

Bearing	Type	U1Type	U2Type	U3Type	R1Type	R2Type	R3Type
Pinned	User	Fixed	Fixed	Fixed	Free	Free	Free
Roller	User	Fixed	Fixed	Free	Free	Free	Free

Table: Bridge Bent Definitions 1 - General

Table: Bridge Bent Definitions 1 - General

Bent	BeamLength	BeamSect	Type	GirderSup1	BearDist1	GirderSup2	BearDist2	NumCols
	m				m		m	
Abt-BENT	17.75	Abutment	Double	Bottom	0.4572	Bottom	0.4572	5
BENT1	17.75	Transom	Double	Bottom	0.4572	Bottom	0.4572	5

Table: Bridge Bent Definitions 2 - Column Data, Part 1 of 2

Table: Bridge Bent Definitions 2 - Column Data, Part 1 of 2

Bent	ColNum	Section	Distance	Height	Angle	ColSupport	RHLong	RHTrans
			m	m	Degrees			
Abt-BENT	1	Piers-piles	1.669	8.	0.	Fixed	1.	1.
Abt-BENT	2	Piers-piles	5.247	8.	0.	Fixed	1.	1.
Abt-BENT	3	Piers-piles	8.826	8.	0.	Fixed	1.	1.

Table: Bridge Bent Definitions 2 - Column Data, Part 1 of 2

Bent	ColNum	Section	Distance	Height	Angle	ColSupport	RHLong	RHTrans
			m	m	Degrees			
Abt-BENT	4	Piers-piles	12.405	8.	0.	Fixed	1.	1.
Abt-BENT	5	Piers-piles	15.984	8.	0.	Fixed	1.	1.
BENT1	1	Piers-piles	1.669	8.	0.	Fixed	1.	1.
BENT1	2	Piers-piles	5.247	8.	0.	Fixed	1.	1.
BENT1	3	Piers-piles	8.826	8.	0.	Fixed	1.	1.
BENT1	4	Piers-piles	12.405	8.	0.	Fixed	1.	1.
BENT1	5	Piers-piles	15.984	8.	0.	Fixed	1.	1.

Table: Bridge Bent Definitions 2 - Column Data, Part 2 of 2

Table: Bridge Bent Definitions 2 - Column Data, Part 2 of 2

Bent	ColNum	Section	ColSupport	HingeTop	HingeBot	R1Release	R2Release	R3Release
Abt-BENT	1	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed
Abt-BENT	2	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed
Abt-BENT	3	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed
Abt-BENT	4	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed
Abt-BENT	5	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed
BENT1	1	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed
BENT1	2	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed
BENT1	3	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed
BENT1	4	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed
BENT1	5	Piers-piles	Fixed	Auto	Auto	Fixed	Fixed	Fixed

Table: Bridge Design Preferences - AASHTO LRFD 2017

Table: Bridge Design Preferences - AASHTO LRFD 2017

Interims	Amendments
No Interims	No Amendments

Table: Bridge Diaphragm Definitions

Table: Bridge Diaphragm Definitions

Diaph	DiaphType	Thickness	Depth	UseGDepth	MatSolidDia	UseBSectMat
		m	m			
Diaphragm 0.3	Solid	0.3	1.85	Yes	4000Psi	Yes

Table: Bridge Foundation Spring Definitions, Part 1 of 2

Table: Bridge Foundation Spring Definitions, Part 1 of 2

FndSpring	Type	U1Type	U2Type	U3Type	R1Type	R2Type	R3Type	DefLength
								m
Fixed	User	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	1.

Table: Bridge Foundation Spring Definitions, Part 2 of 2

Table: Bridge Foundation Spring Definitions, Part 2 of 2

FndSpring	DefArea
	m2
Fixed	1.

Table: Bridge Layout Line 1 - General

Table: Bridge Layout Line 1 - General

LayoutLine	CoordSys	X	Y	Z	GlobalX	GlobalY	GlobalZ
		m	m	m	m	m	m
BLL1	GLOBAL	0.	0.	0.	0.	0.	0.

Table: Bridge Layout Line 2 - Horizontal Layout Data, Part 1 of 2

Table: Bridge Layout Line 2 - Horizontal Layout Data, Part 1 of 2

LayoutLine	SegType	Station	Radius	Bearing	CoordSys	X
		m	m			m
BLL1	Initial Station and Bearing	0.		N900000E	GLOBAL	0.
BLL1	Straight at Previous Bearing to End	80.			GLOBAL	80.

Table: Bridge Layout Line 2 - Horizontal Layout Data, Part 2 of 2

Table: Bridge Layout Line 2 - Horizontal Layout Data, Part 2 of 2

LayoutLine	Y	GlobalX	GlobalY
	m	m	m
BLL1	0.	0.	0.
BLL1	0.	80.	0.

Table: Bridge Layout Line 3 - Vertical Layout Data

Table: Bridge Layout Line 3 - Vertical Layout Data

LayoutLine	SegType	Station	Grade	CoordSys	Z	GlobalZ
		m	Percent		m	m
BLL1	Initial Station, Elevation Z and Grade	0.	0.	GLOBAL	0.	0.
BLL1	Constant at Previous Grade to End	80.	0.	GLOBAL	0.	0.

Table: Bridge Object Definitions 01 - General, Part 1 of 2

Table: Bridge Object Definitions 01 - General, Part 1 of 2

BridgeObj	Type	LayoutLine	NumSpans	NumBents	NumHinges	NumTendons	NumGroups	SuperElev
2-30-26deg	General	BLL1	2	1	0	0	6	Yes

Table: Bridge Object Definitions 01 - General, Part 2 of 2

Table: Bridge Object Definitions 01 - General, Part 2 of 2

BridgeObj	LockUpdate
2-30-26deg	No

Table: Bridge Object Definitions 02 - Reference Line

Table: Bridge Object Definitions 02 - Reference Line

BridgeObj	SpanName	Station	Length	StartSupp	EndSupp
		m	m		
2-30-26deg	Start Abutment	10.	0.	Abt-BENT	Abt-BENT
2-30-26deg	Abutment 1 to Span1	40.	30.	Abt-BENT	BENT1
2-30-26deg	Span1 to Abutment 2	70.	30.	BENT1	Abt-BENT

Table: Bridge Object Definitions 03 - Spans 1 - General

Table: Bridge Object Definitions 03 - Spans 1 - General

BridgeObj	SpanName	BridgeSect	Variation
2-30-26deg	Abutment 1 to Span1	BSEC1	No

Table: Bridge Object Definitions 03 - Spans 1 - General

BridgeObj	SpanName	BridgeSect	Variation
2-30-26deg	Span1 to Abutment 2	BSEC1	No

Table: Bridge Object Definitions 06 - Abutments, Part 1 of 2

Table: Bridge Object Definitions 06 - Abutments, Part 1 of 2

BridgeObj	Location	Support Name	Bearing Dir	DiaphProp	SubType	BentProp	SubElev	HorizOff
							m	m
2-30-26deg	Start	Start Abutment	64	Diaphragm 0.3	Bent	Abt-BENT	-2.4384	0.
2-30-26deg	End	End Abutment	64	Diaphragm 0.3	Bent	Abt-BENT	-2.4384	0.

Table: Bridge Object Definitions 06 - Abutments, Part 2 of 2

Table: Bridge Object Definitions 06 - Abutments, Part 2 of 2

BridgeObj	Location	Support Name	BearProp	BearResProp	BearElev	BearAngle
					m	Degrees
2-30-26deg	Start	Start Abutment	Pinned	None	-1.8288	0.
2-30-26deg	End	End Abutment	Roller	None	-1.8288	0.

Table: Bridge Object Definitions 07 - Bents, Part 1 of 3

Table: Bridge Object Definitions 07 - Bents, Part 1 of 3

BridgeObj	SpanName	BentProp	Continuous	Support Name	Bearing Dir	BentElev	HorizOff	DiaphBefore
						m	m	
2-30-26deg	Abutment 1 to Span1	BENT1	No	Span 2	64	-2.4384	0.	Diaphragm 0.3

Table: Bridge Object Definitions 07 - Bents, Part 2 of 3

Table: Bridge Object Definitions 07 - Bents, Part 2 of 3

BridgeObj	SpanName	SupportName	DiaphAfter	ResPropSS	ResElevSS	MeshAtBent	BearProp1	BrResProp1
					m			
2-30-26deg	Abutment 1 to Span1	Span 2	Diaphragm 0.3	None	-0.6096	Yes	Roller	None

Table: Bridge Object Definitions 07 - Bents, Part 3 of 3

Table: Bridge Object Definitions 07 - Bents, Part 3 of 3

BridgeObj	SpanName	SupportName	BearElev1	BearAngle1	BearProp2	BrResProp2	BearElev2	BearAngle2
			m	Degrees			m	Degrees
2-30-26deg	Abutment 1 to Span1	Span 2	-1.8288	0.	Pinned	None	-1.8288	0.

Table: Bridge Object Definitions 09 - Super Elevation 1 - General

Table: Bridge Object Definitions 09 - Super Elevation 1 - General

BridgeObj	IsConstant	SuperElev
		Percent
2-30-26deg	Yes	2.

Table: Bridge Object Definitions 14 - Diaphragms

Table: Bridge Object Definitions 14 - Diaphragms

BridgeObj	SpanName	DiaphProp	DiaphLoc	DiaphBrg	DiaphDist	RefLine
					m	
2-30-26deg	Abutment 1 to Span1	Diaphragm 0.3	All Spaces	64	10.	Layout Line
2-30-26deg	Abutment 1 to Span1	Diaphragm 0.3	All Spaces	64	20.	Layout Line
2-30-26deg	Span1 to Abutment 2	Diaphragm 0.3	All Spaces	64	10.	Layout Line

Table: Bridge Object Definitions 14 - Diaphragms

BridgeObj	SpanName	DiaphProp	DiaphLoc	DiaphBrg	DiaphDist	RefLine
					m	
2-30-26deg	Span1 to Abutment 2	Diaphragm 0.3	All Spaces	64	20.	Layout Line

Table: Bridge Section Definitions - Girder Output Location Data

Table: Bridge Section Definitions - Girder Output Location Data

Section	GirderNum	VertLoc	HorizLoc
BSEC1	1	Center of gravity	Web center
BSEC1	2	Center of gravity	Web center
BSEC1	3	Center of gravity	Web center
BSEC1	4	Center of gravity	Web center
BSEC1	5	Center of gravity	Web center
BSEC1	6	Center of gravity	Web center

Table: Bridge Section Definitions 09 - PCC I Girders 1 - General, Part 1 of 4

Table: Bridge Section Definitions 09 - PCC I Girders 1 - General, Part 1 of 4

Section	Material	NumIntGird	TotalWidth	GirdLayout	DiffSpacing	DiffHaunch	DiffSection
			m				
BSEC1	4000Psi	4	15.95	Along Layout Line	No	No	No

Table: Bridge Section Definitions 09 - PCC I Girders 1 - General, Part 2 of 4

Table: Bridge Section Definitions 09 - PCC I Girders 1 - General, Part 2 of 4

Section	TopSlabThk	HaunchHSame	GirdSecSame	LOLength	LOFillDist	LOOuterThk	ROLength	ROFillDist
	m	m		m	m	m	m	m
BSEC1	0.225	0.075	Girder 30m	1.1	0.45	0.225	1.1	0.45

Table: Bridge Section Definitions 09 - PCC I Girders 1 - General, Part 3 of 4

Table: Bridge Section Definitions 09 - PCC I Girders 1 - General, Part 3 of 4

Section	ROOuterThk	FHoriz1	FHoriz2	CurbLoc	CurbLeft	CurbRight	CurbMedian
	m	m	m		m	m	m
BSEC1	0.225	0.	0.	Program Determined	0.4	0.4	0.

Table: Bridge Section Definitions 09 - PCC I Girders 1 - General, Part 4 of 4

Table: Bridge Section Definitions 09 - PCC I Girders 1 - General, Part 4 of 4

Section	CurbMWidth	RefPtOffX	RefPtOffY
	m	m	m
BSEC1	0.	0.	0.

Table: Bridge Section Load Definitions 01 - Haunch

Table: Bridge Section Load Definitions 01 - Haunch

Section	LoadPat	AutoHaunchL	HaunchL
			Tonf/m
BSEC1	Haunch	Yes	

Table: Bridge Section Load Definitions 05 - Barrier, Part 1 of 2

Table: Bridge Section Load Definitions 05 - Barrier, Part 1 of 2

Section	LoadPat	MeasureFrom	Dist	Width	Height	Wecc
			m	m	m	m
BSEC1	Barrier	Left Edge of Deck	0.	0.4	0.94	-0.0762
BSEC1	Barrier	Right Edge of Deck	0.	0.4	0.94	-0.0762

Table: Bridge Section Load Definitions 05 - Barrier, Part 2 of 2

Table: Bridge Section Load Definitions 05 - Barrier, Part 2 of 2

Section	WperL
	Tonf/m
BSEC1	0.6
BSEC1	0.6

Table: Bridge Section Load Definitions 07 - Wearing Surface

Table: Bridge Section Load Definitions 07 - Wearing Surface

Section	LoadPat	WperA
		Tonf/m2
BSEC1	DW	0.173

Table: Bridge Section Load Definitions 08 - Temperature Change

Table: Bridge Section Load Definitions 08 - Temperature Change

Section	LoadPatPos	TChange Pos	LoadPatNeg	TChange Neg
		C		C
BSEC1	Temperature Pos	30.	Temperature Neg	-40.

Table: Bridge Seismic Design Preferences - AASHTO Seismic 2011

Table: Bridge Seismic Design Preferences - AASHTO Seismic 2011

Interims	HingeOpt	HingeStlOpt	NumCurves	NumPoints	HingeLenOpt
No Interims	Auto: AASHTO/Caltrans Hinge	Auto: FEMA 356 Hinge	16	21	Use Shorter Hinge Length

Table: Case - Moving Load 1 - Lane Assignments

Table: Case - Moving Load 1 - Lane Assignments

Case	AssignNum	VehClass	ScaleFactor	MinLoaded	MaxLoaded	NumLanes
Class-A	1	Class-A	1.	0	0	3
Class-AA	1	Class-AA	1.	0	0	1
Class-AA-1	1	Class-AA	1.	0	0	1
Class-AA-2	1	Class-AA	1.	0	0	1

Table: Case - Moving Load 2 - Lanes Loaded

Table: Case - Moving Load 2 - Lanes Loaded

Case	AssignNum	Lane
Class-A	1	LANE1
Class-A	1	LANE2
Class-A	1	LANE3
Class-AA	1	LANE1
Class-AA-1	1	LANE2
Class-AA-2	1	LANE3

Table: Case - Multistep Static 1 - Load Assignments

Table: Case - Multistep Static 1 - Load Assignments

Case	LoadType	LoadName	LoadSF
Wind	Load pattern	Wind	1.
Wind-live	Load pattern	Wind-live	1.

Table: Case - Response Spectrum 1 - General, Part 1 of 2

Table: Case - Response Spectrum 1 - General, Part 1 of 2

Case	ModalCombo	GMCf1	GMCf2	PerRigid	DirCombo	ABSSF	MotionType
		Cyc/sec	Cyc/sec				
Seismic	CQC	1.0000E+00	0.0000E+00	ABS	ABS	9.81	Acceleration
Seismic1	CQC	1.0000E+00	0.0000E+00	ABS	ABS	9.81	Acceleration

Table: Case - Response Spectrum 1 - General, Part 2 of 2

Table: Case - Response Spectrum 1 - General, Part 2 of 2

Case	DampingType	ConstDamp	EccenRatio	NumOverride
Seismic	Constant	0.05	0.	0
Seismic1	Constant	0.05	0.	0

Table: Case - Response Spectrum 2 - Load Assignments

Table: Case - Response Spectrum 2 - Load Assignments

Case	LoadType	LoadName	CoordSys	Function	Angle	TransAccSF
					Degrees	m/sec2
Seismic	Acceleration	U1	GLOBAL	FUNC1	0.	1.
Seismic	Acceleration	U2	GLOBAL	FUNC1	0.	0.3
Seismic1	Acceleration	U1	GLOBAL	FUNC1	0.	0.3
Seismic1	Acceleration	U2	GLOBAL	FUNC1	0.	1.

Table: Case - Static 1 - Load Assignments

Table: Case - Static 1 - Load Assignments

Case	LoadType	LoadName	LoadSF
DEAD	Load pattern	DEAD	1.
Earth Pressure	Load pattern	Earth Pressure	1.

Table: Element Forces - Frames, Part 1 of 3

Table: Element Forces - Frames, Part 1 of 3

Frame	Station	OutputCase	CaseType	StepType	StepNum	P	V2	V3
	m					Tonf	Tonf	Tonf
1_0._DEAD								

Section Name	RebarMatL	RebarMatC	ReinfConfig	LatReinf	Cover	NumBarsCirc	BarSizeL	BarSizeC
					m			
Piers-piles	A615Gr60	A615Gr60	Circular	Spiral	0.05	16	#10	#4

Table: Frame Section Properties 02 - Concrete Column, Part 2 of 2

Table: Frame Section Properties 02 - Concrete Column, Part 2 of 2

Section Name	SpacingC	ReinfType
	m	
Piers-piles	0.1	Design

Table: Frame Section Properties 03 - Concrete Beam

Table: Frame Section Properties 03 - Concrete Beam

Section Name	RebarMatL	RebarMatC	TopCover	BotCover	TopLeftArea	TopRghtArea	BotLeftArea	BotRghtArea
			m	m	m2	m2	m2	m2
Abutment	A615Gr60	A615Gr60	0.05	0.05	0.	0.	0.	0.
Transom	A615Gr60	A615Gr60	0.05	0.05	0.	0.	0.	0.

Table: Frame Section Properties 08 - PCC I Girder, Part 1 of 2

Table: Frame Section Properties 08 - PCC I Girder, Part 1 of 2

Section Name	B1	B2	B3	B4	D1	D2	D3	D4
	m	m	m	m	m	m	m	m
Girder 30m	0.9	0.6	0.1	0.	2.1	0.13	0.07	0.1

Table: Frame Section Properties 08 - PCC I Girder, Part 2 of 2

Table: Frame Section Properties 08 - PCC I Girder, Part 2 of 2

Section Name	D5	D6	D7	T1	T2	C1
	m	m	m	m	m	m
Girder 30m	0.2	0.25	0.	0.2	0.2	0.

Table: Function - Response Spectrum - AASHTO 2006

Table: Function - Response Spectrum - AASHTO 2006

Name	Period	Accel	FuncDamp	A	SoilType
	Sec				
FUNC1	0.	0.6	0.05	0.24	II
FUNC1	0.437153	0.6			
FUNC1	0.6	0.485817			
FUNC1	0.8	0.401033			
FUNC1	1.	0.3456			
FUNC1	1.2	0.306046			
FUNC1	1.4	0.276156			
FUNC1	1.6	0.252635			
FUNC1	1.8	0.233557			
FUNC1	2.	0.217714			
FUNC1	2.5	0.187621			
FUNC1	3.	0.166147			
FUNC1	3.5	0.149921			
FUNC1	4.	0.137151			
FUNC1	4.5	0.116296			
FUNC1	5.	0.101054			
FUNC1	5.5	0.088995			
FUNC1	6.	0.079246			
FUNC1	6.5	0.071224			
FUNC1	7.	0.064523			
FUNC1	7.5	0.058853			
FUNC1	8.	0.054			
FUNC1	8.5	0.049807			
FUNC1	9.	0.046152			
FUNC1	9.5	0.042942			
FUNC1	10.	0.040103			

Table: Function - Response Spectrum - User

Table: Function - Response Spectrum - User

Name	Period	Accel	FuncDamp
	Sec		
UNIFRS	0.	1.	0.05
UNIFRS	1.	1.	

Table: Lane Definition Data, Part 1 of 3

Table: Lane Definition Data, Part 1 of 3

Lane	LaneFrom	LayoutLine	Station	LaneType	Width	Offset	Radius	LoadGroup
			m		m	m	m	
LANE1	Layout Line	BLL1	0.	Fixed Lane	3.65	4.55	0.	Default
LANE1	Layout Line	BLL1	80.		3.65	4.55	0.	Default
LANE2	Layout Line	BLL1	0.	Fixed Lane	3.65	0.9	0.	Default
LANE2	Layout Line	BLL1	80.		3.65	0.9	0.	Default
LANE3	Layout Line	BLL1	0.	Fixed Lane	3.65	-2.752	0.	Default
LANE3	Layout Line	BLL1	80.		3.65	-2.752	0.	Default

Table: Lane Definition Data, Part 2 of 3

Table: Lane Definition Data, Part 2 of 3

Lane	DiscAlong	DiscAcross	DiscSpan	DiscSpanFac	DiscLane	DiscLaneFac	LeftType	RightType
	m	m						
LANE1	3.	3.	Yes	4.	Yes	10.	Interior	Interior
LANE1								
LANE2	3.	3.	Yes	4.	Yes	10.	Interior	Interior
LANE2								
LANE3	3.	3.	Yes	4.	Yes	10.	Interior	Interior
LANE3								

Table: Lane Definition Data, Part 3 of 3

Table: Lane Definition Data, Part 3 of 3

Lane	Color	Notes
LANE1	Magenta	
LANE1		
LANE2	Yellow	
LANE2		
LANE3	4259584	
LANE3		

Table: Load Case Definitions, Part 1 of 3

Table: Load Case Definitions, Part 1 of 3

Case	Type	MLFactVert	MLFactBrake	MLFactCentr	InitialCond	ModalCase	BaseCase
DEAD	LinStatic				Zero		
MODAL	LinModal				Zero		
Class-A	LinMoving	1.	1.	0.	Zero		
Class-AA	LinMoving	1.	1.	0.	Zero		
Class-AA-1	LinMoving	1.	1.	0.	Zero		
Class-AA-2	LinMoving	1.	1.	0.	Zero		
Wind	LinMSStat				Zero		
Wind-live	LinMSStat				Zero		
Seismic	LinRespSpec					MODAL	
Seismic1	LinRespSpec					MODAL	
Earth Pressure	LinStatic				Zero		

Table: Load Case Definitions, Part 2 of 3

Table: Load Case Definitions, Part 2 of 3

Case	MassSource	DesTypeOpt	DesignType	DesActOpt	DesignAct	AutoType	RunCase	CaseStatus
DEAD		Prog Det	Dead	Prog Det	Non-Composite	None	Yes	Finished
MODAL		Prog Det	Other	Prog Det	Other	None	Yes	Finished
Class-A		Prog Det	Vehicle Live	Prog Det	Short-Term Composite	None	Yes	Finished
Class-AA		Prog Det	Vehicle Live	Prog Det	Short-Term Composite	None	Yes	Finished
Class-AA-1		Prog Det	Vehicle Live	Prog Det	Short-Term Composite	None	Yes	Finished
Class-AA-2		Prog Det	Vehicle Live	Prog Det	Short-Term Composite	None	Yes	Finished

Table: Load Case Definitions, Part 2 of 3

Case	MassSource	DesTypeOpt	DesignType	DesActOpt	DesignAct	AutoType	RunCase	CaseStatus
Wind		User	Wind	Prog Det	Short-Term Composite	None	Yes	Finished
Wind-live		User	Wind - Live Load	Prog Det	Short-Term Composite	None	Yes	Finished
Seismic		Prog Det	Quake	Prog Det	Short-Term Composite	None	Yes	Finished
Seismic1		Prog Det	Quake	Prog Det	Short-Term Composite	None	Yes	Finished
Earth Pressure		Prog Det	Hor Earth Pr	Prog Det	Long-Term Composite	None	Yes	Finished

Table: Load Case Definitions, Part 3 of 3

Table: Load Case Definitions, Part 3 of 3

Case	GUID	Notes
DEAD	20f36f52-441c-49b1-b5a0-e181290d1fc5	
MODAL	65bf0bcd-eb6a-405c-aebf-e087887c684d	
Class-A	b71c3efa-304e-4f49-bc8d-deff46ee57ab	
Class-AA	f2a2b8c2-9060-4548-8380-ea0e7be2b4f8	
Class-AA-1	7bf759e7-ff43-450d-9e8d-6d50c375fb40	

Table: Load Case Definitions, Part 3 of 3

Case	GUID	Notes
Class-AA-2	aa012ccb-6399-459a-91cc-47b73b352bdc	
Wind	6bd5e9b9-550d-49a2-82a3-34429f9f9d1d	
Wind-live	2455aeb9-10e8-4529-8d50-4953f1597365	
Seismic	355b27f2-5952-463d-ad68-2593f4731591	
Seismic1	f30aeb9e-8b55-4372-bd0e-0f10785be9a9	
Earth Pressure	10603035-f8f5-4249-ae59-2bd69b143178	

Table: Load Pattern Definitions

Table: Load Pattern Definitions

LoadPat	DesignType	SelfWtMult	AutoLoad	GUID	Notes
DEAD	Dead	1.		7c3d286c-44d2-4990-ad0c-c58ca6376489	
Haunch	Dead	0.		daf85e3d-49db-4bd8-a0ce-0861d7736539	Program generated for auto bridge section load - Haunch load.
DW	Wearing Surface	0.		1e67c4a9-8f3b-40ec-9627-3d7e28637106	Program generated for auto bridge section load - Wearing Surface load.
Class-A	Vehicle Live	0.		2d532c99-7c1d-4b42-a5f1-f889803dfa61	Added 25/11/2020 12:23:01 PM
Class-AA	Vehicle Live	0.		8a35bd8b-bf99-4852-9f33-ab785db465c0	Added 25/11/2020 12:27:17 PM
Class-AA-1	Vehicle Live	0.		8a35bd8b-bf99-4852-9f33-ab785db465c0	Added 25/11/2020 12:28:13 PM

Table: Load Pattern Definitions

LoadPat	DesignType	SelfWtMult	AutoLoad	GUID	Notes
Class-AA-2	Vehicle Live	0.		8a35bd8b-bf99-4852-9f33-ab785db465c0	Added 25/11/2020 12:28:31 PM
Wind	Wind	0.	AASHTO 2018	268c5428-c821-424a-a81e-f8cbc75e6bae	Added 25/11/2020 12:29:09 PM
Wind-live	Wind - Live Load	0.	Auto	dc19b27e-76d9-4bfe-8192-982fcb7e38cf	Added 25/11/2020 12:29:23 PM
Seismic	Quake	0.	None	2e2530d7-f128-407d-8a27-6809631762c0	Added 25/11/2020 12:29:51 PM
Seismic1	Quake	0.	None	c909efa3-5ea2-40a0-b36b-477dae53ec74	Added 25/11/2020 12:30:00 PM
Earth Pressure	Hor Earth Pr	0.		c41fac7b-3146-47e3-a94c-fb394082452f	Added 26/11/2020 10:02:39 AM

Table: Material Properties 01 - General, Part 1 of 2

Table: Material Properties 01 - General, Part 1 of 2

Material	Type	Grade	SymType	TempDepend	Color	GUID
4000Psi	Concrete	f'c 4000 psi	Isotropic	No	Cyan	e83048b4-628b-4a11-81d8-fff93acfa954
5000Psi	Concrete	f'c 5000 psi	Isotropic	No	Cyan	e626bfc1-bfb4-45c2-8b96-3f8cb4bd9e82
A615Gr60	Rebar	Grade 60	Uniaxial	No	Green	89a564c0-e13f-4276-b5a5-817116b3aca1
A709Gr50	Steel	Grade 50	Isotropic	No	Green	
A722Gr150TypII	Tendon	Grade 150 - Deformed (Type II)	Uniaxial	No	Green	cb09cf6c-ba40-4ad5-9a60-86f7cc73758e

Table: Material Properties 01 - General, Part 2 of 2

Table: Material Properties 01 - General, Part 2 of 2

Material	Notes
4000Psi	Customary f'c 4000 psi 25/11/2020 10:49:28 AM
5000Psi	United States Customary f'c 5000 psi added 25/11/2020 10:54:02 AM
A615Gr60	United States ASTM A615 Grade 60 added 25/11/2020 10:53:50 AM
A709Gr50	ASTM A709 Grade 50 25/11/2020 10:49:28 AM
A722Gr150TypII	ASTM A722 Grade 150 - Deformed (Type II) 25/11/2020 10:56:00 AM

Table: Material Properties 02 - Basic Mechanical Properties

Table: Material Properties 02 - Basic Mechanical Properties

Material	UnitWeight	UnitMass	E1	G12	U12	A1
	Tonf/m3	Tonf-s2/m4	Tonf/m2	Tonf/m2		1/C
4000Psi	2.4028E+00	2.4501E-01	2534563.54	1056068.14	0.2	9.9000E-06
5000Psi	2.4028E+00	2.4501E-01	2833728.24	1180720.1	0.2	9.9000E-06
A615Gr60	7.8490E+00	8.0038E-01	20389019.16			1.1700E-05
A709Gr50	7.8490E+00	8.0038E-01	20389019.16	7841930.45	0.3	1.1700E-05
A722Gr150TypII	7.8490E+00	8.0038E-01	21092088.78			1.1700E-05

Table: Material Properties 03b - Concrete Data, Part 1 of 2

Table: Material Properties 03b - Concrete Data, Part 1 of 2

Material	Fc	eFc	LtWtConc	SSCurveOpt	SSHysType	SFc	SCap	FinalSlope
	Tonf/m2	Tonf/m2						
4000Psi	2812.28	2812.28	No	Mander	Takeda	0.002219	0.005	-0.1
5000Psi	3515.35	3515.35	No	Mander	Takeda	0.002481	0.005	-0.1

Table: Material Properties 03b - Concrete Data, Part 2 of 2

Table: Material Properties 03b - Concrete Data, Part 2 of 2

Material	FAngle	DAngle
	Degrees	Degrees
4000Psi	0.	0.
5000Psi	0.	0.

Table: Material Properties 03e - Rebar Data, Part 1 of 2

Table: Material Properties 03e - Rebar Data, Part 1 of 2

Material	Fy	Fu	EffFy	EffFu	SSCurveOpt	SSHysType	SHard	SCap
	Tonf/m2	Tonf/m2	Tonf/m2	Tonf/m2				
A615Gr60	42184.18	63276.27	46402.6	69603.89	Simple	Kinematic	0.01	0.09

Table: Material Properties 03e - Rebar Data, Part 2 of 2

Table: Material Properties 03e - Rebar Data, Part 2 of 2

Material	FinalSlope	UseCTDef
A615Gr60	-0.1	No

Table: Multi-Step Moving Load 1 - General

Table: Multi-Step Moving Load 1 - General

LoadPat	LoadDur	LoadDisc
	Sec	Sec
Class-A	5.	0.1
Class-AA	9.	0.1
Class-AA-1	9.	0.1
Class-AA-2	9.	0.1

Table: Multi-Step Moving Load 2 - Vehicle Data

Table: Multi-Step Moving Load 2 - Vehicle Data

LoadPat	Vehicle	Lane	Station	StartTime	Direction	Speed	FLLocation
			m	Sec		m/sec	
Class-A	Class-A	LANE1	0.	0.	Forward	30.55	
Class-A	Class-A	LANE2	0.	0.	Forward	30.55	
Class-A	Class-A	LANE3	0.	0.	Forward	30.55	
Class-AA	Class-AA	LANE1	0.	0.	Forward	11.11	
Class-AA-1	Class-AA	LANE2	0.	0.	Forward	11.11	
Class-AA-2	Class-AA	LANE3	0.	0.	Forward	11.11	

Table: Program Control, Part 1 of 3

Table: Program Control, Part 1 of 3

Program Name	Version	ProgLevel	License Num	License OS	License SC	License BR	License HT	CurrUnits
CSiBridge	21.1.0	Advanced w/Rating	3010*1YW4RFTYRMGUZP9	Yes	Yes	Yes	No	Tonf, m, C

Table: Program Control, Part 2 of 3

Table: Program Control, Part 2 of 3

SteelCode	ConcCode	AlumCode	ColdCode	BridgeCode
AISC 360-10	AASHTO LRFD 2014	AA-ASD 2000	AISI-ASD96	AASHTO LRFD 2017

Table: Program Control, Part 3 of 3

Table: Program Control, Part 3 of 3

BridgeRat	BridgeSeism	RegenHinge	BSchedGUID
AASHTO Rating 2018	AASHTO Seismic 2011	Yes	

Table: Response Spectrum Modal Information, Part 1 of 2

Table: Response Spectrum Modal Information, Part 1 of 2

OutputCase	ModalCase	StepType	StepNum	Period	DampRatio	U1Acc	U2Acc	U3Acc
				Sec		m/sec2	m/sec2	m/sec2
Seismic	MODAL	Mode	1.	-52.534161	0.05	0.6	0.18	0.
Seismic	MODAL	Mode	2.	0.928462	0.05	0.36543	0.10963	0.
Seismic	MODAL	Mode	3.	0.568472	0.05	0.50792	0.15238	0.
Seismic	MODAL	Mode	4.	0.318645	0.05	0.6	0.18	0.
Seismic	MODAL	Mode	5.	0.235324	0.05	0.6	0.18	0.
Seismic	MODAL	Mode	6.	0.219381	0.05	0.6	0.18	0.
Seismic	MODAL	Mode	7.	0.216978	0.05	0.6	0.18	0.
Seismic	MODAL	Mode	8.	0.213147	0.05	0.6	0.18	0.
Seismic	MODAL	Mode	9.	0.20547	0.05	0.6	0.18	0.
Seismic	MODAL	Mode	10.	0.193606	0.05	0.6	0.18	0.
Seismic	MODAL	Mode	11.	0.154051	0.05	0.6	0.18	0.
Seismic	MODAL	Mode	12.	0.14527	0.05	0.6	0.18	0.
Seismic1	MODAL	Mode	1.	-52.534161	0.05	0.18	0.6	0.
Seismic1	MODAL	Mode	2.	0.928462	0.05	0.10963	0.36543	0.
Seismic1	MODAL	Mode	3.	0.568472	0.05	0.15238	0.50792	0.
Seismic1	MODAL	Mode	4.	0.318645	0.05	0.18	0.6	0.
Seismic1	MODAL	Mode	5.	0.235324	0.05	0.18	0.6	0.
Seismic1	MODAL	Mode	6.	0.219381	0.05	0.18	0.6	0.
Seismic1	MODAL	Mode	7.	0.216978	0.05	0.18	0.6	0.
Seismic1	MODAL	Mode	8.	0.213147	0.05	0.18	0.6	0.
Seismic1	MODAL	Mode	9.	0.20547	0.05	0.18	0.6	0.
Seismic1	MODAL	Mode	10.	0.193606	0.05	0.18	0.6	0.
Seismic1	MODAL	Mode	11.	0.154051	0.05	0.18	0.6	0.
Seismic1	MODAL	Mode	12.	0.14527	0.05	0.18	0.6	0.

Table: Response Spectrum Modal Information, Part 2 of 2

Table: Response Spectrum Modal Information, Part 2 of 2

OutputCase	StepType	StepNum	U1Amp	U2Amp	U3Amp
			m	m	m
Seismic	Mode	1.	340.575591	0.003656	0.
Seismic	Mode	2.	0.031798	-0.018598	0.
Seismic	Mode	3.	0.032837	0.001088	0.
Seismic	Mode	4.	0.000819	0.004145	0.

Table: Response Spectrum Modal Information, Part 2 of 2

OutputCase	StepType	StepNum	U1Amp	U2Amp	U3Amp
			m	m	m
Seismic	Mode	5.	0.002625	-0.000384	0.
Seismic	Mode	6.	-0.001804	-0.000815	0.
Seismic	Mode	7.	-0.000347	0.000057	0.
Seismic	Mode	8.	-0.001367	-0.000013	0.
Seismic	Mode	9.	0.000063	0.000081	0.
Seismic	Mode	10.	-0.001222	-0.000342	0.
Seismic	Mode	11.	-0.000915	-0.000268	0.
Seismic	Mode	12.	-4.191E-06	-1.908E-07	0.
Seismic1	Mode	1.	102.172677	0.012187	0.
Seismic1	Mode	2.	0.009539	-0.061993	0.
Seismic1	Mode	3.	0.009851	0.003627	0.
Seismic1	Mode	4.	0.000246	0.013817	0.
Seismic1	Mode	5.	0.000788	-0.00128	0.
Seismic1	Mode	6.	-0.000541	-0.002716	0.
Seismic1	Mode	7.	-0.000104	0.00019	0.
Seismic1	Mode	8.	-0.00041	-0.000043	0.
Seismic1	Mode	9.	0.000019	0.000271	0.
Seismic1	Mode	10.	-0.000367	-0.001139	0.
Seismic1	Mode	11.	-0.000275	-0.000893	0.
Seismic1	Mode	12.	-1.257E-06	-6.360E-07	0.

Table: Vehicles 2 - General Vehicles 1 - General, Part 1 of 6

Table: Vehicles 2 - General Vehicles 1 - General, Part 1 of 6

VehName	FromLibrary	LibraryName	FltAxleFac	AxleFac	UnifFac	SupportMom	IntSupport
Class-A	No	User Defined	1.	1.	1.	Yes	Yes
Class-AA	No	User Defined	1.	1.	1.	Yes	Yes

Table: Vehicles 2 - General Vehicles 1 - General, Part 2 of 6

Table: Vehicles 2 - General Vehicles 1 - General, Part 2 of 6

VehName	OtherResp	AxleMom	AxleMType	AxleMWidth	AxleMDbl	AxleOther	AxleOType
		Tonf		m		Tonf	
Class-A	Yes	0.		1.	No	0.	
Class-AA	Yes	0.		1.	No	0.	

Table: Vehicles 2 - General Vehicles 1 - General, Part 3 of 6

Table: Vehicles 2 - General Vehicles 1 - General, Part 3 of 6

VehName	AxleOWidth	LEffAxle	LEffUnif	ForStraddle	StraddleFac	NumInter	MinExtDist
	m						m
Class-A	1.	None	None	No		16	0.
Class-AA	1.	None	None	No		11	0.

Table: Vehicles 2 - General Vehicles 1 - General, Part 4 of 6

Table: Vehicles 2 - General Vehicles 1 - General, Part 4 of 6

VehName	MinIntDist	StayInLane	CGHTAxle	CGHTUnif	Notes	AdjustSuper
	m		m	m		
Class-A	0.	No	0.	0.		No
Class-AA	0.	No	0.	0.		No

Table: Vehicles 2 - General Vehicles 1 - General, Part 5 of 6

Table: Vehicles 2 - General Vehicles 1 - General, Part 5 of 6

VehName	IgnoreVert	Centrifugal	Braking	BrakAxleSF1	BrakUnifSF1	BrakingSet2	BrakingSkew
Class-A	No	No	Yes	0.3	0.	No	No

Table: Vehicles 2 - General Vehicles 1 - General, Part 5 of 6

VehName	IgnoreVert	Centrifugal	Braking	BrakAxleSF1	BrakUnifSF1	BrakingSet2	BrakingSkew
Class-AA	No	No	Yes	0.15	0.	No	No

Table: Vehicles 2 - General Vehicles 1 - General, Part 6 of 6

Table: Vehicles 2 - General Vehicles 1 - General, Part 6 of 6

VehName	NosingForce	DesignType
	Tonf	
Class-A	0.	Vehicle Live
Class-AA	0.	Vehicle Live

Table: Vehicles 3 - General Vehicles 2 - Loads, Part 1 of 2

Table: Vehicles 3 - General Vehicles 2 - Loads, Part 1 of 2

VehName	LoadType	InterUnif	UnifType	UnifWidth	InterAxle	AxleType	AxleWidth	InterMinD
		Tonf/m		m	Tonf		m	m
Class-A	Leading Load	0.	Zero Width		2.753	Two Points	1.83	
Class-A	Fixed Length	0.	Zero Width		2.753	Two Points	1.83	1.07
Class-A	Fixed Length	0.	Zero Width		11.32	Two Points	1.83	3.2
Class-A	Fixed Length	0.	Zero Width		11.32	Two Points	1.83	1.22
Class-A	Fixed Length	0.	Zero Width		6.832	Two Points	1.83	4.27
Class-A	Fixed Length	0.	Zero Width		6.832	Two Points	1.83	3.05
Class-A	Fixed Length	0.	Zero Width		6.832	Two Points	1.83	3.05
Class-A	Fixed Length	0.	Zero Width		6.832	Two Points	1.83	3.05
Class-A	Fixed Length	0.	Zero Width		2.753	Two Points	1.83	19.82
Class-A	Fixed Length	0.	Zero Width		2.753	Two Points	1.83	1.07
Class-A	Fixed Length	0.	Zero Width		11.32	Two Points	1.83	3.2
Class-A	Fixed Length	0.	Zero Width		11.32	Two Points	1.83	1.22

Table: Vehicles 3 - General Vehicles 2 - Loads, Part 1 of 2

VehName	LoadType	InterUnif	UnifType	UnifWidth	InterAxle	AxleType	AxleWidth	InterMinD
		Tonf/m		m	Tonf		m	m
Class-A	Fixed Length	0.	Zero Width		6.832	Two Points	1.83	4.27
Class-A	Fixed Length	0.	Zero Width		6.832	Two Points	1.83	3.05
Class-A	Fixed Length	0.	Zero Width		6.832	Two Points	1.83	3.05
Class-A	Fixed Length	0.	Zero Width		6.832	Two Points	1.83	3.05
Class-AA	Leading Load	0.	Zero Width		3.5	Two Points	2.06	
Class-AA	Fixed Length	0.	Zero Width		7.	Two Points	2.06	0.366
Class-AA	Fixed Length	0.	Zero Width		7.	Two Points	2.06	0.366
Class-AA	Fixed Length	0.	Zero Width		7.	Two Points	2.06	0.366
Class-AA	Fixed Length	0.	Zero Width		7.	Two Points	2.06	0.366
Class-AA	Fixed Length	0.	Zero Width		7.	Two Points	2.06	0.366
Class-AA	Fixed Length	0.	Zero Width		7.	Two Points	2.06	0.366
Class-AA	Fixed Length	0.	Zero Width		7.	Two Points	2.06	0.366
Class-AA	Fixed Length	0.	Zero Width		7.	Two Points	2.06	0.366
Class-AA	Fixed Length	0.	Zero Width		7.	Two Points	2.06	0.366
Class-AA	Fixed Length	0.	Zero Width		3.5	Two Points	2.06	0.366

Table: Vehicles 3 - General Vehicles 2 - Loads, Part 2 of 2

Table: Vehicles 3 - General Vehicles 2 - Loads, Part 2 of 2

VehName	InterMaxD
	m
Class-A	
Class-A	
Class-A	

Table: Vehicles 3 - General Vehicles 2 - Loads, Part 2 of 2

VehName	InterMaxD
	m
Class-A	
Class-A	
Class-A	
Class-A	
Class-A	
Class-A	
Class-A	
Class-A	
Class-A	
Class-A	
Class-A	
Class-A	
Class-A	
Class-AA	
Class-AA	
Class-AA	
Class-AA	
Class-AA	
Class-AA	
Class-AA	
Class-AA	
Class-AA	
Class-AA	
Class-AA	

Table: Vehicles 4 - Vehicle Classes

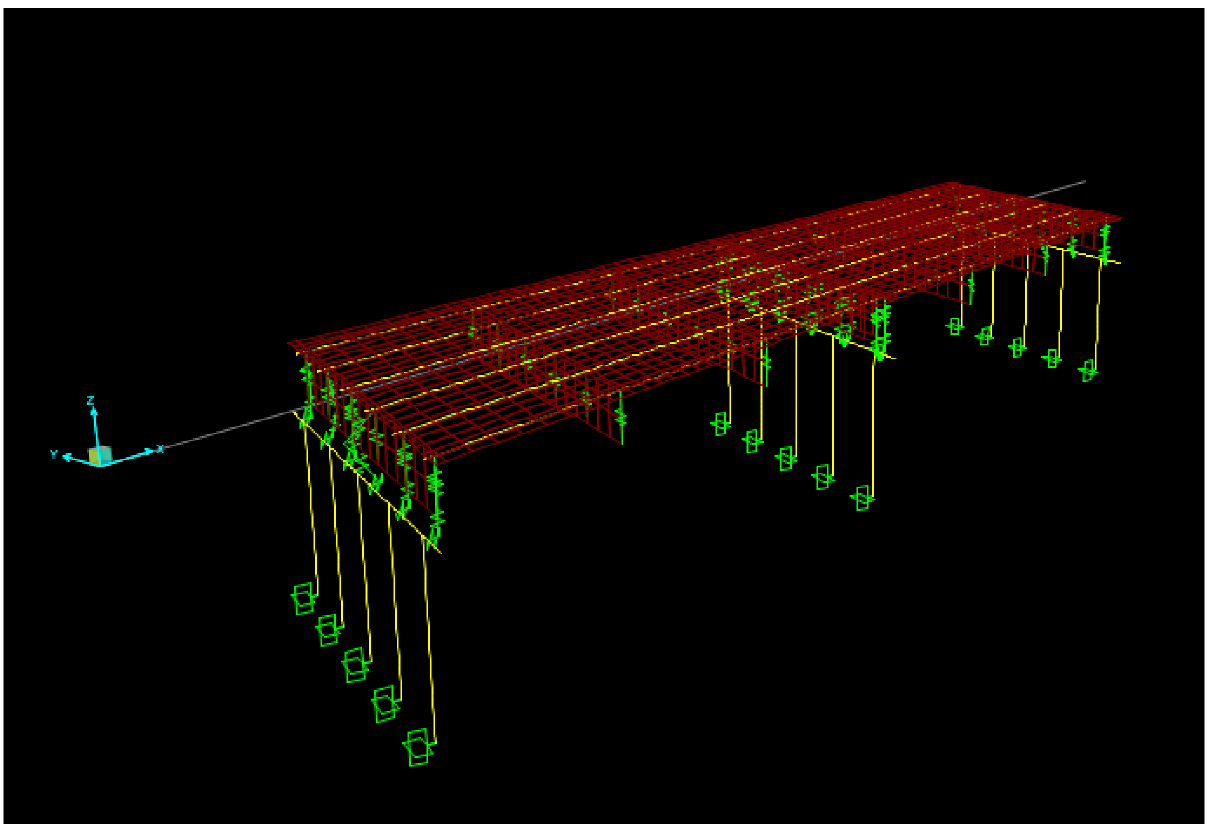
Table: Vehicles 4 - Vehicle Classes

VehClass	VehName	ScaleFactor
Class-A	Class-A	1.
Class-AA	Class-AA	1.

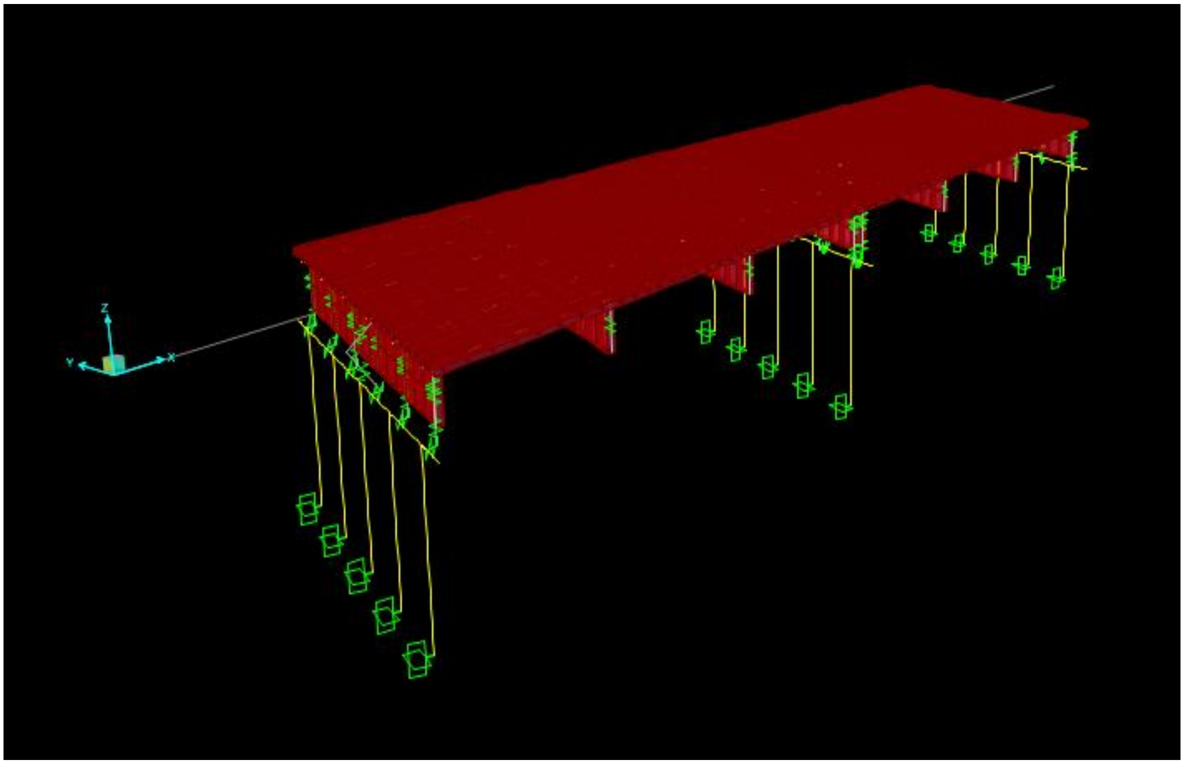
SUPER STRUCTURE ANALYSIS AND DESIGN

LOAD ON STRUCTURE

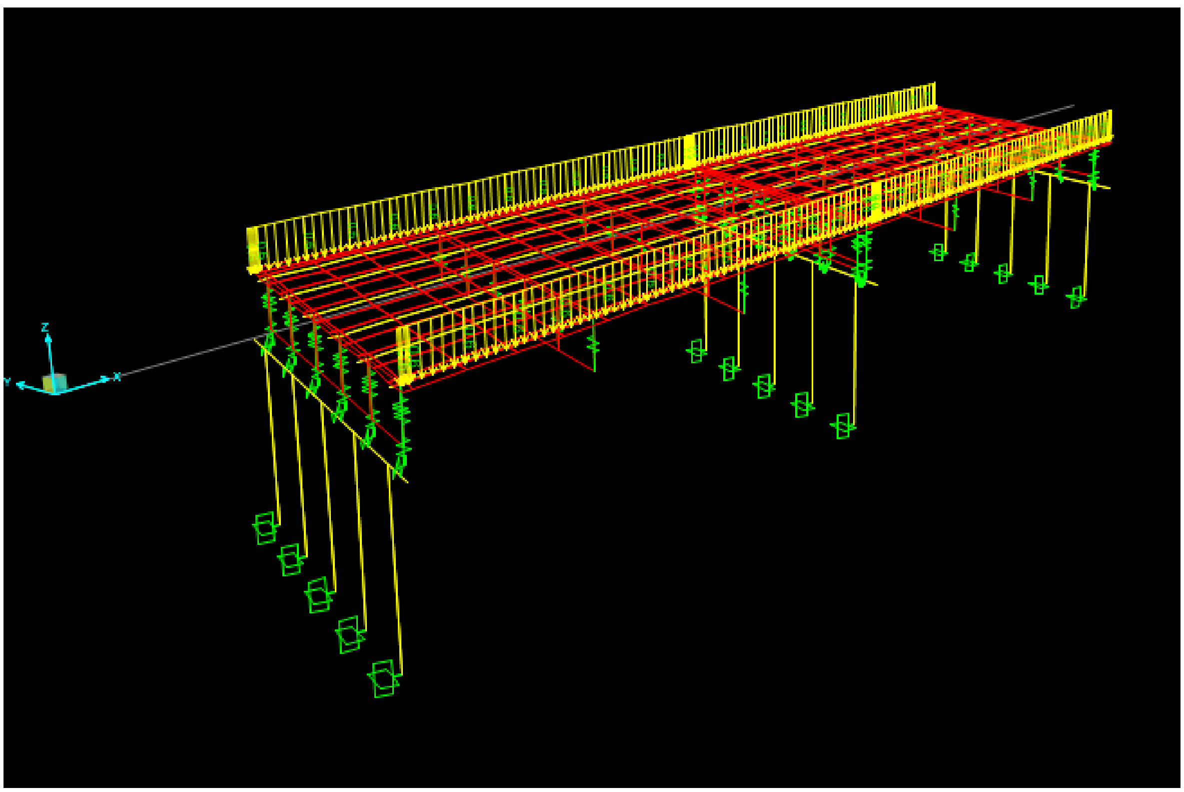
LOADS FOR STAAD MODELLING						
	Self Weight	**Area (m²)**	**Unit Weight (KN/m³)**	**Load/unit length (KN/m)**	**Load t/m**	**slab+haunch (KN/m)**
1	Girder	0.6925	23.6000	16.3430	1.666986	
2	Slab	0.6188	23.6000	14.6025	1.53085884	15.0084
3	Exterior portion of slab	0.5569	23.6000	13.1423	1.38191334	13.5482
4	Wearing surface	0.1375	23.6000	3.2450	0.33099	
5	Exterior portion of W/S	0.1238	23.6000	2.9205	0.297891	
6	Barrier	0.2490	23.6000	5.8764	0.5993928	
7	Diaphragm	0.4950	23.6000	11.6820	1.191564	
8	Haunch	0.0172	23.6000	0.4059	0.04140384	



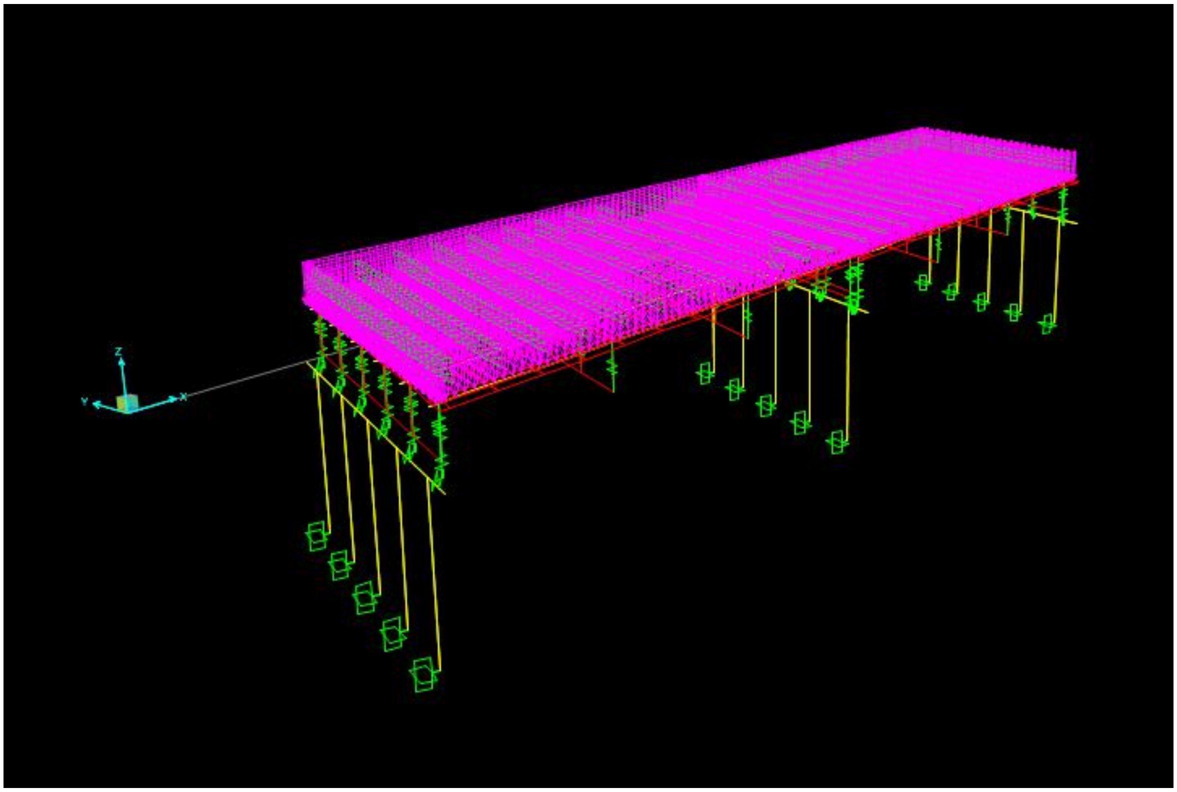
COMPLETE VIEW



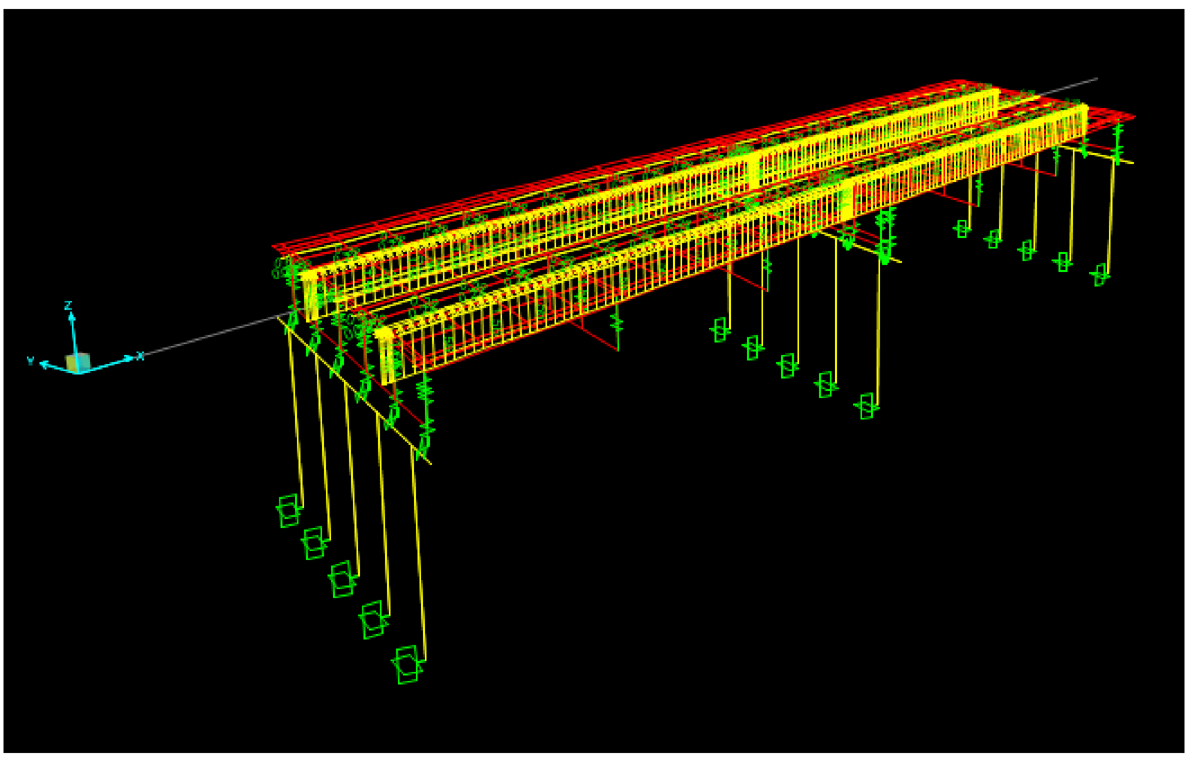
RENDERED VIEW



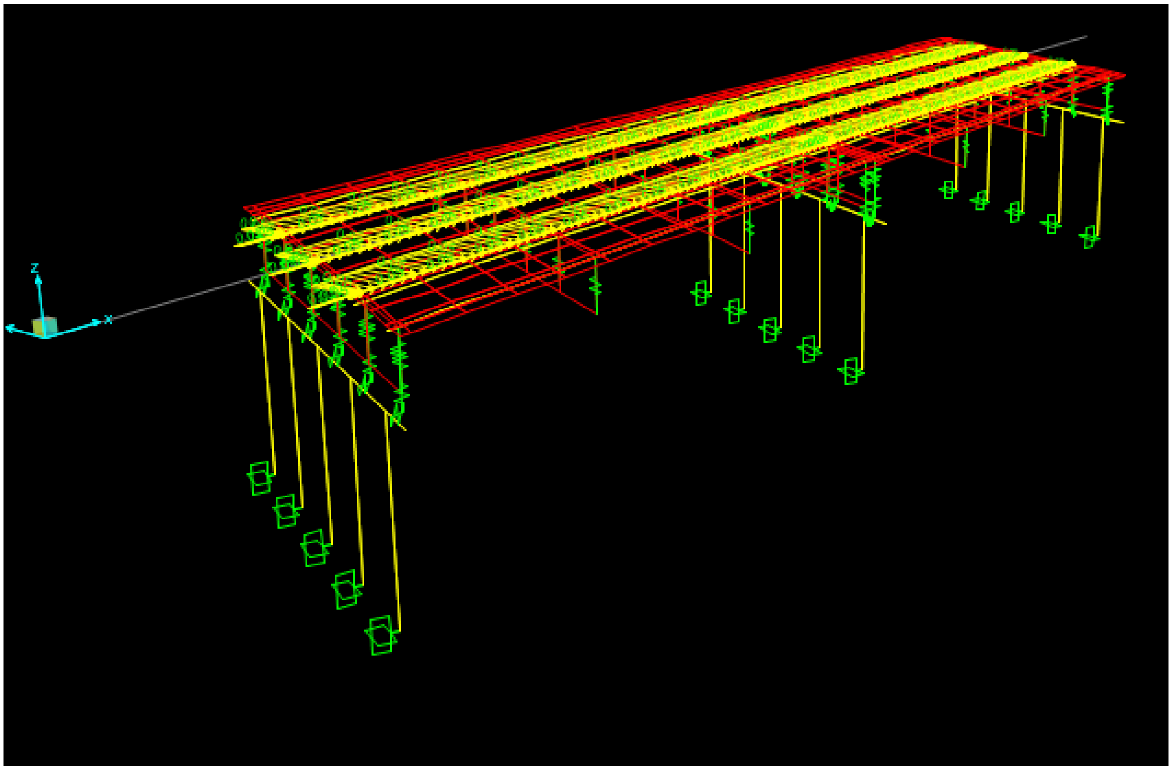
BARRIER



WEARING



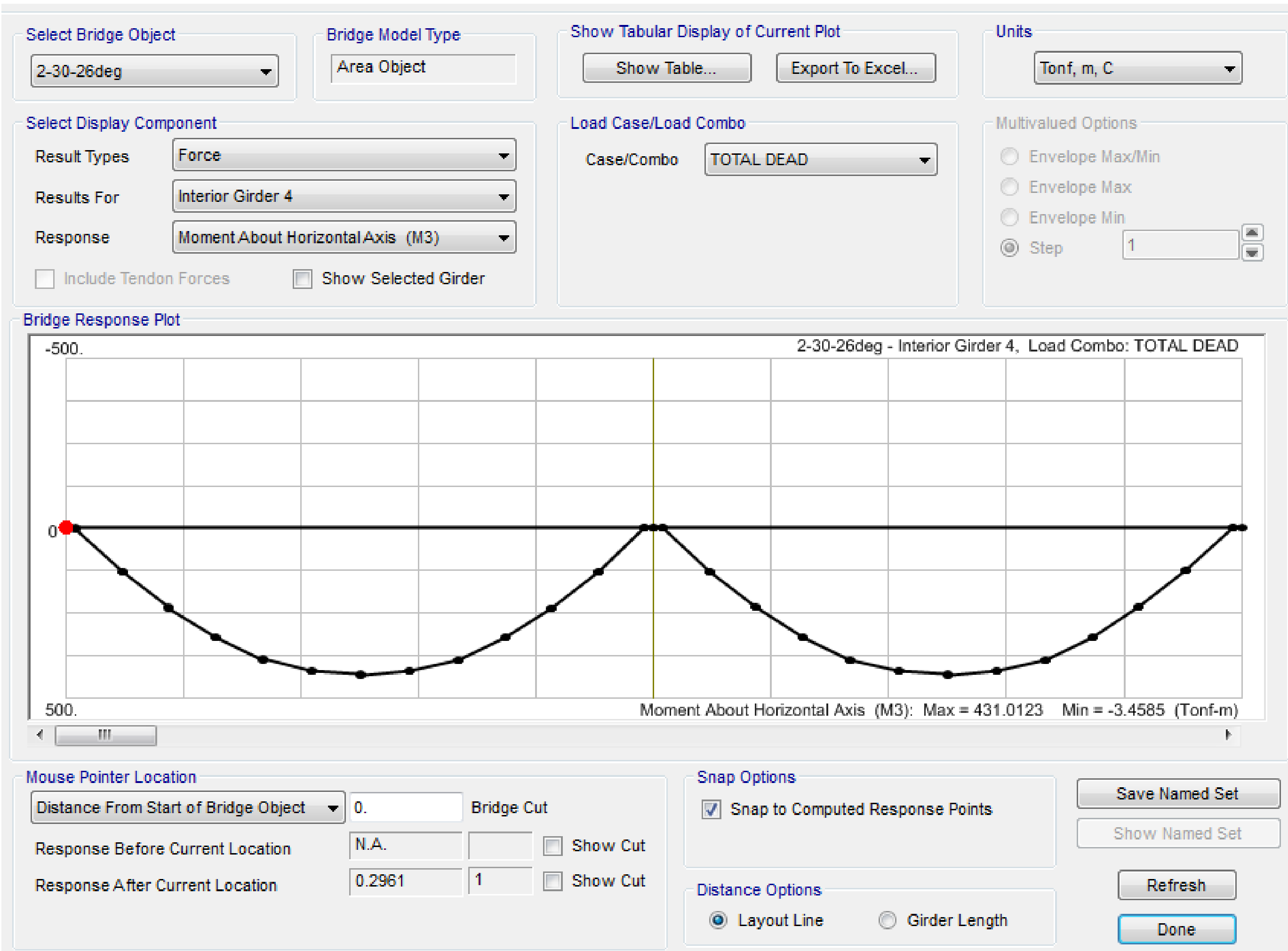
WIND ON STRUCTURES



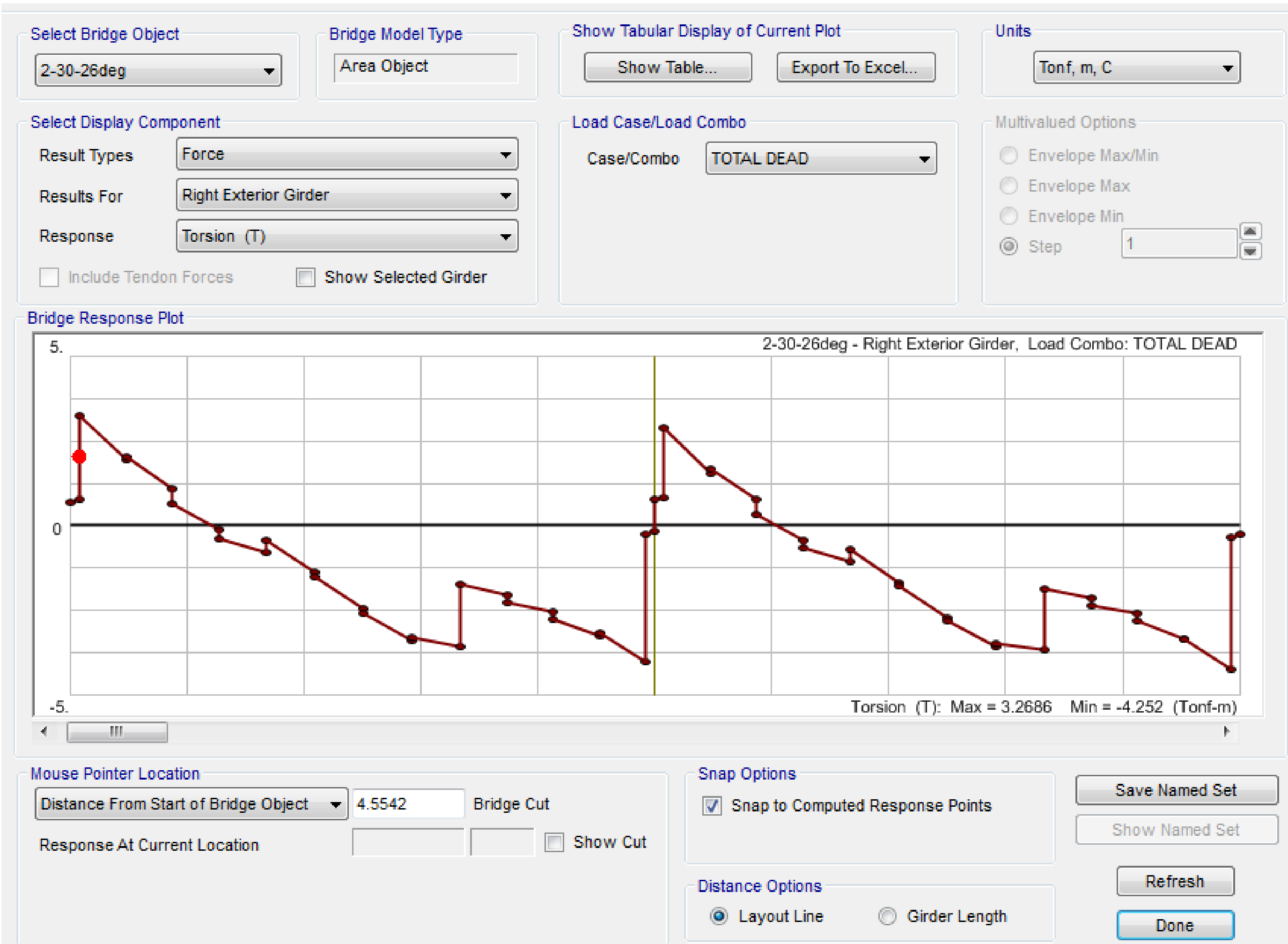
WIND ON LIVE

MAXIMUM FORCES IN MAIN GIRDER

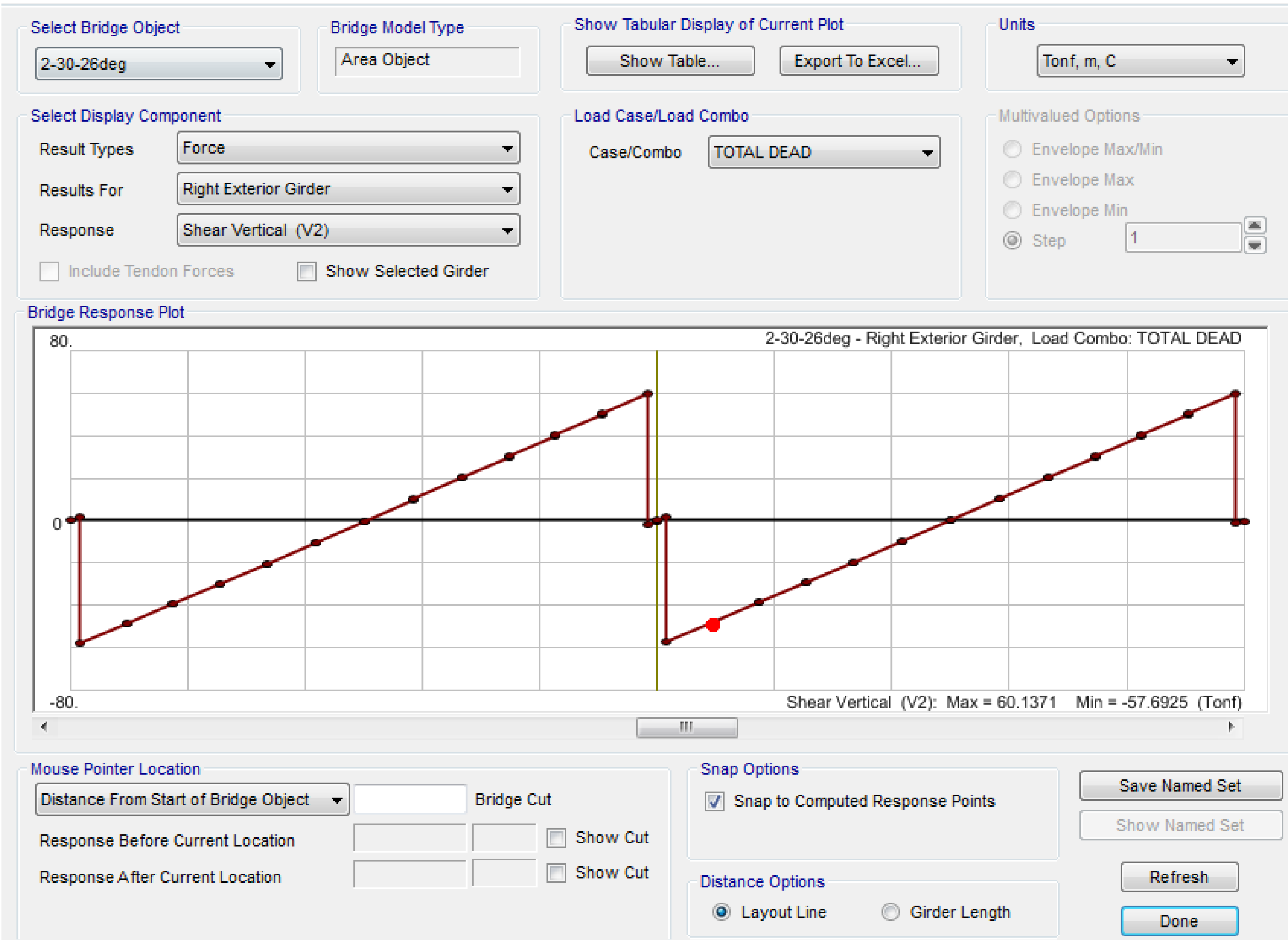
MAX DEAD LOAD MOMENT



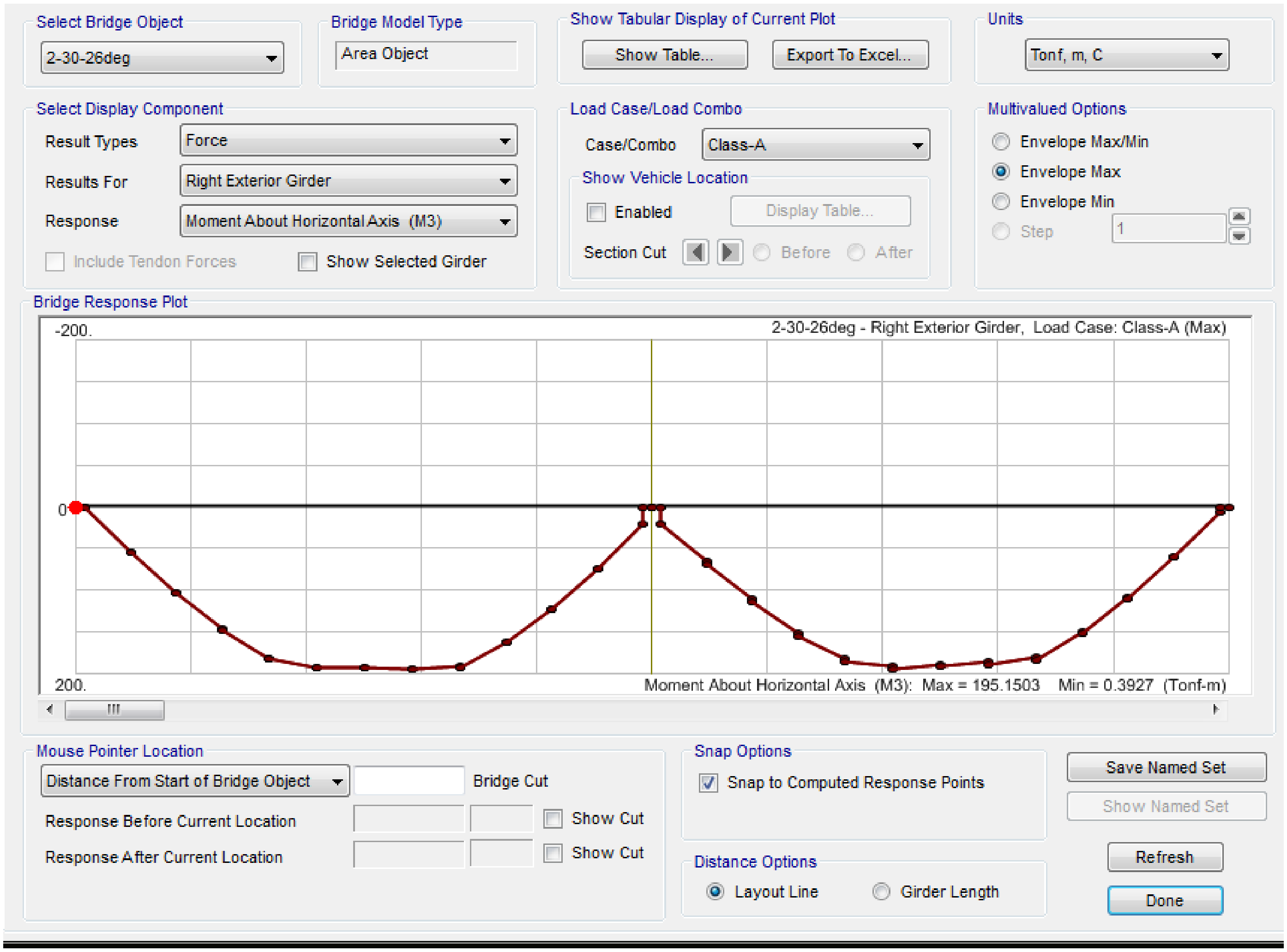
MAX DEAD TORSION



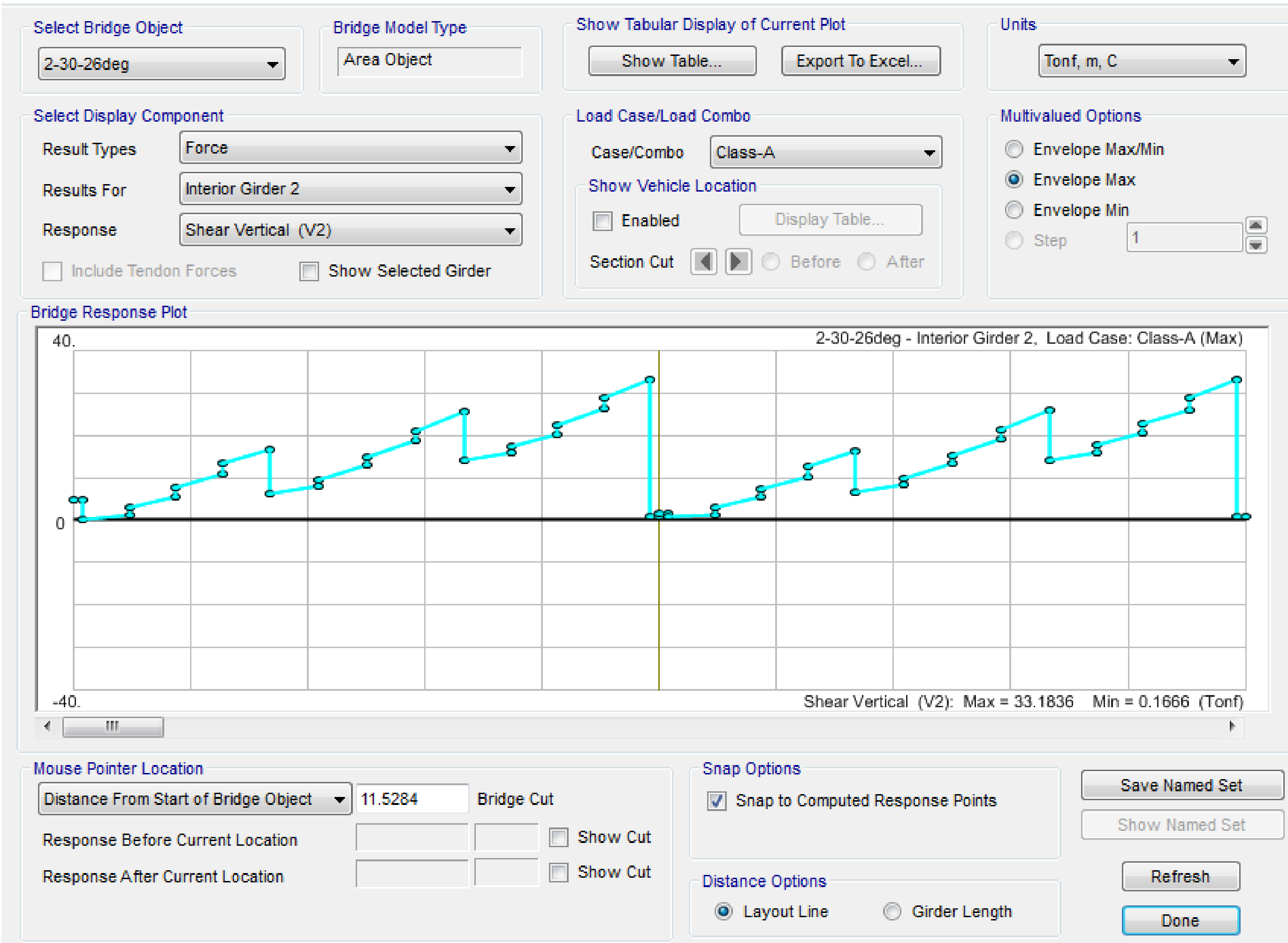
<u>**MAX DEAD SHEAR**</u>



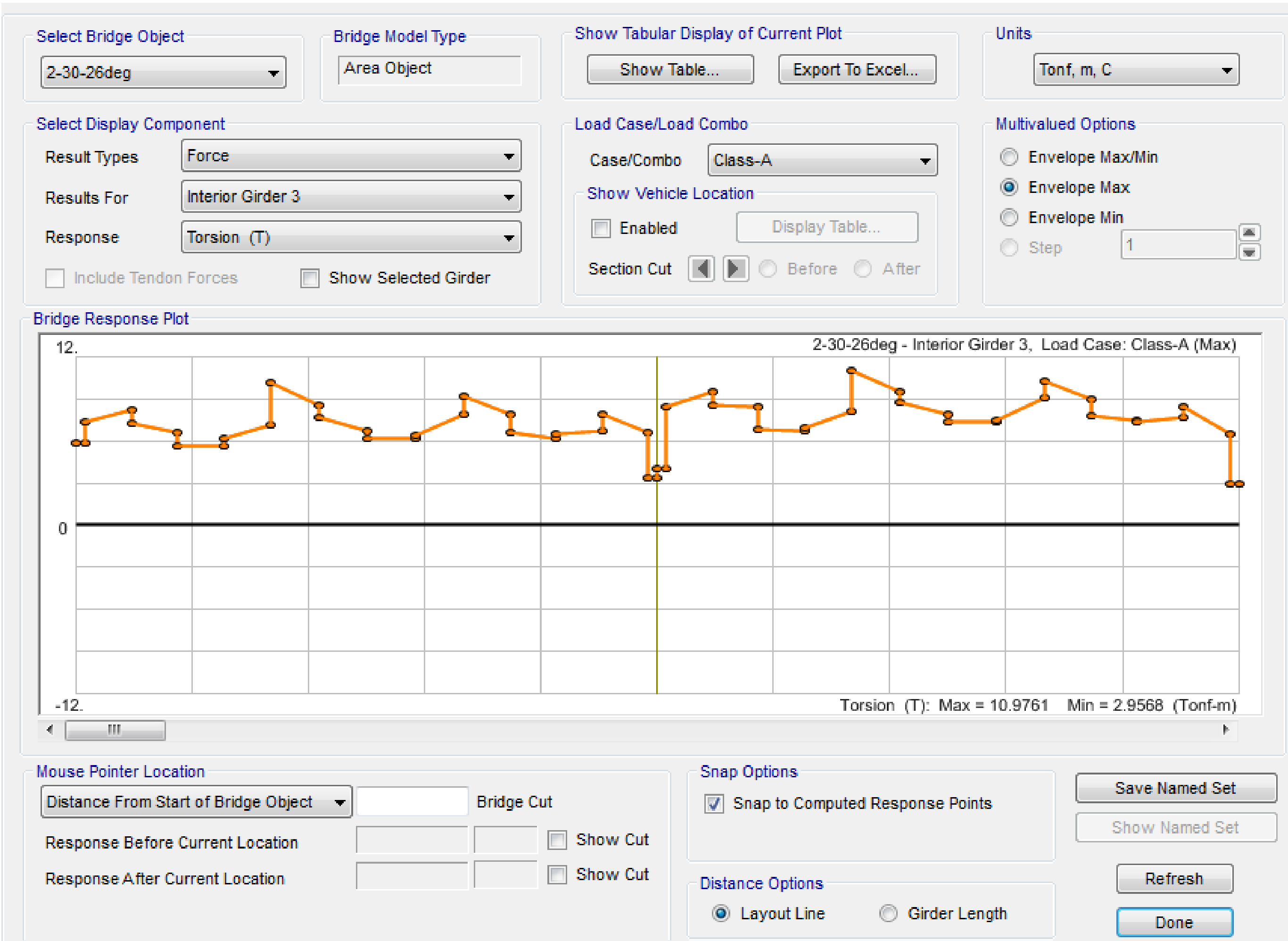
MAX LIVE LOAD MOMENT AT TRUCK LOADING



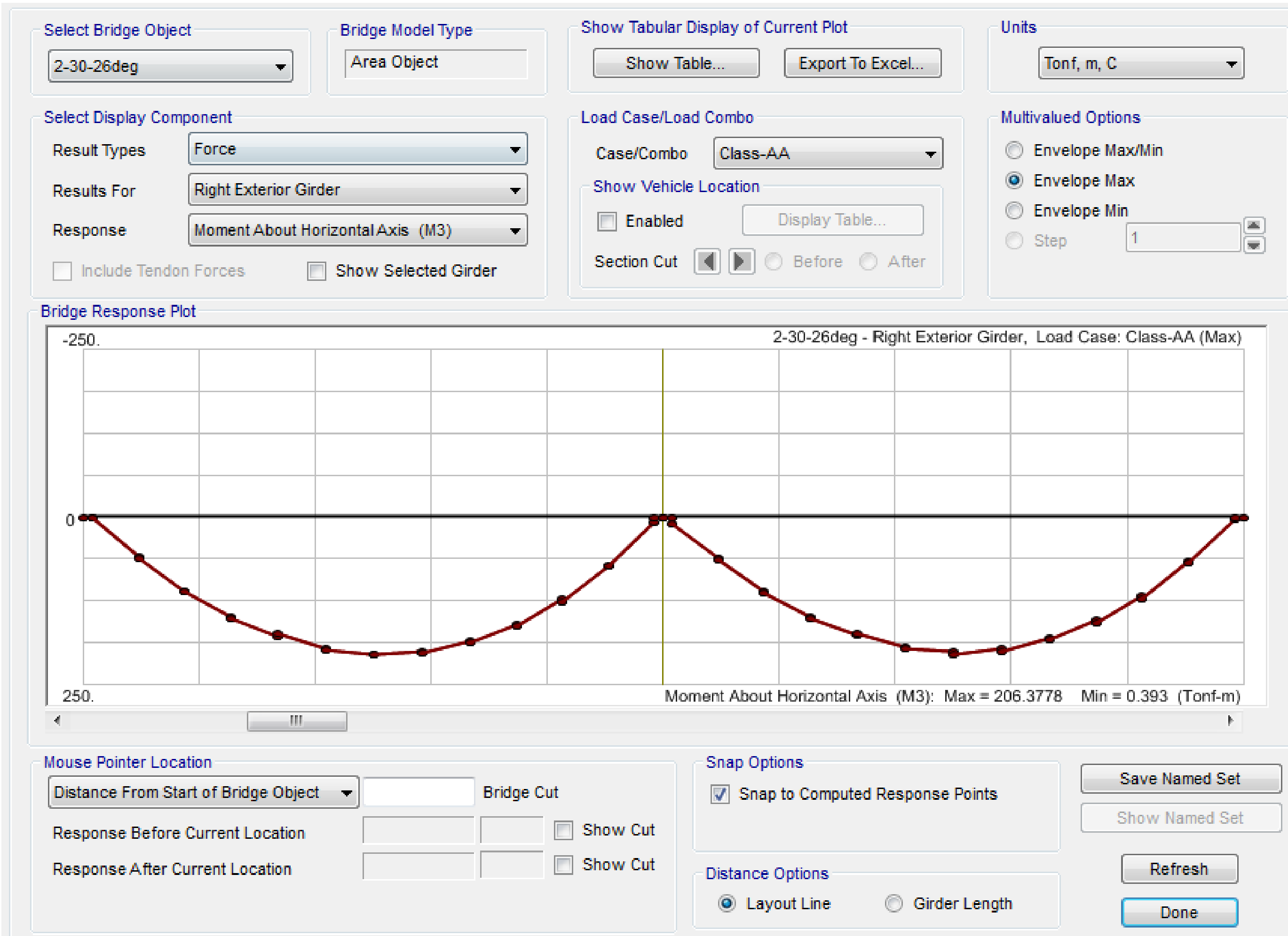
MAX LIVE LOAD SHEAR AT TRUCK LOADING



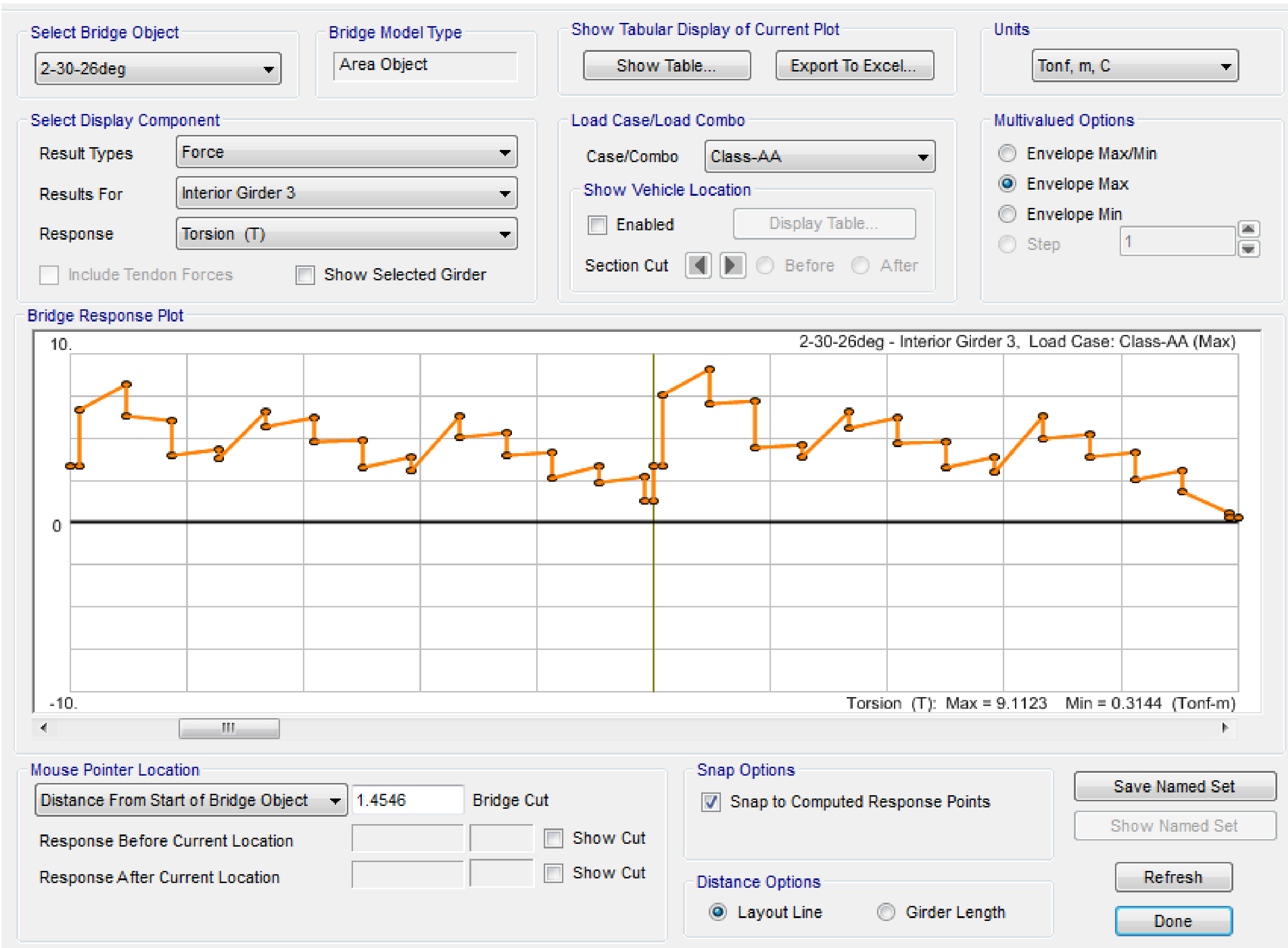
MAX LIVE LOAD TORSION AT TRUCK LOADING



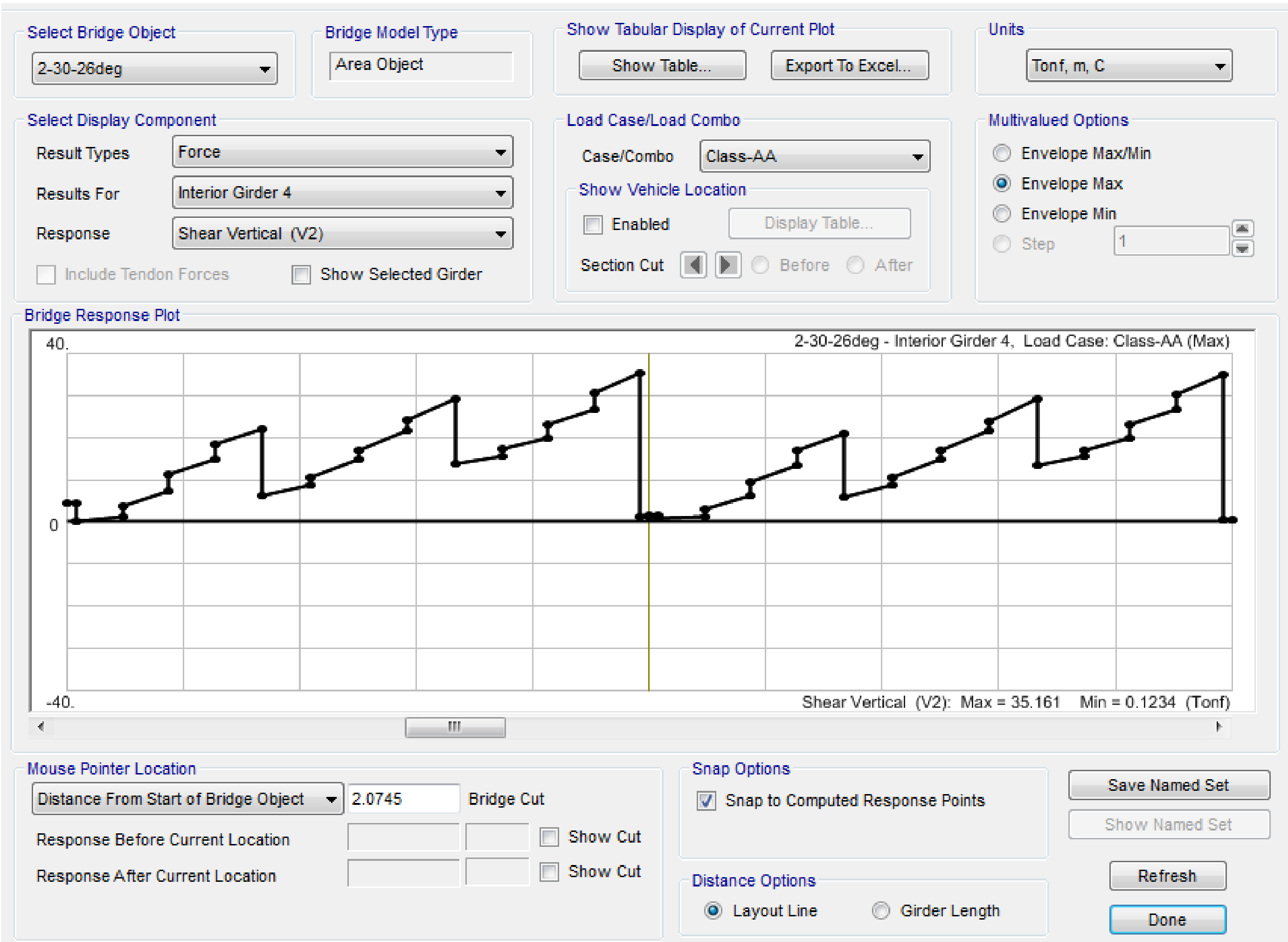
MAX LIVE LOAD MOMENT AT TANK LOADING



<u>**MAX LIVE LOAD TORSION AT TANK LOADING**</u>



MAX LIVE LOAD SHEAR AT TANK LOADING



SPAN OF GIRDERS =	**30.00**	**Metres**	**C/C Spacing Of Girders =**	**2.75**	**Metres**
WIDTH OF BRIDGE=	**15.95**	**Metres**	**Overhang Portion =**	**1.1**	**Metres**
SPAN OF DIAPHRAGM =	**2.550**	**Metres**	**C/C Spacing Of Diaph. =**	**10.00**	**Metres**
NO. OF GIRDERS=	**6**				
NO. OF DIAPHRAGMS=	**4**				

COMPUTATION OF SECTION PROPERTIES

PROPERTIES OF MAIN GIRDER

CALCULATION OF EFFECTIVE FLANGE WIDTH

(i) be=Span/4.0

be= 7500 mm

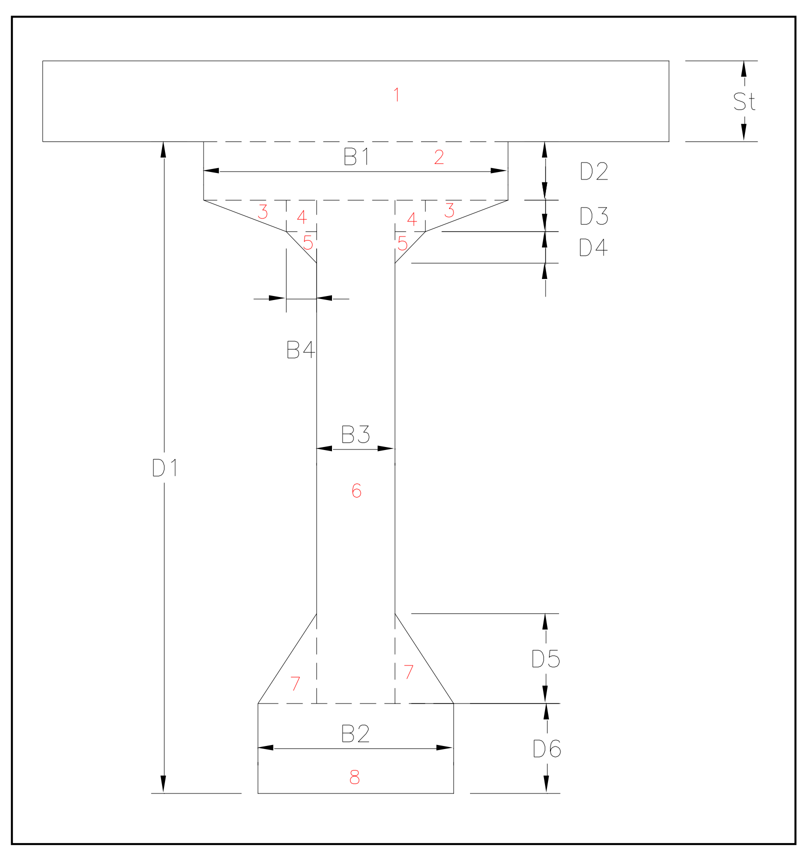
(ii) be=12hf + bw or 1/2 Width of top flange

be= 3150 mm

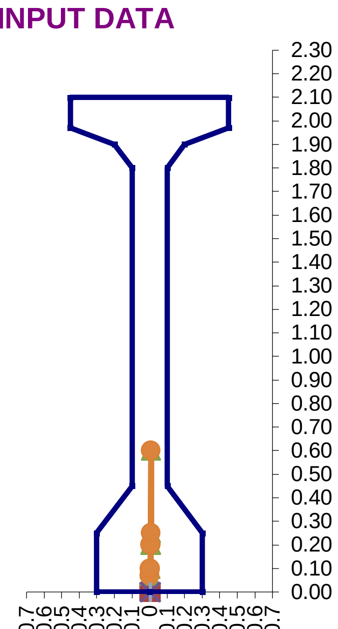
(iii) be= C/C Spacing of Girder

be= 2750 mm

Therefore Effective Flange Width =	**2750**	**mm**
Reduced Effective Flange Width =	**2460**	**mm**



INPUT DATA



GIRDER SECTION

Span	**30m**	
B1 =	**900**	**mm**
B2 =	**600**	**mm**
B3 =	**200**	**mm**
B4 =	**100**	**mm**
St =	**225**	**mm**
D1 =	**2100**	**mm**
D2 =	**130**	**mm**
D3 =	**70**	**mm**
D4 =	**100**	**mm**
D5 =	**200**	**mm**
D6 =	**250**	**mm**

CONCRETE STRENGTH FOR SLAB	=	**28**	**Mpa**	=	**4**	**Ksi**
CONCRETE FOR GIRDER	=	**35**	**Mpa**	=	**5**	**Ksi**
CONCRETE FOR COMPOSITE SEC.	=	**35**	**Mpa**	=	**5**	**Ksi**

OUTPUT		**COMPOSITE SECTION**			**ONLY GIRDER**	
AREA (Ax)	=	1311250	mm^2	=	692500	mm^2
AREA (Reduced)	=	1245926.8	mm^2	=	692500	mm^2
y' LOCATON OF N.A FROM BOTTOM	=	1569.6202	mm	=	1055.848375	mm
M.O.I (Ix) (Iz)	=	7.961E+11	mm^4	=	3.82149E+11	mm^4
M.O.I (Iy)	=	2.952E+11	mm^4	=	16719791667	mm^4
SHEAR AREA (Ay) (Web)	=	465000	mm^2	=	420000	mm^2
SHEAR AREA (Az) (Flang)	=	618750	mm^2	=		
SECTION MODULUS (BOTTOM) Zb	=	0.5072	m^3	=	0.3619	m^3
SECTION MODULUS (TOP) Zt	=	1.0539	m^3	=	0.3660	m^3

TORSIONAL CONSTANT 'C' FOR MAIN GIRDER

PART	**B**	**T**	**C**	**B/T**
SLAB	2459.67	225	4669538831	10.93
TOP FLANGE	942.42424	215	2673438834	4.38
WEB	1350	200	3600000000	6.75
BOTTOM FLANGE	657.14	350	6261486295	1.88
TOTAL			**17204463960** mm^4	

PROPERTIES OF EXTERIOR GIRDER

CALCULATION OF EFFECTIVE FLANGE WIDTH

(i) be= be of Interior Girder

be= 2750 mm

(ii) be= 1/2 be of Interior Girder + overhang

be= 2475 mm

Reduced Effective Flange Width = 2214 mm

INPUT		COMPOSITE SECTION		ONLY GIRDER
TOTAL DEPTH OF GIRDER	=	2325 mm	=	2100 mm
B SLAB	=	2475 mm	=	mm
D SLAB	=	225 mm	=	mm
B TOP FLANGE	=	900 mm	=	900 mm
D TOP FLANGE	=	130 mm	=	130 mm
B TOP LARGE TRIANGLE	=	250 mm	=	250 mm
D TOP LARGE TRIANGLE	=	70 mm	=	70 mm
B TOP RECTANGLE	=	100 mm	=	100 mm
D TOP RECTANGLE	=	70 mm	=	70 mm
B TOP SMALL TRIANGLE	=	100 mm	=	100 mm
D TOP SMALL TRIANGLE	=	100 mm	=	100 mm
B WEB	=	200 mm	=	200 mm
B BOTTOM TRIANGLE	=	200 mm	=	200 mm
D BOTTOM TRIANGLE	=	200 mm	=	200 mm
B BOTTOM FLANGE	=	600 mm	=	600 mm
D BOTTOM FLANGE	=	250 mm	=	250 mm
CONCRETE STRENGTH FOR SLAB	=	28 Mpa	=	28 Mpa
CONCRETE FOR GIRDER	=	35 Mpa	=	35 Mpa
CONCRETE FOR COMPOSITE SEC.	=	35 Mpa		

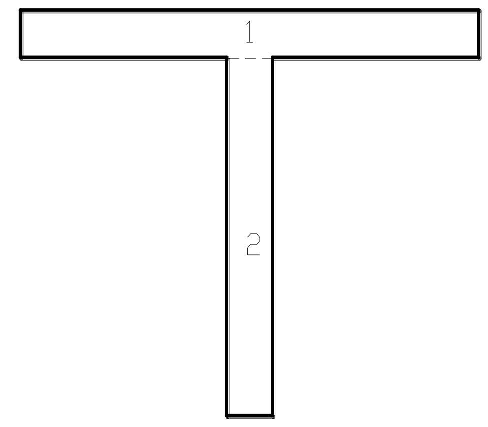
OUTPUT		COMPOSITE SECTION			ONLY GIRDER	
AREA (Ax)	=	1249375	mm^2	=	692500	mm^2
AREA (Reduced)	=	1190584.1	mm^2	=	692500	mm^2
y' LOCATON OF N.A FROM BOTTOM	=	1539.7368	mm	=	1055.848375	mm
M.O.I (Ix)	=	7.719E+11	mm^4	=	3.82149E+11	mm^4
M.O.I (Iy)	=	2.196E+11	mm^4	=	16719791667	mm^4
SHEAR AREA (Ay)	=	465000	mm^2	=	420000	mm^2
SHEAR AREA (Az)	=	556875	mm^2			
SECTION MODULUS (BOTTOM) Zb	=	0.501321	m^3	=	0.3619	m^3
SECTION MODULUS (TOP) Zt	=	0.9829854	m^3	=	0.3660	m^3

TORSIONAL CONSTANT C FOR EXTERIOR GIRDER

PART	B	T	C	B/T
SLAB	2213.71	225	4202584948	9.84
TOP FLANGE	942.42424	215	2673438834	4.38
WEB	1350	200	3600000000	6.75
BOTTOM FLANGE	657.14	350	6261486295	1.88
TOTAL			**16737510077** mm^4	

PROPERTIES OF INTERIOR DIAPHRAGM

CALCULATION OF EFFECTIVE FLANGE WIDTH



(i) be=12hf + bw

be= 3000

(i) be=Span / 4.0

be= 637.5

(i) be= C/C Spacing of Diaphragm

be= 10000

INPUT

TOTAL DEPTH OF DIAPHRAGM (upto top of slab)	=	1875	mm
B SLAB	=	637.5	mm
D SLAB	=	225	mm
B WEB	=	300	mm
D WEB	=	1650	mm

OUTPUT

AREA (Ax)	=	638438	mm^2	0.63844
y' LOCATON OF N.A FROM BOTTOM	=	1035.63	mm	
M.O.I (Ix)	=	2.10653E+11	mm^4	0.21065
M.O.I (Iy)	=	8570324707	mm^4	0.00857
SHEAR AREA (Ay)	=	562500	mm^2	0.5625
SHEAR AREA (Az)	=	143437.5	mm^2	0.14344

TORSIONAL CONSTANT C FOR INTERIOR DIAPHRAGM

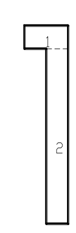
PART	B	T	C	B/T
SLAB	638	225	1210253906	2.83
WEB	1650	300	14850000000	5.50
TOTAL			**16060253906** mm^4	

PROPERTIES OF EXTERIOR DIAPHRAGM

CALCULATION OF EFFECTIVE FLANGE WIDTH

(i) be=0.8*Span/4.0

be= 102



(i) be=12*hf/2 + bw

be= 1650

INPUT

TOTAL DEPTH OF DIAPHRAGM	=	1875	mm
B SLAB	=	102	mm
D SLAB	=	225	mm
B WEB	=	300	mm
D WEB	=	1650	mm

OUTPUT

AREA (Ax)	=	517950	mm^2	0.51795
y' LOCATON OF N.A FROM BOTTOM	=	866.54	mm	
x' LOCATON OF N.A FROM LEFT	=	-43.61	mm	
M.O.I (Ix)	=	1.31677E+11	mm^4	0.13168
M.O.I (Iy)	=	3947363979	mm^4	0.00395
SHEAR AREA (Ay)	=	562500	mm^2	0.5625
SHEAR AREA (Az)	=	22950	mm^2	0.02295

TORSIONAL CONSTANT C FOR EXTERIOR DIAPHRAGM

PART	B	T	C	B/T
SLAB	102	225	193640625	0.45
WEB	1650	300	14850000000	5.50
TOTAL			**15043640625** mm^4	

CALCULATION OF LOSSES

Span =	30	(m)
fc' =	5000	(psi)
fci' =	5000	(psi)
Es =	28000000	(psi)
	193192561.8	(KN/m2)
Eci =	4286825.749	(psi)
	29577958.87	(KN/m2)

Girder Self Wt. Momemt Mo =	205.67	(T-m)		
D.L.Moments(slab+diaph) Mdp=	181.91	(T-m)	total dl moment from model	
D.L.Moments(w.surface+barrier) Mdc=	70.37	(T-m)	From Model	
Total Dead Load Moments Md =	457.96	(T-m)	Live + Impact	
Live Load Moments Ml =	206.37	(T-m)	From Model	227.01 (T-m)

Effective Prestress Req'd= 749.19 (Tons)

Concrete Beam Section Data:

Sectional Area Ac =	0.6925	(m2)
Moment Of Inertia Ic =	0.3821	(m4)
Sectional Modulus Bottom Z	0.3619	(m3)
Sectional Modulus Top Zt =	0.3660	(m3)

Composite Beam Section Data:

Sectional Area Ac =	1.3113	(m2)
Sectional Modulus Bottom Z	0.5072	(m3)
Sectional Modulus Top Ztc=	1.0539	(m3)
Moment of Inertia Icc =	0.7961	(m4)

Prestress Cable Data: END SECTION MID SECTION

Breaking Load Fpu =	18.96	(Tons)	Strong Hold Table I
Jacking Force = 0.75*Fpu =	14.22	(Tons)	
Wobble Coefficent, K =	0.00656	(per meter)	ACI Code: for Grouted Tendons in metal
Curvature Coefficient, μ =	0.25		sheathing Wire Strand (Page # 270)
Anchorege Set "Δ L"=	0.006	(m)	
Relative Humidity RH =	50	%	

Eccentricity e = 0.793 (m)
of Tendons for girder section only

Approx. Losses= 25 %

App no. of Strands= 70

Tendon Vertical distance from bottom at mid Span

1	2	3
125	125	125
225	225	225
4	5	6

Cover T & B = 300 300
No.of Strands provided= 40
No. of tendons = 4 10/0.5in

Tendon Vertical distance from bottom at end

1	2	3
300	800	1300
1800		500
4	5	6

FRICTRION LOSSES

Pj = Px * (1 + K*L + μ*α) **stressing from** 2 **ends**

Cable	Length (m)	Dip (m)	Ap (m^2)	α (rad)	K*L+μ*α by AASHTO <=0.3	Pj (Tons)	Px (Tons)	Δ P (Tons)
C1	30	0.175	0.000987	0.047	0.104	140	126.785	13.215
C2	30	0.675	0.000987	0.180	0.121	140	124.900	15.100
C3	30	1.175	0.000987	0.313	0.138	140	123.070	16.930
C4	30	1.575	0.000987	0.420	0.151	140	121.644	18.356
				0.000	0.000		0.000	0.000
C1	30	0.275	0.000987	0.073	0.000		0.000	0.000

Sum =	0.004935	560	496.398	63.602

Av. Force at mid span after Friction Loss= 496.40 (Tons)
= 4869.67 (KN)

Stress Loss due to Friction FR= 126430.58 (KN/m2)

Loss Of Prestress Force at midspan= 63.60 (Tons) = 11.36 %
623.93 (KN)

ELASTIC SHORTENING

ES=0.5 * Es/Eci * fcir 19.94 19.97

Note:- The v . be the value of cell "G" untill it becomes equal

fcir = -Pi/Ac * (1 + e^2 / r^2) + Mo * e / Ic

= -12135.34203 (KN/m2)

Stress Loss due to Elastic Shortening ES= 39631.84 (KN/m2)

Loss Of Prestress Force = 19.94 (Tons) = 3.56 %
195.58 (KN)

ANCHORAGE SLIP

Length affected by Anchorage Slip W = SQRT(Δ L * Es * Ap / ΔP)

Δ P = (Pj - Px) / x

= 4.24 (T/m)
41.60 (KN/m)

Length W = 11.7 (m) from end

Therefore Anchorage Slip does not extend upto center

Loss of Prestress Force = 0.00 (Tons) = 0.00 %
0.00 (KN)

CREEP OF CONCRETE

CRc = 12 * fcir - 7 * fcds

fcds = Md * e / Ic

= 9326.59 (KN/m2)

Stress Loss due to Creep of Concrete CRc = 80338.0 (KN/m2)

Loss of Prestress Force= 40.41 (Tons) = 7.22 %
396.47 (KN)

SHRINKAGE OF CONCRETE

SH = 0.8 * (17000 - 150 * RH) (psi)

Stress Loss due to Shrinkage of Concrete SH= 7600.00 (psi)
= 52437.98 (KN/m2)

Loss of Prestress Force= 26.38 (Tons) = 4.71 %
258.78 (KN)

RELAXATION OF PRESTRESSING STEEL

For **Low** Relaxation Steel

Normal Relaxation Steel
Low Relaxation Steel

CRs = 5000 - 0.0.07 * FR - 0.1 * ES - 0.05 * (SH+CRc) (psi)

Stress Loss due to Steel Relaxation CRs =	2181.30	(psi)			
	15043.45	(KN/m2)			
Loss of Prestress Force =	7.57	(Tons)	=	1.35	%
	74.24	(KN)			

TOTAL LOSSES

Total Immidiate Losses=Friction+Anchorage Set+Elastic Shortening

=	83.54	(Tons)	=	14.92	%
	819.52	(KN)			

Total Time Dependant Losses=Creep+Shrinkage+Relaxation

=	74.36	(Tons)	=	13.28	%
	729.49	(KN)			

Total Losses=Total immidiate+Total Time Dependant

=	157.90	(Tons)	=	**28.20**	**%**
	1549.01	(KN)			

STRESSES AT EXTREME FIBRES

Stage 1: At Yard

Pi = 4674.08 (KN) **: minus sign indicates Tension**

Ft = Pi/Ac - Pi*e/Zt + Mo/Zt	=	**2130.5**	**(KN/m^2)**	309.01 psi	**OK**
Fb = Pi/Ac + Pi*e/Zb - Mo/Zb	=	**11420.4**	**(KN/m^2)**	1656.39 psi	**OK**
	allowable tension =	**-1463.6**	**(KN/m^2)**	-212.28 psi	
	allowable compression =	**18974.2**	**(KN/m^2)**	2751.98 psi	

Stage 2: Intermediate Condition

Pe = 3944.59 (KN)

Ft = Pe/Ac - Pe*e/Zt + (Mo + Mdp)/Zt	=	**7534.4**	(KN/m^2)	1092.77 psi	**OK**
Fb = Pe/Ac + Pe*e/Zb - (Mo + Mdp)/Zb	=	**3837.3**	(KN/m^2)	556.56 psi	**OK**
	allowable tension =	**-1463.6**	**(KN/m^2)**	-212.28 psi	
	allowable compression =	**18974.2**	**(KN/m^2)**	2751.98 psi	

Stage 3: At Service Loads

Pe = 3944.59 (KN)

Ft = Pe/Ac - Pe*e/Zt + (Mo + Mdp)/Zt + (Mdc+Ml)/Ztc =		**10302.6**	**(KN/m^2)**	1494.26 psi	**OK**
Fb = Pe/Ac + Pe*e/Zb - (Mo + Mdp)/Zb - (Mdc + Ml)/Z =		**-1914.7**	**(KN/m^2)**	-277.7 psi	**OK**
		: minus sign indicates Tension			
	allowable tension =	**-2927.3**	**(KN/m^2)**	-424.57 psi	
	allowable compression =	**13799.4**	**(KN/m^2)**	2001.44 psi	

CALCULATIONS FOR SHEAR

$V_{L.L}$ = For live load at critcal section from face	=	32.02	Ton			From Model
$V_{girder+}V_{slab}$ = For Dead load at critcal section from face	=	47.12	Ton			
V_{slab} = For slab load at critcal section from face	=	17.60	Ton			
V_{sdl} = For superimposed dead loads at critcal section from face	=	9.84	Ton			From Model
$M_{L.L}$ = For live load at critcal section from face	=	227.01	Ton - m			
M_{girder} = For girder load at critcal section from face	=	78.14	Ton - m			
M_{slab} = For slab load at critcal section from face	=	62.80	Ton - m			
M_{sdl} = For superimposed dead loads at critcal section from face	=	70.37	Ton - m			
b' = Thickness of web of the girder	=	0.200	m	=	7.87	inches
d = 0.8 h	=	1.860	m	=	73.23	inches
f_c' = Concrete strength of girder	=	5,000	Psi			
f_{sy} = Steel strength	=	60,000	Psi			
M_d = (girder + slab)	=	140.94	Ton - m			
V dead load = V girder + V slab	=	47.12	Ton			
V_u = 1.3(V dead load + 1.67xV live load)	=	143.56	Ton	=	316.40	Kips
V_i =1.3(V dead load + V sdl + 1.67x VL.L) - (V dead load + Vsdl)	=	86.60	Ton	=	190.87	Kips
				=	190871.01	lbs
Total height of composite section	=	2.325	m	=	91.54	inch
x = distance from end to the critical section	=	2.325	m			
y = centroid of tendons from bottom at critical section	=	0.718	m			
d = distance of centroid of girder section from bottom	=	1.056	m			
e = d-y	=	0.337	m			
p_e	=	3944.59	kN	=	402.10	tons
$f_{pe} = p_e / A_c + p_e * e / Z_b$	=	955.58	Ton /m^2	=	195.76	k/ft^2
				=	1358.77	lbs/in^2
f_d = stress due to unfactored dead loads = M_d / Z_b	=	528.14	Ton /m^2	=	108.13	k /ft^2
				=	750.99	lbs/in^2
$M_{cr} = I / Y_b (6 (fc')^{1/2} + f_{pe} - f_d)$	=	368.12	Ton-m	=	2662.01	kip- feet
$M_{max} = 1.3 (M_d + M_{sdl} + 1.67 M_{L.L}) - (M_d + M_{sdl})$	=	556.22	Ton - m	=	4022.24	kip- feet
				=	4.826E+07	lb - in
$V_{ci} = 0.6(f_c')^{1/2} b'd + V_d + V_i (M_{cr}/M_{max})$	**=**	**115.53**	**Tons**	**=**	**254.63**	**kips**
Check: $1.7(f_c')^{1/2}b'd$	=	31.45	Tons	**OK**		

$f_{pc} = P_e/A_c$	=	306.65	Ton /m^2	=	62.78	k /ft^2
V_p = Vertical component of effective prestress force	=	48.02	Ton	=	105.84	kips
	=					
$V_{cw} = (3.5(f_c')^{1/2} + 0.3 f_{pc})b'd + V_p$	**=**	**147.00**	**Tons**	**=**	**323.98**	**kips**
Shear Strength provided by concrete = lesser of V_{ci} & V_{cw}	=	115.53	Tons	=	254.63	kips
Ø V_c =		98.20	Tons	=	216.43	kips
V_u	=	143.56	Tons	=	316.40	kips
$V_S = V_u$ - Ø V_c	=	45.36	Tons	=	99.97	kips
V_S Should not be taken greater than $8(f_c')^{1/2}b'd$						
$8(f_c')^{1/2}b'd$	=	147.99	Tons	=	326.17	kips
V_S	<	8(fc')1/2b'd		**OK**		
Area of shear reinforcement provided/leg	=	0.20	in^2			
No. of shear reinforcement legs provided	=	2	Nos.			
s = Avfyd/Vs	=	14.94	in	=	380	mm
When V_S exceeds $4(f_c')^{1/2}b'd$						
$4(f_c')^{1/2}b'd$		74.00	Tons	=	163.09	kips

CRITERIA FOR MAXIMUM SPACING

i) Spacing should not be greater than	=	24.00	inches			
ii) Spacing should not be greater than 0.75h	=	68.65	inches			
iii) Spacing = $A_v f_{sy}/50b'$ (if A_v = 0.4 in)	=	60.96	inches			
s required (Min. of Three & s calculated)	**=**	**14.94**	**inches c/c**	**=**	**380**	**mm**

CHECK FOR HORIZONTAL SHEAR

b_v = width of girder section at top	=	0.90	m	=	35.43	inch
d = 0.8h (h is total depth of girder puls slab)	=	1.86	m	=	73.23	inch
$V_{nh} = 80\ b_v\ d$	=	94.18	Tons	=	207.58	kips
Ø V_{nh}	=	80.05	Tons	=	176.44	kips
V_u	=	143.56	Tons	=	316.40	kips

V_u>fV_{nh} stirrups of pre cast girder must be extend into the deck slab

CALCULATIONS FOR END BLOCK REINFORCEMENT

Jacking Force in Cable = Pj	=	140.0	Tons			
Effective Force after Losses = Pe	=	100.5	Tons			
fc' of girder	=	3516.68	Ton /m^2	=	5000	lbs/in^2
fci' i.e conc. Strength at jacking	=	3516.68	Ton /m^2	=	5000	lbs/in^2
fy	=	42200.21	Ton /m^2	=	60000	lbs/in^2
Height of girder	=	2.10	m			
Try Size of Anchorage Plate (Square)	=	240	mm			
Dia of Sheathing (hole)	=	75	mm			
Size of symmeterical concrete block around anchorage plate	=	300	mm			
Anchorage Plate Area = A1	=	0.0532	m2			
Concrete block Area = A2	=	0.0900	m2			

Check at Service Loads:

After Losses Bearing Stress = Pe / A1	=	1890.3	Ton /m^2	=	2687.6	lbs/in^2
Allowable Anchorage Bearing Stress	=	2110.0	Ton /m^2	=	3000.0	lbs/in^2

Anchorage Plate Size is O.K.

Check at Ultimate Loads:

At Jacking Bearing Stress = 1.15 Pj / A1	=	3027.4	Ton /m^2	=	4304.4	lbs/in^2
Allowable Bearing Stress at Jacking =						
i) 0.8 fci' $(A2 / A1 - 0.2)^{1/2}$	=	3436.8	Ton /m^2	=	4886.5	lbs/in^2
ii) 1.5 Ø 0.85 fci' $(A2 / A1)^{1/2}$	=	3499.8	Ton /m^2	=	4976.0	lbs/in^2
Minimum of the two		3436.8	Ton /m^2	=	4886.5	lbs/in^2
but should be less than 1.25 fci'	=	4395.9	Ton /m^2	=	6250.0	lbs/in^2

O.K.

Anchorage Plate Size is O.K.

After Losses Bearing Stress = 1.15 Pe / A1	=	2173.8	Ton /m^2	=	3090.7	lbs/in^2
Allowable Bearing Stress after Losses =						
0.6 fc' $(A2 / A1)^{1/2}$	=	2744.9	Ton /m^2	=	3902.7	lbs/in^2
but should be less than fc'	=	3516.7	Ton /m^2	=	5000.0	lbs/in^2

O.K.

Anchorage Plate Size is O.K.

Ref. Stronghold Brocheure

1/2 of symmeterical concrete block = Yo	=	150	mm			
1/2 of steel anchor plate = Y_{po}	=	120	mm			
Y_{po} / Yo	=	0.800				
Bursting Force/Jacking Force = F_{bst} / P_j	=	0.14				
Area of Steel = As = F_{bst} / (0.9 fy)	=	0.00049921	m2	=	**0.77**	**in2**

Horizontal and Vertical over a Length of 2Yo = 300 mm from face behind each anchor

Height of Plate/Height of Girder = h_b / h	=	0.1143	<	0.2	**O.K.**	
T = 0.3 Pj (1- h_b / h)	=	37.2000	Tons			
Area of Steel = As = T / (0.32 fy)	=	0.0028	m2	=	**4.27**	**in2**

Vertical Stirrups only over a Length of h = 2100 mm from face

CALCULATIONS OF FLEXURAL STRENGTH

$M_{D.L}$ = Moment due to all dead loads including selfweight of girder	=	457.96	Ton-m			
$M_{L.L}$ = Moment at mid span due to live load	=	227.01	Ton-m		Live + Impact	
Mu = 1.3(M deadload + 1.67M liveload)	**=**	**1088.17**	**Ton-m**			
b =Average top flange width of composite Section	=	2.073	m	=	81.60	inches
b' = web width of a Girder Section	=	0.200	m	=	7.87	inches
h = Total height of Girder Section	=	2.325	m	=	91.54	inches
t = Average Thickness of compression flange	=	0.355	m	=	13.98	inches
As* = Area of prestressing steel	=	7.650	$inches^2$	=	0.00494	m2
As = Area of non prestressing tension steel	=	4.29	$inches^2$			
As' = Area of non prestressing compression steel	=	1.20	$inches^2$			
d* = Prestressing steel centroid from bottom at mid point	=	0.263	m	=	10.34	inches
d = Effective depth from top to prestressing steel centroid	=	81.20	inches	at mid section		
dt = Distance from the extreme compression fiber to centriod of Non prestressing steel	=	88.54	inches			
f_s' = ultimate tensile strength of prestressing steel	=	270.00	Ksi			
fsy = yield strength of non prestressing steel	=	60.00	Ksi			
f_c' slab = concrete strength of deck slab at 28 days	=	4.06	Ksi			
f_c' girder = concrete strength of girder at 28 days	=	5.08	Ksi			
fr Modulus of rupture of concrete = 7.5√fc'	=	0.53033009	Ksi			
f_c' composite = concrete strength of composite section	=	5.00	Ksi			
fpe =Compressive stress in concrete due to Effective Prestress	=	0.44	Ksi			
γ* = factor for type of prestressing steel	=	0.40	for normal relaxation steel			
β1 = factor for concrete strength	=	0.80				
Ø = capacity reduction factor	=	0.90	for post-tensioned cast in place concrete			
p =Non-Prestressed Tension Reinforcement = As/bdt	=	0.00059433				
p* = prestressing steel ratio = A_s*/(bd)	=	0.00115				
p' = Ratio of compression reinforcement = As'/bdt	=	0.0001811				
f_{su}* = stress in prestressing steel at ultimate loads	=	261.58	Ksi			
$fsu^* = fs'\{1-(\gamma^*/\beta1)(p^*\,fs'/fc')\}$ for prestressing only	=	261.583749	Ksi			
$fsu^* = fs'\left[1-\frac{\gamma^*}{\beta1}\left[\frac{p^*\,fs'}{fc'}+\frac{dt}{d}\left(\frac{pfsy}{fc'}\right)\right]\right]$ with non-prestressing steel included	=	260.533967	Ksi			
A_{sf} = steel area for flange overhang portion = 0.85fc'slab(b-b')t/f_{su}*	=	13.598	$inches^2$			
Non prestressed tension reinforcement		**included**	(included / not included)			
Asr = steel area for web = As*+(Asfsy/fsu*)-Asf	=	4.963	$inches^2$			

Check 1:

Non-prestressed steel contribution to tensile strength

$(Asfsy)/(b'dfc') + (Asrfsu^*)/(b'dfc') - (As'fy')/(b'dfc') \le 0.36\beta 1$

0.4572 0.288

Not OK Use AASHTO Eq.(9.22) or Eq.(9.23)

Check 2:

$\left(\frac{pfsy}{fc'}\right)\frac{dt}{d} + \left(\frac{p^* fsu^*}{fc'}\right) - \left(\frac{p' fy'}{fc'}\right) \le 0.36\beta 1$

0.066 0.288

OK Use AASHTO Eq.(9.13a), (9.14a)

AASHTO Eq. (9.14a)

$(Asrfsu^*)/(0.85 fc'b')$ If Greater than flange thickness "t" and Check 1 is OK, use AASHTO Eq(9-14a)

38.795 in Use AASHTO Eq 19_14a

$$\varphi Mn = \varphi\{Asrfsu^* d\left[1 - 0.6\left(\frac{Asrfsu^*}{b'dfc'}\right)\right] + Asfsy(dt - d) + 0.85 fc'(b - b')(t)(d - 0.5t)\}$$

= 365993 K.in **4217.69** T.m Invalid Results

AASHTO Eq. (9.13a)

$(As^* fsu^* + Asfsy)/(0.85 fc'b)$ If Greater than flange thickness "t" and Check 2 is OK, use AASHTO Eq(9-13a)

6.5131 inches Use AASHTO Eq (19_13a)

$$\varphi Mn = \varphi\{As^* fsu^* d\left[1 - 0.6\left(\frac{p^* fsu^*}{fc'} + \frac{dtpfsy}{dfc'}\right)\right] + Asfsydt\left[1 - 0.6\left(\frac{dp^* fsu^*}{dtfc'} + \frac{pfsy}{fc'}\right)\right]$$

= 160028 K.in **1844.15** T.m Invalid Results

AASHTO Eq. (9.23)

$$\varphi Mn = \varphi\{(0.36\beta 1 - 0.08\beta 1^2) fc'b'd^2 + 0.85 fc'(b - b')t(d - 0.5t)\}$$

347857 K.in **4008.68** T.m Result is Valid

$\varphi Mn \ge 1.2 Mcr^*$

$Mcr^* = Sc(fr + fpe) - Md/nc(Sc/Sb - 1)$ 22750 K.in 262.17 T.m 1.2Mcr* = 314.604 T.m OK

Minimum Reinforcement = 0.004 A

A = 0.6925 sq. m

0.00277 sq. m = **4.29** sq. inch

DEFLECTION CALCULATIONS

Span	=	30.00	m		
Dead loads					
Self Weight	=	17.9	kN / m		
Weight of Slab + Diaphragm	=	15.86	kN / m		
Weight of w.surface + footpath + barrier	=	6.14	kN / m		
Total Imposed Dead Load	=	22.00	kN / m		
Total Dead Load	**=**	**39.9**	**kN / m**		
Live Loads					
Live Load	=	18.00	kN / m		
Live Load with Impact	**=**	**19.8**	**kN / m**		
DEFLECTIONS:					
Deflection due to Self Weight	=	5 * Wo * L^4 / 384 / Ec / Ic			
	=	16.73	mm	Downward	
Deflection(Camber) due to Initial Prestress	**=**	**5 * Pe * e * L^2 / 48 / Ec / Ic**			
		-30.76	**mm**	**Upward**	
Net Deflection(Camber) at Transfer	**=**	**-14.02**	**mm**	**Upward**	
Deflection due to Super Imposed Dead Load	=	5 * Wd * L^4 / 384 / Ec / Icc			
	=	9.85	mm	Downward	
Total Dead Load deflection	=	26.59	mm	Downward	
Deflection due to Final Effective Prestress	=	5 * Pe * e * L^2 / 48 / Ec / Icc			
		-12.46	mm	Upward	
Net Deflection without Live Load	**=**	**14.13**	**mm**	**Downward**	
Total Live Load Deflection	=	5 * Wl * L^4 / 384 / Ec / Icc			
	=	8.87	mm	Downward	
Final Deflection at Service Load Stage		**23.00**	**mm**	**Downward**	
Allowable Service Live load Deflection including Impact	=	L / 800			
	=	**37.50**	**mm**	>	**23.00** **Ok**

DESIGN OF BEARINGS

SUMMARY

Service Loads:

Total D.L. Reaction on Bearing	=	60.5	tons	=	133 Kips
Total L.L. Reaction on Bearing (without impact)	=	33.18	tons	=	73 Kips

Max. Rotation at Bearing including provision of uncertainties = (= 0.001514 radians
θ dl = 0.000214 θ uncertainties = 0.001 **Ref Tab. 14.4.1 AASHTO**
θ ll = 0.0003

Shear Modulus of Elastomer = G = 130 lb/in^2 **Ref Tab. 14.6.5.2 AASHTO**
Hardness 50

σTL ≤ 1.6 Ksi => Plan Area≥ P/1.6 = 129 in^2 **Ref Tab. 14.6.5.3.2 AASHTO** For bearing subjected to shear deformation
σTL ≤ 1.75 Ksi => Plan Area≥ P/1.6 = 118 in^2 **Ref Tab. 14.6.5.3.2 AASHTO** For bearing fixed against shear deformation
Try 300 400 mm Bearing (overall)
Area = 186 in^2 O.K.

Check for Compressive Stresses: (For Bearings Subjected to Shear Deformation

σTL ≤ 1.66 GS σ TL = = 1.11 $Kips/in^2$
S = Shape Factor = σTL/(1.66* G) = 5.14
Thickness of Thickest layer hri < LW/2S(L+W) = 17 mm

Try 8 mm thick each elastomer layer
Shape Factor = 10.71 O.K.

σ L ≤0.66 G S 0.66GS = = 0.92 $Kips/in^2$ σ L ≤0.66 G S
σ due to LL. = 0.39 $Kips/in^2$ O.K. σ due to LL.

Minimum Elastomer Thickness for Shear:

Assuming Shortening due to Shrinkage and Creep = 20 mm
Due to Temperature = 12.7 mm
Total Shortening = Δ = 32.7 mm

Total thickness of Elastomer in Bearing = hrt = 2 Δ = 65 mm
Use 40 mm thick total elastomer 5 No. of internal layers
8 mm thick each

Combined Compression and Rotation:

$$\sigma_{TL} \geq 1.0GS\left(\frac{\theta}{n}\right)\left(\frac{B}{hri}\right)^2$$

$\sigma_{TL} =$ 1110.08 psi

$1.0GS\left(\frac{\theta}{n}\right)\left(\frac{B}{hri}\right)^2 =$ 1054.3929 psi OK

Where Shear Deformation is Allowed

$$\sigma_{TL} \leq 1.875GS\left(1-0.2\left(\frac{\theta}{n}\right)\left(\frac{B}{hri}\right)^2\right)$$

$1.875GS\left(1-0.2\left(\frac{\theta}{n}\right)\left(\frac{B}{hri}\right)^2\right)$ 2216.2098 psi OK

Where Shear Deformation is Not Allowed

$$\sigma_{TL} \leq 2.25GS\left(1-0.167\left(\frac{\theta}{n}\right)\left(\frac{B}{hri}\right)^2\right)$$

$2.25GS\left(1-0.167\left(\frac{\theta}{n}\right)\left(\frac{B}{hri}\right)^2\right)$ 2738 Psi OK

Check Stability of Bearing:

$$\sigma_{TL} \leq \frac{G}{\left(\frac{3.84\left(\frac{hrt}{L}\right)}{S\sqrt{1+\frac{2L}{W}}}\right)-\left(\frac{2.67}{S(S+2)(1+L/4W)}\right)}$$

= 9.48 $Kips/in^2$ vs 1.11 $Kips/in^2$

σ allow > σc, O.K.

Steel Reinforcement:

Using A-36 steel

Thickness of steel plate $hs > \frac{3.0hr\max\sigma_{TL}}{Fy}$ = 1.9 mm

Thickness of steel plate $hs > \frac{2.0hr\max\sigma_{TL}}{Fsr}$ = 0.7 mm

Greater of two values = 1.9 mm
Use Thickness of steel Laminates = 3 mm

Provide 2.5 mm elastomer at top and bottom as cover must not be greater than 70% of internal layer

Therefore total Thickness of bearing =

Elastomers	5 layers	8 mm thick	=	40 mm
Steel Laminates	6 layers	3 mm thick	=	18 mm
Elatomer Cover	2 layers	2.5 mm thick	=	5 mm

$\sum$ = 63 mm

Provide 300 x 400 x 63 mm Bearing

DESIGN OF SLAB

Project:	**RAWALPINDI RING ROAD**	**By:**	**SAR**
Subject:	**15.95M Deck Slab**	**Chk:**	**ISB**
Job No.:	**3888**	**Date:**	**NOV 2020**

DESIGN OF DECK SLAB

DATA AVAILABLE

Girder Span Length =	30	m	=	98.43	ft.		
c/c spacing of girders=	**2.75**	m	=	9.02	ft.		
Girder Flange Width =	0.9	m	=	2.95	ft.	=	35.43 inches
Total depth of slab, h =	**225**	mm	=	0.74	ft.	=	8.86 inches
Cantilever / Overhang =	**1.1**	mm		0.0036	ft.		
Clear cover =	40	mm					
effective depth, d =	175	mm	=	0.57	ft.	=	6.89 inches
Wearing Surface =	50	mm					

DESIGN CRITERIA

Density of soil, Ws =	120	pcf
Density of conc., Wc =	150	pcf
Density of W.C., Ww =	140	pcf

Load Calculations:

1- Dead Loads

Self wt. of slab= 0.111 k/ft

Wearing Surface = 50 mm

= 0.023 k/ft

Total Dead Load, W = 0.134 k/ft

Clear Span, S = 2.3 m 7.55 ft

Ult. Moment D.L = $1.3\,(WS^2)/8$

Mu (dl) = 1.241 k-ft/ft

2- Live Loads

(i) Truck Loading

For Main Reinforcement Perpendicular to Traffic

M_L = (S+2) P/25 (Impact not included)

where,

P = 21 kips (NLC Loading)

M_L = 8.019 k-ft/ft

Impact Factor = 15/(S+20)= 30% 50 / (L+125) 0.38

30%

Max. allowed = 30%

Also apply continuity factor of 0.8

$M_{(L+I)}$ = 1.3 * 0.8 * ML = 8.34 k-ft/ft

$M_{(L+I)\,ult.}$ = 1.3 * 1.67 * $M_{(L+I)}$ = 18.11 k-ft/ft

Project:	**RAWALPINDI RING ROAD**	**By:**	**SAR**
Subject:	**15.95M Deck Slab**	**Chk:**	**ISB**
Job No.:	**3888**	**Date:**	**NOV 2020**

(ii) Tank Load:

For Main Reinforcement Perpendicular to Traffic

M_L = 1.1 S - 0.5= 7.80 k-ft/ft

Impact Factor = 25%

Also apply continuity factor of 0.8

$M_{(L+I)}$ = 1.25 * 0.8 * ML = 7.80 k-ft/ft

$M_{(L+I)\ ult.}$ = 1.3 * 1.67 * $M_{(L+I)}$ = 16.94 k-ft/ft

→ Max. Live Load Moment out of Two Conditions = 18.10537511 k-ft/ft

Total ult. Moments, Mu = Mud + MuL

Mu = 19.35 k-ft/ft

Design of Reinforcement

b = 12 in. cover = 1.57 "

h = 8.8587 in.

d = 6.89 in.

fc' = 4,000 psi

fy = 60,000 psi

Main Steel:

Max. Moment at Ends = **232.15** k-in

rho (ρ) = 0.85 fc'/fy [1 - {1 -2*Mu/0.85fc'*b*d^2}^0.5]

= 0.0081

As = **0.672** sq. in/ft

Required	#	6	@	7.88	" c/c	Top & Bottom	200.23 mm
Provide	#	6	@	7.00	" c/c	Top & Bottom	177.80 mm

Distribution Reinforcement :

As (%) = 220 / sqrt(S) ≤ 67%

= 80.09%

Use lesser of two = 67.00%

As (dist) = 0.450 sq. in/ft

Required	#	5	@	8.17	" c/c	Bottom Distribution	207.53 mm
Provide	#	5	@	7.00	" c/c		177.80 mm

Minimum Reinforcement:

rho (ρ) min. = **0.002**

As = **0.213** sq. in/ft

Required	#	4	@	11.08	" c/c		281.35 mm
Provide	#	4	@	7.00	" c/c	Top Distribution	177.80 mm

Project:	**RAWALPINDI RING ROAD**	**By:**	**SAR**
Subject:	**15.95M Deck Slab**	**Chk:**	**ISB**
Job No.:	**3888**	**Date:**	**NOV 2020**

Cantilever Portion:

D.L.	0.134	k/ft
Volume of N.J. Barrier	2.7	cu.ft/ft
Load of N.J. Barrier	0.405	kip
Mu (D.L)	0.0019	k.ft/ft
M (L.L)	12.80	k.ft/ft
Mu (L.L) with impact	28.89	k.ft/ft
Mu (L.L + D.L)	346.72	k.in/ft

rho (ρ) = 0.85 fc'/fy [1 - {1 -2*Mu/0.85^2/fc'*b*d^2}^0.5]
= 0.0127

As = 1.05 sq. in

Required	#	6	@	5.05	" c/c			128.25	mm
Provide	#	6	@	7.00	" c/c	Top Distribution		177.80	mm
Plus	#	4	@	7.00	" c/c	As Additional		177.80	mm

SUB STRUCTURE ANALYSIS AND DESIGN

TARNSOM CAP/ABUTMENT CAP

MAX DESIGN FORCES (FACTORED) IN TARNSOM/ABUTMENT

Frame Text	Station m	OutputCase	CaseType Text	StepType	StepNum	P Tonf	V2 Tonf	V3 Tonf	T Tonf-m	M2 Tonf-m	M3 Tonf-m	FrameElem Text	ElemStation
175	7.34493	MODAL	LinModal	Mode	11	-2513.8532	785.848	37.4151	-583.95675	1095.2794	557.87833	175-6	0
175	8.826	MODAL	LinModal	Mode	11	-2513.8532	785.848	37.4151	-583.95675	1039.86484	-606.02132	175-6	1.48107
182	0	MODAL	LinModal	Mode	11	-2482.7492	-1301.9709	345.2433	-3.61642	1978.63776	-4790.37007	182-1	0
182	3.4	MODAL	LinModal	Mode	11	-2482.7492	-1301.9709	345.2433	-3.61642	804.81065	-363.66889	182-1	3.4
182	3.4	MODAL	LinModal	Mode	11	-2477.7268	-1168.2802	282.7234	-3.61642	804.81065	-363.66889	182-2	0
182	6.8	MODAL	LinModal	Mode	11	-2477.7268	-1168.2802	282.7234	-3.61642	-156.44904	3608.48383	182-2	3.4
175	8.826	MODAL	LinModal	Mode	11	-2333.4845	44.7033	-2.2026	-312.04721	921.78055	412.68875	175-7	0
175	8.875	MODAL	LinModal	Mode	11	-2333.4845	44.7033	-2.2026	-312.04721	921.88848	410.49828	175-7	0.049
175	10.40507	MODAL	LinModal	Mode	11	-2333.4845	44.7033	-2.2026	-312.04721	925.25865	342.09887	175-7	1.57907
175	10.40507	MODAL	LinModal	Mode	11	-2224.217	291.0696	-164.6344	-765.41431	754.21414	216.07771	175-8	0
175	12.405	MODAL	LinModal	Mode	11	-2224.217	291.0696	-164.6344	-765.41431	1083.47064	-366.03965	175-8	1.99993
176	0	MODAL	LinModal	Mode	6	-2100.8644	-587.6258	98.1678	-101.4498	272.42541	-2205.01767	176-1	0
176	3.4	MODAL	LinModal	Mode	6	-2100.8644	-587.6258	98.1678	-101.4498	-61.34506	-207.08997	176-1	3.4
176	3.4	MODAL	LinModal	Mode	6	-2098.7688	-557.0634	94.8701	-101.4498	-61.34506	-207.08997	176-2	0
176	6.8	MODAL	LinModal	Mode	6	-2098.7688	-557.0634	94.8701	-101.4498	-383.90349	1686.92562	176-2	3.4
175	4.28478	MODAL	LinModal	Mode	11	-2080.9734	1015.7321	210.9579	-137.0132	1580.56446	730.66993	175-4	0
175	5.247	MODAL	LinModal	Mode	11	-2080.9734	1015.7321	210.9579	-137.0132	1377.57559	-246.69229	175-4	0.96222
175	12.405	MODAL	LinModal	Mode	11	-2040.7497	-63.0117	-204.5162	-431.51195	990.54685	698.40094	175-9	0
175	13.46522	MODAL	LinModal	Mode	11	-2040.7497	-63.0117	-204.5162	-431.51195	1207.37988	765.20747	175-9	1.06022
121	0	MODAL	LinModal	Mode	7	-2037.6997	49.4162	-9.9414	18.29347	-10.6847	-2155.29738	121-1	0
121	0.5	MODAL	LinModal	Mode	7	-2037.6997	49.4162	-9.9414	18.29347	-5.71402	-2180.00548	121-1	0.5
121	1	MODAL	LinModal	Mode	7	-2037.6997	49.4162	-9.9414	18.29347	-0.74334	-2204.71359	121-1	1
121	1.5	MODAL	LinModal	Mode	7	-2037.6997	49.4162	-9.9414	18.29347	4.22734	-2229.42169	121-1	1.5
121	2	MODAL	LinModal	Mode	7	-2037.6997	49.4162	-9.9414	18.29347	9.19802	-2254.12979	121-1	2
121	2.5	MODAL	LinModal	Mode	7	-2037.6997	49.4162	-9.9414	18.29347	14.1687	-2278.83789	121-1	2.5
127	0	MODAL	LinModal	Mode	7	-2024.383	-71.9356	-8.4925	15.72172	-6.52892	-2294.09528	127-1	0
127	0.5	MODAL	LinModal	Mode	7	-2024.383	-71.9356	-8.4925	15.72172	-2.28268	-2258.12748	127-1	0.5
127	1	MODAL	LinModal	Mode	7	-2024.383	-71.9356	-8.4925	15.72172	1.96356	-2222.15968	127-1	1
127	1.5	MODAL	LinModal	Mode	7	-2024.383	-71.9356	-8.4925	15.72172	6.2098	-2186.19188	127-1	1.5
127	2	MODAL	LinModal	Mode	7	-2024.383	-71.9356	-8.4925	15.72172	10.45603	-2150.22408	127-1	2
127	2.5	MODAL	LinModal	Mode	7	-2024.383	-71.9356	-8.4925	15.72172	14.70227	-2114.25629	127-1	2.5
122	0	MODAL	LinModal	Mode	7	-1973.2262	45.683	-11.5668	16.89052	-14.65658	-2007.54518	122-1	0
122	0.5	MODAL	LinModal	Mode	7	-1973.2262	45.683	-11.5668	16.89052	-8.8732	-2030.38669	122-1	0.5
122	1	MODAL	LinModal	Mode	7	-1973.2262	45.683	-11.5668	16.89052	-3.08982	-2053.2282	122-1	1
122	1.5	MODAL	LinModal	Mode	7	-1973.2262	45.683	-11.5668	16.89052	2.69356	-2076.06971	122-1	1.5
122	2	MODAL	LinModal	Mode	7	-1973.2262	45.683	-11.5668	16.89052	8.47694	-2098.91122	122-1	2
122	2.5	MODAL	LinModal	Mode	7	-1973.2262	45.683	-11.5668	16.89052	14.26032	-2121.75274	122-1	2.5
128	0	MODAL	LinModal	Mode	7	-1954.8232	-69.9674	-10.576	15.74211	-10.4331	-2143.42531	128-1	0
128	0.5	MODAL	LinModal	Mode	7	-1954.8232	-69.9674	-10.576	15.74211	-5.1451	-2108.4416	128-1	0.5

DESIGN OF TARNSOM/ABUTMENT CAP

Frame Text	DesignSect Text	DesignType Text	Status Text	Location m	FTopCombo Text	FTopArea m2	FBotCombo Text	FBotArea m2	VCombo Text	VRebar m2/m	ErrMsg Text	WarnMsg Text
169	Abutment	Brace	No Messages	0	Str-V20	0	Str-V20	0	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	1.22463	Str-IV1	0.000134	Str-V20	0	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	1.22463	Str-I4	0.000529	Str-V20	0	Str-V20	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	1.669	Str-I4	0.001557	Str-V20	0	Str-V20	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	1.669	Str-V12	0.001504	Str-V20	0	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	4.28478	Str-V20	0	Str-I4	0.001462	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	4.28478	Str-V20	0	Str-I4	0.000861	Str-V20	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	5.247	Str-I1	0.00128	Str-V20	0	Str-V20	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	5.247	Str-V9	0.001354	Str-V20	0	Str-I1	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	7.34493	Str-V20	0	Str-I1	0.001804	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	7.34493	Str-V20	0	Str-I1	0.001203	Str-I1	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	8.826	Str-I1	0.001426	Str-V20	0	Str-V9	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	8.826	Str-I1	0.001443	Str-V20	0	Str-V17	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	8.875	Str-I1	0.001364	Str-V20	0	Str-V17	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	10.40507	Str-V20	0	Str-I3	0.001836	Str-V11	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	10.40507	Str-V20	0	Str-I3	0.001255	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	12.405	Str-I1	0.001232	Str-V20	0	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	12.405	Str-I1	0.001212	Str-V20	0	Str-V18	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	13.46522	Str-V20	0	Str-I2	0.001526	Str-V18	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	13.46522	Str-V20	0	Str-I2	0.000936	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	15.984	Str-V6	0.00106	Str-V20	0	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	15.984	Str-I2	0.001138	Str-V20	0	Str-V18	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	16.52537	Str-V20	0	Str-I2	0.000419	Str-V18	0.001896	No Messages	No Messages
169	Abutment	Brace	No Messages	16.52537	Str-IV1	0.000134	Str-V20	0	Str-V20	0	No Messages	No Messages
169	Abutment	Brace	No Messages	17.75	Str-V20	0	Str-V20	0	Str-V20	0	No Messages	No Messages
175	Transom	Brace	No Messages	0	Str-V20	0	Str-V20	0	Str-V20	0	No Messages	No Messages
175	Transom	Brace	No Messages	1.22463	Str-IV1	0.000178	Str-V20	0	Str-V20	0	No Messages	No Messages
175	Transom	Brace	No Messages	1.22463	Str-V13	0.001315	Str-V9	0.001068	Str-V20	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	1.669	Str-V5	0.002765	Str-V20	0	Str-V20	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	1.669	Str-V9	0.003025	Str-V13	4.3E-05	Str-V9	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	4.28478	Str-V20	0	Str-V9	0.002209	Str-V20	0	No Messages	No Messages
175	Transom	Brace	No Messages	4.28478	Str-V13	0.000297	Str-V9	0.002343	Str-V20	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	5.247	Str-V5	0.002387	Str-V20	0	Str-V20	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	5.247	Str-V9	0.00285	Str-V20	0	Str-V17	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	7.34493	Str-V20	0	Str-V9	0.00256	Str-V9	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	7.34493	Str-V20	0	Str-I1	0.002709	Str-V17	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	8.826	Str-V5	0.002628	Str-V20	0	Str-V20	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	8.826	Str-V9	0.002926	Str-V20	0	Str-V20	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	8.875	Str-V9	0.002777	Str-V20	0	Str-V20	0.002528	No Messages	No Messages
175	Transom	Brace	No Messages	10.40507	Str-V20	0	Str-V9	0.002594	Str-V19	0.002528	No Messages	No Messages

PILE PIERS/ABUTMENT PIER

MAX DESIGN FORCES IN PIERS PILE/ABUTMENT PIER

Frame Text	Combo Text	Station m	P Tonf	V2 Tonf	V3 Tonf	T Tonf-m	M2 Tonf-m	M3 Tonf-m
180	StrVGroup2	0	-335.5072	15.1525	34.1604	-5.81712	223.59689	54.53211
180	StrVGroup2	0	-335.5072	-17.4838	34.1604	-5.81712	-170.84221	54.53211
180	StrVGroup2	0	-335.5072	15.1525	-23.1512	-5.81712	223.59689	-62.07676
180	StrVGroup2	0	-335.5072	-17.4838	-23.1512	-5.81712	-170.84221	-62.07676
180	Str-V5	0	-335.5072	14.6639	34.1604	-0.9939	223.59689	52.96684
180	Str-V5	0	-335.5072	-10.3143	34.1604	-0.9939	-93.53868	52.96684
180	Str-V5	0	-335.5072	14.6639	-10.3961	-0.9939	223.59689	-36.39931
180	Str-V5	0	-335.5072	-10.3143	-10.3961	-0.9939	-93.53868	-36.39931
180	StrVGroup2	3.4	-323.958	13.9509	33.3914	-5.81712	113.65801	7.14141
180	StrVGroup2	3.4	-323.958	13.9509	33.3914	-5.81712	113.65801	7.14141
180	StrVGroup2	3.4	-323.958	-16.2821	33.3914	-5.81712	-95.52172	7.14141
180	StrVGroup2	3.4	-323.958	-16.2821	33.3914	-5.81712	-95.52172	7.14141
180	StrVGroup2	3.4	-323.958	13.9509	-22.3822	-5.81712	113.65801	-5.38644
180	StrVGroup2	3.4	-323.958	13.9509	-22.3822	-5.81712	113.65801	-5.38644
180	StrVGroup2	3.4	-323.958	-16.2821	-22.3822	-5.81712	-95.52172	-5.38644
180	StrVGroup2	3.4	-323.958	-16.2821	-22.3822	-5.81712	-95.52172	-5.38644
180	Str-V5	3.4	-323.958	13.4623	33.3914	-0.9939	113.65801	7.14141
180	Str-V5	3.4	-323.958	13.4623	33.3914	-0.9939	113.65801	7.14141
180	Str-V5	3.4	-323.958	-10.0506	33.3914	-0.9939	-59.35909	7.14141
180	Str-V5	3.4	-323.958	-10.0506	33.3914	-0.9939	-59.35909	7.14141
180	Str-V5	3.4	-323.958	13.4623	-10.9368	-0.9939	113.65801	-2.39485
180	Str-V5	3.4	-323.958	13.4623	-10.9368	-0.9939	113.65801	-2.39485
180	Str-V5	3.4	-323.958	-10.0506	-10.9368	-0.9939	-59.35909	-2.39485
180	Str-V5	3.4	-323.958	-10.0506	-10.9368	-0.9939	-59.35909	-2.39485
180	Str-V6	0	-323.2051	9.7085	16.7507	3.96167	107.39962	35.03209

DESIGN OF COLOUMN PIER/ABUTMENT PIER

Frame Text	DesignSect Text	DesignType Text	DesignOpt Text	Status Text	Location m	PMMCombo Text	PMMArea m2	VMajCombo Text	VMajRebar m2/m	VMinCombo Text	VMinRebar m2/m	ErrMsg Text	WarnMsg Text
170	Piers-piles	Column	Design	No Messages	0	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
170	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
170	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
170	Piers-piles	Column	Design	No Messages	6.8	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
171	Piers-piles	Column	Design	No Messages	0	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
171	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
171	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
171	Piers-piles	Column	Design	No Messages	6.8	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
172	Piers-piles	Column	Design	No Messages	0	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
172	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
172	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
172	Piers-piles	Column	Design	No Messages	6.8	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
173	Piers-piles	Column	Design	No Messages	0	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
173	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
173	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
173	Piers-piles	Column	Design	No Messages	6.8	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
174	Piers-piles	Column	Design	No Messages	0	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
174	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
174	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
174	Piers-piles	Column	Design	No Messages	6.8	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
176	Piers-piles	Column	Design	No Messages	0	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
176	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
176	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
176	Piers-piles	Column	Design	No Messages	6.8	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
177	Piers-piles	Column	Design	No Messages	0	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
177	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
177	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
177	Piers-piles	Column	Design	No Messages	6.8	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
178	Piers-piles	Column	Design	No Messages	0	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
178	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
178	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
178	Piers-piles	Column	Design	No Messages	6.8	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
179	Piers-piles	Column	Design	No Messages	0	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
179	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
179	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
179	Piers-piles	Column	Design	No Messages	6.8	StrlGroup1	0.01131	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
180	Piers-piles	Column	Design	No Messages	0	StrVGroup2	0.012529	Str-V20	0.0022	Str-V20	0.0022	No Messages	No Messages
180	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages
180	Piers-piles	Column	Design	No Messages	3.4	StrlGroup1	0.01131	Str-V20	0.001568	Str-V20	0.001568	No Messages	No Messages

DESIGN OF UNDERPASS 10m X 5.1m

SUBWAY/CATTLE CREEP 4X3M

DESIGN OF UNDERPASS (10 x 5.5) m

Project: Rawalpindi Ring Road
Task : Design of Underpass (10 x 5.5)
Job No.: 3888
Client : RDA

Underpass PROPERTIES
=================
Type of Underpass: Cast-in-Place
Specification : AASHTO LRFD 2017
Operating Mode : DESIGN

Physical Dimensions

No. of Boxes: 1 Name: UNDERPASS (10 x 5.5)
Clear Span : 32.8100 ft Fill Depth : 6.56 ft
Clear Height: 18.0455 ft Center Skew: 0.00 deg Left Skew: 90.00 deg Right Skew: 90.00 deg
Length :100.0000 ft
Bottom Slab Support: Full Slab
Haunches: Top: 8.0000 in Bottom: 0.0000 in
Minimum Thicknesses: Top Slab: 27.5590 in
Bot Slab: 27.5590 in
Ext Wall: 25.5900 in

Material Properties

Concrete: Strength,f'c: 4.000 ksi Density: 0.150 kcf Elasticity,Ec: 3834 ksi
Type: Normal Weight
Steel: Yield,fy: 60.00 ksi Allow Stress: 24.00 ksi Elasticity,Es: 29000 ksi
Yield,fyv: 60.00 ksi Diameter : 1.000 in
Soil: Density: 0.120 kcf Slope Factor: 1.150 (Granular)
Fe Factor: 1.150 (Maximum for Compacted Fill)
Serviceability, Gamma-e: 1.00

Loads

Live Load: Vehicle: Class AA

Axle No.	Weight(k)	Dist. From Previous(ft)
1	3.86	0.00
2	7.72	1.20
3	7.72	1.20
4	7.72	1.20
5	7.72	1.20
6	7.72	1.20
7	7.72	1.20
8	7.72	1.20

9	7.72	1.20
10	3.86	1.20

Gage Width: 9.50 ft, Tread Width: 33.07 in, Tread Length: 47.24 in
Include Tandem: no
Lane Load: 0.64 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck Or Tandem Or Lane
Include Lane Load: yes
Max. No. of Lanes: Computed by Program
Override MPF: no
Traffic Direction: Lanes Parallel to Main Reinforcement
Neglect Live Load for Large Fill Depths: yes
Apply Surcharge at Fill Depths > 2 foot: yes
Surcharge Depth : 2.00 ft
Dead Load: Future Wearing Surf.: 0.05 k/ft
Additional Dead Load: 0.00 k/ft
Concentrated Loads : none
Lateral Soil Loads: Max. Equiv. Fluid Press.: 60.00 pcf
Min. Equiv. Fluid Press.: 30.00 pcf
Fluid Pressures : Consider Int. Water Press.: no

Load and Resistance Factors

	Max	Min
DC:	1.25	0.90
DW:	1.50	0.65
EV:	1.30	0.90
EH:	1.35	0.90
WA:	1.00	

LL I: 1.75 LL II: 1.35
Ductility: 1.00 Importance: 1.00 Redundancy: 1.00 Condition: 1.00 System: 1.00
Phi Shear: 0.85 Phi Moment: 0.90

Reinforcement

Rebar Covers:	Exterior	Interior
Top Slab:	2.0000 in	1.0000 in
Walls :	1.0000 in	1.0000 in
Bot Slab:	1.0000 in	1.0000 in

Design Options

Member Thick.: Top Slab: Fixed
Bottom Slab: Fixed
Ext. Wall: Fixed
LL Analysis : Automatically Set Traffic Direction to Account for Skew Effects: yes
Limit Distribution Width to Underpass Length for Fills < 2 foot: no
Limit Distribution Width to Underpass Length for Fills > 2 foot: no

Combine Axle Overlaps for Fills > 2 foot: yes
Override DLA: no
Include Impact on Bottom Slab: yes
Always Distribute Wheel Load: no

Reinforcement: Always Include Distribution Steel: no
User Defined Longitudinal Steel: no
Ind. Top and Bottom Slab Design: yes
Max. As used in Vc Calcs: 2.00 in2/ft

Slenderness : Checked K Factor: 2.00

Modeling : Use Haunches in the Structural Model: yes

Crit. Section: Consider Haunches when Selecting Critical Section Locations: yes
Extend Critical Section for Shear Beyond the End of the Haunch: no
Use Max. Moment with Max. Shear at the Critical Section for Shear: no

Misc. Options: Use Strength II: no
Ignore Axial Thrust: no

Live Load Deflection Criteria: 1/800

DESIGN RESULTS
==============

Top Slab Thickness = 27.56 in
Bottom Slab Thickness = 27.56 in
Exterior Wall Thickness = 25.59 in

Modular Ratio (N) = 7.56
Max. Steel Ratio = 0.021
Design Span = 34.94 ft
Design Height = 20.34 ft
Design Fill Depth = 6.56 ft

Volume of Concrete: 9.174 cy/ft Weight of Steel : 1173 lb/ft

Reinforcing Steel Schedule

Location	Bar Mark	Qty	Size	Type	Spacing (in)	As,prv (in2/ft)	As,rqd (in2/ft)	Length (ft-in)	Wgt (lbs)	H Leg (ft-in)	V Leg (ft-in)
Top Slab (int)	A100 (AS2)	150	9	STR	8.00	1.500	1.459	36-10	18803		
Bot Slab (int)	A200 (AS3)	120	11	STR	10.00	1.872	1.759	36-10	23465		
Top Slab (ext)	A300 (AS7)	150	4	STR	8.00	0.300	0.281	36-10	3759		
Bot Slab (ext)	A400 (AS8)	150	4	STR	8.00	0.300	0.281	36-10	3759		
Corner (Top)	A1 (AS1)	480	7	L-BAR	5.00	1.440	1.207	14-11	14615	9- 0	5-11
Corner (Bottom)	A2 (AS1)	480	7	L-BAR	5.00	1.440	1.408	14- 2	13880	8-10	5- 4
Ext Wall (int)	B1 (AS4)	300	4	STR	8.00	0.300	0.281	18- 7	3793		
Ext Wall (ext)	B2 (AS1)	480	6	STR	5.00	1.056	0.920	17- 5	12520		
Top Slab (int- 2)	C100 (AS5)	100	4	STR	8.00	0.300	0.281	50- 9	3453		

Bot Slab (int- 2) C200			100	4	STR	8.00	0.300	0.281	50- 9	3453
Temperature	(2) C1	(AS6)	53	4	STR	8.00	0.300	0.281	50- 9	1830
Temperature	(2) C1	(AS6)	53	4	STR	8.00	0.300	0.281	50- 9	1830
Temperature	(2) C1	(AS6)	62	4	STR	8.00	0.300	0.281	50- 9	2141
Temperature	(2) C1	(AS6)	62	4	STR	8.00	0.300	0.281	50- 9	2141
										Total

117453

Note: A denotes flexural steel, B denotes vertical steel, C denotes longitudinal steel

Splice Lengths Table

Bar Mark	Size	Splice Length (ft-in)
B1	4	1- 9
C1	4	1- 9
C100	4	1- 9
C200	4	1- 9

Load Parameters:

Fe = 1.04

Unfactored Moments due to All Loads: (k-ft)

M-PT	Mdc	Mev	Mdw	Meh	Mls	Mwa	Mll+	Mll-
Member 1: (Exterior Wall)								
Bottom								
1- 0	-46.33	-47.73	-2.92	-16.75	-1.73	0.00	0.00	-9.02
1- 1	-43.41	-48.06	-2.94	7.14	0.50	0.00	0.00	-9.21
1- 2	-40.48	-48.40	-2.96	24.31	2.22	0.00	0.00	-9.40
1- 3	-37.56	-48.74	-2.98	35.31	3.46	0.00	0.00	-9.68
1- 4	-34.63	-49.08	-3.00	40.65	4.19	0.00	0.00	-10.04
1- 5	-31.71	-49.42	-3.02	40.87	4.43	0.00	0.00	-10.44
1- 6	-28.78	-49.75	-3.05	36.52	4.17	0.00	0.00	-10.85
1- 7	-25.86	-50.09	-3.07	28.12	3.42	0.00	0.00	-11.27
1- 8	-22.93	-50.43	-3.09	16.20	2.17	0.00	0.00	-11.69
1- 9	-20.01	-50.77	-3.11	1.30	0.42	0.00	0.00	-12.12
1-10	-17.08	-51.10	-3.13	-16.04	-1.82	0.00	0.04	-12.56
Top								
Member 2: (Top Slab)								
Left								
2- 0	-17.08	-51.10	-3.13	-16.04	-1.82	0.00	0.04	-12.56

2- 1	1.85	-6.22	-0.38	-16.04	-1.82	0.00	2.51	-4.34
2- 2	16.57	28.69	1.76	-16.04	-1.82	0.00	8.19	-0.08
2- 3	27.08	53.62	3.28	-16.04	-1.82	0.00	13.70	0.00
2- 4	33.39	68.58	4.20	-16.04	-1.82	0.00	17.02	0.00
2- 5	35.50	73.57	4.50	-16.04	-1.82	0.00	18.14	0.00
2- 6	33.39	68.58	4.20	-16.04	-1.82	0.00	17.02	0.00
2- 7	27.08	53.62	3.28	-16.04	-1.82	0.00	13.70	0.00
2- 8	16.57	28.69	1.76	-16.04	-1.82	0.00	8.19	-0.08
2- 9	1.85	-6.22	-0.38	-16.04	-1.82	0.00	2.51	-4.34
2-10	-17.08	-51.10	-3.13	-16.04	-1.82	0.00	0.04	-12.56

Right

Member 4: (Bottom Slab)

Left

4- 0	-46.33	-47.73	-2.92	-16.75	-1.73	0.00	0.00	-9.02
4- 1	-6.94	-2.84	-0.17	-16.75	-1.73	0.00	0.22	-0.97
4- 2	23.70	32.06	1.96	-16.75	-1.73	0.00	6.44	0.00
4- 3	45.58	57.00	3.49	-16.75	-1.73	0.00	10.87	0.00
4- 4	58.71	71.96	4.40	-16.75	-1.73	0.00	13.52	0.00
4- 5	63.09	76.95	4.71	-16.75	-1.73	0.00	14.40	0.00
4- 6	58.71	71.96	4.40	-16.75	-1.73	0.00	13.52	0.00
4- 7	45.58	57.00	3.49	-16.75	-1.73	0.00	10.87	0.00
4- 8	23.70	32.06	1.96	-16.75	-1.73	0.00	6.44	0.00
4- 9	-6.94	-2.84	-0.17	-16.75	-1.73	0.00	0.22	-0.97
4-10	-46.33	-47.73	-2.92	-16.75	-1.73	0.00	0.00	-9.02

Right

Unfactored Shears due to All Loads: (k-ft)

M-PT	Vdc	Vev	Vdw	Veh	Vls	Vwa	Vll+	Vll-

Member 1: (Exterior Wall)

Bottom

1- 0	1.44	-0.17	-0.01	13.48	1.22	0.00	0.09	-0.22
1- 1	1.44	-0.17	-0.01	10.05	0.97	0.00	0.09	-0.22
1- 2	1.44	-0.17	-0.01	6.88	0.73	0.00	0.09	-0.22
1- 3	1.44	-0.17	-0.01	3.97	0.48	0.00	0.09	-0.22
1- 4	1.44	-0.17	-0.01	1.33	0.24	0.00	0.09	-0.22
1- 5	1.44	-0.17	-0.01	-1.06	0.00	0.00	0.09	-0.22
1- 6	1.44	-0.17	-0.01	-3.18	-0.25	0.00	0.09	-0.22
1- 7	1.44	-0.17	-0.01	-5.04	-0.49	0.00	0.09	-0.22
1- 8	1.44	-0.17	-0.01	-6.63	-0.74	0.00	0.09	-0.22
1- 9	1.44	-0.17	-0.01	-7.97	-0.98	0.00	0.09	-0.22
1-10	1.44	-0.17	-0.01	-9.04	-1.23	0.00	0.09	-0.22

Top

Member 2: (Top Slab)

Left								
2- 0	6.02	14.27	0.87	0.00	0.00	0.00	3.54	0.00
2- 1	4.81	11.42	0.70	0.00	0.00	0.00	3.01	-0.04
2- 2	3.61	8.56	0.52	0.00	0.00	0.00	2.47	-0.15
2- 3	2.41	5.71	0.35	0.00	0.00	0.00	1.94	-0.34
2- 4	1.20	2.85	0.17	0.00	0.00	0.00	1.42	-0.61
2- 5	0.00	0.00	0.00	0.00	0.00	0.00	0.97	-0.97
2- 6	-1.20	-2.85	-0.17	0.00	0.00	0.00	0.61	-1.42
2- 7	-2.41	-5.71	-0.35	0.00	0.00	0.00	0.34	-1.94
2- 8	-3.61	-8.56	-0.52	0.00	0.00	0.00	0.15	-2.47
2- 9	-4.81	-11.42	-0.70	0.00	0.00	0.00	0.04	-3.01
2-10	-6.02	-14.27	-0.87	0.00	0.00	0.00	0.00	-3.54
Right								

Member 4: (Bottom Slab)

Left								
4- 0	12.53	14.27	0.87	0.00	0.00	0.00	2.61	0.00
4- 1	10.02	11.42	0.70	0.00	0.00	0.00	2.09	0.00
4- 2	7.52	8.56	0.52	0.00	0.00	0.00	1.58	0.00
4- 3	5.01	5.71	0.35	0.00	0.00	0.00	1.06	0.00
4- 4	2.51	2.85	0.17	0.00	0.00	0.00	0.55	0.00
4- 5	0.00	0.00	0.00	0.00	0.00	0.00	0.04	-0.04
4- 6	-2.51	-2.85	-0.17	0.00	0.00	0.00	0.00	-0.55
4- 7	-5.01	-5.71	-0.35	0.00	0.00	0.00	0.00	-1.06
4- 8	-7.52	-8.56	-0.52	0.00	0.00	0.00	0.00	-1.58
4- 9	-10.02	-11.42	-0.70	0.00	0.00	0.00	0.00	-2.09
4-10	-12.53	-14.27	-0.87	0.00	0.00	0.00	0.00	-2.61
Right								

Live Load Parameters: Traffic Direction is Parallel to Main Reinforcement

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Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)	
Truck	1	0.231	22.28	0.00	(largest truck used)

All Vehicles:
Distribution Width: 14.30 ft
Impact Factor : 1.06
Lane:
Lane Load : 0.046 k/ft Distribution Width: 27.54 ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.231	22.28	17.47

Coincident Bottom Slab Load: 0.15 k/ft

Maximum -Moment in Top Slab
Truck   1   0.231   22.28   16.38
Coincident Bottom Slab Load: 0.15 k/ft

Maximum +Shear in Top Slab
Truck   1   0.231   22.28   11.14
Coincident Bottom Slab Load: 0.15 k/ft

Maximum -Shear in Top Slab
Truck   1   0.231   22.28   23.80
Coincident Bottom Slab Load: 0.15 k/ft

Maximum Deflection in Top Slab Due to Lane Load =   0.013 in

Unfactored Moments and Shears due to Live Loads: (k, k-ft)

	Truck				Tandem				Lane			
M-PT	Mll+	Mll-	Vll+	Vll-	Mll+	Mll-	Vll+	Vll-	Mll+	Mll-	Vll+	Vll-
Member 1: (Exterior Wall)												
Bottom												
1- 0	0.00	-9.02	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.72	0.03	-0.04
1- 1	0.00	-9.21	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.73	0.03	-0.04
1- 2	0.00	-9.40	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.75	0.03	-0.04
1- 3	0.00	-9.68	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.77	0.03	-0.04
1- 4	0.00	-10.04	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.79	0.03	-0.04
1- 5	0.00	-10.44	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.81	0.03	-0.04
1- 6	0.00	-10.85	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.83	0.03	-0.04
1- 7	0.00	-11.27	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.85	0.03	-0.04
1- 8	0.00	-11.69	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.87	0.03	-0.04
1- 9	0.00	-12.12	0.09	-0.22	0.00	0.00	0.00	0.00	0.00	-2.89	0.03	-0.04
1-10	0.04	-12.56	0.09	-0.22	0.00	0.00	0.00	0.00	0.01	-2.91	0.03	-0.04
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.04	-12.56	3.54	0.00	0.00	0.00	0.00	0.00	0.01	-2.91	0.81	0.00
2- 1	2.51	-4.34	3.01	-0.04	0.00	0.00	0.00	0.00	0.52	-0.87	0.66	-0.01
2- 2	8.19	-0.08	2.47	-0.15	0.00	0.00	0.00	0.00	1.67	-0.04	0.52	-0.03
2- 3	13.70	0.00	1.94	-0.34	0.00	0.00	0.00	0.00	3.05	0.00	0.39	-0.07
2- 4	17.02	0.00	1.42	-0.61	0.00	0.00	0.00	0.00	3.90	0.00	0.28	-0.12
2- 5	18.14	0.00	0.97	-0.97	0.00	0.00	0.00	0.00	4.19	0.00	0.19	-0.19
2- 6	17.02	0.00	0.61	-1.42	0.00	0.00	0.00	0.00	3.90	0.00	0.12	-0.28
2- 7	13.70	0.00	0.34	-1.94	0.00	0.00	0.00	0.00	3.05	0.00	0.07	-0.39
2- 8	8.19	-0.08	0.15	-2.47	0.00	0.00	0.00	0.00	1.67	-0.04	0.03	-0.52

2- 9	2.51	-4.34	0.04	-3.01	0.00	0.00	0.00	0.00	0.52	-0.87	0.01	-0.66
2-10	0.04	-12.56	0.00	-3.54	0.00	0.00	0.00	0.00	0.01	-2.91	0.00	-0.81
Right												

Member 4: (Bottom Slab)

Left												
4- 0	0.00	-9.02	2.61	0.00	0.00	0.00	0.00	0.00	0.00	-2.72	0.81	0.00
4- 1	0.22	-0.97	2.09	0.00	0.00	0.00	0.00	0.00	0.08	-0.24	0.65	0.00
4- 2	6.44	0.00	1.58	0.00	0.00	0.00	0.00	0.00	1.82	0.00	0.49	0.00
4- 3	10.87	0.00	1.06	0.00	0.00	0.00	0.00	0.00	3.24	0.00	0.32	0.00
4- 4	13.52	0.00	0.55	0.00	0.00	0.00	0.00	0.00	4.09	0.00	0.16	0.00
4- 5	14.40	0.00	0.04	-0.04	0.00	0.00	0.00	0.00	4.38	0.00	0.01	-0.01
4- 6	13.52	0.00	0.00	-0.55	0.00	0.00	0.00	0.00	4.09	0.00	0.00	-0.16
4- 7	10.87	0.00	0.00	-1.06	0.00	0.00	0.00	0.00	3.24	0.00	0.00	-0.32
4- 8	6.44	0.00	0.00	-1.58	0.00	0.00	0.00	0.00	1.82	0.00	0.00	-0.49
4- 9	0.22	-0.97	0.00	-2.09	0.00	0.00	0.00	0.00	0.08	-0.24	0.00	-0.65
4-10	0.00	-9.02	0.00	-2.61	0.00	0.00	0.00	0.00	0.00	-2.72	0.00	-0.81
Right												

Serviceability Check: Crack Control

Bar Mark	Location	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	27.16	5.00	20.88
A2	Bot Corner Bar	33.94	5.00	16.13
A100	Top Slab (int)	40.35	8.00	12.85
A300	Top Slab (ext)	0.00	8.00	0.00
A200	Bot Slab (int)	39.11	10.00	12.95
A400	Bot Slab (ext)	0.00	8.00	0.00
B1	Ext Wall (int)	33.57	8.00	16.92
B2	Ext Wall (ext)	28.06	5.00	20.32

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior Wall)

Thickness = 25.59 in

		Design	Corr.						Load Ratings	
Loc	Dist.	Moment	A. F.	Mu	Ma		As	1.2Mcr	IR	OR
	(in)	(k-ft)	(k)	(k-ft)	(k-ft)	phi	(in2)	(k-ft)	(Str I)	(Str II)
BOT	13.78	-146.06	33.58	148.83	168.74	0.90	1.44	96.92	2.49	3.22
MID	122.05	0.00	18.83	32.56	44.84	0.90	0.30	96.92	NC	NC
MID-	122.05	-92.59	33.58	111.38	131.93	0.90	1.06	96.92	3.12	4.04
TOP	13.78	-125.99	33.58	149.65	169.51	0.90	1.44	96.92	2.97	3.84

Member 2: (Top Slab)

Thickness = 27.56 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	Ma (k-ft)	phi	As (in2)	1.2Mcr (k-ft)	Load Ratings IR (Str I)	Load Ratings OR (Str II)
LT	12.80	-108.63	13.16	155.93	164.53	0.90	1.44	112.41	3.69	4.78
MID	209.66	164.07	6.42	168.02	172.13	0.90	1.50	112.41	1.25	1.63
RT	12.80	-108.63	13.16	155.93	164.53	0.90	1.44	112.41	3.69	4.78

Member 4: (Bottom Slab)
Thickness = 27.56 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	Ma (k-ft)	phi	As (in2)	1.2Mcr (k-ft)	Load Ratings IR (Str I)	Load Ratings OR (Str II)
LT	12.80	-127.38	22.04	162.41	176.55	0.90	1.44	112.41	4.39	5.69
MID	209.66	196.08	13.32	206.20	214.47	0.90	1.87	112.41	1.73	2.24
RT	12.80	-127.38	22.04	162.41	176.55	0.90	1.44	112.41	4.39	5.69

Note: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior Wall)
Thickness = 25.59 in (Controlling Shear Method: Iterative)

Loc	Dist. (in)	Design Shear (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR (Str I)	Load Ratings OR (Str II)
BOT	35.46	14.85	22.97	34.37	2.321	44.42	40.43	0.00	0.00	0.00	12.78	16.57
MID	122.05	0.76	24.12	70.70	4.547	33.05	83.18	0.00	0.00	0.00	NC	NC
MID-	122.05	0.76	23.44	69.35	4.590	32.83	81.59	0.00	0.00	0.00	99.99	99.99
TOP	35.46	-10.33	23.09	25.62	1.721	49.70	30.14	0.00	0.00	0.00	9.06	11.75

Member 2: (Top Slab)
Thickness = 27.56 in (Controlling Shear Method: Box Underpass)

Loc	Dist. (in)	Design Shear (k)	Dv (in)	phi*Vn (k)	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR (Str I)	Load Ratings OR (Str II)
LT	35.35	28.18	25.12	48.58	57.16	0.00	0.00	0.00	4.77	6.18
MID	209.66	1.70	26.00	50.27	59.14	0.00	0.00	0.00	29.63	38.41
RT	35.35	28.18	25.12	48.58	57.16	0.00	0.00	0.00	4.77	6.18

Member 4: (Bottom Slab)
Thickness = 27.56 in (Controlling Shear Method: Box Underpass)

Loc	Dist. (in)	Design Shear (k)	Dv (in)	phi*Vn (k)	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR (Str I)	Load Ratings OR (Str II)
LT	36.25	33.16	26.12	50.52	59.43	0.00	0.00	0.00	5.59	7.24
MID	209.66	0.07	25.85	50.00	58.82	0.00	0.00	0.00	99.99	99.99

RT	36.25	33.16	26.12	50.52	59.43	0.00	0.00	0.00	5.59	7.24

Load Combination Results at Tenth Points: (k, k-ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior Wall)						
Bottom						
1- 0	-112.187	-165.763	18.829	33.582	22.044	13.321
1- 1	-73.728	-130.844	18.829	33.582	16.983	10.231
1- 2	-45.204	-112.534	18.829	33.582	12.276	7.378
1- 3	-25.895	-99.949	18.829	33.582	7.923	4.761
1- 4	-15.081	-92.583	18.829	33.582	3.924	2.380
1- 5	-12.041	-89.885	18.829	33.582	0.763	-0.299
1- 6	-16.055	-91.336	18.829	33.582	-1.146	-3.589
1- 7	-26.404	-96.450	18.829	33.582	-2.819	-6.526
1- 8	-42.366	-104.730	18.829	33.582	-4.255	-9.109
1- 9	-63.221	-115.710	18.829	33.582	-5.456	-11.337
1-10	-88.249	-139.304	18.829	33.582	-6.421	-13.211
Top						
Member 2: (Top Slab)						
Left						
2- 0	-88.249	-139.304	13.211	13.162	33.582	18.829
2- 1	-16.391	-38.792	6.421	13.162	27.177	15.063
2- 2	60.532	17.021	6.421	13.211	20.759	11.297
2- 3	118.016	49.918	6.421	13.211	14.343	7.532
2- 4	152.542	69.656	6.421	13.211	7.956	3.766
2- 5	164.067	76.235	6.421	13.211	1.696	-1.696
2- 6	152.542	69.656	6.421	13.211	-3.766	-7.956
2- 7	118.016	49.918	6.421	13.211	-7.532	-14.343
2- 8	60.532	17.021	6.421	13.211	-11.297	-20.759
2- 9	-16.391	-38.792	6.421	13.162	-15.063	-27.178
2-10	-88.249	-139.304	13.211	13.162	-18.829	-33.582
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-112.187	-165.763	21.467	22.044	40.084	24.685
4- 1	-27.318	-39.976	13.321	22.044	32.079	19.748
4- 2	70.437	25.824	13.321	21.467	24.074	14.811
4- 3	140.247	68.952	13.321	21.467	16.069	9.874
4- 4	182.122	94.829	13.321	21.467	8.064	4.937
4- 5	196.080	103.455	13.321	21.467	0.069	-0.069
4- 6	182.122	94.829	13.321	21.467	-4.937	-8.064
4- 7	140.247	68.952	13.321	21.467	-9.874	-16.069
4- 8	70.437	25.824	13.321	21.467	-14.811	-24.074

4- 9	-27.318	-39.976	13.321	22.044	-19.748	-32.079
4-10	-112.187	-165.763	21.467	22.044	-24.685	-40.084

Right

DESIGN OF CATTLE CREEP (4 x 3) m

Project: Rawalpindi Ring Road
Task : Design of Cattle Creep (4 x 3)
Job No.: 3888
Client : RDA
Agency : None

Cattle Creep PROPERTIES
=================
Type of Culvert: Cast-in-Place
Specification : AASHTO LRFD 2017
Operating Mode : DESIGN

Physical Dimensions

No. of Boxes: 1 Name: Cattle Creep (4 x3)
Clear Span : 13.1240 ft Fill Depth : 10.30 ft
Clear Height: 9.8430 ft Center Skew: 0.00 deg Left Skew: 90.00 deg Right Skew: 90.00 deg
Length :100.0000 ft
Bottom Slab Support: Full Slab
Haunches: Top: 8.0000 in Bottom: 0.0000 in
Minimum Thicknesses: Top Slab: 17.7200 in
Bot Slab: 17.7200 in
Ext Wall: 13.7800 in

Material Properties

Concrete: Strength,f'c: 4.000 ksi Density: 0.150 kcf Elasticity,Ec: 3834 ksi
Type: Normal Weight
Steel: Yield,fy: 60.00 ksi Allow Stress: 24.00 ksi Elasticity,Es: 29000 ksi
Yield,fyv: 60.00 ksi Diameter : 1.000 in
Soil: Density: 0.120 kcf Slope Factor: 1.150 (Granular)
Fe Factor: 1.150 (Maximum for Compacted Fill)
Serviceability, Gamma-e: 1.00

Loads

Live Load: Vehicle: Class AA

Axle No.	Weight(k)	Dist. From Previous(ft)
1	3.86	0.00
2	7.72	1.20
3	7.72	1.20
4	7.72	1.20
5	7.72	1.20
6	7.72	1.20

7	7.72	1.20
8	7.72	1.20
9	7.72	1.20
10	3.86	1.20

Gage Width: 9.50 ft, Tread Width: 33.07 in, Tread Length: 47.24 in
Include Tandem: no
Lane Load: 0.64 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck Or Tandem Or Lane

Include Lane Load: yes
Max. No. of Lanes: Computed by Program
Override MPF: no
Traffic Direction: Lanes Parallel to Main Reinforcement
Neglect Live Load for Large Fill Depths: yes
Apply Surcharge at Fill Depths > 2 foot: yes
Surcharge Depth : 2.00 ft

Dead Load: Future Wearing Surf.: 0.05 k/ft
Additional Dead Load: 0.00 k/ft
Concentrated Loads : none

Lateral Soil Loads: Max. Equiv. Fluid Press.: 60.00 pcf
Min. Equiv. Fluid Press.: 30.00 pcf

Fluid Pressures : Consider Int. Water Press.: no

Load and Resistance Factors

	Max	Min
DC:	1.25	0.90
DW:	1.50	0.65
EV:	1.30	0.90
EH:	1.35	0.90
WA:	1.00	

LL I: 1.75 LL II: 1.35
Ductility: 1.00 Importance: 1.00 Redundancy: 1.00 Condition: 1.00 System: 1.00
Phi Shear: 0.85 Phi Moment: 0.90

Reinforcement

Rebar Covers:	Exterior	Interior
Top Slab:	2.0000 in	1.0000 in
Walls :	1.0000 in	1.0000 in
Bot Slab:	1.0000 in	1.0000 in

Design Options

Member Thick.: Top Slab: Fixed
Bottom Slab: Fixed
Ext. Wall: Fixed

LL Analysis : Automatically Set Traffic Direction to Account for Skew Effects: yes

Limit Distribution Width to Culvert Length for Fills < 2 foot: no
Limit Distribution Width to Culvert Length for Fills > 2 foot: no
Combine Axle Overlaps for Fills > 2 foot: yes
Override DLA: no
Include Impact on Bottom Slab: yes
Always Distribute Wheel Load: no
Reinforcement: Always Include Distribution Steel: no
User Defined Longitudinal Steel: no
Ind. Top and Bottom Slab Design: yes
Max. As used in Vc Calcs: 2.00 in2/ft
Slenderness : Checked K Factor: 2.00
Modeling : Use Haunches in the Structural Model: yes
Crit. Section: Consider Haunches when Selecting Critical Section Locations: yes
Extend Critical Section for Shear Beyond the End of the Haunch: no
Use Max. Moment with Max. Shear at the Critical Section for Shear: no
Misc. Options: Use Strength II: no
Ignore Axial Thrust: no
Live Load Deflection Criteria: 1/800

DESIGN RESULTS
==============
Top Slab Thickness = 17.72 in
Bottom Slab Thickness = 17.72 in
Exterior Wall Thickness = 13.78 in

Modular Ratio (N) = 7.56
Max. Steel Ratio = 0.021
Design Span = 14.27 ft
Design Height = 11.32 ft
Design Fill Depth = 10.30 ft

Volume of Concrete: 2.540 cy/ft Weight of Steel : 249 lb/ft

Reinforcing Steel Schedule

Location	Bar Mark	Qty	Size	Type	Spacing (in)	As,prv (in2/ft)	As,rqd (in2/ft)	Length (ft-in)	Wgt (lbs)	H Leg (ft-in)	V Leg (ft-in)
Top Slab (int)	A100 (AS2)	150	6	STR	8.00	0.660	0.656	15- 2	3407		
Bot Slab (int)	A200 (AS3)	150	6	STR	8.00	0.660	0.659	15- 2	3407		
Top Slab (ext)	A300 (AS7)	100	4	STR	12.00	0.200	0.175	15- 2	1032		

Bot Slab (ext)	A400	(AS8)	100	4	STR	12.00	0.200	0.175	15- 2	1032	
Corner (Top)	A1	(AS1)	344	5	L-BAR	7.00	0.531	0.525	8- 0	2903	4- 4 3- 8
Corner (Bottom)	A2	(AS1)	344	5	L-BAR	7.00	0.531	0.525	7- 1	2570	4- 0 3- 1
Ext Wall (int)	B1	(AS4)	200	4	STR	12.00	0.200	0.175	10- 5	1418	
Ext Wall (ext)	B2	(AS1)	344	4	STR	7.00	0.343	0.229	9- 3	2165	
Top Slab (int- 2)	C100	(AS5)	28	4	STR	12.00	0.200	0.175	50- 9	967	
Bot Slab (int- 2)	C200		28	4	STR	12.00	0.200	0.175	50- 9	967	
Temperature (2)	C1	(AS6)	15	4	STR	12.00	0.200	0.175	50- 9	518	
Temperature (2)	C1	(AS6)	15	4	STR	12.00	0.200	0.175	50- 9	518	
Temperature (2)	C1	(AS6)	24	4	STR	12.00	0.200	0.175	50- 9	829	
Temperature (2)	C1	(AS6)	24	4	STR	12.00	0.200	0.175	50- 9	829	
							Total		25255		

Note: A denotes flexural steel, B denotes vertical steel, C denotes longitudinal steel

Splice Lengths Table

Bar Mark	Size	Splice Length (ft-in)
B1	4	1- 9
C1	4	1- 9
C100	4	1- 9
C200	4	1- 9

Load Parameters:

Fe = 1.14

Unfactored Moments due to All Loads: (k-ft)

Member 1: (Exterior Wall)

Bottom

	M-PT	Mdc	Mev	Mdw	Meh	Mls	Mwa	Mll+	Mll-
1- 0	-3.72	-8.61	-0.31	-6.92	-0.78	0.00	0.00	-0.86	
1- 1	-3.44	-8.79	-0.31	-0.51	-0.10	0.00	0.00	-0.87	
1- 2	-3.16	-8.97	-0.32	4.21	0.42	0.00	0.00	-0.89	
1- 3	-2.88	-9.15	-0.32	7.34	0.80	0.00	0.00	-0.91	
1- 4	-2.60	-9.33	-0.33	8.98	1.01	0.00	0.00	-0.93	
1- 5	-2.32	-9.50	-0.34	9.21	1.08	0.00	0.00	-0.95	
1- 6	-2.04	-9.68	-0.34	8.13	0.99	0.00	0.00	-0.96	
1- 7	-1.76	-9.86	-0.35	5.82	0.75	0.00	0.00	-0.98	
1- 8	-1.48	-10.04	-0.36	2.40	0.35	0.00	0.00	-1.00	
1- 9	-1.20	-10.21	-0.36	-2.07	-0.20	0.00	0.00	-1.02	

1-10	-0.92	-10.39	-0.37	-7.47	-0.91	0.00	0.01	-1.04

Top

Member 2: (Top Slab)

Left

2- 0	-0.92	-10.39	-0.37	-7.47	-0.91	0.00	0.01	-1.04
2- 1	1.12	2.55	0.09	-7.47	-0.91	0.00	0.40	-0.15
2- 2	2.69	12.62	0.45	-7.47	-0.91	0.00	1.26	0.00
2- 3	3.82	19.81	0.70	-7.47	-0.91	0.00	1.97	0.00
2- 4	4.50	24.13	0.85	-7.47	-0.91	0.00	2.40	0.00
2- 5	4.72	25.56	0.91	-7.47	-0.91	0.00	2.54	0.00
2- 6	4.50	24.13	0.85	-7.47	-0.91	0.00	2.40	0.00
2- 7	3.82	19.81	0.70	-7.47	-0.91	0.00	1.97	0.00
2- 8	2.69	12.62	0.45	-7.47	-0.91	0.00	1.26	0.00
2- 9	1.12	2.55	0.09	-7.47	-0.91	0.00	0.40	-0.15
2-10	-0.92	-10.39	-0.37	-7.47	-0.91	0.00	0.01	-1.04

Right

Member 4: (Bottom Slab)

Left

4- 0	-3.72	-8.61	-0.31	-6.92	-0.78	0.00	0.00	-0.86
4- 1	0.82	4.33	0.15	-6.92	-0.78	0.00	0.43	0.00
4- 2	4.35	14.40	0.51	-6.92	-0.78	0.00	1.43	0.00
4- 3	6.87	21.59	0.76	-6.92	-0.78	0.00	2.15	0.00
4- 4	8.38	25.90	0.92	-6.92	-0.78	0.00	2.58	0.00
4- 5	8.88	27.34	0.97	-6.92	-0.78	0.00	2.72	0.00
4- 6	8.38	25.90	0.92	-6.92	-0.78	0.00	2.58	0.00
4- 7	6.87	21.59	0.76	-6.92	-0.78	0.00	2.15	0.00
4- 8	4.35	14.40	0.51	-6.92	-0.78	0.00	1.43	0.00
4- 9	0.82	4.33	0.15	-6.92	-0.78	0.00	0.43	0.00
4-10	-3.72	-8.61	-0.31	-6.92	-0.78	0.00	0.00	-0.86

Right

Unfactored Shears due to All Loads: (k-ft)

Member 1: (Exterior Wall)

Bottom

M-PT	Vdc	Vev	Vdw	Veh	Vls	Vwa	Vll+	Vll-
1- 0	0.25	-0.16	-0.01	6.43	0.67	0.00	0.01	-0.03
1- 1	0.25	-0.16	-0.01	4.90	0.53	0.00	0.01	-0.03
1- 2	0.25	-0.16	-0.01	3.46	0.40	0.00	0.01	-0.03
1- 3	0.25	-0.16	-0.01	2.09	0.26	0.00	0.01	-0.03
1- 4	0.25	-0.16	-0.01	0.81	0.12	0.00	0.01	-0.03
1- 5	0.25	-0.16	-0.01	-0.39	-0.01	0.00	0.01	-0.03
1- 6	0.25	-0.16	-0.01	-1.51	-0.15	0.00	0.01	-0.03
1- 7	0.25	-0.16	-0.01	-2.54	-0.28	0.00	0.01	-0.03

1- 8	0.25	-0.16	-0.01	-3.50	-0.42	0.00	0.01	-0.03
1- 9	0.25	-0.16	-0.01	-4.37	-0.55	0.00	0.01	-0.03
1-10	0.25	-0.16	-0.01	-5.16	-0.69	0.00	0.01	-0.03

Top

Member 2: (Top Slab)

Left

2- 0	1.58	10.08	0.36	0.00	0.00	0.00	1.00	0.00
2- 1	1.26	8.06	0.29	0.00	0.00	0.00	0.81	-0.01
2- 2	0.95	6.05	0.21	0.00	0.00	0.00	0.64	-0.04
2- 3	0.63	4.03	0.14	0.00	0.00	0.00	0.49	-0.09
2- 4	0.32	2.02	0.07	0.00	0.00	0.00	0.36	-0.16
2- 5	0.00	0.00	0.00	0.00	0.00	0.00	0.25	-0.25
2- 6	-0.32	-2.02	-0.07	0.00	0.00	0.00	0.16	-0.36
2- 7	-0.63	-4.03	-0.14	0.00	0.00	0.00	0.09	-0.49
2- 8	-0.95	-6.05	-0.21	0.00	0.00	0.00	0.04	-0.64
2- 9	-1.26	-8.06	-0.29	0.00	0.00	0.00	0.01	-0.81
2-10	-1.58	-10.08	-0.36	0.00	0.00	0.00	0.00	-1.00

Right

Member 4: (Bottom Slab)

Left

4- 0	3.53	10.08	0.36	0.00	0.00	0.00	1.00	0.00
4- 1	2.82	8.06	0.29	0.00	0.00	0.00	0.80	0.00
4- 2	2.12	6.05	0.21	0.00	0.00	0.00	0.60	0.00
4- 3	1.41	4.03	0.14	0.00	0.00	0.00	0.40	0.00
4- 4	0.71	2.02	0.07	0.00	0.00	0.00	0.20	0.00
4- 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	-0.71	-2.02	-0.07	0.00	0.00	0.00	0.00	-0.20
4- 7	-1.41	-4.03	-0.14	0.00	0.00	0.00	0.00	-0.40
4- 8	-2.12	-6.05	-0.21	0.00	0.00	0.00	0.00	-0.60
4- 9	-2.82	-8.06	-0.29	0.00	0.00	0.00	0.00	-0.80
4-10	-3.53	-10.08	-0.36	0.00	0.00	0.00	0.00	-1.00

Right

Live Load Parameters: Traffic Direction is Parallel to Main Reinforcement

----

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)	
Truck	1	0.141	26.58	0.00	(largest truck used)

All Vehicles:

Distribution Width: 18.60 ft

Impact Factor : 1.00

Lane:

Lane Load : 0.040 k/ft Distribution Width: 31.85 ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.141	26.58	13.29

Coincident Bottom Slab Load: 0.14 k/ft

Maximum -Moment in Top Slab

Truck	1	0.141	26.58	14.00

Coincident Bottom Slab Load: 0.13 k/ft

Maximum +Shear in Top Slab

Truck	1	0.141	26.58	13.29

Coincident Bottom Slab Load: 0.14 k/ft

Maximum -Shear in Top Slab

Truck	1	0.141	26.58	13.29

Coincident Bottom Slab Load: 0.14 k/ft

Maximum Deflection in Top Slab Due to Lane Load = 0.002 in

Unfactored Moments and Shears due to Live Loads: (k, k-ft)

	Truck				Tandem				Lane			
M-PT	Mll+	Mll-	Vll+	Vll-	Mll+	Mll-	Vll+	Vll-	Mll+	Mll-	Vll+	Vll-
Member 1: (Exterior Wall)												
Bottom												
1- 0	0.00	-0.86	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.25	0.01	-0.01
1- 1	0.00	-0.87	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.25	0.01	-0.01
1- 2	0.00	-0.89	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.26	0.01	-0.01
1- 3	0.00	-0.91	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.26	0.01	-0.01
1- 4	0.00	-0.93	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.27	0.01	-0.01
1- 5	0.00	-0.95	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.27	0.01	-0.01
1- 6	0.00	-0.96	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.28	0.01	-0.01
1- 7	0.00	-0.98	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.28	0.01	-0.01
1- 8	0.00	-1.00	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.29	0.01	-0.01
1- 9	0.00	-1.02	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.29	0.01	-0.01
1-10	0.01	-1.04	0.01	-0.03	0.00	0.00	0.00	0.00	0.01	-0.30	0.01	-0.01
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.01	-1.04	1.00	0.00	0.00	0.00	0.00	0.00	0.01	-0.30	0.29	0.00
2- 1	0.40	-0.15	0.81	-0.01	0.00	0.00	0.00	0.00	0.12	-0.05	0.23	0.00
2- 2	1.26	0.00	0.64	-0.04	0.00	0.00	0.00	0.00	0.36	0.00	0.18	-0.01

2- 3	1.97	0.00	0.49	-0.09	0.00	0.00	0.00	0.00	0.56	0.00	0.14	-0.02
2- 4	2.40	0.00	0.36	-0.16	0.00	0.00	0.00	0.00	0.69	0.00	0.10	-0.04
2- 5	2.54	0.00	0.25	-0.25	0.00	0.00	0.00	0.00	0.73	0.00	0.07	-0.07
2- 6	2.40	0.00	0.16	-0.36	0.00	0.00	0.00	0.00	0.69	0.00	0.04	-0.10
2- 7	1.97	0.00	0.09	-0.49	0.00	0.00	0.00	0.00	0.56	0.00	0.02	-0.14
2- 8	1.26	0.00	0.04	-0.64	0.00	0.00	0.00	0.00	0.36	0.00	0.01	-0.18
2- 9	0.40	-0.15	0.01	-0.81	0.00	0.00	0.00	0.00	0.12	-0.05	0.00	-0.23
2-10	0.01	-1.04	0.00	-1.00	0.00	0.00	0.00	0.00	0.01	-0.30	0.00	-0.29
Right												

Member 4: (Bottom Slab)

Left												
4- 0	0.00	-0.86	1.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.25	0.29	0.00
4- 1	0.43	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.23	0.00
4- 2	1.43	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.17	0.00
4- 3	2.15	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.11	0.00
4- 4	2.58	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.06	0.00
4- 5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00
4- 6	2.58	0.00	0.00	-0.20	0.00	0.00	0.00	0.00	0.74	0.00	0.00	-0.06
4- 7	2.15	0.00	0.00	-0.40	0.00	0.00	0.00	0.00	0.61	0.00	0.00	-0.11
4- 8	1.43	0.00	0.00	-0.60	0.00	0.00	0.00	0.00	0.41	0.00	0.00	-0.17
4- 9	0.43	0.00	0.00	-0.80	0.00	0.00	0.00	0.00	0.12	0.00	0.00	-0.23
4-10	0.00	-0.86	0.00	-1.00	0.00	0.00	0.00	0.00	0.00	-0.25	0.00	-0.29
Right												

Serviceability Check: Crack Control

Bar Mark	Location	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	21.05	7.00	26.28
A2	Bot Corner Bar	20.78	7.00	26.65
A100	Top Slab (int)	33.95	8.00	15.66
A300	Top Slab (ext)	0.00	12.00	0.00
A200	Bot Slab (int)	41.06	8.00	12.47
A400	Bot Slab (ext)	0.00	12.00	0.00
B1	Ext Wall (int)	0.00	12.00	99.99
B2	Ext Wall (ext)	8.85	7.00	66.70

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior Wall)
Thickness = 13.78 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	Ma (k-ft)	phi	As (in2)	1.2Mcr (k-ft)	Load Ratings IR (Str I)	Load Ratings OR (Str II)

BOT	8.86	-22.04	17.37	28.73	34.62	0.90	0.53	28.10	6.96	9.02
MID	67.92	3.46	10.72	11.14	14.96	0.90	0.20	28.10	NC	NC
MID-	67.92	-9.41	17.37	18.94	24.99	0.90	0.34	28.10	10.40	13.48
TOP	9.97	-22.49	17.37	28.88	34.76	0.90	0.53	28.10	5.96	7.72

Member 2: (Top Slab)
Thickness = 17.72 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	Ma (k-ft)	phi	As (in2)	1.2Mcr (k-ft)	Load Ratings IR (Str I)	OR (Str II)
LT	6.89	-20.50	8.13	35.91	39.58	0.90	0.53	46.47	8.04	10.42
MID	85.63	38.23	4.53	47.10	49.06	0.90	0.66	46.47	3.43	4.45
RT	6.89	-20.50	8.13	35.91	39.58	0.90	0.53	46.47	8.04	10.42

Member 4: (Bottom Slab)
Thickness = 17.72 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	Ma (k-ft)	phi	As (in2)	1.2Mcr (k-ft)	Load Ratings IR (Str I)	OR (Str II)
LT	6.89	-19.44	9.97	38.30	42.68	0.90	0.53	46.47	11.66	15.11
MID	85.63	46.63	5.84	47.10	49.63	0.90	0.66	46.47	1.63	2.11
RT	6.89	-19.44	9.97	38.30	42.68	0.90	0.53	46.47	11.66	15.11

Note: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior Wall)
Thickness = 13.78 in (Controlling Shear Method: Simplfied)

Loc	Dist. (in)	Design Shear (k)	Dv (in)	phi*Vn (k)	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR (Str I)	OR (Str II)
BOT	19.91	6.65	12.01	15.49	18.22	0.00	0.00	0.00	11.50	14.91
MID	67.92	0.23	12.38	15.97	18.78	0.00	0.00	0.00	NC	NC
MID-	67.92	0.23	12.28	15.83	18.62	0.00	0.00	0.00	99.99	99.99
TOP	19.91	-6.16	12.08	15.57	18.32	0.00	0.00	0.00	11.36	14.73

Member 2: (Top Slab)
Thickness = 17.72 in (Controlling Shear Method: Box Culvert)

Loc	Dist. (in)	Design Shear (k)	Dv (in)	phi*Vn (k)	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR (Str I)	OR (Str II)
LT	20.59	13.22	15.41	29.80	35.06	0.00	0.00	0.00	13.19	17.10
MID	85.63	0.43	16.35	31.61	37.19	0.00	0.00	0.00	73.43	95.19
RT	20.59	13.22	15.41	29.80	35.06	0.00	0.00	0.00	13.19	17.10

Member 4: (Bottom Slab)

Thickness = 17.72 in (Controlling Shear Method: Box Culvert)

Loc	Dist. (in)	Design Shear (k)	Dv (in)	phi*Vn (k)	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR (Str I)	OR (Str II)
LT	21.49	14.83	16.41	31.73	37.33	0.00	0.00	0.00	13.85	17.96
MID	85.63	0.01	16.35	31.61	37.19	0.00	0.00	0.00	99.99	99.99
RT	21.49	14.83	16.41	31.73	37.33	0.00	0.00	0.00	13.85	17.96

Load Combination Results at Tenth Points: (k, k-ft)

Member 1: (Exterior Wall)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Bottom						
1- 0	-22.004	-28.510	10.724	17.366	9.968	5.835
1- 1	-12.078	-18.594	10.724	17.366	7.668	4.460
1- 2	-4.694	-13.857	10.724	17.366	5.478	3.159
1- 3	0.274	-10.958	10.724	17.366	3.399	1.932
1- 4	2.951	-9.408	10.724	17.366	1.431	0.778
1- 5	3.463	-9.122	10.724	17.366	-0.233	-0.497
1- 6	1.934	-10.016	10.724	17.366	-1.239	-2.244
1- 7	-1.510	-12.009	10.724	17.366	-2.172	-3.881
1- 8	-6.744	-15.015	10.724	17.366	-3.031	-5.407
1- 9	-13.643	-20.238	10.724	17.366	-3.816	-6.823
1-10	-21.910	-28.698	15.611	17.366	-4.528	-8.128
Top						

Member 2: (Top Slab)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Left						
2- 0	-21.910	-28.698	4.528	8.128	17.366	10.724
2- 1	-1.168	-8.307	4.528	8.099	13.910	8.579
2- 2	15.921	2.406	4.528	8.099	10.487	6.434
2- 3	28.313	10.059	4.528	8.099	7.099	4.290
2- 4	35.749	14.651	4.528	8.099	3.746	2.145
2- 5	38.228	16.181	4.528	8.099	0.430	-0.430
2- 6	35.749	14.651	4.528	8.099	-2.145	-3.746
2- 7	28.313	10.059	4.528	8.099	-4.290	-7.099
2- 8	15.921	2.406	4.528	8.099	-6.434	-10.487
2- 9	-1.168	-8.307	4.528	8.099	-8.579	-13.910
2-10	-21.910	-28.698	4.528	8.128	-10.724	-17.366
Right						

Member 4: (Bottom Slab)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Left						
4- 0	-22.004	-28.510	9.927	9.968	19.803	12.479
4- 1	1.407	-5.975	5.835	9.927	15.843	9.983

4- 2	21.192	6.492	5.835	9.927	11.882	7.487
4- 3	35.324	15.397	5.835	9.927	7.921	4.991
4- 4	43.803	20.740	5.835	9.927	3.961	2.496
4- 5	46.630	22.521	5.835	9.927	0.008	-0.008
4- 6	43.803	20.740	5.835	9.927	-2.496	-3.961
4- 7	35.324	15.397	5.835	9.927	-4.991	-7.921
4- 8	21.192	6.492	5.835	9.927	-7.487	-11.882
4- 9	1.407	-5.975	5.835	9.927	-9.983	-15.843
4-10	-22.004	-28.510	9.927	9.968	-12.479	-19.803
Right						

RETAINING WALL HEIGHT 5M

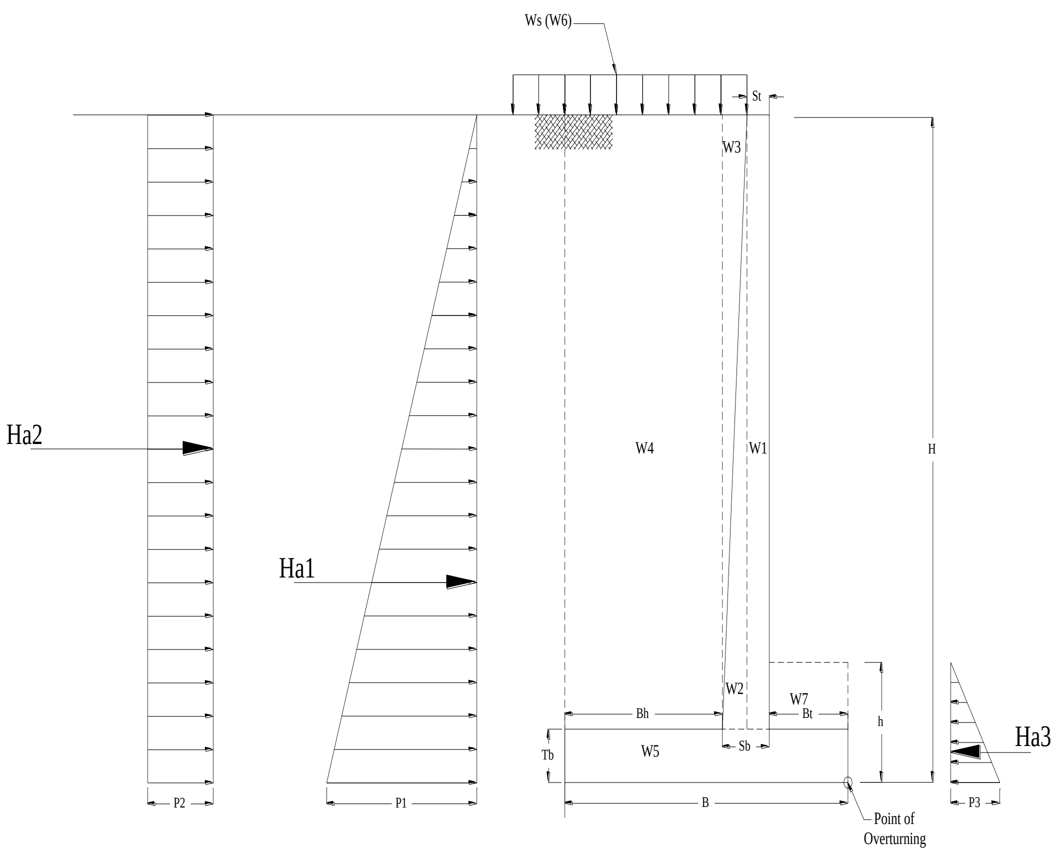
Project:	RAWALPINDI RING ROAD PROJECT	**By:**	SAQ
Subject	RC. Wall	**Chk:**	ISB
Job No.	3888	**Date:**	12/1/2020

DESIGN OF CANTILEVER RETAINING WALL

For Height = 5 m

DATA:

Height	**H** =	5.0	m	16.41	ft
Base Width	**B** =	3.90	m	12.80	ft
Heel Width	B_H =	2.00	m	6.56	ft
Toe Width	B_T =	1.10	m	3.61	ft
Th. of Base Slab	T_B =	0.4	m	15.75	in
Th. of Stem at TOP	S_T =	0.25	m	9.84	in
Th. of Stem at BOTTOM	S_B =	0.8	m	31.50	in
Height of Soil on Toe Side	**h** =	0.9	m	2.95	ft
Unit wt. of soil	γ_s =	120	pcf	0.12	K/ft^3
Unit wt. of concrete	$\gamma_{conc.}$ =	150	pcf	0.15	K/ft^3
Surcharge	w_s =	240	psf	0.24	K/ft^2
Allowable Pressure	$q_{allowable}$ =	1	T/ft^2	2.20	K/ft^2
Coeffiecient of Friction	**μ** =	0.5			
Angle of internal Friction	**Φ** =	30			
	f'c =	4000	psi		
	fy =	60000	psi		



TYPICAL CROSS- SECTION OF CANTILEVER RC. WALL

STABILITY ANALYSIS:

STABILIZING FORCES:

FORCES (Kip)		MOMENT ARM (ft)	MOMENT (Kip-ft)	
W1=	1.86	4.02	7.46	
W2=	2.04	5.03	10.28	
W3=	1.63	5.63	9.20	
W4=	11.88	9.51	113.08	
W5=	2.52	6.40	16.12	
W6=	2.01	8.61	17.29	
W7=	0.71	1.80	1.28	
$\sum F_R$ =	**22.66 Kip**	**$\sum M_R$ =**	**174.72 Kip-ft**	**(With Surcharge)**
$\sum F_R$ =	**20.65 Kip**	**$\sum M_R$ =**	**157.42 Kip-ft**	**(With out Surcharge)**

Ka = $\frac{1-Sin\Phi}{1+Sin\Phi}$ ⟹ 0.333 ⟹ Kp =1/Ka= 3.0

HORIZONTAL FORCES:

For h = 16.41 ft

Lateral Earth Pressure:

P_1 = γ_s*Ka*H ⟹ 0.66 K/ft^2

Ha_1 = $\gamma_s*Ka*H^2/2$ ⟹ 5.38 Kip

M_{O1} = $Ha_1*H/3$ ⟹ 29.43 Kip-ft

Surcharge Pressure:

P_2 = $Ka*w$ ⟹ 0.080 K/ft^2

Ha_2 = $Ka*w*H$ ⟹ 1.312 Kip

M_{O2} = $Ha_2*H/2$ ⟹ 10.76 Kip-ft

Passive Earth Pressure

P_3 = $\gamma s*Kp*h_2/2$ ⟹ 1.06 K/ft^2

Ha_3 = $\gamma_s*Kp*h^2/2$ ⟹ 1.57 Kip

M_{O3} = $Ha_3*h/3$ ⟹ 1.55 Kip-ft

TOTAL HORIZONTAL OVERTIRNING FORCES:

With Surcharge

Ha = Ha_1+Ha_2 ⟹ 6.694 Kip

M_O = $M_{O1}+M_{O2}-M_{O3}$ ⟹ 38.65 Kip-ft

Without Surcharge

Ha = Ha_1 ⟹ 5.38 Kip

M_O = $M_{O1}-M_{O3}$ ⟹ 27.88 Kip-ft

TOTAL VERTICAL STABILIZING FORCES:

With Surcharge

$\sum F_R$ = 22.66 Kip

$\sum M_R$ = 174.72 Kip-ft

Without Surcharge

$\sum F_R$ = 20.65 Kip

$\sum M_R$ = 157.42 Kip-ft

STABILITY CHECK :

With Surcharge

F.O.S (Over turning) = $\sum M_R/M_O$ ⟹ **4.521** > 2

Satisfactory

F.O.S (Sliding) = $\frac{H_{a3}+\mu*\sum F_R}{Ha}$ ⟹ **1.927** > 1.5

Satisfactory

Without Surcharge

F.O.S (Over turning) = $\sum M_R / M_O$ ⟹ **5.65** > 2 **Satisfactory**

F.O.S (Sliding) = $\frac{H_{a3} + \mu * \sum F_R}{Ha}$ ⟹ **2.2** > 1.5 **Satisfactory**

CHECK FOR BEARING PRESSURE:(With Surcharge)

Eccentricity

Allowable Eccentricity $E_{allow.}$ ***B/6*** ⟹ 2.13 ft

$\bar{x}$ = $\frac{M_R - M_O}{\sum F_R}$ ⟹ 6.01 ft

e = $B/2 - \bar{x}$ ⟹ 0.39 ft < $E_{allow.}$

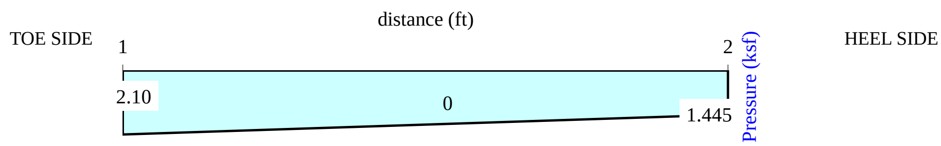
O.K Within Middle Third

Bearing Pressure

$P_{MAX/MIN} = \frac{\sum F_R}{B}\left(1 \pm \frac{6*e}{B}\right)$ ⟹ **2.10** **K/ft²** < $q_{allowable}$

1.445 **K/ft²**

Satisfactory



BEARING PRESSURE DIAGRAM

FOR SEISMIC CONDITION

Horizontal EQ. Coefficient , a_h = 0.16 g For Multan Area

Kae = 0.529 From Mononobe Okabey Formula

HORIZONTAL OVERTURNING FORCES

Ha_{EA} = $\gamma_s * Ka * h^2 / 2$ ⟹ 8.54 Kip

Ha_E = $(Ha_{EA} - Ha)$ ⟹ 3.16 Kip

M_{OE} = $Ha_1 * h/3$ ⟹ 25.92 Kip-ft

Horizontal Forces Due to Stem and Soil Weight.

FORCES (Kip)		MOMENT ARM (ft)	MOMENT (Kip-ft)
W1=	0.30	8.86	2.63
W2=	0.33	6.34	2.07
W5=	0.40	0.66	0.26
$\sum F_{OE}$ =	**1.03 Kip**	**$\sum M_{OE}$ =**	**4.97 Kip-ft**

TOTAL HORIZONTAL OVERTIRNING FORCES:

$\sum F_{OE}$ = 9.57
$\sum M_{OE}$ = 58.78

TOTAL VERTICAL STABILIZING FORCES:

$\sum F_R$ = 20.65 Kip
$\sum M_R$ = 157.42 Kip-ft

STABILITY CHECK :

F.O.S (Over turning) =	$\sum M_R / M_O$ ⟹	**2.678**	>	1.5	**Satisfactory**
F.O.S (Sliding) =	$\dfrac{H_{a3} + \mu * \sum F_R}{F_{OE}}$ ⟹	**1.243**	>	1.125	**Satisfactory**

CHECK FOR BEARING PRESSURE:

Eccentricity

Allowable Eccentricity $E_{allow.}$ ***B/6*** ⟹ 2.13 ft

$\bar{x}$ = $\dfrac{M_R - M_O}{\sum F_R}$ ⟹ 4.78 ft

e = $B/2 - \bar{x}$ ⟹ 1.62 ft < $E_{allow.}$

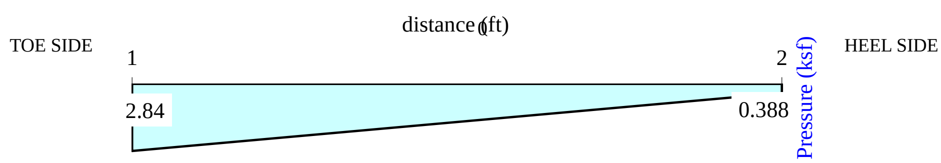
O.K Within Middle Third

Bearing Pressure

Allowable Bearing Capacity $q_{allowable}$ = 2.931 Ksf ⅓ inc. for EQ.

$$P_{\substack{MAX\\MIN}} = \frac{\sum F_R}{B}\left(1 \pm \frac{6*e}{B}\right)$$ ⟹ **2.84** K/ft^2 < $q_{allowable}$
0.388 K/ft^2

Satisfactory



BEARING PRESSURE DIAGRAM

DESIGN OF STEM OF RETAINING WALL

(For Bending Face)

DESIGN FOR SHEAR:

Φ Vc = ***2*Φ*√f'c *b*d*** ⇒ 32.37 Kip

Height @ which Shear Check (h')= **12.72** ft

d =	25.09	in
b =	12.00	in

Vu = *1.69(.5*γs*Ka*h'²)+1.69(Ka*Ws*h')* *arge) for cantilever wall*

Vu **=** **7.19** Kip < Φ Vc

Satisfactory

DESIGN FOR FLEXURE:

h_m = 15.09 ft

Mu = *1.69(.5*γs*Ka*h$_m$³/3)+1.69(Ka*Ws*h$_m$²/2)*

Mu **=** **54.12** Kip-ft

d =	28.50	in
b =	12.00	in

ρ = 0.0012

As = **0.427** in²

Distribution or Temperaturre Reinforcement:

For Vertical reinforcement $\rho_{min.}$ = 0.0018

As min = ***.0018*b*h*** ⇒ 0.680 in² > As = 0.427 in²

Use **As min** ⇒ **# 6 @ 7 in c/c** R04

For Horizontal reinforcement $\rho_{min.}$ = 0.002

Distribution R/f = ***.002*b*h/2*** ⇒ 0.15 in²

Use **# 4 @ 15 in c/c** R08

Curtailment @ h_m/2 (h")= 10.66 ft

DESIGN FOR SHEAR: (at mid height)

Φ Vc = ***2*Φ*√f'c *b*d*** ⇒ 28.57 Kip

Height @ which Shear Check = **10.66** ft

d =	22.14	in
b =	12.00	in

Vu = *1.69(.5*γs*Ka*h"²)+1.69(Ka*w$_s$*h")* *arge) for cantilever wall*

Vu **=** **5.28** Kip < Φ Vc

Satisfactory

DESIGN FOR FLEXURE:(at mid height)

H = 10.66 ft

Mu = $1.69(.5*\gamma s*Ka*h"^3/3)+1.69(Ka*w_s*h"^2/2)$

Mu = **21.34** Kip-ft

ρ = 0.0008

As = **0.216** in^2

Distribution or Temperaturre Reinforcement:

For Vertical reinforcement $\rho_{min.}$ = 0.0018

As min = ***0.0018*b*h*** ⇒ 0.543 in^2 > As = 0.216

Use **As min** ⇒ **# 5 @ 6 in c/c** R05

For Horizontal reinforcement $\rho_{min.}$ = 0.00133

Distribution R/f = ***.00133*b*h (2/3 of .002)*** ⇒ 0.401 in^2

Use **# 4 @ 5 in c/c**

(For Non-Bending Face only Temperature reinforcement)

Distribution or Temperature Reinforcement:

d =	28.50	in
b =	12.00	in

For Vertical reinforcement $\rho_{min.}$ = 0.0015

As min/2 = ***0.0015*b*h*2/3*** ⇒ 0.171 in^2

R06

Use **As min** ⇒ **# 4 @ 13 in c/c**

For Above Vertical reinforcement $\rho_{min.}$ 0.125

As min = ***1/8 in ^{2}*** ⇒ 0.125 in^2

R07

Use **As min** ⇒ **# 4 @ 18 in c/c**

For Horizontal reinforcement $\rho_{min.}$ = 0.0025

As min/2. = ***0.0025*b*h*2/3*** ⇒ 0.256 in^2

Use **# 4 @ 9 in c/c** R09

DESIGN OF HEEL OF RETAINING WALL

CHECK FOR SHEAR:

In HEEL; Shear is checked at the face of the stem.

d = 12.75 in
b = 12.00 in

Φ Vc = ***2*Φ*√f'c *b*d*** ⟹ 16.45 Kip

Vu = ***1.3(Soil above HEEL)+1.3(HEEL Selfweight)+2.171(Surcharge)-1.3(Upward Pressure)***

Vu = **6.77** Kip < Φ Vc

Satisfactory

DESIGN FOR FLEXURE:

Mu = ***1.3(Soil above HEEL)+1.3(HEEL Selfweight)+2.171(Surcharge)-1.3(Upward Pressure)***

Mu **=** **23.80** Kip-ft **0.00**

ρ = 0.0028

As = **0.425** in^2

As min = ***.0018*b*h*** ⟹ **0.340** in^2 < As = 0.425 in^2

Use **As** ⟹ **# 5 @ 8 in c/c** R02

Dist. R/f = ***.0018*b*h*** ⟹ **0.361** in^2

Use **# 4 @ 6 in c/c** R03

DESIGN OF TOE OF RETAINING WALL

CHECK FOR SHEAR:

In TOE; Shear is check at the distance **"d"** from face of the stem. d = 12.75 in
Length at which Shear is check = 2.547 ft b = 12.00 in

Φ Vc = ***2*Φ*√f'c *b*d*** ⟹ 16.45 Kip

Vu = ***1.69(Upward Pressure)-1.3(Selfweight of TOE)***

Vu = **8.09** Kip < Φ Vc
Satisfactory

DESIGN FOR FLEXURE:

Mu = ***1.69(Upward Pressure)-1.3(Selfweight of TOE)***

Mu = 20.73 Kip-ft

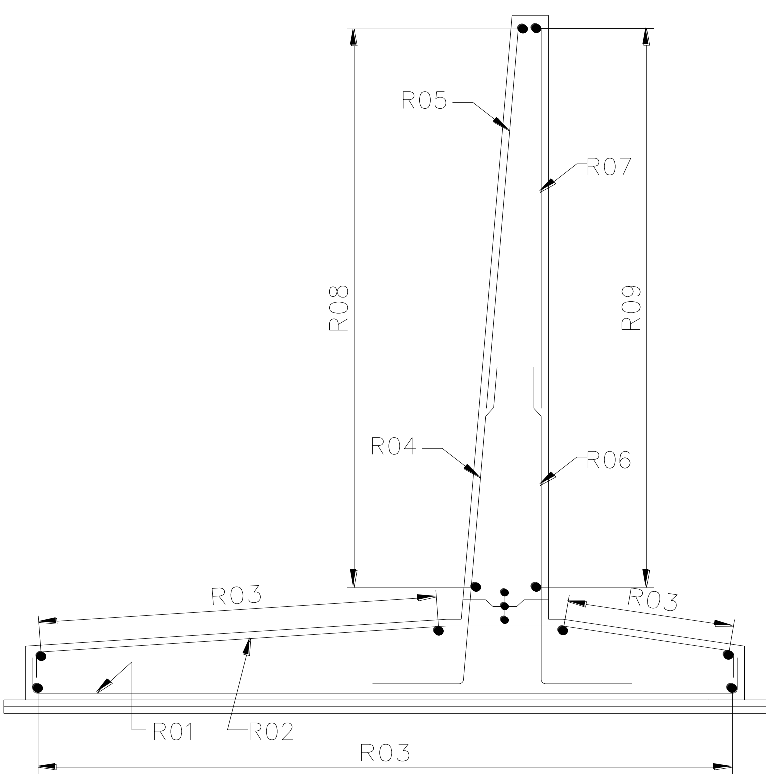
ρ = 0.0024

As = **0.369** in^2

As min = ***.0018*b*h*** ⟹ **0.340** in^2 < As = 0.369 in^2
Use **As** ⟹ **# 5 @ 9 in c/c** R01

Dist. R/f = ***.0018*b*h*** ⟹ **0.361** in^2

Use **# 4 @ 6 in c/c** R03



Typical Section for Reinforcement