CITY OF O'FALLON

Winghaven

Saint Charles County

Bridge No. 3210012

Design Calculations

KDG Project No. 980100-0001

CITY OF O'FALLON
Bridge No. 3210012
Design Calculations
Winghaven
K*d*G Project No. 980100-0001

INDEX

CITY OF O'FALLON
Bridge No. 3210012
Design Calculations
Winghaven
KdG Project No. 980100-0001

RONALD C. PAGAN NUMBER E-15022 STATE OF MISSOURI REGISTERED PROFESSIONAL ENGINEER

ENGINEERING CALCULATION COVER SHEET

PROJECT:	Bridge No. 3210012	DISCIPLINE:	Bridge
	Winghaven	CALCULATION NO.:	Final
		NO. OF SHEETS:	See Index
JOB NO.:	980100-0001	CALCULATED BY:	JVS RCP
CONTRACT NO.:		CHECKED BY:	15 Jul 98
DESIGN CODE:	AASHTO 1996	APPROVED BY:	
		APPROVED BY:	

CALCULATION DESCRIPTION:

Substructure Design

Quantities

DESIGN BASIS OR REFERENCES:

AASHTO 16th Edition, 1996

Missouri Highway & Transportation Department Bridge Manual of Design

DESIGN SCOPE

Structure Type Rigid
- Box Design
- Single Cell
- (10.0 Ft. Wide X 7.0 Ft. High)

Loading:
- HS20-44
- Service Load Design
- Earth 120#/Cu. Ft.
- Equivalent Fluid Pressure 45#/Cu.Ft.

DESIGN CRITERIA

DESIGN SPECIFICATIONS

AASHTO - 1996 Sixteenth Edition

DESIGN LOADING

HS20
Earth 120#/cu.ft.
Equivalent Fluid Pressure 45#/Cu.Ft.

DESIGN UNIT STRESSES

Class B Concrete	(Culverts)	f'c	=	3,000 psi
Reinforcing Steel	(Grade 60)	f'y	=	60,000 psi

REINFORCING STEEL

Minimum clearance to reinforcing steel shall be 1-1/2", unless otherwise shown.

BAR COVER - AASHTO 8.22

Clear Dimensions to be shown on plans:

Top Slab	- Top Reinforcing	=	2" clear
	- Bottom Reinforcing	=	2" clear
Bottom Slab	- Top Reinforcing	=	2" clear
	- Bottom Reinforcing	=	3" clear
Sidewalls	- Reinforcement Stream Face	=	2" clear
	- Reinforcement Fill Face	=	2" clear

MAXIMUM BAR LENGTHS

Longitudinal bars should be made full length without splicing up to about 40'-0"; splice if longer. Bars #5 and larger may be used to a length of 60'-0" without splicing.

BAR SPLICES

See Section 2.4 for minimum bar lap and tension splices in reinforcement. Use a Class C splice for longitudinal bar (22" min.).

JOINT FILLER

All joint filler shall meet requirements of Standard Specification 1057.2.5, except as noted.

DRAWING LIST

Sheet No.	Title
1	Plan, Elevation, General Notes, and Quanities
2	Reinforcement
3	Cross Section and Wing Wall Details
4	Fence Details

DESIGN LAYOUT

Division of Bridges

No. 3210012
Job.

Route Winghaven Drive   County Saint Charles   Rte. Winghaven Drive

STRUCTURE

SUPERSTRUCTURE One Cell (10.0W x 7.0H) (Rigid)

Skew .... Square
Roadway.................................. 2 - 12 foot lanes each direction with a 20 foot median.

Loading HS20
Beg. Sta. ....
Alignment................................ Tangent
Grade..................................... P.I. Sta. 15+65.00 (Elev. 582.70) Bk. -1.93%, Ahd. +2.00%, Length = 470.00

SUBSTRUCTURE

Ftg Loads................................. 10,000 lbs per square foot
Pile Type .... N/A
Length .... N/A
Elev Ftg, Bott. .... 580.0 High 576.0 Low

GENERAL

Revetment/Slope .... Sideslope 3:1 (Normal)
End Fills.................................. Earth
Traffic Handling ....
Present Bridge .... None

SPECIAL REQUIREMENTS

Profile Grade .... Centerline of Winghaven Drive (Centerline Median)
Rail Road Alignment.................... N/A
Tie Station............................... 17 + 15.00
Final Allowable Clearances .... N.A.

Estimate includes 10% for Engineering and Contingencies and 5% for Preliminary Engineering

Dated: By: Estm. $

Date:	Notes or Revisions in Conference
Initials:	

Notes and Revisions after Conference (All revisions to be dated and initialed)

J:\980100\3210012.DOC

CORRESPONDENCE

PICKETT RAY & SILVER

CIVIL ENGINEERS • *PLANNERS* • *LAND SURVEYORS*

KDG, MH FILE 980100

JUL 15 1998

July 14, 1998
Revised July 15, 1998

Mr Ron Pagan
Kuhlmann Design Group, Inc.
66 Progress Parkway
St Louis Missouri 63043

RE WINGHAVEN - BOX CULVERT
PR&S PROJECT NO. 97-034

Dear Ron

Per our meeting today, I am sending you "sealed" confirmation of box culvert information.

	"S"	"H"	Elev 1	Elev 2	A Rt	A Lt	B	Des-Fill	Des-Fill
Winghaven Station 17+15	10	7	575.42	574.58	60	60	24	1	4
Winghaven Station 30+49	10	7							
Winghaven Station 59+00	12	10	516.39	517.11	70	70	30	1	5
Charlie (Phoenix) Station 62+53.89	12	12	488.91	490 09	43	43	37	1	4
David (Red Hawk) Station 5+29 73	8	7	511.20	510.45	60	60	30	1	7

We will send Winghaven Station 30+49 as soon as the street is revised back to the previous grade. If you need anything else, please contact me or Mr. Jim Cannady.

Very truly yours,
PICKETT, RAY & SILVER, INC.

Tanya J Dietz
Project Design Supervisor

STATE OF MISSOURI
HAROLD J. BARTEAUX
NUMBER E-17751
REGISTERED PROFESSIONAL ENGINEER
7/14/98

bjs
cc Mr Joe McKee, Paric Corporation
Mr Dave Rogers, Fred Weber

PICKETT RAY & SILVER

CIVIL ENGINEERS • PLANNERS • LAND SURVEYORS

FAX

CONFIDENTIALITY NOTE

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PLEASE DELIVER THE FOLLOWING PAGES:

TO: Ron

FROM: Tony

PROJECT: Winghaven

PR&S PROJECT NO.: 97034

DATE AND TIME: 7-14-98

TOTAL NO. OF PAGES, INCLUDING COVER SHEET: 2

TELECOPY OPERATOR: 15

PLEASE NOTIFY US IMMEDIATELY IF THE MESSAGE IS INCOMPLETE OR UNCLEAR. THANK YOU.

333 MID RIVERS MALL DRIVE • ST. PETERS, MISSOURI 63376 • 314-397-1211/314-397-1104 FAX

PICKETT RAY & SILVER

CIVIL ENGINEERS • PLANNERS • LAND SURVEYORS

July 14, 1998

KDG, MH FILE 980100

JUL 15 1998

Mr Ron Pagan
Kuhlmann Design Group, Inc.
66 Progress Parkway
St Louis, Missouri 63043

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Winghaven Station 12+[illegible]	10	7	575.42	574 58	60	60		1	4
Winghaven Station [illegible]	10	7							
Winghaven Station [illegible]	12	10	516.39	517 11	70	70		1	5
Charlie (Phoenix) Station 62-53 89	12	12	488.91	490 09	43	43	37	1	4
David (Red Hawk) Station [illegible] 73	8	7	511.20	510 45	60	60	30	1	7

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Very truly yours,
PICKETT RAY & SILVER, INC.

Tanya J Dietz
Project Design Supervisor

STATE OF MISSOURI
HAROLD J. BARTELS
NUMBER E-17751
REGISTERED PROFESSIONAL ENGINEER
7/14/98

bjs
cc Mr Joe McKee, Paric Corporation
Mr Dave Rogers, Fred Weber

314 397 1104

FROM: PICKETT RAY & SILVER FAX NO.: 314 397 1104 07-15-98 07:19A P.01

PICKETT RAY & SILVER

CIVIL ENGINEERS • PLANNERS • LAND SURVEYORS

FAX

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PLEASE DELIVER THE FOLLOWING PAGES:

TO: Ron

FROM: Jerry

PROJECT: Wingfield

PRAS PROJECT NO.: 97034

DATE AND TIME: 7.14.98

TOTAL NO. OF PAGES, INCLUDING COVER SHEET: 2

TELECOPY OPERATOR:

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PICKETT RAY & SILVER

CIVIL ENGINEERS • PLANNERS • LAND SURVEYORS

July 14, 1998

Mr. Ron Pagan
Kuhlmann Design Group, Inc
66 Progress Parkway
St. Louis, Missouri 63043

KDG. MH FILE 980100

JUL 1 [illegible] 1998

RE WINGHAVEN - BOX CULVERT
PR&S PROJECT NO 97-034

Dear Ron

Per our meeting today, I am sending you "sealed" confirmation of box culvert information

	"S"	"H"	Elev 1	Elev 2	A Rt	A Lt	B	De Ft.	De[illegible]
Winghaven Station 17+15	10	7	575.42	574 58	60	60		1	[illegible]
Winghaven Station 30+49	10	7							
Winghaven Station 59+00	12	10	516 39	517.11	70	70		1	[illegible]
Charlie (Phoenix) Station 62+53.89	12	12	488.91	490 09	43	43	37	[illegible]	[illegible]
David (Red Hawk) Station 5+29.73	8	7	511.20	510 45	60	60	30	[illegible]	[illegible]

We will send Winghaven Station 30+49 as soon as the street is revised back to the previou[illegible] need anything else, please contact me or Mr. Jim Cannady.

Very truly yours,
PICKETT, RAY & SILVER, INC

Tanya J. Dietz
Project Design Supervisor

STATE OF MI[illegible]
HAROL[illegible]
J BART[illegible]
NUMBER
E-177[illegible]

bjs
cc: Mr. Joe McKee, Paric Corporation
Mr Dave Rogers, Fred Weber

PICKETT RAY & SILVER

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PLEASE DELIVER THE FOLLOWING PAGES:

TO: Ron

FROM: Tony

PROJECT: Windsor[illegible]

PR&S PROJECT NO.: 97034

DATE AND TIME: 7.14.98

TOTAL NO. OF PAGES, INCLUDING COVER SHEET: (2)

TELECOPY OPERATOR:

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PLEASE DELIVER THE FOLLOWING PAGES:

TO: RON PAGAN (434 8280)

FROM: TANYA

PROJECT: WINGHAVEN

PR&S PROJECT NO.: 97034

DATE AND TIME: 7.10.98

TOTAL NO. OF PAGES, INCLUDING COVER SHEET: 5

TELECOPY OPERATOR:

COPY TO MIKE HARMON - WEBER 3440970

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PICKETT RAY & SILVER

Civil Engineers
Planners
Land Surveyors

333 Mid Rivers Mall Dr
St. Peters, MO 63376

397-1211

PROJECT NAME
PROJECT #/JOB ORDER #
DATE
DESIGNER
PAGE

RON -

7.10.98

- BM @ BOX(S): HAS NOT BEEN SET.

- HW ELEV - PER MY CALC:

WINGHAVEN	521.3
PHOENIX	496.3
RED HAWK	520.6

F.P.

WINGHAVEN	522.0
PHOENIX	496.3
RED HAWK	N/A

UTILITY SURVEY - DELIVERED (THIS WK)
COMPLETE SET PLANS - READY FRI. (7.10.98)
HW CALCS - ENCLOSED
" ELEV + ABOVE

PROJECT: Winghaven - Charlie Dr.

STATION: 62+50

SHEET ____ **OF** ____

CULVERT DESIGN FORM

DESIGNER/DATE: Edg, 12/22/97

REVIEWER/DATE: ____ / ____

HYDROLOGICAL DATA

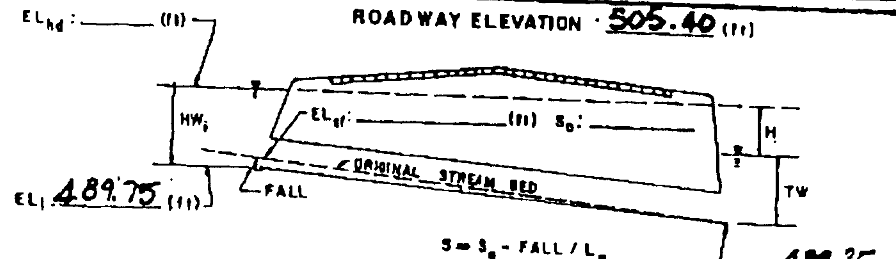
SEE ADD'L SHTS

- ☐ METHOD: ____
- ☒ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
15	3671.5	
100	5102.7	

ROADWAY ELEVATION: 505.40 (ft)



$S = S_o - FALL / L_a$

S = .67%

L_a = 75

F.P. = 496.5±

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW/D (2)	HW	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
5 - 12'x12' Box.	3672	734	.70	9.4	-	498.2	-	4.8	9.4	9.4	0.5	.7	498.4	498.4		outlet
5 - 12'x12' Box. Use FEMA Q.	5103	1021	0.86	10.3	-	500.0	-	6.1	9.0	9.0	0.5	1.4	499.6	500.0		inlet control
5 - 12'x12' Box	2495	499	.54	6.5	—	496.3		3.7	7.9	7.9	0.5	.3	494.3	496.3		inlet control

5/4/98 using Q from FEMA chart (in file)

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] v^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: 5-12x12 Box

SHAPE: Square

MATERIAL: Concrete n .013

ENTRANCE: ____

CULVERT DESIGN FORM

PROJECT: Winghaven - David Dr.

STATION: 5+30

SHEET ____ OF ____

DESIGNER / DATE: [illegible] / 12/22/97

REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

SEE ADD'L SHTS.

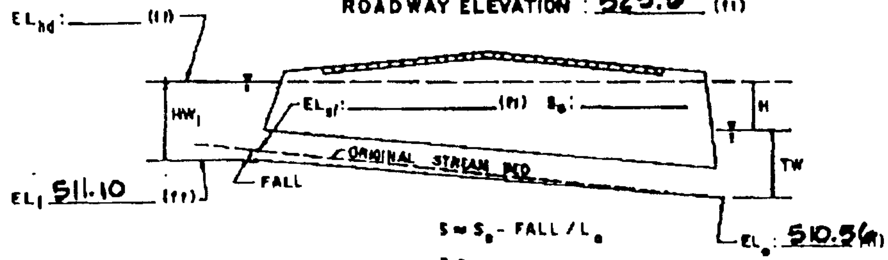
- ☐ METHOD:
- ☒ DRAINAGE AREA: ☐ STREAM SLOPE:
- ☐ CHANNEL SHAPE:
- ☐ ROUTING: ☐ OTHER:

220 Ac

DESIGN FLOWS/TAILWATER

R I (YEARS)	FLOW (cfs)	TW (ft)
15	780.8	
100	1085	

ROADWAY ELEVATION: 525.6 (ft)



S = S o - FALL / L a

S = ____

L a = 108

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HW i /D (2)	HW i	FALL (3)	EL hi (4)	TW (5)	d c	$\frac{d_c+D}{2}$	h o (6)	k e	H (7)	EL ho (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
			INLET CONTROL				OUTLET CONTROL									
2 - 7'h x 8'w (15yr.)	780.8	390.4	1.2	8.4	-	519.5		4.2	5.6	5.6	.5	1.32	517.4			Inlet control
2 - 7x8 (100yr.)	1085	542.5	1.36	9.52	-	520.6		5.2	6.1	6.1	.5	2.58	519.2			Inlet control

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: 7'H x 8'W : 2

SHAPE:

MATERIAL: Conc. n.013

ENTRANCE:

D2W
3.3

PROJECT: Winghaven - Winghaven Dr.

STATION: 59+00

SHEET ___ **OF** ___

CULVERT DESIGN FORM

DESIGNER / DATE: [illegible] / 12/22/97

REVIEWER / DATE: ___ / ___

HYDROLOGICAL DATA

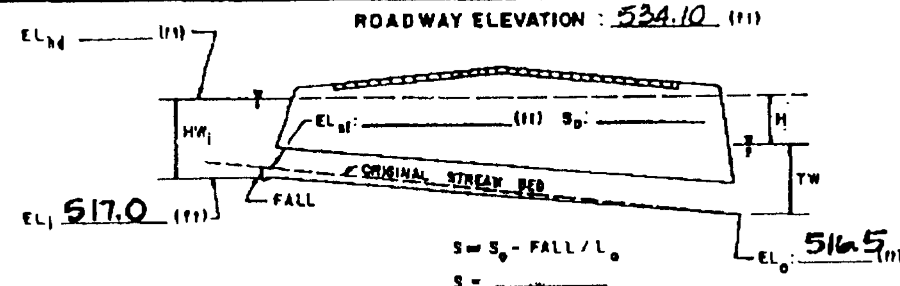
SEE ADD'L SHTS

- ☐ METHOD:
- ☑ DRAINAGE AREA: ___ ☐ STREAM SLOPE:
- ☐ CHANNEL SHAPE:
- ☐ ROUTING: ___ ☐ OTHER

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW(cfs)	TW (ft)
15	3019	
100	4196	

ROADWAY ELEVATION: 534.10 (ft)



$S = S_o - FALL / L_o$

S = ___

L_o = 150.0'

(FP: 522.2)

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW$_i$/D (2)	HW$_i$	FALL (3)	EL$_{hi}$ (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL$_{ho}$ (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
4-10'h x 12'w (15)	3019	755	0.85	8.5		525.5		4.9	7.45	7.45	0.5	1.1	524.1	525.5		Inlet Control
4-10'h x 12'W (100)	4196	1049	1.08	10.8		527.8		6.2	8.1	8.1	0.5	2.01	526.6	527.8		" "
use # from FEMA																
4-10'h x 12'w	244	603.5	.73	7.3		524.3										

6/4/98

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- c. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: 4-10'h x 12'w

SHAPE:

MATERIAL: Concrete n.013

ENTRANCE:

PICKETT RAY & SILVER

CIVIL ENGINEERS • PLANNERS • LAND SURVEYORS

FAX

CONFIDENTIALITY NOTE

PLEASE DELIVER THE FOLLOWING PAGES:

TO: RON PAGAN (434 8280)

FROM: TANYA

PROJECT: WINGHAVEN

PR&S PROJECT NO.: 97034

DATE AND TIME: 7.10.98

TOTAL NO. OF PAGES, INCLUDING COVER SHEET: 5

TELECOPY OPERATOR:

COPY TO MIKE HARMON - WEBER 3440970

PLEASE NOTIFY US IMMEDIATELY IF THE MESSAGE IS INCOMPLETE OR UNCLEAR. THANK YOU.

333 MID RIVERS MALL DRIVE • ST. PETERS, MISSOURI 63376 • 314-397-1211/314-397-1104 FAX

FROM: PICKETT RAY & SILVER FAX NO.: 314 397 1104 07-10-98 02:59P P.01

PICKETT RAY & SILVER
Civil Engineers
Planners
Land Surveyors
333 Mid Rivers Mall Dr.
St. Peters, MO 63376
397-1211

PROJECT NAME ____________
PROJECT #/JOB ORDER # ____________
DATE ____________
DESIGNER ____________
PAGE ____________

RON -

7.10.98

- BM @ BOX(S)* HAS NOT BEEN SET.

- HW ELEV - PER MY CALC*

WINGHAVEN	521.3
PHOENIX	496.3
RED HAWK	520.6

F.P.

WINGHAVEN	522.0
PHOENIX	496.3
RED HAWK	N/A

UTILITY SURVEY - DELIVERED (THIS WK)
COMPLETE SET PLANS - READY FRI. (7.10.98)
HW CALCS - ENCLOSED
* ELEV'S ABOVE

FROM: PICKETT RAY & SILVER FAX NO.: 314 297 1104 07-10-98 02:59P P.02

CULVERT DESIGN FORM

PROJECT: Winghaven - Charlie Dr.

STATION: 62+50

SHEET ____ OF ____

DESIGNER/DATE: Edy / 12/22/97

REVIEWER/DATE: ____ / ____

HYDROLOGICAL DATA

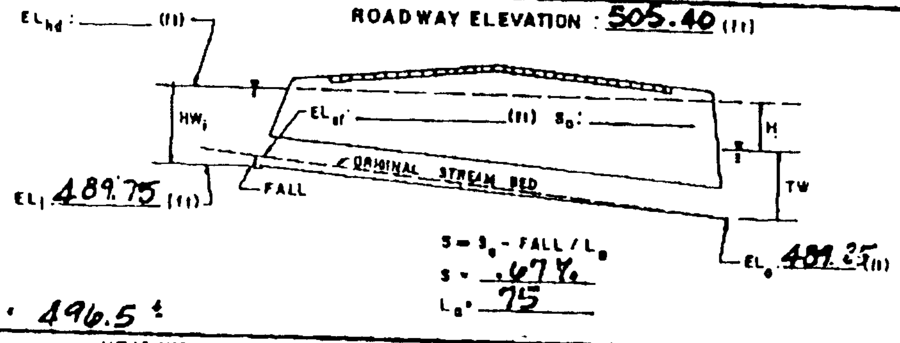
SEE ADD'L SHTS.

- ☐ METHOD: ____
- ☒ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
15	3671.5	
100	5102.7	

ROADWAY ELEVATION: 505.40 (ft)



$S = S_o - FALL / L_a$

S = .67%

L_a = 75

F.P. = 496.5±

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW/D (2)	HW	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
5 - 12'x12' Box.	3672	734	.70	9.4	-	498.2	-	4.8	8.4	8.4	0.5	.7	498.4	498.4		Outlet
5 - 12'x12' Box.	5103	1021	0.86	10.3	-	500.0	-	6.1	9.0	9.0	0.5	1.4	499.6	500.0		inlet Control
Use FEMA Q.																
5 - 12'x12' Box	2495	499	.54	6.5	—	496.3		3.7	7.9	7.9	0.5	.3	494.3	496.3		inlet control

5/4/98 using Q from FEMA chart (in file)

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a APPROXIMATE
- f CULVERT FACE
- hd DESIGN HEADWATER
- hi HEADWATER IN INLET CONTROL
- ho HEADWATER IN OUTLET CONTROL
- i INLET CONTROL SECTION
- o OUTLET
- sf STREAMBED AT CULVERT FACE
- tw TAILWATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: 5-12x12 Box

SHAPE: Square

MATERIAL: Concrete n .013

ENTRANCE: ____

PROJECT: Winghaven - David Dr.	STATION: 5+30 SHEET ___ OF ___	CULVERT DESIGN FORM DESIGNER/DATE: [illegible] / 12/22/97 REVIEWER/DATE: ___ / ___

HYDROLOGICAL DATA

SEE ADD'L SHTS

- ☐ METHOD:
- ☒ DRAINAGE AREA: ☐ STREAM SLOPE:
- ☐ CHANNEL SHAPE:
- ☐ ROUTING: ☐ OTHER:

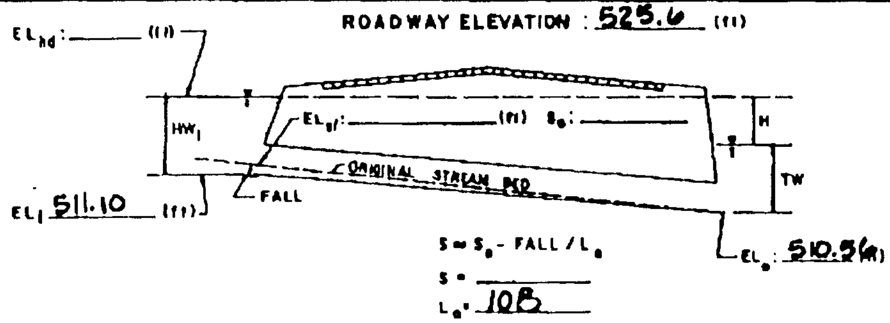
72 W
33

200 Ac

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
15	780.8	
100	1085	

ROADWAY ELEVATION: 525.6 (ft)



$S = S_o - FALL / L_a$
S = ___
L_a = 108

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_{hi} (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
2 - 7'H x 8'W (15yr)	780.8	390.4	1.2	8.4	-	519.5		4.2	5.6	5.6	.5	1.32	517.4			Inlet control
2 - 7x8 (100yr.)	1085	542.5	1.36	9.52	-	520.6		5.2	6.1	6.1	.5	2.58	519.2			Inlet Control

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS
(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS
(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE
(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)
(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.
(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)
(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$
(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: 7'H x 8'W - 2
SHAPE:
MATERIAL: Conc. n .013
ENTRANCE:

PROJECT: Winghaven - Winghaven Dr.

STATION: 59+00

SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: [illegible] / 12/22/97

REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

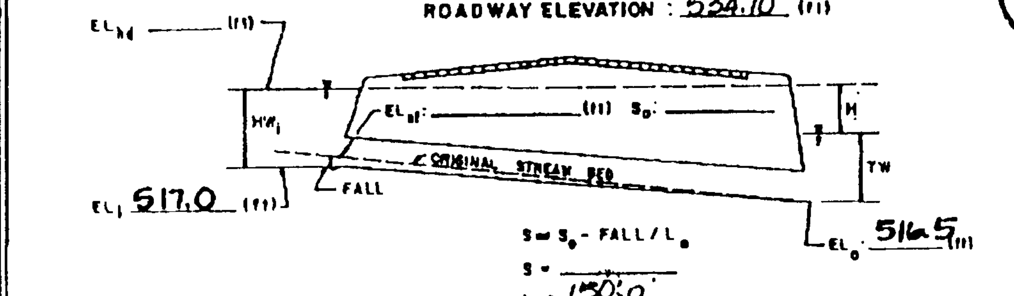
SEE ADD'L SHTS

- ☐ METHOD:
- ☑ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE:
- ☐ ROUTING: ____ ☐ OTHER:

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
15	3019	
100	4196	

ROADWAY ELEVATION: 534.10 (ft)



$S = S_o - FALL / L_a$

S = ____

L_a = 130.0

(FP. 522.2)

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
4-10'h x 12'w (15)	3019	753	0.85	8.5		525.5		4.9	7.45	7.45	0.5	1.1	524.1	525.5		Inlet Control
4-10'h x 12'w (100)	4196	1049	1.08	10.8		527.8		6.2	8.1	8.1	0.5	2.01	526.6	527.8		" "
use # from FEMA																
4-10'h x 12'w	244	605	.73	7.3		524.3										

6/4/98

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2 / 2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf STREAMBED AT CULVERT FACE
- tw TAILWATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: 4-10'h x 12'w

SHAPE: ____

MATERIAL: Concrete n .013

ENTRANCE: ____

KDG. MH FILE 980100

JUL 0 2 1998

Kuhlmann *design* ~~Group, Inc.~~

6 Westbury Drive, St. Charles, MO 63301-2571
Phone 314.946.5566 • Fax 314.946.6713

FACSIMILE TRANSMISSION

PLEASE DELIVER IMMEDIATELY

CORRECTION JULY 2, 98

Post-it® Fax Note 7671 | Date 7-2-98 | # of pages 1 | To JIM CANNADY | From SAL ELKOTT | Co./Dept. PRS | Co. KDG | Phone # | Phone # | Fax # | Fax #

DATE ... 2 1998

TO Mr Ron Pagan

COMPANY

FROM Sal Elkott Sal E

TIME

FAX #:

PROJECT # 97023.

SENT BY

Re:

... are the floor elevations for the Winghaven Drive tunnel as designed by Pickett Ray and Silver (PRS). These ... based on PRS plans dated December 1997 and last revised on March 27, 1998. Mr Jim Cannady verified these eleva... s for me this morning. In addition, He said that even though the tunnel floor elevations are not called out on ... ou have correctly stated), PRS' intent is for the tunnels to slope at one half of one percent (0.005 foot per ... g this slope and the centerline tunnel floor elevation that is shown on the roadway profile one can verify these elevations.

North tunnel: Length 128' Centerline floor elevation = 575.00

West Side floor elevation = 574.68 (measured at end of tunnel ~~75'~~ 64' away from roadway centerline)

East Side floor elevation = 575.32 (measured at end of tunnel ~~75'~~ 64' away from roadway centerline)

South tunnel: length 100' centerline floor elevation = 580.30

West Side floor elevation = 580.05 (measured at end of tunnel 50' away from roadway centerline)

East Side floor elevation = 580.55 (measured at end of tunnel 50' away from roadway centerline)

... understands that you may need to change these lengths by few feet and the elevations by few tenths. It would ... necessary ... o let Jim and us know of these changes. We at the St. Charles office have to design for the drainage of these tunnel.

Copy: Jim Cannady, Frank Bauer, Jim Poole

... COVER PAGE: One

IF YOU ENCOUNTER DIFFICULTIES IN RECEIVING THIS TRANSMISSION, PLEASE CALL 314.946.5566

Kuhlmann *design* Group, Inc.
Transportation Department
66 Progress Parkway
St. Louis, Missouri 63043

Telephone: (314) 434-8898
Fax: (314) 434-8280
E-Mail: kdgmh@kdginc.com

FAX TRANSMITTAL COVER SHEET

TO: MR. FRANK GODWIN P.E.
CITY OF OFALLON
!38 SOUTH MAIN STREET
OFALLON MISSOURI 63366

FAX NO. 314 240 5511
DATE: 25 JUNE 1998
PHONE 314 240 2000

FROM: RONALD C. PAGAN, P.E.

PROJECT NO. 980100

MESSAGE: ATTACHED IS CULVERT DESIGN CRITERIA WE DISCUSSED.

THANK YOU

TOTAL NUMBER OF PAGED TRANSMITTED INCLUDING COVER PAGE: 2

If you encounter difficulties in receiving this transmission, please call (314) 434-8898.

Golf Course Structures

REINFORCEMENT

BAR COVER - AASHTO 8.22

CLEAR DIMENSIONS TO BE SHOWN ON PLANS:

TOP SLAB	-	TOP REINFORCING	= 2" CL.
		BOTTOM REINFORCING	~~= 1" CL.~~ 2"
BOTTOM	-	TOP REINFORCING	= ~~1-1/2" CL.~~ 2"
		BOTTOM REINFORCING	= 3" CL.
SIDEWALLS	-	REINFORCEMENT STREAM FACE	= ~~1-1/2" CL.~~ 2"
		REINFORCEMENT FILL FACE	= 2" CL.

MAXIMUM BAR LENGTHS

LONGITUDINAL BARS SHOULD BE MADE FULL LENGTH WITHOUT SPLICING UP TO ABOUT 40'-0"; SPLICE IF LONGER. BARS #5 AND LARGER MAY BE USED TO A LENGTH OF 60'-0" WITHOUT SPLICING.

BAR SPLICES

SEE SECTION 2.4 FOR MINIMUM BAR LAP AND TENSION SPLICES IN REINFORCEMENT. USE A CLASS C SPLICE FOR LONGITUDINAL BAR (22" MIN.).

BOX CULVERTS ON ROCK

VERTICAL BARS IN THE WALLS SHALL SET ON ROCK. E1 & E2 BARS IN THE WING SHALL BE SET 12" INTO ROCK AND GROUTED (SEE SEC. 4 F1 FOR NOTE FOR PLANS).

REINFORCEMENT

BAR COVER - AASHTO 8.22

CLEAR DIMENSIONS TO BE SHOWN ON PLANS:

1-1/2"

TOP SLAB	-	TOP REINFORCING	= 2" CL.
		BOTTOM REINFORCING	= 1" CL.
BOTTOM	-	TOP REINFORCING	= 1-1/2" CL.
		BOTTOM REINFORCING	= 3" CL.
SIDEWALLS	-	REINFORCEMENT STREAM FACE	= 1-1/2" CL.
		REINFORCEMENT FILL FACE	= 2" CL.

MAXIMUM BAR LENGTHS

LONGITUDINAL BARS SHOULD BE MADE FULL LENGTH WITHOUT SPLICING UP TO ABOUT 40'-0"; SPLICE IF LONGER. BARS #5 AND LARGER MAY BE USED TO A LENGTH OF 60'-0" WITHOUT SPLICING.

BAR SPLICES

SEE SECTION 2.4 FOR MINIMUM BAR LAP AND TENSION SPLICES IN REINFORCEMENT. USE A CLASS C SPLICE FOR LONGITUDINAL BAR (22" MIN.).

BOX CULVERTS ON ROCK

VERTICAL BARS IN THE WALLS SHALL SET ON ROCK. E1 & E2 BARS IN THE WING SHALL BE SET 12" INTO ROCK AND GROUTED (SEE SEC. 4 F1 FOR NOTE FOR PLANS).

GENERAL NOTES:

CONSTRUCTION SPECIFICATIONS:

All materials and methods of construction shall meet the requirements of MoDot Standard Specifications for Highway Construction 1996.

DESIGN SPECIFICATIONS:

A.A.S.H.T.O. – 1996
Service Load Design

DESIGN LOADING:

HS20
Earth 120#/Cu. Ft.,
Equivalent Fluid Pressure 30#/Cu. Ft.

DESIGN UNIT STRESSES:

Class B Concrete (Substructure)	f'c = 3,000 psi
Reinforcing Steel (Grade 60)	fy = 60,000 psi

JOINT FILLER:

All Joint Filler shall meet the requirements of Std. Spec. 1057.2.4, except as noted.

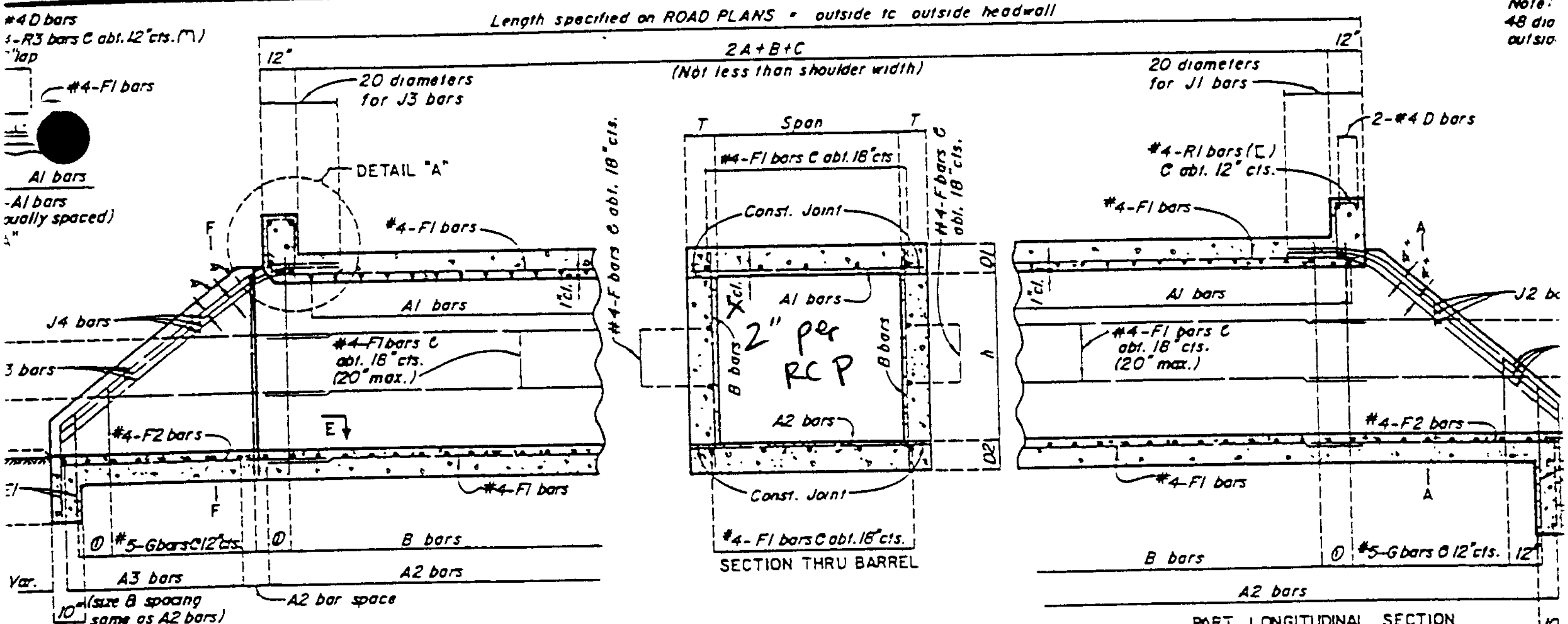
Joint filler shall be securely stitched to one face of the concrete with No. 10 gage copper wire or No. 12 gage soft drawn galvanized steel wire.

REINFORCING STEEL:

Minimum clearance to reinforcing steel shall be 1-1/2", unless otherwise shown.

Lap all reinforcing 24 bar diameters unless otherwise noted.

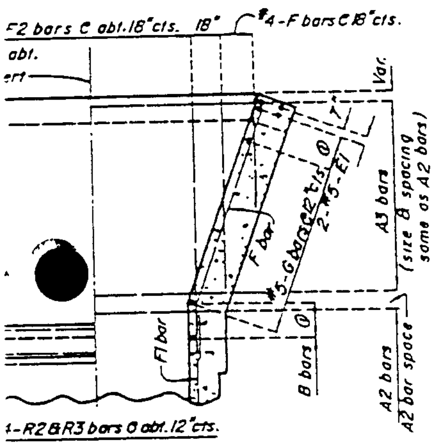
ST. LOUIS COUNTY A100



PART LONGITUDINAL SECTION UPSTREAM

SECTION THRU BARREL

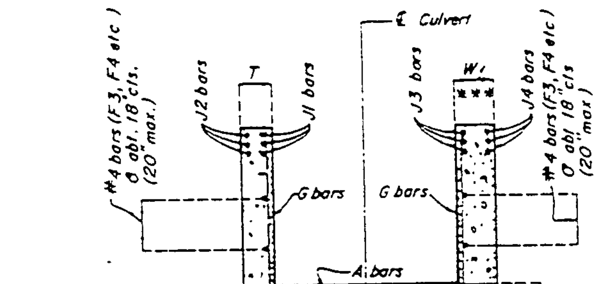
PART LONGITUDINAL SECTION DOWNSTREAM



PART HALF PLAN

PART HALF SECTION E-E

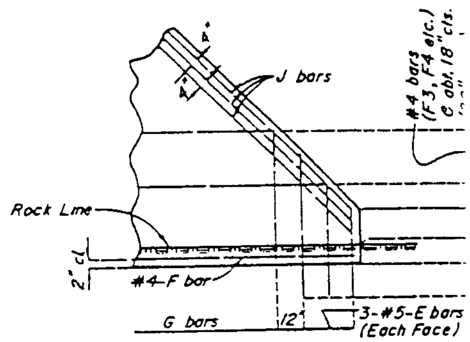
WING WALL UPSTREAM



Note: J1 & J2 bars are to be #5 bars when h+DI** is 12' or less. Use #6 bars when h+DI** is over 12'.

HALF SECTION A-A

HALF SECTION F-F



Notes: Holes to be drilled 12" into solid rock an grouted in.

Omit bottom slab and carry full lengt and wings 6" into and cast against vertica solid undisturbed rock.

Details not shown are same as for box wi slab.

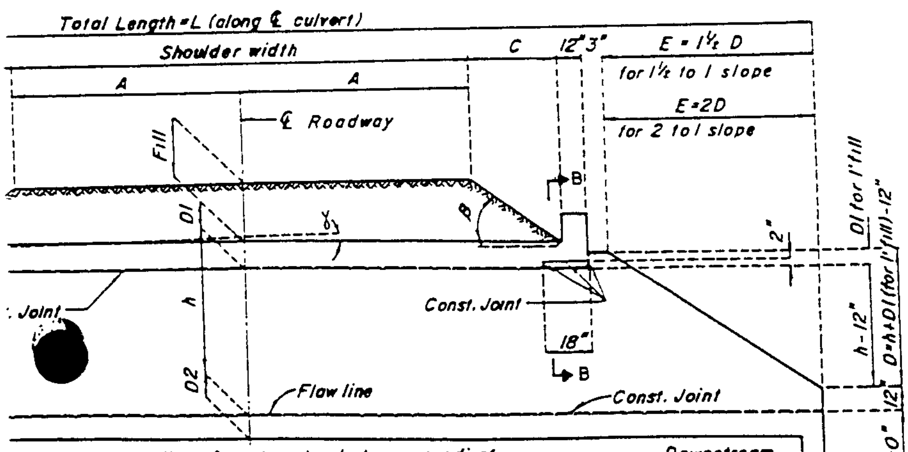
MODIFICATIONS REQUIRED FOR BOX ON F

MINIMUM WING BEAM THICKNESS FOR FLARED WINGS

h + DI **	2:1 SLOPE						1½:1 SLOPE				
	4	5	6	7	8	9	9	10	11	12	13
J3 & J4 bars	3-#5						3-#5		3-#6		3-#7
*** W1	6.5	6.5	6.5	6.5	8.5	10.0	8.5	9.5	11.0	12.0	14.0

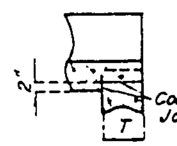
** DI for 1' fill

*** Not less than T

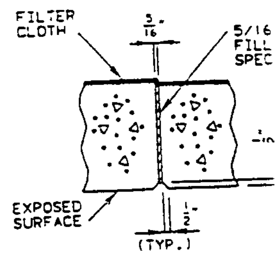


, in general, shall conform to natural stream gradient.

LONGITUDINAL ELEVATION (SQUARE BOX)



SECTION B-B



DETAIL OF TRANSVERSE J THRU BARREL OF CULVE

NOTE: USE A TRANSVERSE JOINT WH IS OVER 75' LONG BETWEEN HEADWA ON ROCK.

A FILTER CLOTH THREE FOO AND DOUBLE THICKNESS SHALL BE ALL TRANSVERSE JOINTS IN THE T SIDEWALLS. THE MATERIAL SHALL ON THE JOINT AND THE EDGES SEAL MASTIC OR WITH TWO SIDED TAPE. CLOTH SHALL BE A GEOTEXTILE ME APPROVAL OF THE ENGINEER AND H TENSILE STRENGTH OF 180 LBS. APPARENT OPENING SIZE OF 50 TO D-4751). NO DIRECT PAYMENT WI FOR FURNISHING AND INSTALLING CLOTH.

USE ADDITIONAL TRANSVERS PROVIDE 50' MAXIMUM SPACING BE

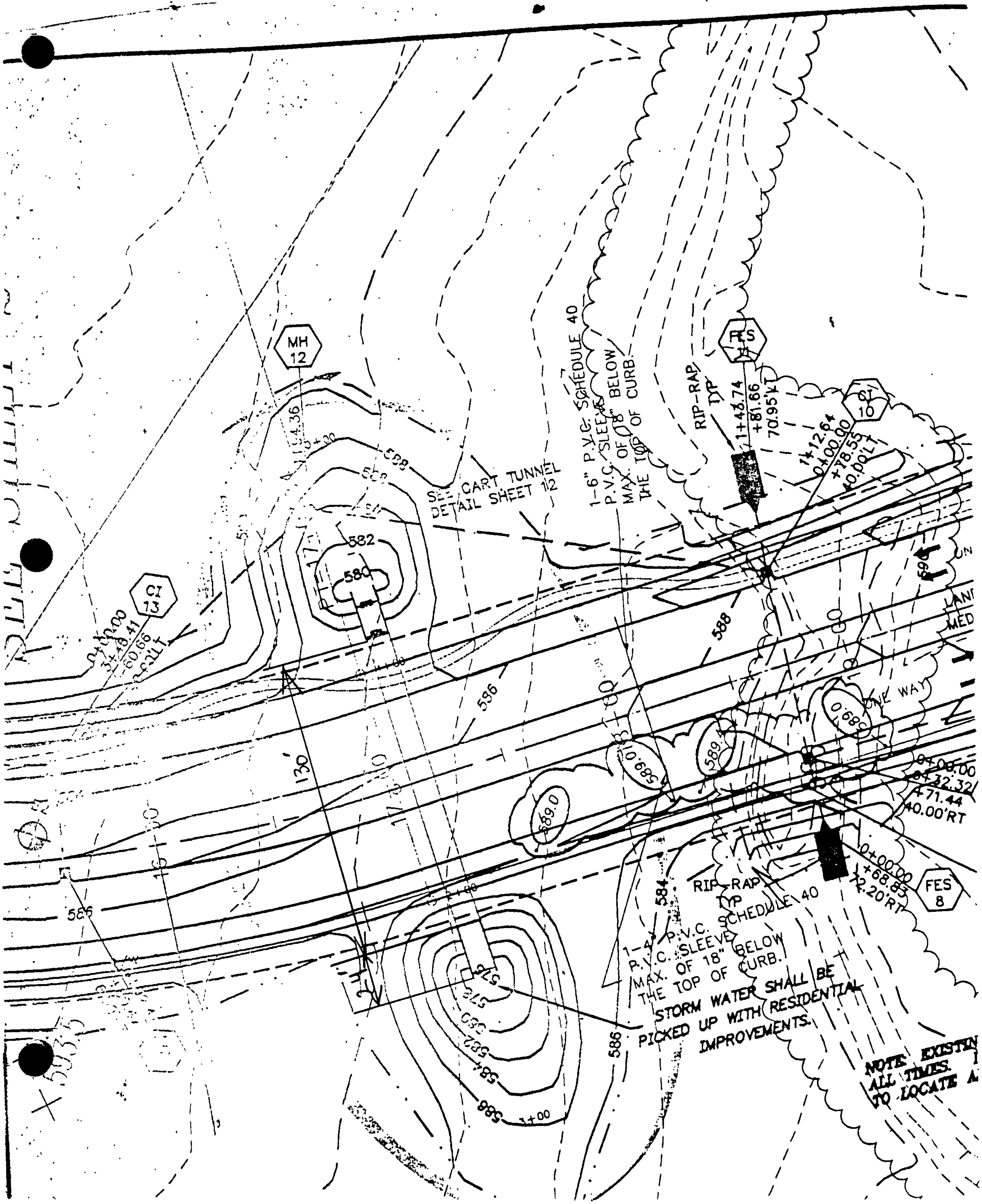
STATE OF MISSOURI
ALLEN LAFOON
NUMBER E-10903
REGISTERED PROFESSIONAL ENGINEER

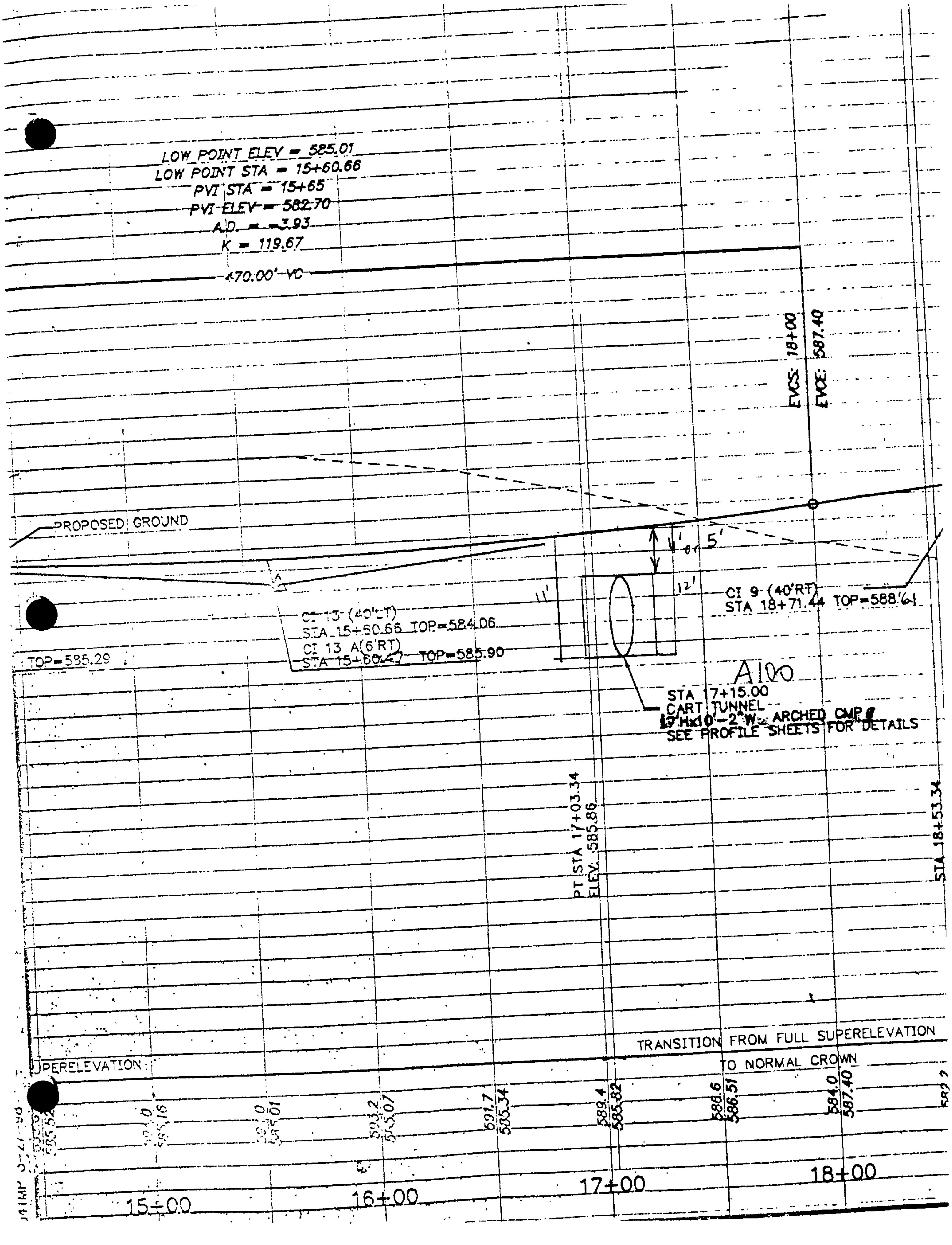
[illegible]

12/27/96

For longitudinal elevation and plan of skewed box see other drawings.)

A100


MH
12
CI
13
CI
10
FES
11
FES
8
SEE CART TUNNEL
DETAIL SHEET 12
1-6" P.V.C. SCHEDULE 40
P.V.C. SLEEVE
MAX. OF 18" BELOW
THE TOP OF CURB.
RIP-RAP
TYP
1+48.74
+81.66
70.95'LT
1+12.64
0+00.00
+78.55
40.00'LT
0+00.00
+68.85
72.20'RT
40.00'RT
+71.44
1-4" P.V.C. SCHEDULE 40
P.V.C. SLEEVE
MAX. OF 18" BELOW
THE TOP OF CURB.
STORM WATER SHALL BE
PICKED UP WITH RESIDENTIAL
IMPROVEMENTS.
ONE WAY
130'
589.0
589.0
580
582
586
588
584
586
NOTE: EXISTIN
ALL TIMES.
TO LOCATE A


LOW POINT ELEV = 585.01
LOW POINT STA = 15+60.66
PVI STA = 15+65
PVI ELEV = 582.70
A.D. = -3.93
K = 119.67
470.00' VC
EVCS: 18+00
EVCE: 587.40
PROPOSED GROUND
4' or 5'
11'
12'
CI 9 (40'RT)
STA 18+71.44 TOP=588.61
CI 13 (40'LT)
STA 15+60.66 TOP=584.06
CI 13 A(6'RT)
STA 15+60.47 TOP=585.90
TOP=585.29
A100
STA 17+15.00
CART TUNNEL
SEE PROFILE SHEETS FOR DETAILS
PT STA 17+03.34
ELEV. 585.86
STA 18+53.34
TRANSITION FROM FULL SUPERELEVATION
TO NORMAL CROWN
SUPERELEVATION
589.4
585.82
591.7
585.34
593.2
585.07
586.6
586.51
584.0
587.40
15+00
16+00
17+00
18+00

GEOTECHNICAL REPORT

SCI

GEOTECHNICAL • ENVIRONMENTAL • WETLANDS • MATERIAL TESTING

July 9, 1998

RDG. MR FILE 980100

JUL 10 1998

Mr. David Rogers
Fred Weber, Inc.
c/o Mr. Ronald C. Pagan, P.E.
Kuhlmann Design Group, Inc.
66 Progress Parkway
Maryland Heights, MO 63043-3706

RE: Addendum Nº 1
Winghaven Box Culverts
O'Fallon, Missouri
SCI No. 980495.11

Dear Mr. Pagan:

This letter provides the additional geotechnical information for the Winghaven Box Culverts you requested to supplement our letter to you dated June 29,1998. Three specific items presented herein pertain to the following:

1) Rock mats for structural slab base footings.

2) Anticipated settlements.

3) Backfill and fluid pressures for below-grade walls.

We understand that the bearing capacity required for the box culverts in the lowland areas will be 1,500 pounds per square foot (psf) and we provided an allowable bearing capacity of 1,000 psf for one box culvert that will pass under Charlie Drive near station 62+50. We recommend that 2 feet of soil be removed below the footing subgrade elevation and replaced with compacted granular material for this culvert. The replacement material should consist of a 3-inch minus gradation crushed stone. This rock mat will help to bridge the soft and wet foundation soils. A similar procedure of varying depths may be utilized for the other culverts in the lowland areas since we anticipate construction difficulties due to the high groundwater elevations.

The box culverts in the highland areas (culverts A and B) will likely be constructed on excavated rock. We anticipate negligible settlements of the foundation rock due to the weight of the structures and fills. In the lowland areas, however, we anticipate total settlement of the foundation soils due to the weight of the structure and fill to be placed to be about 3 to 6 inches. Some of this settlement will likely occur during construction. If construction of the culverts in the lowland areas is not delayed until after the settlement due to the fill has occurred, the structure will likely settle. However, we anticipate this settlement will likely be relatively uniform across the footprint due to the rigidity of the reinforced concrete base mat and structure. A differential settlement of less than 1½ inches can be anticipated across the whole footprint for these structures.

Our letter dated June 29, 1998 states that to use the "granular" values of equivalent fluid unit weight for earth pressures that the granular backfill material should extend horizontally from the wall at least half of the wall height. This distance is <u>not</u> required to provide positive foundation drainage to prevent buildup of hydrostatic pressures. A minimum horizontal distance of about 18 inches with a perforated drain pipe should be sufficient to provide this drainage. Therefore, an equivalent fluid unit weight of 60 pounds per cubic foot may be used to design the below-grade walls assuming the hydrostatic pressures are relieved through proper drainage.

We appreciate the opportunity to be of service to you on this project. If you have any questions or comments, please call.

Respectfully,

SC...

Fred H. Held III
Project Engineer

Jerry Thacker, P.E.
Manager

FHH/GCT:tk

STATE OF MISSOURI
GUY G. TRACKER
NUMBER
EN011189
REGISTERED PROFESSIONAL ENGINEER

c: Mr. Dave Rogers, Fred Weber, Inc. (1)

SCI

GEOTECHNICAL • ENVIRONMENTAL • WETLANDS • MATERIAL TESTING

333 Mid Rivers Mall Drive
St. Peters, MO 63376
Tele: (314) 397-6600
Fax: (314) 397-2600

FAX COVER SHEET

Please deliv[illegible] the following pages to:

FIRM NAME Kuhlmann Design Group DATE: 07/09/98

ATTENTION Mr. Ron Pagan TIME: 3:27 PM

FAX NO 434-8280

FROM Fred Held SCI PROJECT NO: 980495

PROJECT Winghaven Box Culverts SCI FAX NO: 397-2600

TOTAL NO. OF PAGES (INCLUDING COVER SHEET): 3

Please notify [illegible] immediately if the message is incomplete or unclear.
Thank you.

FAX OPERATOR Terry Lynett

MESSAGE:

ORIGINAL:
will be mailed X
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CONFIDENTIALITY NOTE

98 0100

SCI

June 29, 1998

Mr. David Rogers
Fred Weber, Inc.
℅ Mr. Ronald C. Pagan, P.E.
Kuhlmann Design Group, Inc.
66 Progress Parkway
Maryland Heights, MO 63043-3706

RE: Winghaven Box Culverts
O'Fallon, Missouri
SCI № 980495.11

Dear Mr. Pagan:

At the request of Mr. David Rogers with Fred Weber, Inc., this letter provides geotechnical design recommendations for five box culverts planned for the Winghaven development roadways. Plan and Profile sheets prepared by Picket, Ray & Silver, Inc. (PRS), revised March 25 or 27, 1998, depict the locations and elevations of the culverts. Three of the culverts will cross under Winghaven Drive near stations 17+00, 30+50, 59+00. One culvert will pass under David Drive near station 5+50, and one culvert will pass under Charlie Drive near station 62+50. In this letter the box culverts will be named A, B, C, D and E, respectively. Culverts A and B will be tunnels for golf carts to underpass Winghaven Drive in the uplands part of the Winghaven development. The remaining will be multiple cell box culverts for existing creeks in lowland areas to pass under planned roadways. We understand that these culverts will be cast-in-place, reinforced concrete structures that will have light to moderate loads.

We previously explored parts of the Winghaven development in our report, "Preliminary Exploration of Subsurface Conditions and Foundation Recommendations - WINGHAVEN PROJECT SITE COMMERCIAL, RESIDENTIAL, AND GOLF COURSE COMMUNITY - O'FALLON, MISSOURI," dated July 1997 (Revised January 1998). In that exploration we drilled B2 and B3 in the uplands near the golf cart underpasses, B21 in the lowland area near culvert C, and B14 in the bottoms land near culvert E. The four boring logs are included in the Appendix of this letter. These borings indicate that excavations for culverts A and B will encounter rock in the form of weathered siltstone or shale for the full depths of the structures. Also, B2 encountered auger refusal near El. 576.5 and the planned bottom of culvert A is near El. 574. Some or all of this rock may be removed in open-cut excavations with bull dozers equipped with rippers. However, intact ledges of hard rock, boulders, or sound bedrock may be encountered that could require blasting.

SCI explored the subsurface conditions near culverts C, D and E on June 25, 1998 using hand auger methods. The hand auger borings, TH1, TH2, and TH3, were located near culverts C, D and E, respectively, by measuring from existing site features and improvements shown of the plans prepared by PRS. The hand augers were advanced to termination depths of 5, 6, and 7½ feet in TH1, TH2, and TH3, respectively. The soils generally encountered were soft to medium stiff, low plastic silty clays and clayey silts. TH1 terminated in a mixture of silty clay, gravel and sand at a depth of 5 feet, which is about 3 feet above the anticipated bearing elevation of culvert C. TH2 and TH3 terminated at depths of 6 and 7½ feet, respectively, due to caving conditions in the holes. We estimate the termination elevations were near the bearing elevations of culverts D and E. Groundwater was encountered in the hand auger borings at depths of 4 or 5 feet. The nature and thickness of the soils encountered and the results of the field sampling and testing are shown on the Borings Logs, Figures 1-1 through 1-3.

The varied conditions at the culvert locations require different allowable bearing capacities for the locations. An allowable bearing capacity of 10,000 pounds per square foot (psf) may be used to design the structural base slab for culverts A and B if they bear on the weathered siltstone or shale as indicated by B2 and B3 or if they encounter bedrock. An allowable bearing capacity of 3,000 psf may be used to design culvert C if it bears on the anticipated mixture of gravel and sand with some or no clay. An allowable bearing capacity of 1,500 psf may be used to design culvert D if it bears on the silty clay encountered in TH2. An allowable bearing capacity of 1,200 psf may be used to design culvert E.

We understand that higher bearing capacities will be required for culverts D and E. The soft soils below the base of the culverts may be removed and replaced with compacted, crushed rock, such as MODOT Type I Aggregate. The area of removal should extend down and outside the base footprint at an angle of 45 degrees to form a larger area to bear on the soft soils. The depth of removal will vary depending on the allowable bearing capacity required. We anticipate about 5 feet of soft soil will need to be removed and replaced with crushed rock to increase the allowable bearing capacity of the culverts to 2,000 or 3,000 psf.

In the lowland areas, placing fill to raise the roadway above existing grade will result in settlement as consolidation of the soft, underlying soils occurs. A delay in construction is anticipated to allow some or most of that settlement to occur prior to construction. We anticipate this delay to be about 30 to 120 days. This delay will likely not apply to culvert C since we anticipate it will bear on sand and gravel near bedrock elevations. Culverts D and E should not be constructed until most of the settlement due to the weight of the fills has occurred. Surcharging can be used as a means to accelerate consolidation due to the weight of fill. Deep fill in the lowland areas should be monitored with settlement plates to assess when most of the settlement has occurred and construction can continue.

The below-grade walls of the box culverts will be required to resist earth pressures. These include the outside walls of the culverts and the wing-walls that may extend from the culverts designed to accommodate surface grade changes.

The equivalent fluid unit weights tabulated below provide recommended lateral earth pressures for design of these walls. Values for granular material should only be used if the granular backfill extends from the wall a lateral distance of at least one-half the wall height. This table assumes that positive foundation drainage is provided to prevent buildup of hydrostatic pressure. The below-grade walls should be designed to resist an additional uniform lateral load of one-half of the surface loads.

Backfill Type	Fixed-Headed Walls (pcf)	Free-Headed Walls (pcf)
Cohesive Soil	60	50
Granular Material	45	40

A fixed-headed wall is a wall which is not permitted to deflect at the top after backfilling. A free-headed wall is designed to deflect at the top and remain fixed at the base, such as a retaining wall. A wing-wall attached to a fixed-headed wall should be considered fixed-headed unless the structural design permits independent rotation.

The maximum toe pressures for wing-walls should not exceed the bearing capacities recommended in this letter. Walls bearing in soil can be designed with a coefficient of friction between the base of a concrete footing and the subgrade soil of 0.3. A passive soil resistance equal to a uniform pressure of 300 psf may be used for natural soil against the face of the exterior base or a key below the base of a retaining wall. Soil backfilled against the exterior face of a retaining wall should not be assumed to provide any lateral resistance.

We recommend that all below-grade walls and retaining walls be provided with a foundation drainage system. A typical below-grade wall drain detail is shown in Figure 2. It should consist of a perforated pipe to transport the fluids collected from the granular backfill to daylight. Granular drainage material around the pipe should consist of 1-inch clean, "GP" classified crushed rock. A synthetic filter fabric indicated on Figure 2 should be Mirafi 140N or equivalent. A minimum 4-inch diameter perforated drain pipe should be used.

We appreciate the opportunity to be of service to you on this project. If you have any questions or comments, please call.

Respectfully,

SCI

Fred H. Held III
Project Engineer

Jerry Thacker, P.E.
Manager

FHH/GGT/tal

c: Mr. Dave Rogers, Fred Weber, Inc. (1)

STATE OF MISSOURI
GUY G. THACKER
NUMBER
EN/011189
REGISTERED PROFESSIONAL ENGINEER

BORING LOG

LEGEND AND NOMENCLATURE

Items shown in Boring Logs refer to the following:
(Where shown in parenthesis, sampling and testing were performed in general accordance with applicable ASTM standard methods or practices.)

1. **Depth** - Depth below ground surface (feet).

2. **Sample** - Types designated by letters.

   SS - Split-spoon sample, disturbed, obtained by driving 2-inch O.D. split-spoon sampler (ASTM D 1586).

   NX - Diamond core bit sample, nominal 2-inch diameter rock sample (ASTM D 2113).

   ST - Thin-walled tube sample, undisturbed, obtained by penetration of a 3-inch diameter tube (ASTM D 1587).

   CS - Continuous sample tube system, undisturbed, obtained by split barrel sampler in conjunction with auger advancement.

   SV - Shear vane, field test to determine strength of cohesive soil by pushing or driving a 2-inch diameter vane then shearing by torquing soil in existing and remolded states (ASTM D 2573).

   AS - Disturbed samples obtained from auger cuttings.

   Recovery - Recovery is expressed as a ratio of the length recovered to the total length pushed, driven, or cored (inches), e.g. - 9/12.

   Blows - Numbers indicate blows per six inches of sampler penetration when driven by a 140-pound hammer falling freely 30 inches (ASTM D 1586). When number of blows reaches 50 without six inches of sampler penetration, the result is shown as a ratio of 50 to the actual penetration, e.g. - 50/2 inches.

   Vane Shear Strength - Shear strength of soil expressed as the peak strength (existing state)/residual strength (remolded state).

3. **Description** - Description according to the Unified Soil Classification: Description indicates soil constituents and other classification characteristics (ASTM D 2488). A solid line indicates approximate location of stratigraphic change between soil types and the transition may be gradual.

4. **Laboratory Test Results**

   - Natural moisture content in percent (ASTM D 2216).
   - Dry density of sample tested in pounds per cubic foot (pcf).
   - Unconfined compressive strength (ASTM D 2166) in kips per square foot (ksf).
   - Liquid limit (ASTM D 4318) in percent.
   - Plastic limit (ASTM D 4318) in percent.

5. **Remarks/Other Data** - See notation at bottom of log for description of data entries.

   RQD Rock Quality Designation; the ratio between the total length of core segments greater than 4 inches in length and the total length of core drilled (expressed as percentage).

SCI TEST PIT LOG

PROJECT WINGHAVEN BOX CULVERTS
LOCATION O'Fallon, Missouri
EXCAVATOR SCI
SURFACE ELEVATION 524+/-
EQUIPMENT Hand auger

TEST PIT NO. TH-1
SHEET 1 OF 1
PROJECT NO. 980495.11
DATE EXCAVATED 6-25-98

DEPTH (FT.)	FIELD SAMPLE / TEST: NUMBER	SAMPLE TYPE	FIELD TEST TYPE	SHEAR STRENGTH (KSF)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0	1	BS			Grayish brown, low plastic SILTY CLAY with trace of fine roots	CL		29					0
2.5	2	BS			Brown, low plastic SILTY CLAY with trace of fine gravel	CL		19					2.5
	3	BS			Brown, low plastic SILTY CLAY and coarse SAND to fine GRAVEL	CL,GC		19					
5					Hand auger refusal at 5.0 ft.								5

WATER LEVEL:

____ NO GROUNDWATER NOTED AT TIME OF EXCAVATION
5 FT WHILE EXCAVATING
____ FT ____ HRS AFTER EXCAVATING

REMARKS:

FIGURE 1-1

SCI TEST PIT LOG

PROJECT WINGHAVEN BOX CULVERTS — TEST PIT NO. TH-2
LOCATION O'Fallon, Missouri — SHEET 1 OF 1
EXCAVATOR SCI — PROJECT NO. 980495.11
SURFACE ELEVATION 516+/- — EQUIPMENT Hand auger — DATE EXCAVATED 6-25-98

DEPTH (FT.)	FIELD SAMPLE / TEST: NUMBER	SAMPLE TYPE	FIELD TEST TYPE	SHEAR STRENGTH (KSF)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					4 inches TOPSOIL								0
	1	BS			Brown with gray, low plastic SILTY CLAY with some gray, silt and trace of organics	CL		23					
2.5	2	BS	SV	2.8/1.4	Brown and gray, low plastic CLAYEY SILT with trace of fine sand and organics	ML		25					2.5
	3	BS						21					
	4	BS			Gray with brown, low plastic SILTY CLAY with trace of fine gravel	CL		24					
5													5
					Hand auger terminated at 6.0 ft.								
7.5													7.5
10													10
12.5													12.5
15													15
17.5													17.5

WATER LEVEL:

____ NO GROUNDWATER NOTED AT TIME OF EXCAVATION
4 FT WHILE EXCAVATING
____ FT ____ HRS AFTER EXCAVATING
____

REMARKS:

FIGURE 1-2

SCI TEST PIT LOG

PROJECT WINGHAVEN BOX CULVERTS
LOCATION O'Fallon, Missouri
EXCAVATOR SCI
SURFACE ELEVATION 494+/-
EQUIPMENT Hand auger

TEST PIT NO. TH-3
SHEET 1 OF 1
PROJECT NO. 980495.11
DATE EXCAVATED 6-25-98

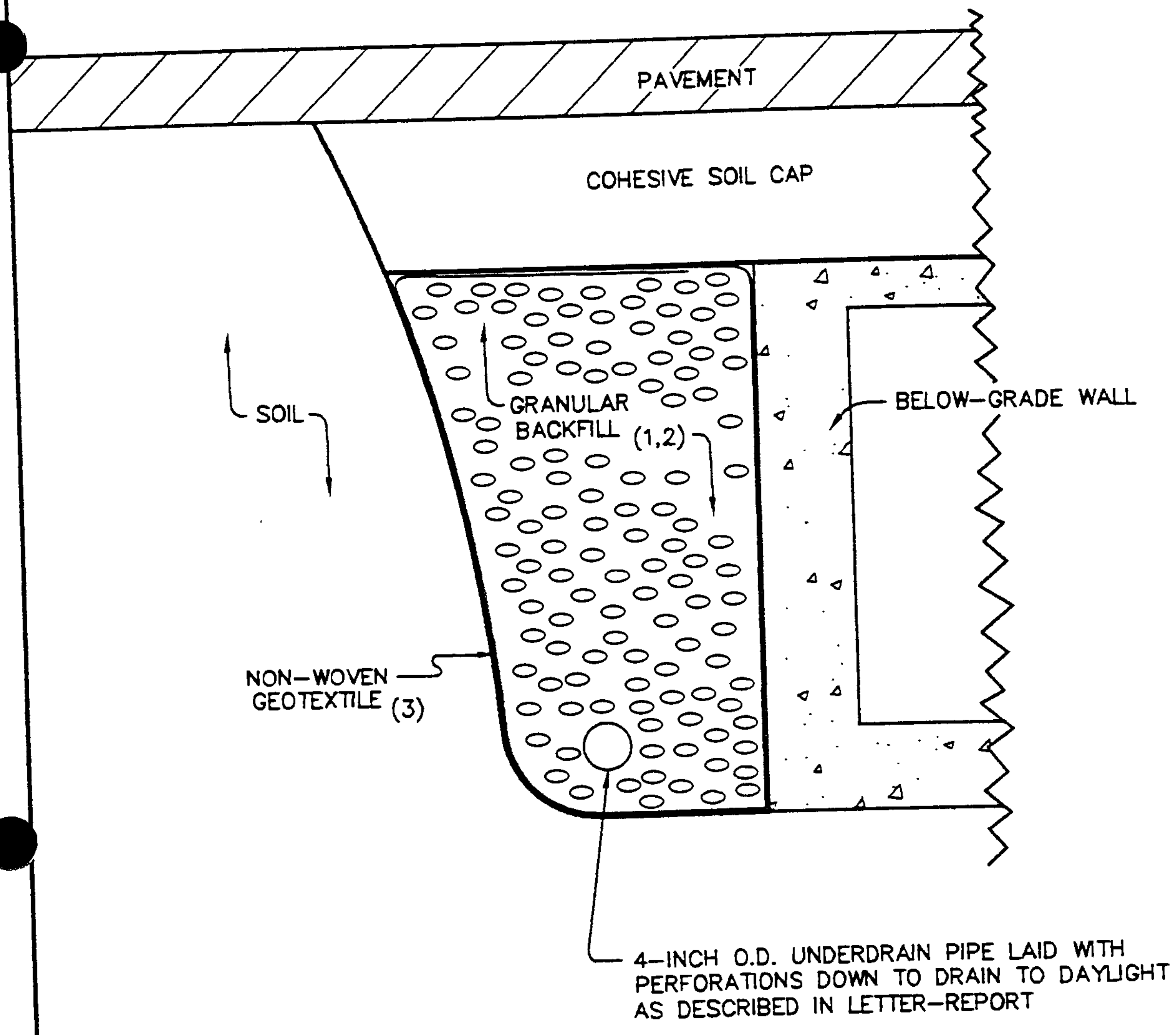
DEPTH (FT.)	FIELD SAMPLE / TEST: NUMBER	SAMPLE TYPE	FIELD TEST TYPE	SHEAR STRENGTH (KSF)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					Brown, low plastic SILTY CLAY	CL							0
	1	BS			Grayish brown, fine SANDY SILTY CLAY with some fine gravel	SC		21					
2.5	2	BS			Grayish brown, low plastic CLAYEY SILT with fine sand	ML		19					2.5
5	3	BS			Brown and gray, low plastic CLAYEY SILT with some fine sand to fine gravel	ML		35					5
7.5	4	BS			Gray, low plastic CLAYEY SILT with trace of fine gravel	ML		29					7.5
					Hand auger terminated at 7.5 ft.								
10													10
12.5													12.5
15													15
17.5													17.5

WATER LEVEL:

____ NO GROUNDWATER NOTED AT TIME OF EXCAVATION
4 FT WHILE EXCAVATING
____ FT ____ HRS AFTER EXCAVATING

REMARKS:

FIGURE 1-3



NOTES:

1. MINIMUM 6" FILTER MATERIAL AROUND PIPE.
2. 1" CLEAN CRUSHED LIMESTONE.
3. TYPICALLY FOUR-OUNCE PER SQUARE YARD

SCI
333 MID RIVERS MALL DRIVE
ST. PETERS, MISSOURI 63376

WINGHAVEN BOX CULVERT
O'FALLON, MISSOURI

BELOW-GRADE WALL DRAIN DETAIL

JUNE 1998 | SCI NO. 980495.11

FIGURE 2

APPENDIX

SCI BORING LOG

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 595+/-   DRILLING METHOD 4" CFA

BORING NO. B-2
SHEET 1 OF 1
PROJECT NO. 97-384-411
DATE DRILLED 6-11-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (IN/IN)	SAMPLE BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					6 inches TOPSOIL								0
					Brown and gray, medium plastic SILTY CLAY	CL/CH							
2	1	SS		2 3 3				26					2
					Brown with some gray, low plastic SILTY CLAY	CL							
4	2	SS		2 2 3				28					4
6	3	SS		2 2 3	Brown with some gray, medium plastic SILTY CLAY	CL/CH		25					6
8	4	SS		3 5 7	Brown with some gray, high plastic CLAY	CH		29					8
10													10
12					Tan, WEATHERED SILTSTONE								12
14	5	SS		50/3				10					14
16	6	AS			Gray with some brown, SILTSTONE								16
18					Auger refusal at 17.5 ft.								18
20													20

WATER LEVEL:

- X NO GROUND WATER NOTED AT TIME OF DRILLING
- ____ FT WHILE DRILLING
- ____ FT ____ HRS AFTER DRILLING
- ____ FT ____ HRS AFTER DRILLING

REMARKS:

FIGURE 2-2

SCI BORING LOG

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 602+/- DRILLING METHOD 4" CFA

BORING NO. B-3
SHEET 1 OF 2
PROJECT NO. 97-384-411
DATE DRILLED 6-11-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	RECOVERY (IN/IN)	BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					1 inch TOPSOIL		1						0
					Brown with some gray, medium plastic SILTY CLAY	CL/CH							
2	1	SS		3 3 4				26					2
					Brown with some gray, low plastic SILTY CLAY	CL							
4	2	SS		2 3 3				25					4
6	3	SS		2 3 4				22					6
8					Brown with some gray, high plastic CLAY	CH							8
	4	SS		3 3 5				33					
10													10
12													12
					Tan, high plastic SHALEY CLAY	CH							
14	5	SS		3 6 15				30					14
					Brown, WEATHERED SHALE								
16													16
18													18
	6	SS		27 50/3				10					
20													20

Continued on sheet 2 of 2

WATER LEVEL:
x NO GROUND WATER NOTED AT TIME OF DRILLING
_____ FT WHILE DRILLING
_____ FT _____ HRS AFTER DRILLING
_____ FT _____ HRS AFTER DRILLING

REMARKS:
1) Driller's observation

FIGURE 2-3a

SCI BORING LOG

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 595+/- DRILLING METHOD 4" CFA

BORING NO. B-2
SHEET 1 OF 1
PROJECT NO. 97-384-411
DATE DRILLED 6-11-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (IN/IN)	SAMPLE BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					6 inches TOPSOIL								0
					Brown and gray, medium plastic SILTY CLAY	CL/CH							
2	1	SS		2 3 3				26					2
					Brown with some gray, low plastic SILTY CLAY	CL							
4	2	SS		2 2 3				28					4
6	3	SS		2 2 3	Brown with some gray, medium plastic SILTY CLAY	CL/CH		25					6
8	4	SS		3 5 7	Brown with some gray, high plastic CLAY	CH		29					8
10													10
12					Tan, WEATHERED SILTSTONE								12
14	5	SS		50/3				10					14
16	6	AS			Gray with some brown, SILTSTONE								16
18					Auger refusal at 17.5 ft.								18
20													20

WATER LEVEL:

x NO GROUND WATER NOTED AT TIME OF DRILLING
____ FT WHILE DRILLING
____ FT ____ HRS AFTER DRILLING
____ FT ____ HRS AFTER DRILLING

REMARKS:

FIGURE 2-2

SCI BORING LOG

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 602+/- DRILLING METHOD 4" CFA

BORING NO. B-3
SHEET 1 OF 2
PROJECT NO. 97-384-411
DATE DRILLED 6-11-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (IN/IN)	SAMPLE BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					1 inch TOPSOIL		1						0
					Brown with some gray, medium plastic SILTY CLAY	CL/CH							
2	1	SS		3 3 4				26					2
					Brown with some gray, low plastic SILTY CLAY	CL							
4	2	SS		2 3 3				25					4
6	3	SS		2 3 4				22					6
8					Brown with some gray, high plastic CLAY	CH							8
	4	SS		3 3 5				33					
10													10
12													12
					Tan, high plastic SHALEY CLAY	CH							
14	5	SS		3 6 15				30					14
					Brown, WEATHERED SHALE								
16													16
18													18
	6	SS		27 50/3				10					
20													20

Continued on sheet 2 of 2

WATER LEVEL:
x NO GROUND WATER NOTED AT TIME OF DRILLING
____ FT WHILE DRILLING
____ FT ____ HRS AFTER DRILLING
____ FT ____ HRS AFTER DRILLING

REMARKS:
1) Driller's observation

FIGURE 2-3a

BORING LOG

SCI

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 602+/- DRILLING METHOD 4" CFA

BORING NO. B-3
SHEET 2 OF 2
PROJECT NO. 97-384-411
DATE DRILLED 6-11-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (IN/IN)	SAMPLE BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
22					Brown, WEATHERED SHALE								22
24	7	SS		50/3				12					24
26					Drilling terminated at 25.0 ft.								26
28													28
30													30
32													32
34													34
36													36
38													38
40													40
42													42

WATER LEVEL:

x NO GROUND WATER NOTED AT TIME OF DRILLING
____ FT WHILE DRILLING
____ FT ____ HRS AFTER DRILLING
____ FT ____ HRS AFTER DRILLING

REMARKS:

FIGURE 2-3b

SCI BORING LOG

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 494+/-
DRILLING METHOD 4" CFA

BORING NO. B-14
SHEET 1 OF 1
PROJECT NO. 97-384-411
DATE DRILLED 6-9-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (IN/IN)	SAMPLE BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					5 inches TOPSOIL		1						0
					Gray and brown, low plastic SILTY CLAY	CL							
2	1	SS		3 2 2				23					2
4	2	SS		2 2 4				22					4
6	3	SS		0 1 2				28					6
8	4	SS		0 1 1				31					8
10					Drilling terminated at 10.0 ft.								10
12													12
14													14
16													16
18													18
20													20

WATER LEVEL:

____ NO GROUND WATER NOTED AT TIME OF DRILLING

5.5 FT WHILE DRILLING

____ FT ____ HRS AFTER DRILLING

____ FT ____ HRS AFTER DRILLING

REMARKS:

1) Driller's observation

FIGURE 2-14

BORING LOG

SCI

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 524+/- DRILLING METHOD 4" CFA

BORING NO. B-21
SHEET 1 OF 1
PROJECT NO. 97-384-411
DATE DRILLED 6-10-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (IN/IN)	SAMPLE BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					3 inches TOPSOIL		1						0
					Brown and gray, low plastic CLAYEY SILT to SILTY CLAY	ML/CL							
2	1	SS		3 2 1				25					2
4	2	SS		3 2 5				22					4
					Brown and gray, low plastic SILTY CLAY with some rock fragments	CL							
6					ROCK FRAGMENTS with some brown and gray, low plastic silty clay	GC							6
	3	SS		15 18 8				21					
8													8
	4	SS		50/1	ROCK and ROCK FRAGMENTS		2						
10					Drilling terminated at 10.0 ft.								10
12													12
14													14
16													16
18													18
20													20

WATER LEVEL:
____ NO GROUND WATER NOTED AT TIME OF DRILLING
6 FT WHILE DRILLING
____ FT ____ HRS AFTER DRILLING
____ FT ____ HRS AFTER DRILLING

REMARKS:
1) Driller's observation
2) Driller's observation

FIGURE 2-21

SCI GEOTECHNICAL • ENVIRONMENTAL • WETLANDS • MATERIAL TESTING

333 Mid Rivers Mall Drive
St. Peters, MO 63376
Tele: (314) 397-6600
Fax: (314) 397-2600

KDG, MH FILE 980100

JUN 29 1998

FAX COVER SHEET

Please deliver the following pages to:

FIRM NAME KDG DATE: 6/29/98

ATTENTION Ron Pagan TIME:

FAX NO 434-8280

FROM: Fred Held SCI PROJECT NO 980495

PROJECT Winghaven Box Culverts SCI FAX NO. 397-2600

TOTAL NO. OF PAGES (INCLUDING COVER SHEET): 15

Please notify us immediately if the message is incomplete or unclear.
Thank you.

FAX OPERATOR:

MESSAGE Please find letter and detail for your review.

ORIGINALS
will be mailed X
will not be mailed ___

After your comments from review are addressed.

CONFIDENTIALITY NOTE

SCI GEOTECHNICAL • ENVIRONMENTAL • WETLANDS • MATERIAL TESTING

June 29, 1998

Mr David Rogers
Fred Weber, Inc.
c/o Mr. Ronald C. Pagan, P.E.
Kuhlmann Design Group, Inc.
66 Progress Parkway
Maryland Heights, MO 63043-3706

RE: Winghaven Box Culverts
O'Fallon, Missouri
SCI No 980495.11

Dear Mr Pagan.

At the request of Mr. David Rogers with Fred Weber, Inc., this letter provides geotechnical design recommendations, for five box culverts planned for the Winghaven development roadways Plan and Profile sheets prepared by Picket, Ray & Silver, Inc. (PRS), revised March 25 or 27, 1998, depict the locations and elevations of the culverts. Three of the culverts will cross under Winghaven Drive near stations 17+00, 30+50, 59+00. One culvert will pass under David Drive near station 5+50, and one culvert will pass under Charlie Drive near station 62+50. In this letter the box culverts will be named A, B, C, D and E, respectively. Culverts A and B will be tunnels for golf carts to underpass Winghaven Drive in the uplands part of the Winghaven development. The remaining will be multiple cell box culverts for existing creeks in lowland areas to pass under planned roadways. We understand that these culverts will be cast-in-place reinforced concrete structures that will have light to moderate loads.

We previously explored parts of the Winghaven development in our report, "Preliminary Exploration of Subsurface Conditions and Foundation Recommendations - WINGHAVEN PROJECT SITE COMMERCIAL, RESIDENTIAL, AND GOLF COURSE COMMUNITY - O'FALLON, MISSOURI," dated July 1997 (Revised January 1998). In that exploration we drilled B2 and B3 in the uplands near the golf cart underpasses, B21 in the lowland area near culvert C, and B14 in the bottoms land near culvert E. The four boring logs are included in the Appendix of this letter. These borings indicate that excavations for culverts A and B will encounter rock in the form of weathered siltstone or shale for the full depths of the structures. Also, B2 encountered auger refusal near El. 576.5 and the planned bottom of culvert A is near El 574 Some or all of this rock may be removed in open-cut excavations with bull dozers equipped with rippers. However, intact ledges of hard rock, boulders, or sound bedrock may be encountered that could require blasting.

SCI explored the subsurface conditions near culverts C, D and E on June 25, 1998 using hand auger methods. The hand auger borings, TH1, TH2, and TH3, were located near culverts C, D and E, respectively, by measuring from existing site features and improvements shown of the plans prepared by PRS. The hand augers were advanced to termination depths of 5, 6, and 7½ feet in TH1, TH2, and TH3, respectively. The soils generally encountered were soft to medium stiff, low plastic silty clays and clayey silts. TH1 terminated in a mixture of silty clay, gravel and sand at a depth of 5 feet, which is about 3 feet above the anticipated bearing elevation of culvert C. TH2 and TH3 terminated at depths of 6 and 7½ feet, respectively, due to caving conditions in the holes. We estimate the termination elevations were near the bearing elevations of culverts D and E. Groundwater was encountered in the hand auger borings at depths of 4 or 5 feet. The nature and thickness of the soils encountered and the results of the field sampling and testing are shown on the Borings Logs, Figures 1-1 through 1-3.

The varied conditions at the culvert locations require different allowable bearing capacities for the locations. An allowable bearing capacity of 10,000 pounds per square foot (psf) may be used to design the structural base slab for culverts A and B if they bear on the weathered siltstone or shale as indicated by B2 and B3 or if they encounter bedrock. An allowable bearing capacity of 3,000 psf may be used to design culvert C if it bears on the anticipated mixture of gravel and sand with some or no clay. An allowable bearing capacity of 1,500 psf may be used to design culvert D if it bears on the silty clay encountered in TH2. An allowable bearing capacity of 1,200 psf may be used to design culvert E.

We understand that higher bearing capacities will be required for culverts D and E. The soft soils below the base of the culverts may be removed and replaced with compacted, crushed rock, such as MODOT Type I Aggregate. The area of removal should extend down and outside the base footprint at an angle of 45 degrees to form a larger area to bear on the soft soils. The depth of removal will vary depending on the allowable bearing capacity required. We anticipate about 5 feet of soft soil will need to be removed and replaced with crushed rock to increase the allowable bearing capacity of the culverts to 2,000 or 3,000 psf.

In the lowland areas, placing fill to raise the roadway above existing grade will result in settlement as consolidation of the soft, underlying soils occurs. A delay in construction is anticipated to allow some or most of that settlement to occur prior to construction. We anticipate this delay to be about 30 to 120 days. This delay will likely not apply to culvert C since we anticipate it will bear on sand and gravel near bedrock elevations. Culverts D and E should not be constructed until most of the settlement due to the weight of the fills has occurred. Surcharging can be used as a means to accelerate consolidation due to the weight of fill. Deep fill in the lowland areas should be monitored with settlement plates to assess when most of the settlement has occurred and construction can continue.

The below-grade walls of the box culverts will be required to resist earth pressures. These include the outside walls of the culverts and the wing-walls that may extend from the culverts designed to accommodate surface grade changes.

The equivalent fluid unit weights tabulated below provide recommended lateral earth pressures for design of these walls. Values for granular material should only be used if the granular backfill extends from the wall a lateral distance of at least one-half the wall height. This table assumes that positive foundation drainage is provided to prevent buildup of hydrostatic pressure. The below-grade walls should be designed to resist an additional uniform lateral load of one-half of the surface loads.

Backfill Type	Fixed-Headed Walls (pcf)	Free-Headed Walls (pcf)
Cohesive Soil	60	50
Granular Material	45	40

A fixed-headed wall is a wall which is not permitted to deflect at the top after backfilling. · free-headed wall is designed to deflect at the top and remain fixed at the base, such as a retaining wall. A wing-wall attached to a fixed-headed wall should be considered xed-headed unless the structural design permits independent rotation.

The maximum toe pressures for wing-walls should not exceed the bearing capacities recommended in this letter. Walls bearing in soil can be designed with a coefficient of friction between the base of a concrete footing and the subgrade soil of 0.3. A passive soil resistance equal to a uniform pressure of 300 psf may be used for natural soil against the face of the exterior base or a key below the base of a retaining wall. Soil backfilled against the exterior face of a retaining wall should not be assumed to provide any lateral resistance.

We recommend that all below-grade walls and retaining walls be provided with a foundation drainage system. A typical below-grade wall drain detail is shown in Figure 2. It should consist of a perforated pipe to transport the fluids collected from the granular backfill to daylight. Granular drainage material around the pipe should consist of 1-inch clean, "GP" classified crushed rock A synthetic filter fabric indicated on Figure 2 should be Mirafi 140N or equivalent. A minimum 4 inch diameter perforated drain pipe should be used.

We appreciate the opportunity to be of service to you on this project. If you have any questions or comments please call.

Respectfully

SCI

Fred H. Held III
Project Engineer

Jerry Thacker, P.E.
Manager

STATE OF MISSOURI
GUY G. THACKER
NUMBER
EN 021189
REGISTERED PROFESSIONAL ENGINEER

FHH/GGT/ta

c: Mr Dave Rogers, Fred Weber, Inc. (1)

BORING LOG

LEGEND AND NOMENCLATURE

Items shown on Boring Logs refer to the following:
(Where shown in parenthesis, sampling and testing were performed in general accordance with applicable ASTM standard methods or practices.)

1 Depth - Depth below ground surface (feet).

2 Sample - Types designated by letters.

- SS - Split-spoon sample, disturbed, obtained by driving 2-inch O.D. split-spoon sampler (ASTM D 1586).
- NX - Diamond core bit sample, nominal 2-inch diameter rock sample (ASTM D 2113).
- ST - Thin-walled tube sample, undisturbed, obtained by penetration of a 3-inch diameter tube (ASTM D 1587).
- CS - Continuous sample tube system, undisturbed, obtained by split barrel sampler in conjunction with auger advancement.
- SV - Shear vane, field test to determine strength of cohesive soil by pushing or driving a 2-inch diameter vane then shearing by torquing soil in existing and remolded states (ASTM D 2573).
- AS - Disturbed samples obtained from auger cuttings.
- Recovery - Recovery is expressed as a ratio of the length recovered to the total length pushed, driven, or cored (inches), e.g. - 9/12.
- Blows - Numbers indicate blows per six inches of sampler penetration when driven by a 140-pound hammer falling freely 30 inches (ASTM D 1586). When number of blows reaches 50 without six inches of sampler penetration, the result is shown as a ratio of 50 to the actual penetration, e.g. - 50/2 inches.
- Vane Shear Strength - Shear strength of soil expressed as the peak strength (existing state)/residual strength (remolded state).

3 Description - Description according to the Unified Soil Classification: Description indicates soil constituents and other classification characteristics (ASTM D 2488). A solid line indicates approximate location of stratigraphic change between soil types and the transition may be gradual.

4 Laboratory Test Results

- Natural moisture content in percent (ASTM D 2216).

  Dry density of sample tested in pounds per cubic foot (pcf).
- Unconfined compressive strength (ASTM D 2166) in kips per square foot (ksf).
- Liquid limit (ASTM D 4318) in percent.
- Plastic limit (ASTM D 4318) in percent.

5 Remarks/Other Data - See notation at bottom of log for description of data entries.

RQD Rock Quality Designation; the ratio between the total length of core segments greater than 4 inches in length and the total length of core drilled (expressed as percentage).

TEST PIT LOG

NGHA EN BOX CULVERTS — TEST PIT NO. TH-1

Fallon Missouri — SHEET 1 OF 1

CL — PROJECT NO. 980495.11

VATION 524 +/- — EQUIPMENT Hand auger — DATE EXCAVATED 6-25-98

FIELD SAMPLE / TEST: SAMPLE TYPE	FIELD TEST TYPE	SHEAR STRENGTH (KSF)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
			Grayish brown, low plastic SILTY CLAY with trace of fine roots	CL							0
BS						29					
			Brown, low plastic SILTY CLAY with trace of fine gravel	CL							2.5
BS						19					
BS			Brown, low plastic SILTY CLAY and coarse SAND to fine GRAVEL	CL,GC		19					
			Hand auger refusal at 5.0 ft.								5
											7.5
											10
											12.5
											15
											17.5

VEL.

NO GROUNDWATER NOTED AT TIME OF EXCAVATION

FT WHILE EXCAVATING

FT ____ HRS AFTER EXCAVATING

REMARKS:

FIGURE 1-1

SCI — TEST PIT LOG

PROJECT WINGHA\ EN BOX CULVERTS
LOCATION O'Fallon Missouri
EXCAVATOR SCI
SURFACE ELEVATION 516+/-
EQUIPMENT Hand auger

TEST PIT NO. TH-2
SHEET 1 OF 1
PROJECT NO. 980495.11
DATE EXCAVATED 6-25-98

DEPTH (FT.)	FIELD SAMPLE / TEST NUMBER	SAMPLE TYPE	FIELD TEST TYPE	SHEAR STRENGTH (KSF)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
					4 inches TOPSOIL								0
	1	BS			Brown with gray, low plastic SILTY CLAY with some gray, silt and trace of organics	CL		23					
2.5	2	BS	V	2.8/1.4	Brown and gray, low plastic CLAYEY SILT with trace of fine sand and organics	ML		25					2.5
	3	BS						21					
	4	BS			Gray with brown, low plastic SILTY CLAY with trace of fine ,gravel	CL		24					5
					Hand auger terminated at 6.0 ft.								
7.5													7.5
10													10
12.5													12.5
15													15
17.5													17.5

WATER LEVEL:
____ NO GROUNDWATER NOTED AT TIME OF EXCAVATION
4 FT WHILE EXCAVATING
____ FT ____ HRS AFTER EXCAVATING

REMARKS:

FIGURE 1-2

TEST PIT LOG

A\ EN BOX CULVERTS — TEST PIT NO. TH-3

ı. Missouri — SHEET 1 OF 1

PROJECT NO. 980495.11

494+/- EQUIPMENT Hand auger — DATE EXCAVATED 6-25-98

SAMPLE / TEST TYPE	SHEAR STRENGTH (KSF)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
		Brown, low plastic SILTY CLAY	CL							0
		Grayish brown, fine SANDY SILTY CLAY with some fine gravel	SC		21					
		Grayish brown, low plastic CLAYEY SILT with fine sand	ML		19					2.5
		Brown and gray, low plastic CLAYEY SILT with some fine sand to fine gravel	ML		35					5
		Gray, low plastic CLAYEY SILT with trace of fine gravel	ML		29					7.5
		Hand auger terminated at 7.5 ft.								
										10
										12.5
										15
										17.5

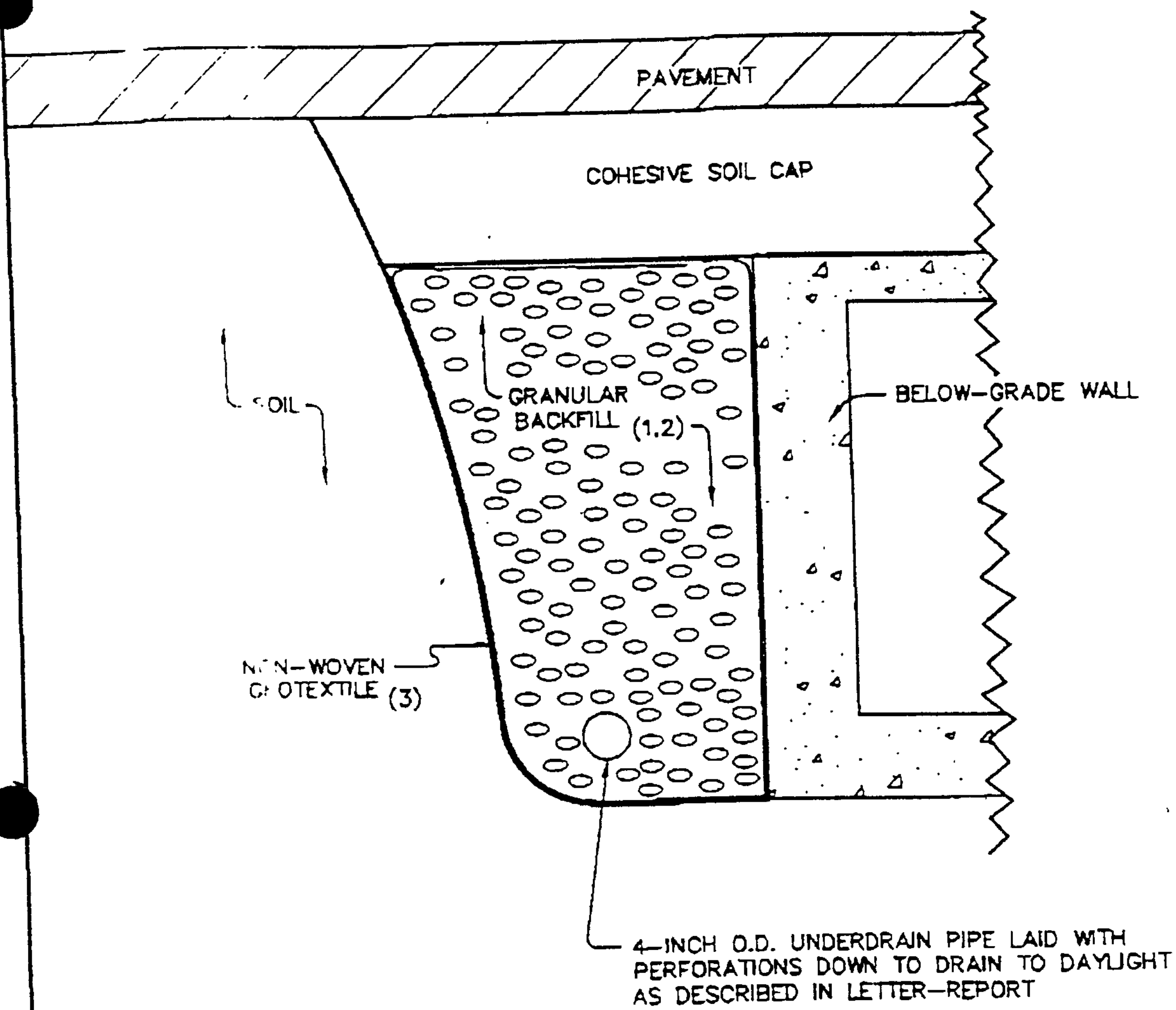
INI…ER NOTED AT EX…TION

…EXCAVATING

HRS AFTER EXCAVATING

REMARKS:

FIGURE 1-3



NOTES:

1. MINIMUM 6" FILTER MATERIAL AROUND PIPE.
2. 1" CLEAN CRUSHED LIMESTONE.
3. TYPICALLY FOUR-OUNCE PER SQUARE YARD

SCI
333 MID RIVERS MALL DRIVE
ST. PETERS, MISSOURI 63376

WINGHAVEN BOX CULVERT
O'FALLON, MISSOURI

BELOW-GRADE WALL DRAIN DETAIL

JUNE 1998

SCI NO. 980495.11

FIGURE 2

APPENDIX

SCI BORING LOG

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 595+/-
DRILLING METHOD 4" CFA

BORING NO. B-2
SHEET 1 OF 1
PROJECT NO. 97-384-411
DATE DRILLED 6-11-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (IN.)	BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					6 inches TOPSOIL								0
					Brown and gray, medium plastic SILTY CLAY	CL/CH							
2	1	SS		2 3 3				26					2
					Brown with some gray, low plastic SILTY CLAY	CL							
4	2	SS		2 2 3				28					4
6													6
	3	SS		2 2 3	Brown with some gray, medium plastic SILTY CLAY	CL/CH		25					
8													8
	4	SS		3 5 7	Brown with some gray, high plastic CLAY	CH		29					
10													10
12					Tan, WEATHERED SILTSTONE								12
14	5	SS		50/3				10					14
16													16
	6	AS			Gray with some brown, SILTSTONE								
18					Auger refusal at 17.5 ft.								18
20													20

WATER LEVEL:
- ___ NO GROUND WATER NOTED AT TIME OF DRILLING
- ___ FT WHILE DRILLING
- ___ FT ___ HRS AFTER DRILLING
- ___ FT ___ HRS AFTER DRILLING

REMARKS:

FIGURE 2-2

SCI **BORING LOG**

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 602+/- DRILLING METHOD 4" CFA

BORING NO. B-3
SHEET 1 OF 2
PROJECT NO. 97-384-411
DATE DRILLED 6-11-97

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (IN/IN)	SAMPLE BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					1 inch TOPSOIL		1						0
					Brown with some gray, medium plastic SILTY CLAY	CL/CH							
2	1	SS		3 3 4				26					2
					Brown with some gray, low plastic SILTY CLAY	CL							
4	2	SS		2 3 3				25					4
6	3	SS		2 3 4				22					6
8					Brown with some gray, high plastic CLAY	CH							8
10	4	SS		3 3 5				33					10
12													12
					Tan, high plastic SHALEY CLAY	CH							
14	5	SS		3 6 15				30					14
					Brown, WEATHERED SHALE								
16													16
18													18
	6	SS		27 50/3				10					
20													20

Continued on sheet 2 of 2

WATER LEVEL:
X NO GROUND WATER NOTED AT TIME OF DRILLING
___ FT WHILE DRILLING
___ FT ___ HRS AFTER DRILLING
___ FT ___ HRS AFTER DRILLING

REMARKS:
1) Driller's observation

FIGURE 2-3a

SCI

BORING LOG

PROJECT WINGHAVEN PROJECT SITE
LOCATION O'Fallon, Missouri
DRILLER Midwest Drilling, Inc.
SURFACE ELEVATION 602+/-
DRILLING METHOD 4" CFA

BORING NO. B-3
SHEET 2 OF 2
PROJECT NO. 97-384-411
DATE DRILLED 6-11-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (IN.)	SAMPLE BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
22					Brown, WEATHERED SHALE								22
24		SS		50/3				12					24
26					Drilling terminated at 25.0 ft.								26
28													28
30													30
32													32
34													34
36													36
38													38
40													40
42													42

WATER LEVEL:

X NO GROUND WATER NOTED AT TIME OF DRILLING
___ FT WHILE DRILLING
___ FT ___ HRS. AFTER DRILLING
___ FT ___ HRS. AFTER DRILLING

REMARKS:

FIGURE 2-3b

SCI BORING LOG

PROJECT WINGHAVEN PROJECT SITE | BORING NO. B-14
LOCATION O'Fallon, Missouri | SHEET 1 OF 1
DRILLER Midwest Drilling, Inc. | PROJECT NO. 97-384-411
SURFACE ELEVATION 494+/- | DRILLING METHOD 4" CFA | DATE DRILLED 6-9-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	RECOVERY (IN, IN)	BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					5 inches TOPSOIL		1						0
					Gray and brown, low plastic SILTY CLAY	CL							
2	1	SS		3 2 2				23					2
4	2	SS		2 2 4				22					4
6	3	SS		0 1 2				28					6
8													8
	4	SS		0 1 1				31					
10					Drilling terminated at 10.0 ft.								10
12													12
14													14
16													16
18													18
20													20

WATER LEVEL:

- ____ NO GROUND WATER NOTED AT TIME OF DRILLING
- 3.5 FT WHILE DRILLING
- ____ FT ____ HRS AFTER DRILLING
- ____ FT ____ HRS AFTER DRILLING

REMARKS:

1) Driller's observation

FIGURE 2-14

SCI BORING LOG

PROJECT: WINGHAVEN PROJECT SITE
LOCATION: O'Fallon, Missouri
DRILLER: Midwest Drilling, Inc.
SURFACE ELEVATION: 524+/-
DRILLING METHOD: 4" CFA

BORING NO.: B-21
SHEET 1 OF 1
PROJECT NO.: 97-384-411
DATE DRILLED: 6-10-97

DEPTH (FT.)	SAMPLE NUMBER	SAMPLE TYPE	RECOVERY (IN.)	BLOWS (PER 6 IN.)	DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)	LIQUID LIMIT	PLASTIC LIMIT	DEPTH (FT.)
0					3 inches TOPSOIL		1						0
					Brown and gray, low plastic CLAYEY SILT to SILTY CLAY	ML/CL							
2	1	SS		3 2 1				25					2
4	2	SS		3 2 5				22					4
					Brown and gray, low plastic SILTY CLAY with some rock fragments	CL							
6					ROCK FRAGMENTS with some brown and gray, low plastic silty clay	GC							6
	3	SS		15 18 8				21					
8													8
	4	SS		50/1	ROCK and ROCK FRAGMENTS		2						
10					Drilling terminated at 10.0 ft.								10
12													12
14													14
16													16
18													18
20													20

WATER LEVEL:
- ——— NO GROUND WATER NOTED AT TIME OF DRILLING
- — ? — FT WHILE DRILLING
- — — FT ____ HRS. AFTER DRILLING
- — — FT ____ HRS. AFTER DRILLING

REMARKS:
1) Driller's observation
2) Driller's observation

FIGURE 2-21

SCI

GEOTECHNICAL • ENVIRONMENTAL • WETLANDS • MATERIAL TESTING

333 Mid Rivers Mall Drive
St. Peters, MO 63376
Tele: (314) 397-6600
Fax: (314) 397-2600

KDG, MH FILE 980100

JUN 29 1998

FAX COVER SHEET

Please deliver the following pages to:

FIRM NAME: KDG — DATE: 6/29/98

ATTENTION: Ron Pagan — TIME: 4:00

FAX NO: 434-8280

FROM: Fred Held — SCI PROJECT NO: 97384411 + 97-385-111

PROJECT: Winghaven Subsurface Report — SCI FAX NO: 397-2600

TOTAL NO OF PAGES (INCLUDING COVER SHEET): 13

Please notify us immediately if the message is incomplete or unclear
Thank you

FAX OPERATOR: Terry Lynett

MESSAGE

ORIGINALS
will be mailed ____
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SCI

GEOTECHNICAL ENGINEERING . CONSTRUCTION MATERIALS TESTING

Preliminary Exploration of Subsurface Conditions and Foundation Recommendations

WINGHAVEN PROJECT SITE
COMMERCIAL, RESIDENTIAL, AND GOLF COURSE COMMUNITY
O'FALLON, MISSOURI

NOVUS CORPORATION
Owner

MCEAGLE
Project Manager

LOOMIS BOULTON PICKETT
Commercial Development Consultant

PICKETT, RAY & SILVER, INC.
Commercial Civil Engineer/Surveyor

STONEWOLF II
Residential Developer

KUHLMANN DESIGN GROUP, INC.
Residential/Golf Course Civil Engineer/Surveyor

July 1997

SCI № 97-384-411 & 97-385-111

SCI
333 Mid Rivers Mall Drive
Saint Peters, Missouri 63376-1516

SCI

GEOTECHNICAL ENGINEERING • CONSTRUCTION MATERIALS TESTING

July 23 1997

Mr Lloyd Schneider
c/o Mr. Paul McKee
Panc Corporation
689 Craig Road
St Louis, Missouri 63141-7124

RE Preliminary Report of Subsurface Exploration
Winghaven Project Site
Commercial, Residential, and Golf Course Community
O'Fallon, Missouri
SCI № 97-384-411 & 97-385-111

Dear Mr Schneider.

Enclosed is our report "Preliminary Exploration of Subsurface Conditions and Foundation Recommendations - WINGHAVEN PROJECT SITE - COMMERCIAL, RESIDENTIAL, AND GOLF COURSE COMMUNITY - O'FALLON, MISSOURI" dated July 1997.

We appreciate the opportunity to be of service to you on this project. If you have any questions or comments, please call.

Very truly yours,

SCI

Fred H. Held III
Project Engineer

Carl L. Jacobi, P.E.
Director of Geotechnical Services

FHH/CLJ/al, jlf
Enclosures
Three copies submitted
c Mr Lloyd Schneider; Novus Corporation (1)
Mr Joe McKee; McEagle Corporation (1)
Mr. Jack Wolfner; c/o Mr. Tom Glosier; Stonewolf II (1)
Mr. Ken Ingram; Kuhlmann Design Group, Inc. (1)
Mr Jerry Loomis; Loomis Boulton Pickett (1)
Mr. Hal Bartch; Pickett, Ray & Silver, Inc. (1)
Mr Mike Harmon; Fred Weber, Inc. (1)

3.3 Mid Rivers Mall Drive • St. Peters. MO 63376 • (314) 397-6600 • FAX (314) 397-2600
SCI Engr & Materials Testing, Inc., Fairview Heights. IL • SCI Environmental, Inc., St. Peters, MO • SCI - St. Clair, MO

Preliminary Exploration of Subsurface Conditions and Foundation Recommendations

WINGHAVEN PROJECT SITE
COMMERCIAL, RESIDENTIAL, AND GOLF COURSE COMMUNITY
O'FALLON, MISSOURI

INTRODUCTION

At the request of Mr. Paul McKee with McEagle Corporation, on behalf of Mr. Lloyd Schneider with Novus Corporation, we conducted a preliminary subsurface exploration for a future commercial residential and golf course development. The purpose of our exploration was to generally characterize and evaluate the subsurface conditions to provide general recommendations for foundations and to address other geotechnical aspects of the proposed project. Our services were provided in general accordance with our proposal dated May 20, 1997.

PROJECT AND SITE CHARACTERISTICS

The Winghaven project site is about 1100 acres and is the combination of several large properties in O'Fallon, Missouri. The site extends from Highway N on the north to Dardenne Creek on the south, and lays north and east of U.S. Highway 40/61. The eastern boundary is comprised partly by Bates Road and partly by the boundary line between the City's of O'Fallon and Dardenne Prairie. The property has frontage on Post Road near the northwestern corner and has extensive frontage along Highway 40/61, Highway N, and Bates Road. The property and surrounding road pattern is shown on the Vicinity Map, Figure 1.

In general the property slopes from north to south with drainage being tributary to Dardenne Creek, along the southernmost boundary line. A deep, wide draw drains southeastward through the south central part of the site. Numerous smaller draws drain into the major draw or directly into the floodplain. Approximately 120 acres of the property lies in the floodplain of Dardenne Creek. Total elevation difference across the project site is approximately 140 feet with the high at El. 620 and the low at El. 480

Much of the property site has remained undeveloped and appears to have been used mostly for agricultural purposes. However, the Monsanto Company owned a majority of the property and constructed an animal research facility near the center of the tract. A laboratory building and numerous buildings housing poultry and livestock were constructed for this facility. Roadways and parking areas were constructed to serve the Monsanto facilities. In the southern portion of the property along Dardenne Creek, a wildlife theme park was once proposed and some preliminary grading and development was undertaken to create the park. This involved a manmade lake near the southeast comer of the property, and some grading was performed in that general area.

A concept plan which you provided indicates the tract will be developed for both residential and business usage in the higher portions of the property. This will entail single-family and multi-family residential areas and several business park areas, offering a wide variety of lot size for industrial and commercial development. A golf course is proposed in the floodplain area near the south property line and in the major draw. Much of the residential development will surround the golf course to the north. Most of the commercial development will be near Highway 40/61. A major roadway is planned through the central and northern portions of the property which will connect Highway 40/61 with Highway N and will eventually extend northward to connect with the Page Avenue extension (Highway D). This development scheme is a concept plan at this time, and numerous changes will likely be made in further planning for the phased development of both the residential and business portions of the property.

We understand the property has been used for agricultural purposes and that your intention is to continue farming the property as the development is phased over several years.

FIELD EXPLORATION

The field exploration for the residential and commercial developments consisted of drilling forty-seven borings at the approximate locations shown on the Site Plan. Three proposed borings (B25, B120, and B121) were inaccessible, and therefore, not drilled. B1 through B15 were drilled for proposed commercial roadways. B16 through B29, excluding B25, were drilled in proposed commercial development areas. B101 through B119 were drilled in areas of proposed residential or golf course development.

The boring locations were established in the field by SCI engineer relative to existing roads, improvements, and topographic features. Approximate boring elevations were determined from Topographic Maps derived from aerial surveys prepared by Walker and Associates, Inc., dated March 21, 1996.

The borings were drilled on June 7 through 14, 1997. Continuous-flight augers powered by a CME-550 drill rig were used to advance the borings to predetermined depths of 10 to 30 feet or to auger refusal at depths ranging from 8½ to 44 feet. Standard penetration tests were performed at 2½- and 5-foot intervals throughout the soil overburden. The standard penetration test provides a guide to soil strength and a disturbed sample for laboratory testing. The nature and thickness of the soils encountered and the results of the field sampling and testing are shown on the Borings Logs, Figures 2-1 through 2-29 (commercial development and roads) and Figures 3-1 through 3-19 (residential and golf course development). Table 1 summarizes some of the drilling information.

LABORATORY TESTING

The samples obtained were described and classified in our laboratory by a soil technician using manual-visual methods. Moisture contents were determined for each of the samples. The results of these laboratory tests are shown on the Boring Logs.

SOIL PROFILE

Presented herein is the general description of the soils encountered. Detailed information regarding the soil type and interpretive soil stratigraphy is presented on the Boring Logs. A Boring Log Legend is included as Figure 2 to aid in the interpretation of the Boring Logs.

Two and three feet of fill was encountered in B8 and B19, respectively. In general, medium-stiff to very-stiff residual soils and glacial tills were found in the upland parts of the property and soft alluvial soils were found in the lowland or floodplain areas. The upland soils were generally capped with wind blown silt that has weathered to silty clay (modified loess). Topsoil 1 to 6 inches thick was usually underlain by a layer of low plastic silty clay that was underlain by high plastic clay. Some of the borings did not encounter the low plastic silty clay soil layer. The high plastic clays generally consisted of glacial tills or residual soils with various amounts of sand, gravel and rock fragments that generally increased with depth.

Auger refusal was encountered in 12 of the borings at depths ranging from 8½ to 44 feet. Excluding the high and low of 44 and 8½ feet, the average refusal depth was about 16 feet in the borings that refused. However, very rocky soils were encountered at relatively shallow depths in most of the borings. The materials encountered just before refusal were weathered siltstones, gravelly clays, rock and fragments, or clayey shales. Auger refusal is a designation applied to any material which cannot be further penetrated by the power auger. This material is usually indicative of a very hard or very dense material, such as boulders or the upper surface of bedrock. Rock coring was beyond the scope of this exploration, therefore, the character and continuity of the refusal materials could not be determined.

Groundwater was encountered in five of the borings generally in the lowland areas (B11, B14, B15, B29, and B110) at depths of 11½ to 14 feet, and one upland area (B118) at a depth of 16 feet. The other borings were dry upon completion of drilling. In relatively impervious soils, a suitable estimate of the groundwater level may not be possible, even after several days of observation. The groundwater table will fluctuate throughout the year depending on climate and rainfall conditions. It is not anticipated that groundwater will influence the construction phase of projects in the upland areas. However, excavations in the lowland areas may experience construction problems.

GENERAL DESIGN CONSIDERATIONS AND RECOMMENDATIONS

Heavily loaded commercial buildings may require deep foundations end bearing on rock due to concentrated column loads that make spread footing foundations uneconomical. The upland areas are conducive to the use of drilled piers. Estimating allowable bearing pressures for rock bearing foundations require rock coring which was beyond the scope of this exploration.

Shallow spread foundations will be suitable for support of light to moderately loaded residences and commercial buildings. Allowable bearing pressures for structures in upland areas will likely be 2,000 to 3,000 pounds per square foot (psf). Allowable bearing pressures for structures in lowland areas on soft soils will be about 1,200 to 1,500 psf. Allowable bearing pressures may be increased in the lowland areas if sufficient depths of fill are placed.

Settlements of foundations can be less than 1-inch excluding settlements induced by filling. Fill settlements should be minor in the upland areas and substantially occur in about 30 to

60 days or less

However, soft and compressible soils were encountered in the lowland areas. It is our opinion that excessive total and differential settlements will occur beneath column and wall loads supported on these natural, soft soils, if precautions are not taken to reduce the post-construction settlement. Shallow foundations with low contact pressures, however, should be suitable for support of most of the proposed improvements in the lowland areas with little reworking of the soil. Moderate contact pressures will require a sufficient thickness of compacted structural fill in the building area. The thickness of fill will be determined by the structural loading. Surcharging can also be used to reduce post-construction settlement if the final grades for the proposed improvements must remain at or near existing grades or as a means to accelerate consolidation due to the weight of fill.

In the lowland areas, placing fill to raise the site above existing grade will result in settlement as consolidation of the soft, underlying soils occurs. A delay in construction is anticipated to allow some or most of that settlement to occur prior to construction. The delay recommended will be based on the building location, building loads and the amount of fill placed in this area. We anticipate this delay to be about 30 to 120 days. Deep fill in the lowland areas should be monitored with settlement plates to assess when most of the settlement has occurred and construction can continue.

Mat and deep foundations are also acceptable foundation types for construction in the lowland areas, however, we anticipate these options will not be economical compared to the suggested remediation. A deeper exploration will be required if deep foundations are to be considered.

Although only a small amount of existing fill was encountered in our limited exploration, other existing fill will likely be encountered on the site due to existing development. Further explorations will be required to better identify the extent of existing fill located on the site. In general, existing fill located in areas to be developed should be removed to naturally occurring soils and replaced with properly compacted structural fill.

<u>Seismic Design Considerations</u>. The 1996 BOCA National Building Code requires the structural design of the proposed structures. A site coefficient is required for the calculation of minimum earthquake design forces. The coefficient is a function of the soil type, consistency,

and bedrock depth. The site can be essentially divided into two areas seismically, uplands and lowlands. Due to the depth to rock and the relatively stiff consistency of the soil in the uplands, the soil-profile type is S_1 and the upland site coefficient (S) is 1.0. The lowlands, which are generally in the southern part of the site and in some of the wide draws, do not fit any of the BOCA standard soil-profile types. Therefore, as required by the code, the soil-profile type is S_4 and the lowland site coefficient (S) is 2.0.

<u>High Plastic Clay Considerations</u>. High plastic clay soils are present at depths which may impact construction. High plastic clay soils have the potential for volume change with fluctuations in soil moisture content. This volume change is normally evidenced by the heaving and cracking of concrete floor slabs and, in severe cases, by the movement and cracking of footings and foundation walls. Remedial measures, if necessary to avoid such distress, may require overexcavation and replacement of these materials with low plastic silty clay soils or crushed stone to a minimum depth of 2 or 3 feet below the base of footings and floor slabs.

Heave of soils with a marginal potential for soil heave can be reduced by not allowing the soils to desiccate prior to pouring the concrete slab. Maintaining the natural moisture content can be accomplished by placing a thin polyethylene vapor barrier over these soils immediately after excavation. Other measures that may be utilized to reduce this problem include, but are not limited to the addition of extra steel reinforcement in the top and bottom of foundation walls, the "floating" of floor slabs such that they are not structurally connected to or bonded to foundation walls or interior columns, the placement of foundation drains to reduce the possibility of water reaching the subgrade soils, and the placement of woven wire mesh to reinforce the floor slab.

<u>Site Drainage and Grading</u>. Positive site drainage should be provided to reduce infiltration of surface water around the perimeter of the buildings, residences, and beneath the floor slabs. All grades should be sloped away from the structures, and roof and surface drainage should be collected and discharged such that water is not permitted to infiltrate the backfill of the structures.

GENERAL SITE DEVELOPMENT RECOMMENDATIONS AND CONSIDERATIONS

Auger refusal was encountered at depths of 8½ and 14 feet in B9 and B8, respectively. Rock excavation will likely be required to achieve the proposed grades in those areas. The central part of the site and several ridge tops around the site will likely require rock excavation for general grading, utility trenches, and/or basement excavations. The rocky clay materials encountered prior to auger refusal can usually be excavated in open cuts, sometimes using large dozers equipped with rippers. However, large rock fragments, intact rock ledges or boulders are sometimes encountered in soils of this type. These materials can also prove very difficult in trench excavations and may require blasting. Further exploration can help to delineate the extent of rock excavation required for specific road and utility alignments, and building sites. A contingency fund should be established for rock excavation.

The surface soils at the site are silty. Such soils may exhibit a significant loss in strength when they become saturated and disturbed, as may occur due to trafficking of construction equipment. This may complicate construction of paved streets, parking areas, and foundations.

Erosion control measures should be taken during the general grading to prevent the transportation of these soils by surface runoff onto adjoining properties. Timely sodding or seeding of the sloped areas will reduce this potential problem.

Site Preparation. All existing vegetation in the cut and fill areas should be removed prior to placing fill. Trees and brush may be burned on site as approved by local ordinances. Burn pits should be located outside of building areas, street areas, or areas designed as slopes steeper than 1 vertical to 5 horizontal. Stumps should be removed from the site or buried in locations approved by the geotechnical engineer.

Soft soils are likely to be encountered in the bottoms of the draws, drainage swales, and in the floodplain or lowland areas. These soils should be removed to firm materials before placement of fill. The existing ponds should be drained, and soft soils removed from the bottom before placement of fill. If removal of soft soils is impractical due to their excessive depth, they should be stabilized or "bridged over" in a manner approved by SCI.

In areas to be developed, the existing buildings and related below-grade components must be properly demolished and the debris removed from the site. Existing foundation walls, cisterns, septic fields and associated backfill must be removed entirely along with footings and below-grade utilities. Masonry rubble generated by the demolition may be placed in the deeper portions of fill areas as approved by a representative of SCI. Where the removal creates excavations below the final proposed grade, the excavations should be brought to final grade with engineered fill.

Our borings do not indicate any highly organic topsoil of any significant thickness on this site. However, if such organic soils are encountered, they should be stripped from the site and stockpiled for later use in lawn or landscaped areas. After stripping, the subgrade and fill areas should be scarified and proofrolled to a minimum depth of 1-foot and to a minimum dry density of 87 percent of the maximum dry density as determined by the modified Proctor compaction test (ASTM D 1557).

Fill Materials and Compaction. The available low to medium plastic silty clay soils encountered at the site may be used as structural fill. Large rubble pieces due to the demolition of the existing structures, in excess of three inches, should not be used as structural fill.

We recommend that all fill placed in building areas near the footing and floor slab elevations have a liquid limit less than 45. Acceptable non-organic fill soils include materials designated CL, ML, CL ML, SP, SW, GP, and GW soils by ASTM D 2487. Where practical, high plastic soils should be placed in deeper portions of fill areas or in landscaped areas. If high plastic clays are placed or are located within three feet of footing or floor slab elevations, remediation may be recommended. Such measures could range from ensuring that the soils do not dry out during construction to overexcavating below structural members and slabs.

Fill should be placed in horizontal lifts not exceeding 8 inches in loose thickness and compacted with a sheepsfoot or tamping roller to minimum dry density of 90 percent of the maximum dry density as determined by the modified Proctor compaction test (ASTM D 1557). Higher densities may be required for deep fills.

Some of the fill materials at the project site may be rocky clay or shaley materials that are traditionally not tested by conventional nuclear densimeter or drive-tube methods. Rock fragments that are ripped or blasted would also fall into that category. Such materials are typically compacted by several passes of a heavy vibratory roller The number of passes and minimum roller weight should be determined in the field. Density tests on the rocky material are generally not performed due to the varying quantities of soil and rock materials at any one location Poorly compacted areas can generally be detected by observing the fill subgrade during passing of a loaded scraper or compactor over the fill area. Any poorly compacted areas detected should be recompacted with additional passes of the vibratory roller.

Cut and Fill Slopes. We recommend that all cut and fill slopes be no steeper than 1 vertical to 3 horizontal Properly compacted fill slopes and cut slopes of less than 20 feet in height should be stable at this inclination. SCI should evaluate the stability of slopes higher than 20 feet Slopes to receive fill which are steeper than 1 vertical to 5 horizontal should be benched prior to placement of fill. Benching will provide level surfaces for compaction and avoid the development of an inclined plane of weakness between the virgin soils and compacted fill. The benches should be spaced such that the maximum height of cut at the up-slope ridge of the bench is 5 feet

PAVEMENT SUBGRADE CONSIDERATIONS

Pavement design recommendations are beyond the scope of work for this report. However, certain aspects should be considered in the design and construction of the paved areas. We suggest that the soil subgrade be compacted to a dry density of at least 90 percent of the material's modified Proctor maximum dry density (ASTM D 1557). The crushed rock base should be compacted to 92 percent of the same criteria. The asphaltic surface course and Portland Concrete pavements should be checked during placement to verify compliance with the specifications.

The natural soils encountered on the site, to a depth of approximately 3 feet below the present ground surface, are silty and exhibit a significant loss of strength when they become saturated and disturbed. The strength of these compacted, silty soils is dependent on the moisture content Significant construction problems may be incurred if pavement construction takes place in the wetter portions of the year (November through April). Special measures may be required to facilitate construction during these periods.

The performance of a pavement section is dependent on the design life, traffic loads, subgrade strength, drainage characteristics, and the desired maintenance level. Pavement recommendations and/or materials testing services can be provided on request.

ADDITIONAL EXPLORATION PROGRAM

Many items should be addressed in one or more detailed subsurface explorations for the proposed development. Detailed explorations should be based on proposed grades, the site layout, and specific building clusters, or individual large or heavily loaded buildings. These explorations will include additional and possible deeper borings and more extensive laboratory testing. The detailed explorations should address the following:

- Recommendations for foundation support.
- Seismic coefficients for building design according to the BOCA code
- Estimation of the shrink/swell potential of subgrade soils.
- Site development recommendations.
- Geotechnical construction considerations.
- Anticipated settlement based on general soil characteristics or based on laboratory consolidation tests.
- Influence of ground water on design and construction.
- Locations and descriptions of existing fill materials within the proposed building areas, if encountered.
- Structural fill considerations.
- Suitability of on-site soils for use as structural fill.
- Engineering criteria for placement of structural fill.
- Pavement subgrade recommendations.
- Lateral earth pressures for the design of below grade and retaining walls.
- Recommendations for design and construction of slopes.
- Provide lake and detention basin and dam design recommendations.
- Recommend a construction monitoring program.

LIMITATIONS

The recommendations provided herein are preliminary and are based on the information obtained at forty-seven specific drilling locations within the project area and regionally accepted practice. These recommendations should be reevaluated after a more detailed exploration is performed.

BOX CULVERT DESIGN

JVS 15Jul98

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OM
OM                    CULVERT BR#A100
OM                    File: A106LRF1.pol
OM                    Date: 15Jul98
OM                    Golf Cart Design
OM                    Single Box Culvert (No Haunch)
OM                    1-Cell Box 10'x  7'
OM                    Load Factor Design
OM                    Rigid Frame Method
OM                    Top and Bot Slab Different
OM
OM                    Minumum Fill Ht Condition (1.0 Ft)
OM
STDLOD      2, 0, 0, 0, 0
SWPRES      1, 2, 60, 15, 62.4
BOXDIM      1, 1, 10,  7, 1, 10
SLBTHK      1, 11.5, 11, 8, 8, 1111
H&SKEW      1, 90, 90, 0, 0, 0
REEBAR      18, 9, 1, 11, 4, .016
CONCOV      2, 3, 2, 2, .5, .5
MATPRP      120, 60, 24, 3, 0, 0
PRTCTL      1, 1, 1, 0
F&HCTL      1, 1, 1
DESCTL      1, 0, 1, 0, 0, 9
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15 July 98

CONSTANT DATA

STANDARD LIVE LOAD				DESIGN METHOD		PRINT CONTROL		
TRUCK CODE	OMIT L.L.	STRESS 0-FILL	OVERLD AXLE	SERVICE LOAD	LOAD FACTOR	10th Pt MOMENT	INFL LINE	LOC. NEG MOMENT
HS20	NO	NO	0.	NO	YES	YES	YES	1.00

MATERIAL PROPERTIES						THICKNESS INCREMENTS	
SOIL WEIGHT	STEEL Fy	STEEL Fs	CONCRETE STRENGTH	CONCRETE SHEAR	CON.SHEAR W/ STIRRUP	SLAB	WALL
120.	60000.	24000.	3000.	0.	0.	0.50	0.50

CONCRETE COVER EXTERIOR TOP SLAB	EXTERIOR BOT SLAB	EXTERIOR WALL	INTERIOR (ALL)	DESIGN SAME THICKNESS SLAB	DESIGN SAME THICKNESS WALL	PRINT BAR TABLE	REINFORCING BAR SPACING MAX	BAR SPACING MIN	BAR SIZE MAX	BAR SIZE MIN
2.00	3.00	2.00	2.00	NO	NO	YES	18.0	9.0	11	4

CRACK PARAMETER Z = 98.0
MODULAR RATIO N = 9.0

SUPERIMPOSED DEAD LOADS UNIFORM LOAD	CONCENTRATED LOAD WT.	X1	WT.	X2	WT.	X3	SPECIAL LIVE LOADS WHEEL LOAD	FILL HEIGHT	OVERSTRESS FACTOR
0.000	0.00	0.0	0.00	0.0	0.00	0.0	0.000	0.000	1.00

DATA FOR STRUCTURE NUMBER 1

CULVERT TYPE	SPAN LENGTH	CLEAR HEIGHT	DESIGN FILL	CENTERLINE LENGTH	SKEW LEFT	SKEW RIGHT	FLOOR TYPE
SINGLE	10.00	7.00	1.00	10.00	90	90	FULL

SLAB THICKNESSES TOP SLAB	BOT. SLAB	EXT. WALL	INT. WALL	LIVE LOAD SURCHARGE	SOIL PRESSURE MAX	SOIL PRESSURE MIN	WATER PRESSURE
11.50F	11.00F	8.00F	8.00F	2.00	60.0	15.0	62.4

TOP HAUNCH HEIGHT	BOTTOM HAUNCH HEIGHT	RIGID OR FLEXIBLE	CHECK MILITARY	BAR SPACING INCREMENT
0.0	0.0	RIGID	NO	1 INCH

BOTH HEADWALLS ELIMINATED.

***** LOAD FACTOR DESIGN *****
***** STRESSES AT CRITICAL SECTIONS *****

*** MAXIMUM REINFORCEMENT RATIO (As/bd) = .016

MEMBER NUMBER = 1
MEMBER THICKNESS = 8.00
EXTERIOR WAL

	-MOMENT-	-AXIAL- FORCE	-SHEAR-	-Po-	-Mu-	-Mbal-	-Pbal-	-STEEL- AREA	-SHEAR- STRESS	-ALL.- MOM.	-ALL.- SHEAR
LT	-7.1	1.0	2.5	191.2	7.1	16.0	53.2	0.30	48.2	7.3	109.5
MID	1.3	9.8	0.9	186.8	4.6	15.0	58.5	0.19	17.9	6.3	109.5
MID-	-6.5	6.9	0.9	190.1	6.5	16.0	54.5	0.32	17.9	7.7	109.5
RT	-6.8	6.4	1.5	190.7	6.8	16.0	53.8	0.35	27.6	7.9	109.5

MEMBER NUMBER = 2
MEMBER THICKNESS = 11.50
TOP SLAB

	-MOMENT-	-AXIAL- FORCE	-SHEAR-	-Po-	-Mu-	-Mbal-	-Pbal-	-STEEL- AREA	-SHEAR- STRESS	-ALL.- MOM.	-ALL.- SHEAR
LT	-5.6	1.6	9.6	268.5	10.8	38.0	103.7	0.28	104.5	11.3	110.5
MID	24.4*	-0.2	4.9	283.5	24.4	43.0	84.7	0.75	52.9	24.3	109.5
RT	-5.6	1.6	9.6	268.5	10.8	38.0	103.7	0.28	104.5	11.3	110.5

MEMBER NUMBER = 4
MEMBER THICKNESS = 11.00
BOTTOM SLAB

	-MOMENT-	-AXIAL- FORCE	-SHEAR-	-Po-	-Mu-	-Mbal-	-Pbal-	-STEEL- AREA	-SHEAR- STRESS	-ALL.- MOM.	-ALL.- SHEAR
LT	-5.6	2.5	5.7	256.9	8.6	31.0	84.7	0.26	74.9	9.3	109.5
MID	19.9	-0.9	0.1	270.9	21.8	38.0	80.0	0.64	0.7	21.6	109.5
RT	-5.6	2.5	5.7	256.9	8.6	31.0	84.7	0.26	74.9	9.3	109.5

NOTE: ASTERISK IMPLIES DESIGN VALUES EXCEED CRITICAL VALUES

***** ATTENTION: OVERSTRESS DUE TO FIXED THICKNESS

A CORNER BAR(T)				A CORNER BAR(B)				A TSLAB+		A TSLAB-	
H	V	SZ	SPG	H	V	SZ	SPG	SZ	SPG	SZ	SPG
47	26	5	9.0	38	31	6	9.0	8	9.0	0	0.0

A BSLAB+		A BSLAB-		B EXTIN		B EXTOUT		B INTWL		C1
SZ	SPG	SZ	SPG	SZ	SPG	SZ	SPG	SZ	SPG	BARS
8	9.0	0	0.0	5	12.0	5	9.0	0	0.0	40

** T.SLAB *	B.SLAB *	WALL *	INWALL ***	VOLUME ***	STEEL **
IN	IN	IN	IN	CY/FT	LB/FT
11.50	11.00	8.00	0.00	1.133	179

** REINFORCING STEEL BAR SCHEDULE **

* LOCATN *		BAR	* NO.	* SZ	* TYP	* LNGTH *	WT.	* H LEG	* V LEG
TOP SLAB POSV	MAIN	A100	14	8	STR	10-11	408		
BOT SLAB POSV	MAIN	A200	14	8	STR	10-11	408		
CORNER (TOP)		A1	28	5	6	6- 1	178	3-11	2- 2
CORNER (BOTTOM)		A2	28	6	6	5- 9	242	3- 2	2- 7
EXTWALL IN		B1	20	5	STR	8- 4	174		
EXTWALL OUT		B2	28	5	STR	6- 4	185		
LONGTD	(1)	C1	40	4	STR	9- 8	258		
						TOTAL	1853		

***** SPLICE LENGTHS CHART *****

BAR	SIZE	SPLICE LENGTH
A200	8	3-11
B1	5	1- 8
C1	4	2- 2

** MOMENT * AXIAL FORCE * SHEAR FOR LOAD FACTOR DESIGN AT TENTH POINT **

M-PT	+MOMENT	-MOMENT	+A.F.	-A.F.	+SHEAR	-SHEAR
1- 0	-0.901	-8.287	3.741	1.037	3.259	-1.008
1- 1	-1.393	-6.197	3.741	1.037	2.636	-0.735
1- 2	-0.233	-6.278	12.712	8.859	2.062	-0.496
1- 3	0.660	-6.369	11.266	7.881	1.537	-0.289
1- 4	1.155	-6.467	9.796	6.888	1.062	-0.115
1- 5	1.293	-6.399	9.796	6.888	0.947	-0.285
1- 6	1.112	-6.298	9.057	6.388	1.055	-0.662
1- 7	0.651	-6.090	9.057	6.388	1.131	-0.990
1- 8	0.131	-5.835	9.057	6.388	1.174	-1.269
1- 9	0.517	-6.316	9.057	6.388	1.184	-1.499
1-10	1.450	-7.513	9.057	6.388	1.161	-1.679
2- 0	1.450	-7.513	-0.327	1.670	10.739	1.031
2- 1	9.506	-1.281	-0.830	1.532	9.608	0.361
2- 2	15.923	-0.262	-0.573	1.430	8.446	-0.786
2- 3	20.587	0.288	-0.388	1.430	7.262	-1.959
2- 4	23.418	0.618	-0.278	1.430	6.063	-3.152
2- 5	24.367	0.728	-0.241	1.430	4.856	-4.356
2- 6	23.418	0.618	-0.278	1.430	3.650	-5.563
2- 7	20.587	0.288	-0.388	1.430	2.451	-6.767
2- 8	15.923	-0.262	-0.573	1.430	1.267	-7.960
2- 9	9.506	-1.281	-0.830	1.532	0.105	-9.133
2-10	1.450	-7.513	-0.327	1.670	-1.026	-10.281
4- 0	-0.901	-7.503	-0.088	2.588	6.977	2.063
4- 1	3.972	-1.384	-0.881	2.375	5.593	1.651
4- 2	10.963	0.156	-0.922	2.348	4.209	1.238
4- 3	15.935	1.257	-0.922	2.348	2.825	0.825
4- 4	18.913	1.917	-0.922	2.348	1.441	0.413
4- 5	19.921	2.137	-0.936	2.339	0.057	-0.057
4- 6	18.913	1.917	-0.922	2.348	-0.413	-1.441
4- 7	15.935	1.257	-0.922	2.348	-0.825	-2.825
4- 8	10.963	0.156	-0.922	2.348	-1.238	-4.209
4- 9	3.972	-1.384	-0.881	2.375	-1.651	-5.593
4-10	-0.901	-7.503	-0.088	2.588	-2.063	-6.977

***** INFLUENCE LINES FOR MOMENT *****

***** MEMBER NO. 1 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
100	-0.42	-0.37	-0.31	-0.26	-0.20	-0.15	-0.09	-0.04	0.02	0.07	0.13
105	-0.40	-0.36	-0.32	-0.28	-0.24	-0.20	-0.16	-0.12	-0.08	-0.04	0.00
110	-0.39	-0.36	-0.33	-0.30	-0.28	-0.25	-0.22	-0.19	-0.16	-0.14	-0.11
115	-0.37	-0.35	-0.33	-0.32	-0.30	-0.29	-0.27	-0.25	-0.24	-0.22	-0.20
120	-0.35	-0.34	-0.34	-0.33	-0.32	-0.32	-0.31	-0.30	-0.30	-0.29	-0.28
125	-0.33	-0.33	-0.33	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.35
130	-0.31	-0.32	-0.33	-0.34	-0.35	-0.35	-0.36	-0.37	-0.38	-0.39	-0.40
135	-0.30	-0.31	-0.32	-0.34	-0.35	-0.36	-0.38	-0.39	-0.40	-0.42	-0.43
140	-0.28	-0.30	-0.32	-0.33	-0.35	-0.37	-0.38	-0.40	-0.42	-0.44	-0.45
145	-0.27	-0.29	-0.31	-0.33	-0.35	-0.37	-0.39	-0.41	-0.43	-0.44	-0.46
150	-0.26	-0.28	-0.30	-0.32	-0.34	-0.36	-0.38	-0.40	-0.42	-0.44	-0.46
155	-0.25	-0.27	-0.29	-0.31	-0.33	-0.35	-0.37	-0.39	-0.41	-0.43	-0.45
160	-0.25	-0.27	-0.28	-0.30	-0.32	-0.34	-0.35	-0.37	-0.39	-0.41	-0.42
165	-0.25	-0.26	-0.28	-0.29	-0.30	-0.32	-0.33	-0.35	-0.36	-0.37	-0.39
170	-0.26	-0.27	-0.27	-0.28	-0.29	-0.30	-0.31	-0.32	-0.32	-0.33	-0.34
175	-0.27	-0.27	-0.27	-0.27	-0.27	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28
180	-0.29	-0.28	-0.27	-0.27	-0.26	-0.25	-0.25	-0.24	-0.23	-0.23	-0.22
185	-0.31	-0.29	-0.28	-0.26	-0.24	-0.23	-0.21	-0.19	-0.18	-0.16	-0.15
190	-0.34	-0.31	-0.29	-0.26	-0.23	-0.20	-0.17	-0.15	-0.12	-0.09	-0.06
195	-0.38	-0.34	-0.30	-0.26	-0.22	-0.18	-0.14	-0.10	-0.06	-0.01	0.03
200	-0.43	-0.37	-0.32	-0.26	-0.21	-0.15	-0.10	-0.04	0.01	0.07	0.12

***** MEMBER NO. 2 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
100	0.13	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.12
105	0.00	0.48	0.43	0.38	0.33	0.28	0.23	0.18	0.13	0.08	0.03
110	-0.11	0.86	0.75	0.65	0.55	0.45	0.35	0.24	0.14	0.04	-0.06
115	-0.20	0.71	1.09	0.93	0.78	0.63	0.47	0.32	0.16	0.01	-0.15
120	-0.28	0.58	1.44	1.23	1.02	0.82	0.61	0.40	0.20	-0.01	-0.22
125	-0.35	0.46	1.27	1.54	1.28	1.02	0.76	0.50	0.24	-0.02	-0.28
130	-0.40	0.36	1.11	1.86	1.55	1.23	0.92	0.60	0.29	-0.03	-0.34
135	-0.43	0.27	0.96	1.66	1.83	1.46	1.09	0.72	0.35	-0.02	-0.39
140	-0.45	0.19	0.83	1.48	2.12	1.69	1.27	0.85	0.42	0.00	-0.42
145	-0.46	0.12	0.71	1.30	1.89	1.94	1.47	0.99	0.51	0.03	-0.45
150	-0.46	0.07	0.60	1.14	1.67	2.20	1.67	1.14	0.60	0.07	-0.46
155	-0.45	0.03	0.51	0.99	1.47	1.94	1.89	1.30	0.71	0.12	-0.46
160	-0.42	0.00	0.42	0.85	1.27	1.69	2.12	1.48	0.83	0.19	-0.45
165	-0.39	-0.02	0.35	0.72	1.09	1.46	1.83	1.66	0.96	0.27	-0.43
170	-0.34	-0.03	0.29	0.60	0.92	1.23	1.55	1.86	1.11	0.36	-0.40
175	-0.28	-0.02	0.24	0.50	0.76	1.02	1.28	1.54	1.27	0.46	-0.35
180	-0.22	-0.01	0.20	0.40	0.61	0.82	1.02	1.23	1.44	0.58	-0.28
185	-0.15	0.01	0.16	0.32	0.47	0.63	0.78	0.93	1.09	0.71	-0.20
190	-0.06	0.04	0.14	0.24	0.35	0.45	0.55	0.65	0.75	0.86	-0.11
195	0.03	0.08	0.13	0.18	0.23	0.28	0.33	0.38	0.43	0.48	0.00
200	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13

***** MEMBER NO. 4 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
100	0.42	-0.06	-0.43	-0.70	-0.86	-0.91	-0.86	-0.70	-0.43	-0.05	0.43
105	0.40	-0.08	-0.45	-0.72	-0.89	-0.94	-0.89	-0.73	-0.47	-0.10	0.38
110	0.39	-0.10	-0.48	-0.75	-0.91	-0.97	-0.92	-0.77	-0.50	-0.13	0.34

115	0.37	-0.12	-0.50	-0.77	-0.94	-0.99	-0.95	-0.79	-0.53	-0.16	0.31
120	0.35	-0.14	-0.52	-0.79	-0.96	-1.02	-0.97	-0.81	-0.55	-0.19	0.29
125	0.33	-0.16	-0.54	-0.81	-0.97	-1.03	-0.99	-0.83	-0.57	-0.21	0.27
130	0.31	-0.17	-0.55	-0.82	-0.99	-1.05	-1.00	-0.85	-0.59	-0.22	0.26
135	0.30	-0.19	-0.57	-0.84	-1.00	-1.06	-1.01	-0.86	-0.59	-0.23	0.25
140	0.28	-0.20	-0.58	-0.85	-1.01	-1.07	-1.02	-0.86	-0.60	-0.23	0.25
145	0.27	-0.21	-0.59	-0.86	-1.02	-1.07	-1.02	-0.86	-0.60	-0.23	0.25
150	0.26	-0.22	-0.59	-0.86	-1.02	-1.07	-1.02	-0.86	-0.59	-0.22	0.26
155	0.25	-0.23	-0.60	-0.86	-1.02	-1.07	-1.02	-0.86	-0.59	-0.21	0.27
160	0.25	-0.23	-0.60	-0.86	-1.02	-1.07	-1.01	-0.85	-0.58	-0.20	0.28
165	0.25	-0.23	-0.59	-0.86	-1.01	-1.06	-1.00	-0.84	-0.57	-0.19	0.30
170	0.26	-0.22	-0.59	-0.85	-1.00	-1.05	-0.99	-0.82	-0.55	-0.17	0.31
175	0.27	-0.21	-0.57	-0.83	-0.99	-1.03	-0.97	-0.81	-0.54	-0.16	0.33
180	0.29	-0.19	-0.55	-0.81	-0.97	-1.02	-0.96	-0.79	-0.52	-0.14	0.35
185	0.31	-0.16	-0.53	-0.79	-0.95	-0.99	-0.94	-0.77	-0.50	-0.12	0.37
190	0.34	-0.13	-0.50	-0.77	-0.92	-0.97	-0.91	-0.75	-0.48	-0.10	0.39
195	0.38	-0.10	-0.47	-0.73	-0.89	-0.94	-0.89	-0.72	-0.45	-0.08	0.40
200	0.43	-0.05	-0.43	-0.70	-0.86	-0.91	-0.86	-0.70	-0.43	-0.06	0.42

***** INFLUENCE LINES FOR SHEAR AND AXIAL FORCE *****

***** MEMBER NO. 1 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	A.F.
100	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	-1.00
105	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-0.95
110	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	-0.90
115	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.86
120	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.81
125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.76
130	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.71
135	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.65
140	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.60
145	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.55
150	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.50
155	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.45
160	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.40
165	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.35
170	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.29
175	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.24
180	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.19
185	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.14
190	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	-0.10
195	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-0.05
200	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.00

***** MEMBER NO. 2 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	A.F.
100	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
105	0.95	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	0.05
110	0.90	0.90	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	0.03
115	0.86	0.86	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	0.02
120	0.81	0.81	0.81	-0.19	-0.19	-0.19	-0.19	-0.19	-0.19	-0.19	-0.19	0.01
125	0.76	0.76	0.76	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	0.00
130	0.71	0.71	0.71	0.71	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.01
135	0.65	0.65	0.65	0.65	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.02
140	0.60	0.60	0.60	0.60	0.60	-0.40	-0.40	-0.40	-0.40	-0.40	-0.40	-0.02
145	0.55	0.55	0.55	0.55	0.55	-0.45	-0.45	-0.45	-0.45	-0.45	-0.45	-0.02
150	0.50	0.50	0.50	0.50	0.50	0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.03
155	0.45	0.45	0.45	0.45	0.45	0.45	-0.55	-0.55	-0.55	-0.55	-0.55	-0.02
160	0.40	0.40	0.40	0.40	0.40	0.40	0.40	-0.60	-0.60	-0.60	-0.60	-0.02
165	0.35	0.35	0.35	0.35	0.35	0.35	0.35	-0.65	-0.65	-0.65	-0.65	-0.02
170	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	-0.71	-0.71	-0.71	-0.01
175	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	-0.76	-0.76	-0.76	0.00
180	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	-0.81	-0.81	0.01
185	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	-0.86	-0.86	0.02
190	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	-0.90	0.03
195	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-0.95	0.05
200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07

***** MEMBER NO. 4 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	A.F.
100	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.07
105	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.05
110	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.03

115	-0.51	-0.41	-0.31	-0.21	-0.11	-0.01	0.09	0.19	0.29	0.39	0.49	-0.02
120	-0.51	-0.41	-0.31	-0.21	-0.11	-0.01	0.09	0.19	0.29	0.39	0.49	-0.01
125	-0.51	-0.41	-0.31	-0.21	-0.11	-0.01	0.09	0.19	0.29	0.39	0.49	0.00
130	-0.51	-0.41	-0.31	-0.21	-0.11	-0.01	0.09	0.19	0.29	0.39	0.49	0.01
135	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
140	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
145	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
150	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.03
155	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
160	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
165	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
170	-0.49	-0.39	-0.29	-0.19	-0.09	0.01	0.11	0.21	0.31	0.41	0.51	0.01
175	-0.49	-0.39	-0.29	-0.19	-0.09	0.01	0.11	0.21	0.31	0.41	0.51	0.00
180	-0.49	-0.39	-0.29	-0.19	-0.09	0.01	0.11	0.21	0.31	0.41	0.51	-0.01
185	-0.49	-0.39	-0.29	-0.19	-0.09	0.01	0.11	0.21	0.31	0.41	0.51	-0.02
190	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.03
195	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.05
200	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.07

JVS 15Jul98

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OM
OM                      CULVERT BR#A200
OM                      File: A206LRF4.pol
OM                      Date: 15Jul98
OM                      Golf Cart Design
OM                      Single Box Culvert (No Haunch)
OM                      1-Cell Box 10'x  7'
OM                      Load Factor Design
OM                      Rigid Frame Method
OM                      Top and Bot Slab Different
OM
OM                      Maximum Fill Ht Condition (4.0 Ft)
OM
STDLOD     2, 0, 0, 0, 0
SWPRES     1, 2, 60, 15, 62.4
BOXDIM     1, 1, 10,  7, 4, 10
SLBTHK     1, 11.5, 11, 8, 8, 1111
H&SKEW     1, 90, 90, 0, 0, 0
REEBAR     18, 9, 1, 11, 4, .016
CONCOV     2, 3, 2, 2, .5, .5
MATPRP     120, 60, 24, 3, 0, 0
PRTCTL     1, 1, 1, 0
F&HCTL     1, 1, 1
DESCTL     1, 0, 1, 0, 0, 9
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JW 15Jul98

CONSTANT DATA

STANDARD LIVE LOAD				DESIGN METHOD		PRINT CONTROL		
TRUCK CODE	OMIT L.L.	STRESS 0-FILL	OVERLD AXLE	SERVICE LOAD	LOAD FACTOR	10th Pt MOMENT	INFL LINE	LOC. NEG MOMENT
HS20	NO	NO	0.	NO	YES	YES	YES	1.00

MATERIAL PROPERTIES						THICKNESS INCREMENTS	
SOIL WEIGHT	STEEL Fy	STEEL Fs	CONCRETE STRENGTH	CONCRETE SHEAR	CON.SHEAR W/ STIRRUP	SLAB	WALL
120.	60000.	24000.	3000.	0.	0.	0.50	0.50

CONCRETE COVER				DESIGN SAME		PRINT	REINFORCING			
EXTERIOR			INTERIOR	THICKNESS		BAR	BAR SPACING		BAR SIZE	
TOP SLAB	BOT SLAB	WALL	(ALL)	SLAB	WALL	TABLE	MAX	MIN	MAX	MIN
2.00	3.00	2.00	2.00	NO	NO	YES	18.0	9.0	11	4

CRACK PARAMETER Z = 98.0
MODULAR RATIO N = 9.0

SUPERIMPOSED DEAD LOADS							SPECIAL LIVE LOADS		
UNIFORM	CONCENTRATED LOAD								
LOAD	WT.	X1	WT.	X2	WT.	X3	WHEEL LOAD	FILL HEIGHT	OVERSTRESS FACTOR
0.000	0.00	0.0	0.00	0.0	0.00	0.0	0.000	0.000	1.00

DATA FOR STRUCTURE NUMBER 1

CULVERT TYPE	SPAN LENGTH	CLEAR HEIGHT	DESIGN FILL	CENTERLINE LENGTH	SKEW LEFT	SKEW RIGHT	FLOOR TYPE
SINGLE	10.00	7.00	4.00	10.00	90	90	FULL

SLAB THICKNESSES				LIVE LOAD	SOIL PRESSURE		WATER PRESSURE
TOP SLAB	BOT. SLAB	EXT. WALL	INT. WALL	SURCHARGE	MAX	MIN	
11.50F	11.00F	8.00F	8.00F	2.00	60.0	15.0	62.4

TOP HAUNCH HEIGHT	BOTTOM HAUNCH HEIGHT	RIGID OR FLEXIBLE	CHECK MILITARY	BAR SPACING INCREMENT
0.0	0.0	RIGID	NO	1 INCH

BOTH HEADWALLS ELIMINATED.

***** LOAD FACTOR DESIGN *****
***** STRESSES AT CRITICAL SECTIONS *****

*** MAXIMUM REINFORCEMENT RATIO (As/bd) = .016

MEMBER NUMBER = 1
MEMBER THICKNESS = 8.00
EXTERIOR WAL

	-MOMENT-	-AXIAL- FORCE	-SHEAR-	-Po-	-Mu-	-Mbal-	-Pbal-	-STEEL- AREA	-SHEAR- STRESS	-ALL.- MOM.	-ALL.- SHEAR
LT	-6.7	9.1	2.7	190.6	6.7	16.0	53.9	0.29	50.3	8.3	120.8
MID	0.9	3.5	0.3	186.8	4.6	15.0	58.5	0.19	6.6	5.2	119.7
MID-	-5.5	7.6	0.3	188.3	5.5	16.0	56.7	0.32	6.6	6.9	117.7
RT	-6.2	7.6	2.0	189.6	6.2	16.0	55.2	0.26	38.3	7.5	119.9

MEMBER NUMBER = 2
MEMBER THICKNESS = 11.50
TOP SLAB

	-MOMENT-	-AXIAL- FORCE	-SHEAR-	-Po-	-Mu-	-Mbal-	-Pbal-	-STEEL- AREA	-SHEAR- STRESS	-ALL.- MOM.	-ALL.- SHEAR
LT	-5.3	2.4	7.7	268.5	10.8	38.0	103.7	0.28	83.4	11.5	129.0
MID	19.7*	-0.2	1.8	278.2	19.7	41.0	91.4	0.57	20.0	19.7	118.7
RT	-5.3	2.4	7.7	268.5	10.8	38.0	103.7	0.28	83.4	11.5	129.0

MEMBER NUMBER = 4
MEMBER THICKNESS = 11.00
BOTTOM SLAB

	-MOMENT-	-AXIAL- FORCE	-SHEAR-	-Po-	-Mu-	-Mbal-	-Pbal-	-STEEL- AREA	-SHEAR- STRESS	-ALL.- MOM.	-ALL.- SHEAR
LT	-6.1	3.5	6.8	256.9	8.6	31.0	84.7	0.26	89.1	9.5	126.7
MID	17.4*	-0.5	0.0	265.6	17.4	37.0	86.7	0.50	0.3	17.3	117.2
RT	-6.1	3.5	6.8	256.9	8.6	31.0	84.7	0.26	89.1	9.5	126.7

NOTE: ASTERISK IMPLIES DESIGN VALUES EXCEED CRITICAL VALUES

***** ATTENTION: OVERSTRESS DUE TO FIXED THICKNESS

A CORNER BAR(T)				A CORNER BAR(B)				A TSLAB+		A TSLAB-	
H	V	SZ	SPG	H	V	SZ	SPG	SZ	SPG	SZ	SPG
32	26	5	9.0	33	24	5	9.0	7	9.0	0	0.0

A BSLAB+		A BSLAB-		B EXTIN		B EXTOUT		B INTWL		C1
SZ	SPG	SZ	SPG	SZ	SPG	SZ	SPG	SZ	SPG	BARS
7	9.0	0	0.0	5	12.0	5	9.0	0	0.0	40

** T.SLAB *	B.SLAB *	WALL *	INWALL ***	VOLUME ***	STEEL **
IN	IN	IN	IN	CY/FT	LB/FT
11.50	11.00	8.00	0.00	1.133	147

** REINFORCING STEEL BAR SCHEDULE **

* LOCATN *		BAR	* NO.	* SZ	* TYP	* LNGTH *	WT.	* H LEG	* V LEG
TOP SLAB POSV	MAIN	A100	14	7	STR	10-11	312		
BOT SLAB POSV	MAIN	A200	14	7	STR	10-11	312		
CORNER (TOP)		A1	28	5	6	4-10	141	2- 8	2- 2
CORNER (BOTTOM)		A2	28	5	6	4- 9	139	2- 9	2- 0
EXTWALL IN		B1	20	5	STR	8- 4	174		
EXTWALL OUT		B2	28	5	STR	6- 4	185		
LONGTD	(1)	C1	40	4	STR	9- 8	258		
						TOTAL	1521		

***** SPLICE LENGTHS CHART *****

BAR	SIZE	SPLICE LENGTH
A200	7	3- 0
B1	5	1- 8
C1	4	2- 2

** MOMENT * AXIAL FORCE * SHEAR FOR LOAD FACTOR DESIGN AT TENTH POINT **

M-PT	+MOMENT	-MOMENT	+A.F.	-A.F.	+SHEAR	-SHEAR
1- 0	-2.663	-8.203	3.527	9.133	3.583	-0.623
1- 1	-2.968	-5.684	3.527	9.133	2.774	-0.397
1- 2	-1.379	-5.513	3.527	9.133	2.015	-0.204
1- 3	-0.100	-5.519	3.527	8.384	1.304	-0.043
1- 4	0.633	-5.462	3.527	7.626	0.643	0.085
1- 5	0.862	-5.355	3.527	7.626	0.348	-0.138
1- 6	0.624	-5.186	3.527	7.626	0.411	-0.701
1- 7	-0.042	-4.980	3.527	7.626	0.440	-1.215
1- 8	-1.095	-4.765	3.527	7.626	0.436	-1.679
1- 9	-1.598	-5.465	3.527	7.626	0.400	-2.095
1-10	-1.342	-7.276	3.527	7.626	0.331	-2.461
2- 0	-1.342	-7.276	-0.286	2.461	9.133	3.527
2- 1	5.111	-0.825	-0.331	2.338	7.678	2.822
2- 2	11.456	1.809	-0.218	2.338	6.215	2.116
2- 3	16.137	3.690	-0.218	2.338	4.749	1.411
2- 4	18.939	4.819	-0.162	2.338	3.286	0.705
2- 5	19.720	5.195	-0.162	2.338	1.831	-1.460
2- 6	18.939	4.819	-0.162	2.338	0.010	-2.914
2- 7	16.137	3.690	-0.218	2.338	-1.411	-4.377
2- 8	11.456	1.809	-0.218	2.338	-2.116	-5.843
2- 9	5.111	-0.825	-0.331	2.338	-2.822	-7.307
2-10	-1.342	-7.276	-0.286	2.461	-3.527	-8.761
4- 0	-2.663	-8.203	-0.454	3.538	8.305	4.559
4- 1	3.282	-1.347	-0.499	3.414	6.650	3.647
4- 2	9.453	2.057	-0.499	3.414	4.994	2.736
4- 3	13.859	4.489	-0.499	3.414	3.339	1.824
4- 4	16.499	5.948	-0.499	3.414	1.683	0.912
4- 5	17.373	6.434	-0.499	3.414	0.028	-0.028
4- 6	16.499	5.948	-0.499	3.414	-0.912	-1.683
4- 7	13.859	4.489	-0.499	3.414	-1.824	-3.339
4- 8	9.453	2.057	-0.499	3.414	-2.736	-4.994
4- 9	3.282	-1.347	-0.499	3.414	-3.647	-6.650
4-10	-2.663	-8.203	-0.454	3.538	-4.559	-8.305

***** INFLUENCE LINES FOR MOMENT *****

***** MEMBER NO. 1 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
100	-0.42	-0.37	-0.31	-0.26	-0.20	-0.15	-0.09	-0.04	0.02	0.07	0.13
105	-0.40	-0.36	-0.32	-0.28	-0.24	-0.20	-0.16	-0.12	-0.08	-0.04	0.00
110	-0.39	-0.36	-0.33	-0.30	-0.28	-0.25	-0.22	-0.19	-0.16	-0.14	-0.11
115	-0.37	-0.35	-0.33	-0.32	-0.30	-0.29	-0.27	-0.25	-0.24	-0.22	-0.20
120	-0.35	-0.34	-0.34	-0.33	-0.32	-0.32	-0.31	-0.30	-0.30	-0.29	-0.28
125	-0.33	-0.33	-0.33	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.35
130	-0.31	-0.32	-0.33	-0.34	-0.35	-0.35	-0.36	-0.37	-0.38	-0.39	-0.40
135	-0.30	-0.31	-0.32	-0.34	-0.35	-0.36	-0.38	-0.39	-0.40	-0.42	-0.43
140	-0.28	-0.30	-0.32	-0.33	-0.35	-0.37	-0.38	-0.40	-0.42	-0.44	-0.45
145	-0.27	-0.29	-0.31	-0.33	-0.35	-0.37	-0.39	-0.41	-0.43	-0.44	-0.46
150	-0.26	-0.28	-0.30	-0.32	-0.34	-0.36	-0.38	-0.40	-0.42	-0.44	-0.46
155	-0.25	-0.27	-0.29	-0.31	-0.33	-0.35	-0.37	-0.39	-0.41	-0.43	-0.45
160	-0.25	-0.27	-0.28	-0.30	-0.32	-0.34	-0.35	-0.37	-0.39	-0.41	-0.42
165	-0.25	-0.26	-0.28	-0.29	-0.30	-0.32	-0.33	-0.35	-0.36	-0.37	-0.39
170	-0.26	-0.27	-0.27	-0.28	-0.29	-0.30	-0.31	-0.32	-0.32	-0.33	-0.34
175	-0.27	-0.27	-0.27	-0.27	-0.27	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28
180	-0.29	-0.28	-0.27	-0.27	-0.26	-0.25	-0.25	-0.24	-0.23	-0.23	-0.22
185	-0.31	-0.29	-0.28	-0.26	-0.24	-0.23	-0.21	-0.19	-0.18	-0.16	-0.15
190	-0.34	-0.31	-0.29	-0.26	-0.23	-0.20	-0.17	-0.15	-0.12	-0.09	-0.06
195	-0.38	-0.34	-0.30	-0.26	-0.22	-0.18	-0.14	-0.10	-0.06	-0.01	0.03
200	-0.43	-0.37	-0.32	-0.26	-0.21	-0.15	-0.10	-0.04	0.01	0.07	0.12

***** MEMBER NO. 2 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
100	0.13	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.12
105	0.00	0.48	0.43	0.38	0.33	0.28	0.23	0.18	0.13	0.08	0.03
110	-0.11	0.86	0.75	0.65	0.55	0.45	0.35	0.24	0.14	0.04	-0.06
115	-0.20	0.71	1.09	0.93	0.78	0.63	0.47	0.32	0.16	0.01	-0.15
120	-0.28	0.58	1.44	1.23	1.02	0.82	0.61	0.40	0.20	-0.01	-0.22
125	-0.35	0.46	1.27	1.54	1.28	1.02	0.76	0.50	0.24	-0.02	-0.28
130	-0.40	0.36	1.11	1.86	1.55	1.23	0.92	0.60	0.29	-0.03	-0.34
135	-0.43	0.27	0.96	1.66	1.83	1.46	1.09	0.72	0.35	-0.02	-0.39
140	-0.45	0.19	0.83	1.48	2.12	1.69	1.27	0.85	0.42	0.00	-0.42
145	-0.46	0.12	0.71	1.30	1.89	1.94	1.47	0.99	0.51	0.03	-0.45
150	-0.46	0.07	0.60	1.14	1.67	2.20	1.67	1.14	0.60	0.07	-0.46
155	-0.45	0.03	0.51	0.99	1.47	1.94	1.89	1.30	0.71	0.12	-0.46
160	-0.42	0.00	0.42	0.85	1.27	1.69	2.12	1.48	0.83	0.19	-0.45
165	-0.39	-0.02	0.35	0.72	1.09	1.46	1.83	1.66	0.96	0.27	-0.43
170	-0.34	-0.03	0.29	0.60	0.92	1.23	1.55	1.86	1.11	0.36	-0.40
175	-0.28	-0.02	0.24	0.50	0.76	1.02	1.28	1.54	1.27	0.46	-0.35
180	-0.22	-0.01	0.20	0.40	0.61	0.82	1.02	1.23	1.44	0.58	-0.28
185	-0.15	0.01	0.16	0.32	0.47	0.63	0.78	0.93	1.09	0.71	-0.20
190	-0.06	0.04	0.14	0.24	0.35	0.45	0.55	0.65	0.75	0.86	-0.11
195	0.03	0.08	0.13	0.18	0.23	0.28	0.33	0.38	0.43	0.48	0.00
200	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13

***** MEMBER NO. 4 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
100	0.42	-0.06	-0.43	-0.70	-0.86	-0.91	-0.86	-0.70	-0.43	-0.05	0.43
105	0.40	-0.08	-0.45	-0.72	-0.89	-0.94	-0.89	-0.73	-0.47	-0.10	0.38
110	0.39	-0.10	-0.48	-0.75	-0.91	-0.97	-0.92	-0.77	-0.50	-0.13	0.34

115	0.37	-0.12	-0.50	-0.77	-0.94	-0.99	-0.95	-0.79	-0.53	-0.16	0.31
120	0.35	-0.14	-0.52	-0.79	-0.96	-1.02	-0.97	-0.81	-0.55	-0.19	0.29
125	0.33	-0.16	-0.54	-0.81	-0.97	-1.03	-0.99	-0.83	-0.57	-0.21	0.27
130	0.31	-0.17	-0.55	-0.82	-0.99	-1.05	-1.00	-0.85	-0.59	-0.22	0.26
135	0.30	-0.19	-0.57	-0.84	-1.00	-1.06	-1.01	-0.86	-0.59	-0.23	0.25
140	0.28	-0.20	-0.58	-0.85	-1.01	-1.07	-1.02	-0.86	-0.60	-0.23	0.25
145	0.27	-0.21	-0.59	-0.86	-1.02	-1.07	-1.02	-0.86	-0.60	-0.23	0.25
150	0.26	-0.22	-0.59	-0.86	-1.02	-1.07	-1.02	-0.86	-0.59	-0.22	0.26
155	0.25	-0.23	-0.60	-0.86	-1.02	-1.07	-1.02	-0.86	-0.59	-0.21	0.27
160	0.25	-0.23	-0.60	-0.86	-1.02	-1.07	-1.01	-0.85	-0.58	-0.20	0.28
165	0.25	-0.23	-0.59	-0.86	-1.01	-1.06	-1.00	-0.84	-0.57	-0.19	0.30
170	0.26	-0.22	-0.59	-0.85	-1.00	-1.05	-0.99	-0.82	-0.55	-0.17	0.31
175	0.27	-0.21	-0.57	-0.83	-0.99	-1.03	-0.97	-0.81	-0.54	-0.16	0.33
180	0.29	-0.19	-0.55	-0.81	-0.97	-1.02	-0.96	-0.79	-0.52	-0.14	0.35
185	0.31	-0.16	-0.53	-0.79	-0.95	-0.99	-0.94	-0.77	-0.50	-0.12	0.37
190	0.34	-0.13	-0.50	-0.77	-0.92	-0.97	-0.91	-0.75	-0.48	-0.10	0.39
195	0.38	-0.10	-0.47	-0.73	-0.89	-0.94	-0.89	-0.72	-0.45	-0.08	0.40
200	0.43	-0.05	-0.43	-0.70	-0.86	-0.91	-0.86	-0.70	-0.43	-0.06	0.42

***** INFLUENCE LINES FOR SHEAR AND AXIAL FORCE *****

***** MEMBER NO. 1 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	A.F.
100	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	-1.00
105	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-0.95
110	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	-0.90
115	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.86
120	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.81
125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.76
130	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.71
135	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.65
140	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.60
145	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.55
150	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.50
155	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.45
160	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.40
165	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.35
170	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.29
175	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.24
180	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.19
185	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.14
190	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	-0.10
195	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-0.05
200	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.00

***** MEMBER NO. 2 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	A.F.
100	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
105	0.95	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	0.05
110	0.90	0.90	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	0.03
115	0.86	0.86	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	0.02
120	0.81	0.81	0.81	-0.19	-0.19	-0.19	-0.19	-0.19	-0.19	-0.19	-0.19	0.01
125	0.76	0.76	0.76	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	0.00
130	0.71	0.71	0.71	0.71	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.01
135	0.65	0.65	0.65	0.65	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.02
140	0.60	0.60	0.60	0.60	0.60	-0.40	-0.40	-0.40	-0.40	-0.40	-0.40	-0.02
145	0.55	0.55	0.55	0.55	0.55	-0.45	-0.45	-0.45	-0.45	-0.45	-0.45	-0.02
150	0.50	0.50	0.50	0.50	0.50	0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.03
155	0.45	0.45	0.45	0.45	0.45	0.45	-0.55	-0.55	-0.55	-0.55	-0.55	-0.02
160	0.40	0.40	0.40	0.40	0.40	0.40	0.40	-0.60	-0.60	-0.60	-0.60	-0.02
165	0.35	0.35	0.35	0.35	0.35	0.35	0.35	-0.65	-0.65	-0.65	-0.65	-0.02
170	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	-0.71	-0.71	-0.71	-0.01
175	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	-0.76	-0.76	-0.76	0.00
180	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	-0.81	-0.81	0.01
185	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	-0.86	-0.86	0.02
190	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	-0.90	0.03
195	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-0.95	0.05
200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07

***** MEMBER NO. 4 *****

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	A.F.
100	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.07
105	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.05
110	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.03

115	-0.51	-0.41	-0.31	-0.21	-0.11	-0.01	0.09	0.19	0.29	0.39	0.49	-0.02
120	-0.51	-0.41	-0.31	-0.21	-0.11	-0.01	0.09	0.19	0.29	0.39	0.49	-0.01
125	-0.51	-0.41	-0.31	-0.21	-0.11	-0.01	0.09	0.19	0.29	0.39	0.49	0.00
130	-0.51	-0.41	-0.31	-0.21	-0.11	-0.01	0.09	0.19	0.29	0.39	0.49	0.01
135	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
140	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
145	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
150	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.03
155	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
160	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
165	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	0.02
170	-0.49	-0.39	-0.29	-0.19	-0.09	0.01	0.11	0.21	0.31	0.41	0.51	0.01
175	-0.49	-0.39	-0.29	-0.19	-0.09	0.01	0.11	0.21	0.31	0.41	0.51	0.00
180	-0.49	-0.39	-0.29	-0.19	-0.09	0.01	0.11	0.21	0.31	0.41	0.51	-0.01
185	-0.49	-0.39	-0.29	-0.19	-0.09	0.01	0.11	0.21	0.31	0.41	0.51	-0.02
190	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.03
195	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.05
200	-0.50	-0.40	-0.30	-0.20	-0.10	0.00	0.10	0.20	0.30	0.40	0.50	-0.07

JVS 13 JUL 98
KSW 14 JULY 98

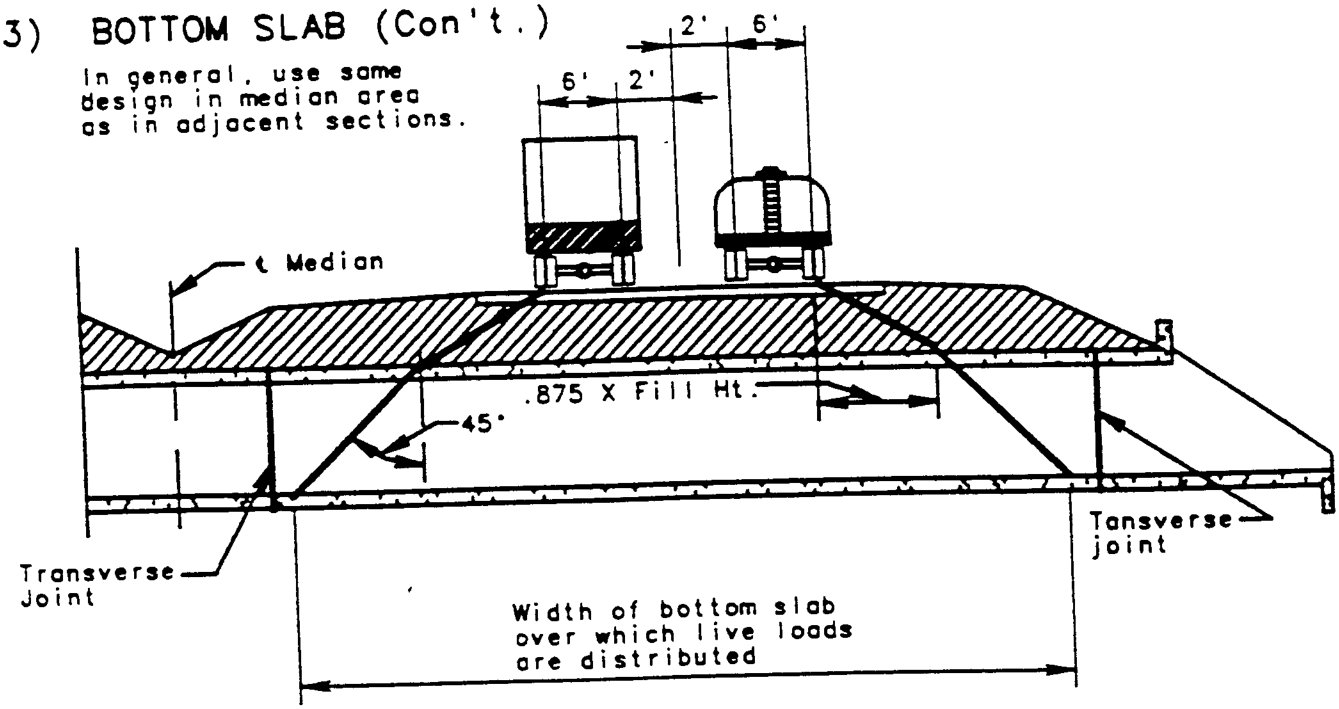
WINGHAVEN BEARING PRESSURES (MAX FILL) (MIN FILL)

CULVERTP 13-Jul-98

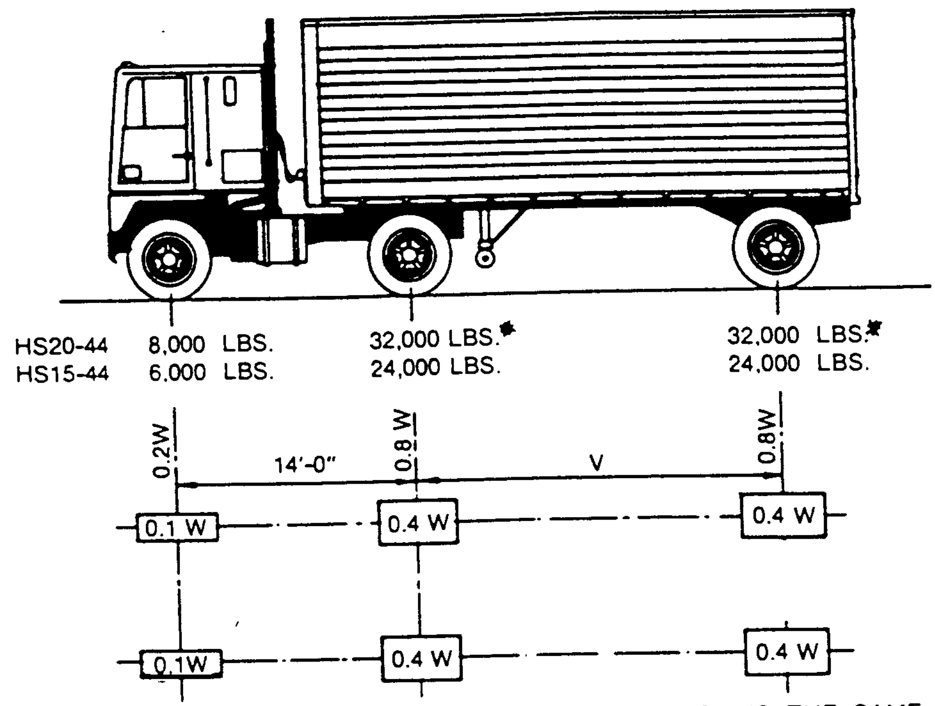
		MAX FILL					MIN FILL				
	BRIDGE #	A3210012	A3210013	A3210014	A3210015	A3210016	A3210012	A3210013	A3210014	A3210015	A3210016
		1 CELL	1 CELL	4 CELL	5 CELL	2 CELL	1 CELL	1 CELL	4 CELL	5 CELL	2 CELL
LIVE LOAD	TWO HS20 AXLE	64000	64000	64000	64000	64000	64000	64000	64000	64000	64000
	LBS PER SQ FT	57	57	44	31	43	92	92	60	47	96
	LANE LOAD	64	64	64	64	64	64	64	64	64	64
	FILL HEIGHT (FT)	5	5	4	6	8	1	1	1	1	1
CULVERT DIMENSIONS											
	NUMBER OF CELLS N =	1	1	4	5	2	1	1	4	5	2
	OPENING WIDTH (FT) S =	10	10	12	12	8	10	10	12	12	8
	OPENING HEIGHT (FT) H =	7	7	10	12	7	7	7	10	12	7
	TOP SLAB THICK (IN) D1 =	11.5	11.5	11.5	11.5	10.5	11.5	11.5	11.5	11.5	10.5
	BOTTOM SLAB THICK (IN) D2 =	11	11	12.5	11.5	9.5	11	11	12.5	11.5	9.5
	EXTERIOR WALL THICK (IN) T =	8	8	8	8.5	7	8	8	8	8.5	7
	INTERIOR WALL THICK (IN)TI =	0	0	8	7	6	0	0	8	7	6
	TOTAL WIDTH(IN) C =	136	136	616	765	212	136	136	616	765	212
	TOTAL WIDTH(FT) C =	11.333	11.333	51.333	63.750	17.667	11.333	11.333	51.333	63.750	17.667
WEIGHT PER FT OF LENGTH											
	LIVE LOAD	64	64	64	64	64	92	92	64	64	96
	FILL	600	600	480	720	960	120	120	120	120	120
	CULVERT	405	405	397	393	349	405	405	397	393	349
TOTAL	LBS PER SQ FT	1069	1069	941	1177	1373	617	617	581	577	565

DISTRIBUTION OF LOADS

(3) BOTTOM SLAB (Con't.)



LOADING CONDITION - INTERIOR SECTION OF BOXES WITH TRANSVERSE JOINTS



W = COMBINED WEIGHT ON THE FIRST TWO AXLES WHICH IS THE SAME AS FOR THE CORRESPONDING H TRUCK.

V = VARIABLE SPACING — 14 FEET TO 30 FEET INCLUSIVE. SPACING TO BE USED IS THAT WHICH PRODUCES MAXIMUM STRESSES.

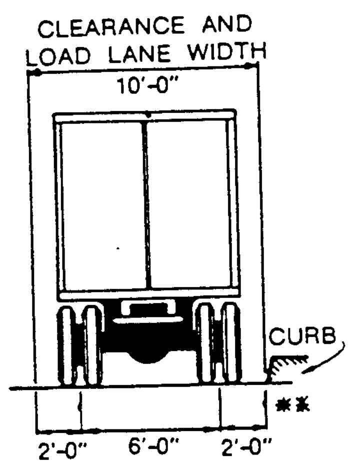


FIGURE 3.7.7A. Standard HS Trucks

*In the design of timber floors and orthotropic steel decks (excluding transverse beams) for H 20 loading, one axle load of 24,000 pounds or two axle loads of 16,000 pounds each, spaced 4 feet apart may be used, whichever produces the greater stress, instead of the 32,000-pound axle shown.

**For slab design, the center line of wheels shall be assumed to be 1 foot from face of curb. (See Article 3.24.2.)

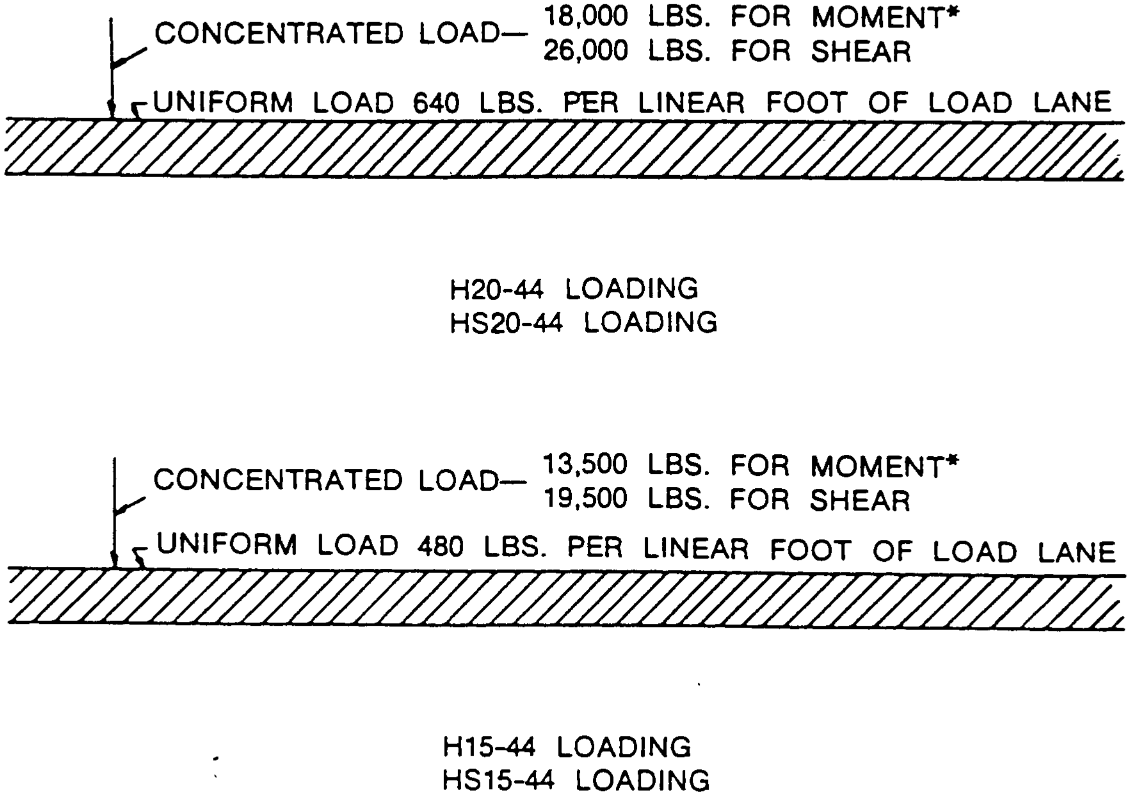


FIGURE 3.7.6B. Lane Loading

*For the loading of continuous spans involving lane loading refer to Article 3.11.3 which provides for an additional concentrated load.

L = length in feet of the portion of the span that is loaded to produce the maximum stress in the member.

3.8.2.2 For uniformity of application, in this formula, the loaded length, L, shall be as follows:

(a) For roadway floors: the design span length.
(b) For transverse members, such as floor beams: the span length of member center to center of supports.
(c) For computing truck load moments: the span length, or for cantilever arms the length from the moment center to the farthermost axle.
(d) For shear due to truck loads: the length of the loaded portion of span from the point under consideration to the far reaction; except, for cantilever arms, use a 30 percent impact factor.
(e) For continuous spans: the length of span under consideration for positive moment, and the average of two adjacent loaded spans for negative moment.

3.8.2.3 For culverts with cover

0′0″ to 1′-0″ inc. I = 30%
1′-1″ to 2′-0″ inc. I = 20%
2′-1″ to 2′-11″ inc. I = 10%

3.9 LONGITUDINAL FORCES

Provision shall be made for the effect of a longitudinal force of 5 percent of the live load in all lanes carrying traffic headed in the same direction. All lanes shall be loaded for bridges likely to become one directional in the future. The load used, without impact, shall be the lane load plus the concentrated load for moment specified in Article 3.7, with reduction for multiple-loaded lanes as specified in Article 3.12. The center of gravity of the longitudinal force shall be assumed to be located 6 feet above the floor slab and to be transmitted to the substructure through the superstructure.

WYOMING DEPARTMENT OF TRANSPORTATION
Program for the Design of Reinforced
Concrete Box Culverts

BRASS - CULVERT

Version 1

User Manual
January, 1995

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	STDLOD
PURPOSE	STDLOD defines the standard truck loads to be used.

5 COMMAND PARAMETERS

2	Truck Code (1-8)	Enter the code for the desired truck load to be applied. The codes are: 1) HS 25 2) HS 20 ~~3) H 20~~ 4) HS 15 5) H 15 6) HS 10 7) H 10 8) Special Live Load Only 9) No Live Load Special live loads are defined with the SPLLOD command.
1	Check Military Load (0,1)	When HS 25 or HS 20 truck loading is specified, the standard military load in two adjacent lanes will be checked if specified here. Enter 1 to check military load as a separate load case, else enter 0.
0	Neglect Live Load (0,1)	Live load may be neglected for single culverts if fill depth is more than 8 feet and exceeds barrel span length. For multiple culverts, it may be neglected if fill depth exceeds the distance between end supports or abutments. (See AASHTO 6.4.2.) Enter 1 to neglect live load according to AASHTO 6.4.2. Enter 0 to use live load regardless of fill height.
0	Stress at Zero Fill (0,1)	Enter 1 for stress check at zero fill (top of top slab) to be performed, else enter 0.
0	Overload Axle Weight, kip	Enter the axle weight for the overload standard truck, kips.

EXAMPLE

To define an HS 25 truck load to be applied to the culvert with live load distribution based on AASHTO 6.4.2, no stress check at zero fill or overload truck effects to be calculated, and military load will not be checked as a separate load case, code:

STDLOD 1, 0, 0, 0, 0

FIGURES

NOTES

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	SWPRES
PURPOSE	SWPRES defines soil and water pressure parameters.

5 COMMAND PARAMETERS

1	Structure Number (1-10)	Enter the reference number for the culvert to be described by the following data. Culverts must be numbered sequentially beginning with 1, 2, 3 ...etc.
2	Live Load Surcharge, ft.	Enter the depth of surcharge to be used for calculating the effects of lateral earth pressure. Surcharge load is applied as a uniform load on the exterior walls and is calculated as the depth of surcharge times the maximum or minimum soil pressure as applicable.
45	Maximum Soil Pressure, pcf	Enter the maximum soil equivalent fluid pressure for lateral earth pressure calculations. Standard maximum is 30 pcf by AASHTO 6.2.1.
15	Minimum Soil Pressure, pcf	Enter the minimum soil equivalent fluid pressure for lateral earth pressure calculations. A minimum of 15 pcf is used for checking positive moments unless otherwise defined.
62.4	Water Pressure, pcf	Enter the unit weight of water (62.4 pcf standard). Enter 0 for no water pressure to be considered. When considered, BRASS-CULVERT uses full height of water and no water as two loading cases.

EXAMPLE

For standard values:

SWPRES 1, 2.0, 30.0, 15.0, 62.4

FIGURES

NOTES

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	BOXDIM
PURPOSE	BOXDIM defines the geometry of the box culvert.

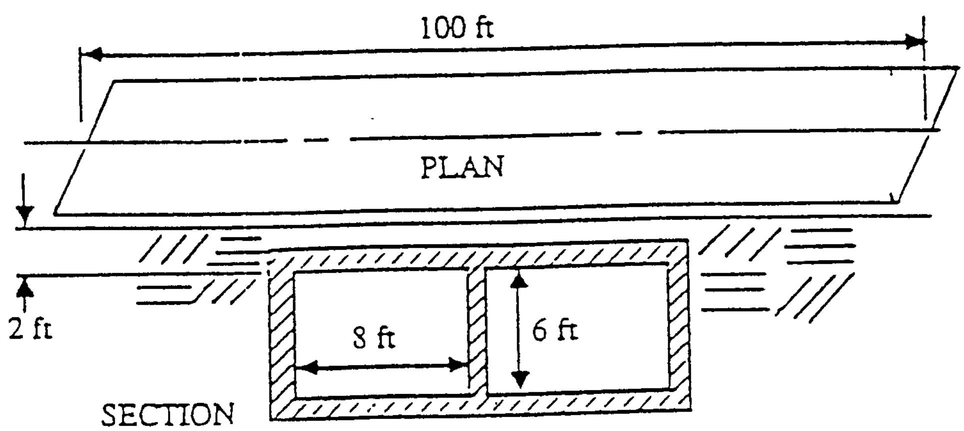
6 COMMAND PARAMETERS

	Parameter	Description
1	Structure Number (1-10)	Enter the reference number for the culvert to be described by the following data. Culverts must be numbered sequentially beginning with 1, 2, 3 ...etc.
1, 1, 2, 4, 5	Number of Barrels (1-4)	Enter the number of barrels for the culvert, four maximum.
10, 10, 8, 12, 12	Clear Span, ft.	Enter the clear span of the barrels, feet. All barrels have the same span.
7, 7, 7, 10, 12	Clear Height, ft.	Enter the clear height of the barrels, feet. All barrels have the same height.
4, 10, 8, 8, 6	Design Fill, ft.	Enter the depth of fill to be used for design. Fill is measured from the bottom of the top slab to the top of fill, feet. Live loads will be applied to the top of this fill.
30, 105, 108, 150, 78	Centerline Length, ft.	Enter the length of the culvert along its centerline, feet.

EXAMPLE

BOXDIM 1, 2, 8, 6, 2, 100

FIGURES



NOTES

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	SLBTHK
PURPOSE	SLBTHK defines the thickness for the top and bottom slabs, and the exterior and interior walls.

6 COMMAND PARAMETERS

1	Structure Number (1-10)	Enter the reference number for the culvert to be defined by the following data. Culverts must be numbered sequentially beginning with 1, 2, 3 ...etc.
6	Top Slab Thickness, in.	Enter the thickness for the top slab. Unless this value is specified as fixed value (see below), BRASS-CULVERT uses this value as minimum thickness.
6	Bottom Slab Thickness, in.	Enter the thickness for the bottom slab. Unless this value is specified as fixed value (see below), BRASS-CULVERT uses this value as minimum thickness.
6	Exterior Wall Thickness, in.	Enter the thickness for the exterior wall. Unless this value is specified as fixed value (see below), BRASS-CULVERT uses this value as minimum thickness.
6	Interior Wall Thickness, in.	Enter the thickness for the interior wall. Unless this value is specified as fixed value (see below), BRASS-CULVERT uses this value as minimum thickness.
0000	Fixed Thickness Code (0 - 1111)	BRASS-CULVERT will use the thicknesses defined above as minimum values unless otherwise specified here. Each digit of the code is for the top slab, bottom slab, exterior walls, and interior walls respectively. Enter 1 to fix the thickness, else enter 0. For example to fix the top slab and exterior wall thicknesses only, enter a code of 1010.

EXAMPLE

For a culvert with a fixed slab and wall thickness of 7 inches, code:

SLBTHK 1, 7, 7, 7, 7, 1111

For a culvert with a fixed top slab of 8 inches and fixed exterior walls of 10 inches, bottom slab and interior wall thicknesses are used as minimum values, code:

SLBTHK 1, 8, 8, 10, 10, 1010

For a culvert with no fixed thicknesses and it is desired for the program to set the thicknesses as required, code:

SLBTHK 1, 0, 0, 0, 0, 0000

FIGURES

NOTES

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	H&SKEW
PURPOSE	H&SKEW defines haunches and end skews.

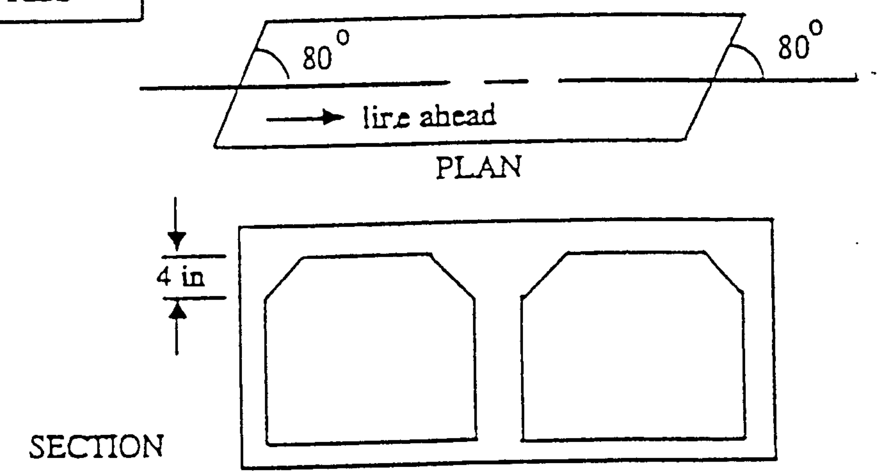
6 COMMAND PARAMETERS

1	Structure Number (1-10)	Enter the reference number for the culvert to be described by the following data. Culverts must be numbered sequentially beginning with 1, 2, 3 ...etc.
90	Skew Angle Left, deg.	Enter the skew angle at the left end of the culvert, degrees. See Note.
90	Skew Angle Right, deg.	Enter the skew angle at the right end of the culvert, degrees. See Note.
0	Top Haunch Height, in.	Enter the height of the top haunch, inches. Enter 0 for no top haunch.
0	Bottom Haunch Height, in.	Enter the height of the bottom haunch, inches. Enter 0 for no bottom haunch.
0	Haunches by AASHTO 0 or 1	Enter 1 for haunches to be considered in effective span length calculations, as per AASHTO Section 8.8, else enter 0.

EXAMPLE

H&SKEW 80, 80, 4, 0, 1

FIGURES



NOTES

Skew angles are measured from line ahead to skew as shown above. Positive angles only.

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	REEBAR
PURPOSE	REEBAR defines allowable bar sizes and spacings, and maximum steel ratio.

6 COMMAND PARAMETERS

12	Maximum Bar Spacing, in. Default = 12	Enter the maximum allowable bar spacing.
9	Minimum Bar Spacing, in. Default = 12	Enter the minimum allowable bar spacing.
1	Bar Spacing Increment (0,1)	Steel design bar spacings will be rounded to the increment defined here. Enter 1 to round spacings to 1 inch increments, or enter 0 to round bar spacings to ½ inch increments.
11	Maximum Bar Size (#) Default = 11	Enter the maximum bar size to be used in design.
4	Minimum Bar Size (#) Default = 4	Enter the minimum bar size to be used in design.
.016	Maximum Steel Ratio Default = 0.012	Enter the maximum ratio of area of steel to area for concrete (A_s / bd) in decimal form.

$$\rho_{MAX} = .75\,\rho_b = .\frac{.85(.85)3000}{60000}\left(\frac{87000}{87000+60000}\right)$$

$$= .016$$

EXAMPLE

For a culvert with a maximum bar spacing of 12 inches, a minimum bar spacing of 4 inches, bar spacing increments of ½ inch, a maximum bar size of #11, a minimum bar size of #4, and a max:.num reinforcement ratio of 0.012, code:

REEBAR 12, 4, 0, 4, 0.012

11

12 0.016

FIGURES

NOTES

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	CONCOV
PURPOSE	CONCOV defines the depth of concrete cover for reinforcement and the slab thickness round off increment.

6 COMMAND PARAMETERS

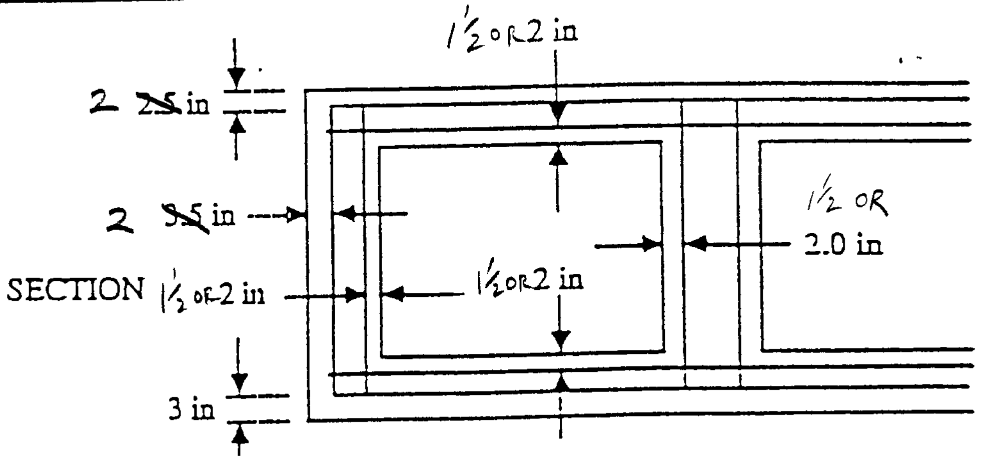
2	Exterior Top Slab, in.	Enter the distance from the face of steel bars to the face of concrete for the top steel of the top slab, inches. See Note.
3	Exterior Bottom Slab, in.	Enter the distance from the face of steel bars to the face of concrete for the bottom steel of the bottom slab, inches. See Note.
2	Exterior Wall, in.	Enter the distance from the face of steel bars to the exterior face of the exterior walls, inches. See Note.
HYDR GULF 2	Interior Cover, in.	Enter the distance from the face of steel bars to the face of concrete for the interior faces of slabs and walls, inches. See Note. NOTE: Default values are 3 inches for bottom slab cover and 2 inches for all other covers.
1/2	Slab Thickness Increment, in.	BRASS-CULVERT "rounds up" slab thickness to the nearest increment defined. Default values are ½ inch.
1/2	Wall Thickness Increment, in.	BRASS-CULVERT "rounds up" wall thickness to the nearest increment defined. Default values are ½ inch.

EXAMPLE

CONCOV ~~2.5~~ 2.0, 3.0, ~~3.5~~ 2.0, 2.0, 0.5, 0.5

HYDR ONLY → 1.5

FIGURES



NOTES

All covers are measured from the outer face of steel to face of slab.

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	MATPRP
PURPOSE	MATPRP defines material properties for steel and concrete.

6 COMMAND PARAMETERS

120	Soil Unit Weight, pcf	Enter the unit weight of the soil fill in pounds per cubic foot. BRASS-CULVERT uses 100% of soil weight for both rigid and flexible box designs.
60	Reinforcing Yield, Fy, ksi	Enter the yield strength for steel reinforcement, ksi.
24	Allowable Steel Stress, ksi	Enter the allowable steel stress, ksi.
3	Concrete Strength, ksi	Enter the 28 day compressive strength for concrete, ksi.
0	Allowable Concrete Shear, ksi	Enter the allowable concrete shear stress, ksi. Enter 0 for BRASS-CULVERT to calculate the concrete shear strength according to AASHTO 8.16.
0	Allowable Concrete Shear, with Stirrups, ksi	Enter the allowable concrete shear stress when stirrups are used. Enter 0 for no stirrups.

EXAMPLE

For a culvert with a soil unit weight of 120 pcf, 40 ksi reinforcing steel, an allowable steel stress of 20 ksi, a concrete strength of 3000 psi, and to have the program calculate the allowable concrete shear stress, code:

```
MATPRP 120, 40, 20, 3, 0, 0
                60  24
```

FIGURES

NOTES

COMMAND NAME	PRTCTL
PURPOSE	PRTCTL controls the output produced.

4 COMMAND PARAMETERS

0 1	Bar Schedule (0,1)	Enter 1 for printing the bar schedule, else enter 0.
0 1	Tenth Point Actions (0,1)	Enter 1 for printing moments, shears, and axial forces at tenth points, else enter 0. These are factored actions for ultimate strength design.
0 1	Influence Lines (0,1)	Enter 1 for printing live load influence line ordinates at tenth points, else enter 0.
0 0 ↑ FINAL RUN	Debug Printout (0,1)	This parameter is to be used for debugging purposes only. Enter 1 for special printout of dead load, soil pressure, and live load moments and shears, else enter 0. These are unfactored actions for ultimate strength design.

EXAMPLE

To print the bar schedule, tenth point actions, and influence line ordinates, code:

```
PRTCTL 1, 1, 1, 0
       0  0  0
```

FIGURES

NOTES

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	F&HCTL
PURPOSE	F&HCTL defines floor type and headwall configuration.

3 COMMAND PARAMETERS

1	Structure Number (1-10)	Enter the reference number for the culvert to be described by the following data. Culverts must be numbered sequentially beginning with 1, 2, 3 ...etc.
1	Floor Type (1,2,3)	Enter 1 for full floor. Enter 2 for no floor with fixed end supports. Enter 3 for no floor with pinned end supports.
2	Headwall Steel (0-3)	Enter 0 to generate headwall steel as per North Carolina standard. Enter 1 to suppress headwall steel generation. Enter 2 to generate left headwall steel only. Enter 3 to generate right headwall steel only.

EXAMPLE

To suppress a full floor and headwall steel design, code:

F&HCTL 1, 1, ~~1~~
2

FIGURES

NOTES

BRASS-CULVERT	COMMAND DESCRIPTION
COMMAND NAME	DESCTL
PURPOSE	DESCTL defines design control parameters.

6 COMMAND PARAMETERS

Design Method (0,1)	Enter 0 for service load design method, or enter 1 for load factor design method.
Rigid or Flexible (0,1)	Enter 0 for rigid box culvert design, else enter 1 for flexible box culvert design.
Design Negative Moment Position (0.0 - 1.0)	The position of design negative moment is defined by a value from zero to one where 0.0 represents the centerline of the wall or slab, 0.5 represents half way between center of the wall or slab and face of the wall or slab, and 1.0 represents the face of the wall or slab.
Design Same Slabs (0,1)	Enter 1 for BRASS-CULVERT to design the same thicknesses and steel for top and bottom slabs, else enter 0. See Note.
Design Same Walls (0,1)	Enter 1 for BRASS-CULVERT to design the same exterior and interior wall thicknesses, else enter 0. See Note.
Modular Ratio (N) Default = 9	Enter the ratio of the modules of elasticity of steel to that of concrete.

QUANTITIES

HEU 7-13-98
JVS 13JUL98

NCRETE QUANTITIES

DESCRIPTION	QUANT.	WIDTH	LENGTH	DEPTH	FACTOR	TOTAL (CU. FT.)	TOTAL (CU. YD.)
TOP SLAB	1.00	11.33	123.00	0.96	1.00	1335.92	49.48
EXTERIOR WALL	2.00	0.67	123.50	7.00	1.00	1152.67	42.69
INTERIOR WALL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BOTTOM SLAB	1.00	11.33	168.00	0.92	1.00	1745.33	64.64
BOTTOM SLAB TRIANGLE	4.00	8.09	22.25	0.92	0.50	330.16	12.23
HEADWALL	2.00	11.33	1.50	0.50	1.00	17.00	0.63
CUT OFF WALL DOWNSTREAM	1.00	27.36	0.83	1.08	1.00	24.70	0.91
CUT OFF WALL UPSTREAM	1.00	27.36	0.83	1.08	1.00	24.70	0.91
INT. WING DOWNSTREAM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T. WING DOWNSTREAM DEDUCT	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EXT. WING DOWNSTREAM	2.00	0.67	23.44	7.96	1.00	248.70	9.21
EXT. WING DOWNSTREAM DEDUCT	2.00	0.67	23.19	6.96	-0.50	-107.56	-3.98
INT. WING UPSTREAM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INT. WING UPSTREAM DEDUCT	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EXT. WING UPSTREAM	2.00	0.67	23.44	7.96	1.00	248.70	9.21
EXT. WING UPSTREAM DEDUCT	2.00	0.67	23.19	6.96	-0.50	-107.56	-3.98
						4912.75	181.95

NOT TOP BARS

2.4.11.3. Development and Tension Lap Splice Lengths - <u>Other Than Top Bars</u> (Fy = 60 ksi)

Step 1	Step 2	Step 3: f'c	Step 4: Bars	Step 5: #3	#4	#5	#6	#7	#8	#9	#10	#11
< 6 in. on Center (Dir. of Spacing ● ⟶)	• NON-EPOXY	• 3 ksi	ld	12	12	15	20	27	35	44	56	69
			B	12	16	20	26	35	45	57	73	89
			C	16	21	26	33	45	59	75	95	117
		• 4 ksi	ld	12	12	15	18	23	30	38	49	60
			B	12	16	20	24	30	39	50	63	78
			C	16	21	26	31	39	51	65	82	101
	• EPOXY 1 (<6db Clear spacing OR <3db Cover (any direction))	• 3 ksi	ld	14	18	23	30	40	52	66	84	103
			B	18	24	30	38	52	68	86	109	134
			C	23	31	39	50	68	88	112	142	175
		• 4 ksi	ld	14	18	23	27	35	45	57	73	89
			B	18	24	30	36	45	59	74	94	116
			C	23	31	39	46	59	76	97	123	152
	• EPOXY 2 (All Other Situations)	• 3 ksi	ld	12	14	18	23	31	40	51	64	79
			B	14	18	23	29	40	52	66	83	103
			C	18	24	30	38	52	68	86	109	134
		• 4 ksi	ld	12	14	18	21	27	35	44	56	69
			B	14	18	23	27	35	45	57	72	89
			C	18	24	30	36	45	59	75	94	116

Step 1	Step 2	f'c	Bars	#3	#4	#5	#6	#7	#8	#9	#10	#11
>= 6 in. on Center (Dir. of Spacing ● ⟶)	• NON-EPOXY	• 3 ksi	ld	12	12	12	16	22	28	36	45	55
			B	12	13	16	21	28	36	46	58	72
			C	13	17	21	27	36	47	60	76	94
		• 4 ksi	ld	12	12	12	15	19	24	31	39	48
			B	12	13	16	19	24	31	40	50	62
			C	13	17	21	25	32	41	52	66	81
	• EPOXY 1 (<6db Clear spacing OR <3db Cover (any direction))	• 3 ksi	ld	12	15	18	24	32	42	53	67	83
			B	15	19	24	31	42	54	69	87	107
			C	19	25	31	40	54	71	90	114	140
		• 4 ksi	ld	12	15	18	22	28	36	46	58	72
			B	15	19	24	29	36	47	60	75	93
			C	19	25	31	37	47	61	78	99	121
	• EPOXY 2 (All Other Situations)	• 3 ksi	ld	12	12	14	18	25	32	41	52	63
			B	12	15	18	24	32	42	53	67	82
			C	15	19	24	31	42	54	69	87	108
		• 4 ksi	ld	12	12	14	17	21	28	35	45	55
			B	12	15	18	22	28	36	46	58	71
			C	15	19	24	29	36	47	60	76	93

Use development and tension lap splices of f'c = 4 ksi for concrete strengths greater than 4 ksi.

AREA OF STEEL

SPACING

SIZE	4"	4½"	5"	5½"	6"	6½"	7"	7½"	8"	8½"	9"	9½"	10"	10½"	11"	11½"	12"	SIZE
3	.332	.295	.265	.241	.221	.204	.189	.177	.166	.156	.147	.140	.133	.126	.121	.115	.111	3
4	.589	.524	.471	.429	.393	.363	.337	.314	.295	.277	.262	.248	.236	.224	.214	.205	.196	4
5	.920	.818	.736	.669	.614	.566	.526	.491	.460	.433	.409	.388	.368	.351	.335	.320	.307	5
6	1.325	1.178	1.050	.964	.884	.816	.757	.707	.663	.624	.589	.558	.530	.505	.482	.461	.442	6
7	1.804	1.603	1.443	1.312	1.203	1.110	1.031	.962	.902	.849	.802	.760	.722	.687	.656	.627	.601	7
8	2.356	2.094	1.885	1.714	1.571	1.450	1.346	1.257	1.178	1.109	1.047	.992	.942	.898	.857	.820	.785	8
9	3.00	2.67	2.40	2.18	2.00	1.85	1.71	1.60	1.50	1.41	1.33		1.20		1.09		1.00	9
10		3.37	3.04	2.76	2.53	2.34	2.17	2.02	1.90	1.79	1.69		1.52		1.38		1.27	10
11			3.75	3.41	3.13	2.88	2.63	2.50	2.34	2.21	2.08		1.88		1.70		1.56	11

NUMBER OF BARS

SIZE	Perimeter	Wt Per Ft.	Diameter (inches)	1	2	3	4	5	6	7	8	9	10	SIZE
3	1.178	.376	.375	.1105	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.105	3
4	1.571	.668	.500	.1963	0.39	0.59	0.79	0.98	1.18	1.37	1.57	1.77	1.96	4
5	1.963	1.043	.625	.3068	0.61	0.92	1.23	1.53	1.84	2.15	2.45	2.76	3.07	5
6	2.356	1.502	.750	.4418	0.88	1.33	1.77	2.21	2.65	3.09	3.53	3.98	4.42	6
7	2.749	2.044	.875	.6013	1.20	1.80	2.41	3.01	3.61	4.21	4.81	5.41	6.01	7
8	3.142	2.670	1.000	.7854	1.57	2.36	3.14	3.93	4.71	5.50	6.28	7.07	7.85	8
9	3.544	3.400	1.128	1.0000	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	9
10	3.990	4.303	1.270	1.2656	2.53	3.80	5.06	6.33	7.59	8.86	10.12	11.39	12.66	10
11	4.430	5.313	1.410	1.5625	3.12	4.69	6.25	7.81	9.37	10.94	12.50	14.06	15.63	11
14S	5.32	7.65	1.693	2.2500	4.50	[illegible]	9.00	11.25	13.50	15.75	18.00	20.25	22.50	14S
18S	7.09	13.60	2.257	4.0000	8.00	[illegible]	16.00	20.00	24.00	28.00	32.00	36.00	[illegible]	18S

WINGHAVEN	CULVERT DIMENSIONS	PROJ NO.	980100
LDG	14-Jul-98	CULVERTD	

A LT	CULVERT	DISTANCE LEFT
A RT	CULVERT	DISTANCE RIGHT
B	CL CULVERT	FROM INSIDE FACE OF HEADWALL TO DOWNSTREAM END OF SLAB
C	DISTANCE	WIDTH OF CULVERT ALONG ROADWAY
D	DISTANCE	FROM END OF UPSTREAM END OF SLAB TO OUTSIDE OF HEADWALL
D1	TOP SLAB THICKNESS	
D2	BOT SLAB THICKNESS	
E	PERPENDICULAR TO ROADWAY FROM OUTSIDE FACE OF HEADWALL TO BEND	
F	SKEW ANGLE	
G	CL CULVERT	FROM END OF WING 3" TO DOWNSTREAM END OF SLAB
H	OPENING	HEIGHT
I	DISTANCE FROM DOWNSTREAM OUTSIDE FACE OF HEADWALL TO START OF WING	
J	HAUNCH	
K LT	ROADWAY	DISTANCE LEFT
K RT	ROADWAY	DISTANCE RIGHT
L	CL CULVERT	FROM UPSTREAM CL CULVERT TO OUTSIDE EDGE FO WINGWALL
M	CL CULVERT	FROM END OF UPSTREAM END OF SLAB TO END OF WING 3"
N	WINGWALL	FROM OUTSIDE FACE OF WING TO BEND ALONG CL CULVERT
P	WINGWALL	DISTANCE ALONG UPSTREAM WINGWALL TO BEND
R	BOT SLAB	FROM UPSTREAM END OF SLAB TO INSIDE FACE OF HEADWALL
S	OPENING	SPAN
T	WALL	EXTERIOR WIDTH
TI	WALL	INTERIOR WIDTH
U	WIDTH	DISTANCE FROM STRAIGHT TO INSIDE FACE OF WING
V	VERTICAL	FROM TOP OF END OF WING TO TOP OF WING
W	WIDTH	FROM INSIDE FACE OF WINGWALL TO OUTSIDE FACE OF WINGWALL
X	LENGTH	DISTANCE ALONG DOWNSTREAM WINGWALL TO BEND
Y	LENGTH	FROM END OF SLAB TO OUTSIDE FACE OF WINGWALL

DES FILL
DES FILL

SPECIFICATIONS

SEE PLAN SHEETS