

# Fort Worth Central City Preliminary Design

Civil/Structural  
Preliminary Design

Draft Environmental  
Impact Statement

Appendix C

May 2005

Volume III - Stability Analysis  
Isolation Gates

Images courtesy of CDM, Gideon Tool, and Bing Thom Architects

**CDM**



## **STABILITY ANALYSES FOR GATE STRUCTURES**

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# **Section 1**

## **Index of Excel Spread Sheets**

## **STABILITY ANALYSES**

### **TRWD ISOLATION GATE STRUCTURE**

#### **Index of Excel Spreadsheets:**

Mass Concrete Foundation:

I1 SPF-NoDrain-Mass TRWD.XLS  
(Standard Project Flood Case)

I2 MAX-NoDrain-Mass TRWD.XLS  
(Maximum Water Level Case)

I2 MAX-Drain-Mass TRWD.XLS  
(Maximum Water Level Case, incl. foundation drains)

Roller Compacted Concrete Foundation:

I1 SPF-NoDrain-RCC TRWD.XLS  
(Standard Project Flood Case)

I2 MAX-NoDrain-RCC TRWD.XLS  
(Maximum Water Level Case, at top of RCC)

I2 MAX-NoDrain-RCC-Base TRWD.XLS  
(Maximum Water Level Case, at base of RCC)

Pile Foundation:

I1 SPF-NoDrain-Pile TRWD.XLS  
(Standard Project Flood Case)

I2 MAX-NoDrain-Pile TRWD.XLS  
(Maximum Water Level Case)

I3 SEISMIC-NoDrain-Pile TRWD.XLS  
(Normal Pool Level, with Seismic)

# **STABILITY ANALYSES**

## **TRINITY POINT ISOLATION GATE STRUCTURE**

### **Index of Excel Spreadsheets:**

Mass Concrete Foundation:

I1 SPF-NoDrain-Mass TPoint.XLS  
(Standard Project Flood Case)

I2 MAX-NoDrain-Mass TPoint.XLS  
(Maximum Water Level Case)

I2 MAX-Drain-Mass TPoint.XLS  
(Maximum Water Level Case, incl. foundation drains)

Roller Compacted Concrete Foundation:

I1 SPF-NoDrain-RCC TPoint.XLS  
(Standard Project Flood Case)

I2 MAX-NoDrain-RCC TPoint.XLS  
(Maximum Water Level Case, at top of RCC)

I2 MAX-NoDrain-RCC-Base TPoint.XLS  
(Maximum Water Level Case, at base of RCC)

Pile Foundation:

I1 SPF-NoDrain-Pile TPoint.XLS  
(Standard Project Flood Case)

I2 MAX-NoDrain-Pile TPoint.XLS  
(Maximum Water Level Case)

I3 SEISMIC-NoDrain-Pile TPoint.XLS  
(Normal Pool Level, with Seismic)

## **STABILITY ANALYSES CLEAR FORK ISOLATION GATE STRUCTURE**

### **Index of Excel Spreadsheets:**

Mass Concrete Foundation:

I1 SPF-NoDrain-Mass CFork.XLS  
(Standard Project Flood Case)

I2 MAX-NoDrain-Mass CFork.XLS  
(Maximum Water Level Case)

I2 MAX-Drain-Mass CFork.XLS  
(Maximum Water Level Case, incl. foundation drains)

Roller Compacted Concrete Foundation:

I1 SPF-NoDrain-RCC CFork.XLS  
(Standard Project Flood Case)

I2 MAX-NoDrain-RCC CFork.XLS  
(Maximum Water Level Case, at top of RCC)

I2 MAX-NoDrain-RCC-Base CFork.XLS  
(Maximum Water Level Case, at base of RCC)

Pile Foundation:

I1 SPF-NoDrain-Pile CFork.XLS  
(Standard Project Flood Case)

I2 MAX-NoDrain-Pile CFork.XLS  
(Maximum Water Level Case)

I3 SEISMIC-NoDrain-Pile CFork.XLS  
(Normal Pool Level, with Seismic)

**Section 2**

**TRWD Isolation Gate Structures-**

**Mass Concrete Foundation**

**TRWD Isolation Gate Structure**

**Usual Load Condition - SPF**

**(File I1 SPF-NoDrain-Mass TRWD.XLS)**

1. Mass concrete foundation on rock.
2. Sliding Factor of Safety = 1.50
3. SPF level at El 540.0 on driving side.
4. Tailwater at El 520.0 on resisting side.
5. Friction angle at rock = 35 degrees.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDA

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
SPF WATER ELEVATION (USUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

**GATE STRUCTURE:**

FLOOD ELEV (FE) :	540 FT	FACTOR OF SAFETY (FS) :	1.5
TAILWATER ELEV (TE) :	520 FT	ACTUAL SOIL FRICTION ANGLE (PHI) :	35 DEGREES
TOP OF PIER ELEV (PE) :	557 FT	ACTUAL SOIL COHESION (CN) :	0 PSF
FDN BASE EL (BE) :	474 FT	FLUID PRESS (EFP) :	62.5 PCF
PIER LENGTH (PL) :	25 FT	CONC UNIT WGT (CUW) :	150 PCF
PIER THICKNESS (PT) :	7.33 FT		
NO. OF CONC PIERS (PN) :	3		
UPSTREAM FACE TO GATE CTR LINE (GCL) :	98 FT		
	13 FT		

**RESULTING DESIGN VALUES & DIMENSIONS:**

**CHANNEL, GATE:**

GATE WIDTH (CGW) :	24 FT	DESIGN FRICTION ANGLE (PHD) :	25.02 DEGREES
SILL ELEV (CSE) :	518 FT	DESIGN COHESION (CND) :	0 PSF
GATE WEIGHT (CGWGT) :	15,000 LBS	UPLIFT AT HEEL (UH) :	4125 PSF

**WALKWAY GATE:**

GATE WIDTH (WG) :	12 FT	CONCRETE WEDGE HEIGHT & LGTH (WH) :	2.2 FT
SILL ELEV (WSE) :	530 FT	(WH = CSE-BE-TPH)	
GATE WEIGHT (WGWT) :	5,000 LBS	FDN LENGTH (L) :	47 FT
		(L = HW + PL + WH + TW)	
ADDL HEEL WIDTH (HW) :	0 FT	FDN WIDTH (B) :	58 FT
HEEL THICKNESS (HTH) :	0 FT	(B = CGW + WGW + PN*PT)	
ADDL TOE WIDTH (TW) :	0 FT		
TOE THICKNESS (TT) :	22 FT		

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDA

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-FEET	OVERTURNING MOMENT: LB-FEET
CHANNEL GATE:	15,000		34.00	510,000	
WALKWAY GATE:	5,000		34.00	170,000	
CONCRETE PIERS:	3,217,500		34.50	111,003,750	
UPPER STRUCTURE:	1,058,400		34.50	36,514,800	
CHANNEL BLOCK FDN:	7,590,000		34.50	261,855,000	
CHANNEL WEDGE FDN:	5,009,400		12.25	61,348,452	
WALKWAY BLOCK FDN:	2,520,000		34.50	86,940,000	
WALKWAY WEDGE FDN:	1,306,800		12.25	16,003,944	
HEEL SLAB:	0		47.00	0	
TOE SLAB:	0		0.00	0	
FLUID ON HEEL:	0		47.00	14,022,000	
FLUID ON CHANNEL SILL:	342,000		41.00	41,000	
FLUID ON WALKWAY SILL:	90,000		41.00	3,690,000	
FLUID ON D/S WEDGE:	877,250		7.33	6,433,167	
FLUID ON TOE:	0		0.00	0	
UPLIFT FORCE (U1):	-7,837,250		23.50		184,175,375
UPLIFT FORCE (U2):	-1,703,750		31.33		53,384,167
FLUID HORZ FORCE (H):		7,895,250	22.00		173,695,500
RESTESTING FLUID FORCE:		-3,835,250	15.33		
SUBTOTAL AT BASE (V,MR,MO)	12,490,350	4,060,000	657,298,279	411,255,042	

#### STABILITY RESULTS:

FRICTION FORCE ( $V^*TAN(\Phi HD)$ ) =	5,830,558 LB	= $U * (WEIGHT \text{ CONC} + GATES + WATER - UPLIFT)$
COHESION FORCE ( $CND*L*B$ ) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	4,060,000 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.44 > 1.0?	= $(\text{FRICITION} + \text{COHESION}) / (\text{NET SLIDING})$
OVERTURNING RATIO ( $MR/MO$ ) =	1.60 > 1.0?	
ECCENTRICITY ( $E=L/2 - (MR-MO)/V$ )	3.80 (RELATIVE TO CL)	
BEARING PRESSURE = $V/L, (1 + 6 * E/L)$		
MAX BEARING PRESS =	6805 PSF	
MIN BEARING PRESS	2358 PSF	
VOLUME OF CONCRETE =	5,112 CY	

**TRWD Isolation Gate Structure**  
**Unusual Load Condition - Max Water Level**

**(File I2 MAX-NoDrain-Mass TRWD.XLS)**

1. Mass concrete foundation on rock.
2. Sliding Factor of Safety = 1.33
3. Maximum water level at El 544.0 on driving side.
4. Tailwater at El 520.0 on resisting side.
5. Friction angle at rock = 35 degrees.

PROJECT: TRWD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDA

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:	
FLOOD ELEV (FE) :	544 FT
TAILWATER ELEV (TE) :	520 FT
TOP OF PIER ELEV (PE) :	557 FT
FDN BASE EL (BE) :	474 FT
PIER LENGTH (PL) :	25 FT
PIER THICKNESS (PT) :	7.33 FT
NO. OF CONC PIERS (PN) :	3
UPPER STRUCTURE OUTLINE (USO) :	98 FT
UPSTREAM FACE TO GATE CTR LINE (GCCL) :	13 FT

**DESIGN PARAMETERS (INPUT):**

	DESIGN FRICTION ANGLE (FS) :	FACTOR OF SAFETY (FS) :
ACTUAL SOIL FRICTION ANGLE (PHI) :	35 DEGREES	1.33
ACTUAL SOIL COHESION (CN) :	0 PSF	35 DEGREES
FLUID PRESS (EFP) :	62.5 PCF	0 PSF
CONC UNIT WGT (CUW) :	150 PCF	62.5 PCF

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:	
GATE WIDTH (CGW) :	24 FT
SILL ELEV (CSE) :	518 FT
GATE WEIGHT (CGWGT) :	15,000 LBS

	DESIGN FRICTION ANGLE (PHD) :	27.77 DEGREES
DESIGN COHESION (CND) :	0 PSF	35 DEGREES
UPLIFT AT HEEL (UH) :	4375 PSF	0 PSF
UPLIFT AT TOE (UT) :	2875 PSF	35 DEGREES

**WALKWAY GATE:**

WALKWAY GATE:	
GATE WIDTH (WCW) :	12 FT
SILL ELEV (WSE) :	530 FT
GATE WEIGHT (WGNGT) :	5,000 LBS
ADDL HEEL WIDTH (HW) :	0 FT
HEEL THICKNESS (HTH) :	0 FT
ADDL TOE WIDTH (TW) :	0 FT
TOE THICKNESS (TTW) :	22 FT

$$(L = HW + PL + WH + TW)$$

$$(B = CGW + WGW + PN * PT)$$

PROJECT: THWU FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275 PRSTR.DCS

DESTINED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDADATE: 12/20/04**STABILITY ANALYSIS:**

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-FEET	OVERTURNING MOMENT: LB-FEET
CHANNEL GATE:	15,000		34.00	510,000	
WALKWAY GATE:	5,000		34.00	170,000	
CONCRETE PIERS:	3,217,500		34.50	111,003,750	
UPPER STRUCTURE:	1,058,400		34.50	36,514,800	
CHANNEL BLOCK FDN:	7,590,000		34.50	261,855,000	
CHANNEL WEDGE FDN:	5,009,400		12.25	61,348,452	
WALKWAY BLOCK FDN:	2,520,000		34.50	86,940,000	
WALKWAY WEDGE FDN:	1,306,800		12.25	16,003,944	
HEEL SLAB:	0		47.00	0	
TOE SLAB:	0		0.00	0	
FLUID ON CHANNEL SILL:	342,000		47.00	14,022,000	
FLUID ON WALKWAY SILL:	90,000		41.00	3,690,000	
FLUID ON D/S WEDGE:	877,250		7.33	6,433,167	
UPLIFT FORCE (U1):	0		0.00	0	
UPLIFT FORCE (U2):	7,837,250		23.50	184,175,375	
UPLIFT FORCE (U2):	-2,044,500		31.33	64,061,000	
FLUID HORIZONTAL FORCE (H):		8,881,250	23.33	207,229,167	
RESISTING FLUID FORCE:		-3,835,250	15.33	58,807,167	
SUBTOTAL AT BASE (V, MR, MO) =	12,149,600	5,046,000	657,298,279	455,465,542	

**STABILITY RESULTS:**

FRICITION FORCE (V*TAN(PHI)) =	6,396,422 LB	U*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	COHESION * BASE AREA
NET SLIDING FORCE =	5,046,000 LB	= DRIVING FORCES MINDS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.27 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =		
ECCENTRICITY (E=L/2 - (MR-MO)/V) =	1.44 > 1.0?	
BEARING PRESSURE = V/L(1 - 6*E/L)	6.89 (RELATIVE TO C1)	
MAX BEARING PRESS = 8376 PSF		
MIN BEARING PRESS = 538 PSF		
VOLUME OF CONCRETE = 5,112 CY		

**TRWD Isolation Gate Structure (with Drains)**

**Unusual Load Condition - Max Water Level**

**(File I2 MAX-Drain-Mass TRWD.XLS)**

1. Mass concrete foundation on rock, with foundation drainage system.
2. Maximum water level at El 544.0 on driving side.
3. Tailwater at El 520.0 on resisting side.
4. Drains 33 percent effective, 10-ft downstream of headwall.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDA

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:				
FLOOD ELEV (FE) :	544 FT	ACTUAL SOIL FRICTION ANGLE (PHI) :	1.33	DEGREES
TAILWATER ELEV (TE) :	520 FT	ACTUAL SOIL COHESION (CN) :	3.5	PSF
TOP OF PIER ELEV (PE) :	557 FT	FLUID PRESSURE (EFP) :	0	PCF
FDN BASE EL (BE) :	474 FT	CONC UNIT WGT (CUW) :	62.5	PCF
PIER LENGTH (PL) :	25 FT	DRAIN EFFICIENCY (DF) :	150	PCF
PIER THICKNESS (PT) :	7.33 FT	DRAIN DIMENSION FROM HEADWALL (DD) :	0.33	FT
NO. OF CONC PIERS (PN) :	3		13	FT
UPPER STRUCTURE OUTLINE (USO) :	98 FT			
TREMAP FACE TO GATE CTR LINE (GCL) :	13 FT			

**DESIGN PARAMETERS (INPUT):**

GATE STRUCTURE:				
FLOOD ELEV (FE) :	544 FT	FACTOR OF SAFETY (FS) :	1.33	
TAILWATER ELEV (TE) :	520 FT	ACTUAL SOIL FRICTION ANGLE (PHI) :	3.5	DEGREES
TOP OF PIER ELEV (PE) :	557 FT	ACTUAL SOIL COHESION (CN) :	0	PSF
FDN BASE EL (BE) :	474 FT	FLUID PRESSURE (EFP) :	62.5	PCF
PIER LENGTH (PL) :	25 FT	CONC UNIT WGT (CUW) :	150	PCF
PIER THICKNESS (PT) :	7.33 FT	DRAIN EFFICIENCY (DF) :	0.33	FT
NO. OF CONC PIERS (PN) :	3	DRAIN DIMENSION FROM HEADWALL (DD) :	13	FT
UPPER STRUCTURE OUTLINE (USO) :	98 FT			
TREMAP FACE TO GATE CTR LINE (GCL) :	13 FT			

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:				
GATE WIDTH (CGW) :	24 FT	DESIGN FRICTION ANGLE (PHI'D) :	27.77	DEGREES
STILL ELEV (CSE) :	518 FT	DESIGN COHESION (CND) :	0	PSF
GATE WEIGHT (CGWGT) :	15,000 LBS	UPLIFT AT HEEL (UH) :	4375	PSF
WALKWAY GATE:		UPLIFT AT TOE (UT) :	2875	PSF
GATE WIDTH (WGW) :	12 FT	UPLIFT AT DRAIN (UD) :	3590	PSF
SILL ELEV (WSE) :	530 FT	CONCRETE WEDGE HEIGHT & LGTH (WH) :	20	FT
GATE WEIGHT (WGWT) :	5,000 LBS	(WH = CSE-BE-TTH)		
ADDL. HEEL WIDTH (HW) :	0 FT	FDN LENGTH (L) :	45	FT
HEEL THICKNESS (HTH) :	0 FT	(L - 11W + PL + WH + TW)		
ADDL. TOE WIDTH (TW) :	0 FT	FDN WIDTH (B) :	58	FT
TOE THICKNESS (TTH) :	2.4 FT	(B = CGW + WGW + PN*PT)		

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDU

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATI. FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-FEET	OVERTURNING MOMENT: LB-FEET
CHANNEL GATE:	15,000		32.00	480,000	
WALKWAY GATE:	5,000		32.00	160,000	
CONCRETE PIERS:	3,217,500		32.50	104,568,750	
UPPER STRUCTURE:	1,058,400		32.50	34,398,000	
CHANNEL BLOCK FDN:	7,590,000		32.50	246,675,000	
CHANNEL WEDGE FDN:	4,692,000		11.00	51,612,000	
WALKWAY BLOCK FDN:	2,520,000		32.50	81,900,000	
WALKWAY WEDGE FDN:	1,224,000		11.00	13,464,000	
HEEL SLAB:	0		45.00	0	
TOE SLAB:	0		0.00	0	
FLUID ON HEEL:	0		45.00	0	
FLUID ON CHANNEL SILL:	342,000		39.00	13,338,000	
FLUID ON WALKWAY SILL:	90,000		39.00	3,510,000	
FLUID ON D/S WEDGE:	725,000		6.67	4,833,333	
FLUID ON TOE:	0		0.00	0	
UPLIFT FORCE (U1):	-5,336,000		16.00	85,376,000	
UPLIFT FORCE (U2):	-663,211		21.33	14,148,494	
UPLIFT FORCE (U3):	-2,706,609		38.50	104,204,434	
UPLIFT FORCE (U4):	-296,071		40.67	12,040,207	
FLUID HORIZ. FORCE (H):		8,881,250	23.33	207,229,167	
RESISTING FLUID FORCE:		-3,835,250	15.33	58,807,167	
SUBTOTAL AT BASE (V,MR,MO) =	12,477,010	5,046,000		613,746,250	422,998,302

#### STABILITY RESULTS:

FRIC'ION FORCE (V*TAN(PHD)) =	6,568,794 LB	= $V * \tan(\phi)$ CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	5,046,000 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.30 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.45 > 1.0?	
ECCENTRICITY (E=L/2-(MR-MO)/V) =	7.21 (RELATIVE TO CL)	
BEARING PRESSURE = $V/L(1 + 6 * E/L)$		
MAX BEARING PRESS =	9377 PSF	
MIN BEARING PRESS =	184 PSF	
VOLUME OF CONCRETE =	5,013 CY	

**Section 3**  
**TRWD Isolation Gate Structures-**  
**RCC Foundation**

## **TRWD Isolation Gate Structure**

### **Usual Load Condition - SPF**

**(File I1 SPF-NoDrain-RCC TRWD.XLS)**

1. Concrete structure on roller compacted concrete foundation to rock.
2. Stability at top of RCC.
3. Sliding Factor of Safety = 1.50
4. SPF level at El 540.0 on driving side.
5. Tailwater at El 520.0 on resisting side.
6. Friction angle on RCC = 45 degrees.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PKSTR.DCS

DESIGNED BY: WES

DATE: 12/18/2004

CHECKED BY: SDA

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
SPF WATER ELEVATION (USUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:  
FLOOD ELEV (FE) : 540 FT  
TAILWATER ELEV (TE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 496 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 7.33 FT  
NO. OF CONC PIERS (PN) : 3  
UPPER STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

CHANNEL GATE:  
GATE WIDTH (CGW) : 24 FT  
SILL ELEV (CSE) : 518 FT  
GATE WEIGHT (CGWGT) : 15,000 LBS

WALKWAY GATE:  
GATE WIDTH (WGW) : 12 FT  
SILL ELEV (WSE) : 530 FT  
GATE WEIGHT (WGWT) : 5,000 LBS

ADJ. HEEL WIDTH (HW) : 0 FT  
HEEL THICKNESS (HTH) : 0 FT  
ADJ. TOE WIDTH (TW) : 0 FT  
TOE THICKNESS (TTH) : 12 FT

**DESIGN PARAMETERS (INPUT):**

ACTUAL SOIL FRICTION ANGLE (PHI) : 45 DEGREES  
ACTUAL SOIL COHESION (CN) : 0 PSF  
FLUID PRESS (EFP) : 62.5 PSF  
CONC UNIT WGT (CUW) : 150 RCF

DESIGN FRICTION ANGLE (PHD) : 33.69 DEGREES  
DESIGN COHESION (CND) : 0 PSF  
UPLIFT AT HEEL (UH) : 2750 PSF  
UPLIFT AT TOE (UT) : 1500 PSF

(WH = CSE-BE-TTH)  
FDN LENGTH (L) : 35 FT  
(L = HW + PL + WH + TW)  
FDN WIDTH (B) : 58 FT  
(B = CGW + WGWT + PN\*PT)

**RESULTING DESIGN VALUES & DIMENSIONS:**

PROJECT: TRWD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: BDA DATE: 12/20/04**STABILITY ANALYSIS:**

	WEIGHT: LB	LATL FORCE: 1.13	ARM TO TOE: 22.00	RESISTING MOMENT: 330,000	OVERTURNING MOMENT: 110,000
CHANNEL GATE:	15,000				
WALKWAY GATE:	5,000				
CONCRETE PIERS:	3,217.500				
UPPER STRUCTURE:	1,058,400				
CHANNEL BLOCK FDN:	3,795,000				
CHANNEL WEDGE FDN:	1,173,000				
WALKWAY BLOCK FDN:	1,530,000				
WALKWAY WEDGE FDN:	306,000				
HEEL SLAB:	0				
TOE SLAB:	0				
FLUID ON HERBL:	0				
FLUID ON CHANNEL STIL:	342,000				
FLUID ON WALKWAY STIL:	90,000				
FLUID ON D/S WEDGE:	181,250				
FLUID ON TOE:	0				
UPLIFT FORCE (U1):	-3,045,000				
UPLIFT FORCE (U2):	-1,268,750				
FLUID HORIZ FORCE (H):					
RESISTING FLUID FORCE:					
SUBTOTAL AT BASE (V,MR,MO) =	7,399,400	2,465,000			
				246,078,917	134,357,000

**STABILITY RESULTS:**

FRICITION FORCE (V*TAN(PHI)) =	4,932,933 LB	= U* (WEIGHT CONC + GATES + WATER UPLIFT)
COHESION FORCE (CND*L*B)	0 LB	- COHESION * BASE AREA
NET SLIDING FORCE =	2,465,000 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	2.00 >1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.83 >1.0?	
ECCENTRICITY (E-L/2-(MR-MO)/VI) =	2.40 (RELATIVE TO CL)	
BEARING PRESSURE = V/L(1+ -6*E/L)		
MAX BEARING PRESS = 5145 PSF		
MIN BEARING PRESS = 2445 PSF		
VOLUME OF CONCRETE = 2,736 CY		

**TRWD Isolation Gate Structure**

**Unusual Load Condition - Max Water Level**

**(File I2 MAX-NoDrain-RCC TRWD.XLS)**

1. Concrete structure on roller compacted concrete foundation to rock.
2. Stability at top of RCC.
3. Sliding Factor of Safety = 1.33
4. Maximum water level at El 544.0 on driving side.
5. Tailwater at El 520.0 on resisting side.
6. Friction angle on RCC = 45 degrees.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521 42275-PRSTR.DCS

DESIGNED BY: WES

DATE: 12/18/2004

CHECKED BY: BDA

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:  
FLOOD ELEV (FE) : 544 FT  
TAILWATER ELEV (TE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 496 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 7.33 FT  
NO. OF CONC PIERS (PN) : 3  
UPPER STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

**DESIGN PARAMETERS (INPUT):**

ACTUAL SOIL FRICTION ANGLE (PHI) : 1.33 DEGREES  
ACTUAL SOIL COHESION (CN) : 45 PSF  
FLUID PRESS (EFP) : 0 PSF  
CONC UNIT WGT (CDW) : 62.5 PCF  
CONC UNIT WGT (CDW) : 150 PCF

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:  
GATE WIDTH (CGW) : 24 FT DESIGN FRICTION ANGLE (PHD) : 36.94 DEGREES  
STILL ELEV (CSE) : 518 FT DESIGN COHESION (CND) : 0 PSF  
GATE WEIGHT (CGWGT) : 15,000 LBS UPLIFT AT HEEL (UH) : 3000 PSF  
UPLIFT AT TOE (UT) : 1500 PSF

WALKWAY GATE:  
GATE WIDTH (WGW) : 12 FT CONCRETE WEDGE HEIGHT & LGTH (WH) : 10 FT  
STILL ELEV (WSE) : 530 FT (WH = CSE - BE - TTH)  
GATE WEIGHT (WGWGT) : 5,000 LBS FDN LENGTH (L) : 3.5 FT  
 $(L = HW + PL + WH + TW)$   
ADDL. HEEL WIDTH (HW) : 0 FT FDN WIDTH (B) : 5.5 FT  
HEEL THICKNESS (HTH) : 0 FT ( $B = CGW + MGW + PN * PT$ )  
ADDL. TOE WIDTH (TW) : 0 FT  
TOE THICKNESS (TTH) : 12 FT

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42273-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDA

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM 'TO TOE': LB	RESISTING MOMENT: LB-FT	OVERTURNING MOMENT: LB-FT
CHANNEL GATE:	15,000		22.00	330,000	
WALKWAY GATE:	5,000		22.00	110,000	
CONCRETE PIERS:	3,217,500		22.50	72,393,750	
UPPER STRUCTURE:	1,058,400		22.50	23,814,000	
CHANNEL BLOCK FDN:	3,795,000		22.50	85,387,500	
CHANNEL WEDGE FDN:	1,173,000		5.50	6,451,500	
WALKWAY BLOCK FDN:	1,530,000		22.50	34,425,000	
WALKWAY WEDGE FDN:	306,000		5.50	1,683,000	
HEEL SLAB:	0		35.00	0	0
TOE SLAB:	0		0.00	0	0
FLUID ON HEEL:	0		35.00	0	0
FLUID ON CHANNEL SILL:	342,000		29.00	9,918,000	
FLUID ON WALKWAY SILL:	90,000		29.00	2,610,000	
FLUID ON D/S WEDGE:	181,250		3.33	604,167	0
FLUID ON TOE:	0		0.00	0	0
UPLIFT FORCE (U1):	-3,045,000		17.50	53,287,500	
UPLIFT FORCE (U2):	-1,522,500		23.33	35,525,000	
FLUID MORTRZ FORCE (H):			16.00	66,816,000	
RESISTING FLUID FORCE:			8.00	8,352,000	
SUBTOTAL AT BASE (V, MR, MO)	7,145,650	3,132,000		246,078,917	155,628,500

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHD))	5,372,669 LB	= U*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*1.0) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE	3,132,000 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO RATIO =	1.72 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
ECCENTRICITY (E=L/2 * (MR-MO)/V) =	1.58 > 1.0?	
BEARING PRESSURE V/L, (1+6*E/L) =	4.84 (RELATIVE 'TO CL')	
MAX BEARING PRESS =	6442 PSF	
MIN BEARING PRESS =	598 PSF	
VOLUME OF CONCRETE =	2,736 CY	

**TRWD Isolation Gate Structure**

**Unusual Load Condition - Max Water Level**

**(File I2 MAX-NoDrain-RCC-Base TRWD.XLS)**

1. Concrete structure on roller compacted concrete foundation to rock.
2. Stability at base of RCC (approximate).
3. Sliding Factor of Safety = 1.33
4. Maximum water level at El 544.0 on driving side.
5. Tailwater at El 520.0 on resisting side.
6. Friction angle at rock = 35 degrees.

PROJECT: 'IRWD - FLOOD GATE CONTROL STRUCTURE'

CHARGE NO.: 2521-422275 PRSTR, ICS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: DDA

DATE: 12/20/04

GATE: STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

DESIGN PARAMETERS (INPUT):

DIMENSIONS & WEIGHTS (INPUT):

GATE STRUCTURE:	
FLOOD ELEV (FE):	544 FT
TAILWATER ELEV (TE):	520 FT
TOP OF PIER ELEV (PE):	557 FT
PUN BASE ELEV (BE):	474 FT
PIER LENGTH (PL):	25 FT
PIER THICKNESS (PT):	7.33 FT
NO. OF CONC PIERS (PN):	3
UPPER STRUCTURE OUTLINE (USO):	98 FT
UPSTREAM FACE TO GATE CTR LINE (GCL):	13 FT

CHANNEL GATE:	
GATE WIDTH (CGW):	24 FT
STILL ELEV (CSE):	518 FT
GATE WEIGHT (CGWT):	15,000 LBS
WALKWAY GATE:	
GATE WIDTH (CGW):	12 FT
STILL ELEV (WSE):	530 FT
GATE WEIGHT (WGWT):	5,000 LBS
ADDL HEEL WIDTH (HW):	2 FT
HEEL THICKNESS (HTH):	22 FT
ADDL TOE WIDTH (TW):	0 FT
TOE THICKNESS (TT):	21 FT

GATE STRUCTURE:	FACTOR OF SAFETY (FS) :	1.33
FLOOD ELEV (FE):	ACTUAL SOIL FRICTION ANGLE (PHI) :	35 DEGREES
TAILWATER ELEV (TE):	ACTUAL SOIL COHESION (CN) :	0 PSF
TOP OF PIER ELEV (PE):	FLUID PRESS (EFP) :	62.5 PSF
PUN BASE ELEV (BE):	CONC UNIT WGT (CUW) :	150 PSF
PIER LENGTH (PL):		
PIER THICKNESS (PT):		
NO. OF CONC PIERS (PN):		
UPPER STRUCTURE OUTLINE (USO):		
UPSTREAM FACE TO GATE CTR LINE (GCL):		

RESULTING DESIGN VALUES & DIMENSIONS:

CHANNEL GATE:	DESIGN FRICTION ANGLE (PHID) :	27.77 DEGREES
GATE WIDTH (CGW):	DESIGN COHESION (CND) :	0 PSF
STILL ELEV (CSE):	UPLIFT AT HEEL (UH) :	4375 PSF
GATE WEIGHT (CGWT):	UPLIFT AT TOE (UT) :	2875 PSF
WALKWAY GATE:		
GATE WIDTH (CGW):	CONCRETE WEIGH & LENGTH (WH) :	23 FT
STILL ELEV (WSE):	(WH = CSE-BE-TTH) :	0 FT
GATE WEIGHT (WGWT):	FDN LENGTH (L) :	50 FT
ADDL HEEL WIDTH (HW):	(L = HW + PL + WH + TW) :	50 FT
HEEL THICKNESS (HTH):	FDN WIDTH (B) :	58 FT
ADDL TOE WIDTH (TW):	(B = CGW + WGWT + PN* PT)	
TOE THICKNESS (TT):		

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275 PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004  
BDA

CHECKED BY: \_\_\_\_\_

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LAT'L FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-FT	OVERTURNING MOMENT: LB-FT
CHANNEL GATE:	15,000		35.00	525,000	
WALKWAY GATE:	5,000		35.00	175,000	
CONCRETE PIENS:	3,217,500		35.50	114,221,250	
UPPER STRUCTURE:	1,058,400		35.50	37,573,200	
CHANNEL BLOCK FDN:	7,590,000		35.50	269,445,000	
CHANNEL WEDGE FDN:	5,157,750		12.88	66,450,070	
WALKWAY BLOCK FDN:	2,520,000		35.50	89,460,000	
WALKWAY WEDGE FDN:	1,345,500		12.88	17,334,801	
HEEL SLAB:	382,800		49.00	18,757,200	
TOE SLAB:	0		0.00	0	
FLUID ON CHANNEL SILL:	348,000		49.00	17,052,000	
FLUID ON WALKWAY SILL:	342,000		42.00	14,364,000	
FLUID ON D/S WEDGE:	90,000		42.00	3,780,000	
FLUID ON TOE:	0		7.67	7,350,896	
UPLIFT FORCE (U1):	-8,337,500		0.00	0	
UPLIFT FORCE (U2):	-2,175,000		25.00	208,437,500	
FLUID HORIZONTAL FORCE (H):		8,881,250	33.33	72,500,000	
RESISTING FLUID FORCE:		-3,835,250	23.33	207,229,167	
SUBTOTAL AT BASE (V, MR, MO)	12,518,262	5,046,000	15.33	58,807,167	
			715,295,584	488,166,667	

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI))	6,590,513 LB	U* (WEIGHT CONC + GATES + WATER UPLIFT)
COHESION FORCE (CND*1.1B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	5,046,000 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.31 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.47 > 1.0?	
ECCENTRICITY (R=L/2 - (MR-MO)/V) =	6.86 (RELATIVE TO CL)	
BEARING PRESSURE: V/L(1+ 6*E/L)	7868 PSF	
MAX BEARING PRESS =	765 PSF	
MIN BEARING PRESS =	765 PSF	
VOLUME OF CONCRETE =	5,252 CY	

# **Section 4**

## **TRWD Isolation Gate Structures-**

## **Pile Foundation**

**TRWD Isolation Gate Structure**

**Usual Load Condition - SPF**

**(File I1 SPF-NoDrain-Pile TRWD.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. SPF level at El 540.0 on driving side.
3. Tailwater at El 520.0 on resisting side.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521 42275-FRSTR.DCS

DATE: 12/18/2004

DESIGNED BY: WCS

BDA

CHECKED BY: — — —

GATE STRUCTURE STABILITY (W/ UPLIFT)  
SPF WATER ELEVATION (USUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:	540	FT	FACTOR OF SAFETY (FS):	1.33
FLOOD ELEV (FE):	520	FT	ACTUAL SOIL FRICTION ANGLE (PHI):	35 DEGREES
TAILWATER ELEV (TE):	55'	FT	ACTUAL SOIL COHESION (CN):	0 PSF
TOP OF PIER ELEV (PE):	496	FT	FLUID PRESSURE (EFP):	62.5 PSF
FDN BASE EL (BE):	25	FT	CONC UNIT WGT (CUW):	150 PSF
PIER LENGTH (PL):	7.33	FT		
PIER THICKNESS (PT):	3			
NO. OF CONC PIERS (PN):	98	FT		
UPPER STRUCTURE OUTLINE (USO):	13	FT		
UPSTREAM FACE TO GATE CTR LINE (GCL):				

CHANNEL GATE:  
GATE WIDTH (CGW): 24 FT DESIGN FRICTION ANGLE (PHID): 27.7° DEGREES  
STILL ELEV (CSE): 51.8 FT DESIGN COHESION (CND): 0 PSF  
GATE WEIGHT (CGWGT): 15,000 LBS UPLIFT AT HEEL (UH): 2750 PSF  
UPLIFT AT TOE (UT): 1500 PSF

WALKWAY GATE:  
GATE WIDTH (WG): 12 FT CONCRETE WEDGE UPTIGHT & LENGTH (ML): 10 FT  
STILL ELEV (WSE): 530 FT (WH = CSE-BE-TW)  
GATE WEIGHT (WGWT): 5,000 LBS FDN LENGTH (L): 35 FT  
ADDL HEEL WIDTH (HW): 0 FT  
HEEL THICKNESS (HTH): 0 FT (L = HW + PL + WH + TW)  
ADDL. TOE WIDTH (TW): 0 FT FDN WIDTH (B): 58 FT  
TOE THICKNESS (TTW): 12 FT (B = CGN + WG + PN\*PT)

**DESIGN PARAMETERS (INPUT):**

GATE STRUCTURE:	540	FT	FACTOR OF SAFETY (FS):	1.33
FLOOD ELEV (FE):	520	FT	ACTUAL SOIL FRICTION ANGLE (PHI):	35 DEGREES
TAILWATER ELEV (TE):	55'	FT	ACTUAL SOIL COHESION (CN):	0 PSF
TOP OF PIER ELEV (PE):	496	FT	FLUID PRESSURE (EFP):	62.5 PSF
FDN BASE EL (BE):	25	FT	CONC UNIT WGT (CUW):	150 PSF
PIER LENGTH (PL):	7.33	FT		
PIER THICKNESS (PT):	3			
NO. OF CONC PIERS (PN):	98	FT		
UPPER STRUCTURE OUTLINE (USO):	13	FT		
UPSTREAM FACE TO GATE CTR LINE (GCL):				

RESULTING DESIGN VALUES & DIMENSIONS:  
CHANNEL GATE:  
GATE WIDTH (CGW): 24 FT DESIGN FRICTION ANGLE (PHID): 27.7° DEGREES  
STILL ELEV (CSE): 51.8 FT DESIGN COHESION (CND): 0 PSF  
GATE WEIGHT (CGWGT): 15,000 LBS UPLIFT AT HEEL (UH): 2750 PSF  
UPLIFT AT TOE (UT): 1500 PSF

PROJECT: TRWD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275 PRSTR,DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: BDA DATE: 12/20/04

**STABILITY ANALYSIS:**

	WEIGHT:	LATL FORCE:	ARM TO TOE:	RESISTING MOMENT:	OVERTURNING MOMENT:
CHANNEL GATE:	15,000 LB		22.00	330,000	
WALKWAY GATE:	5,000		22.00	110,000	
CONCRETE PIERS:	3,217,500		22.50	72,393,750	
UPPER STRUCTURE:	1,058,400		22.50	23,814,000	
CHANNEL BLOCK FDN:	3,795,000		22.50	85,387,500	
CHANNEL WEDGE FDN:	1,173,000		5.50	6,451,500	
WALKWAY BLOCK FDN:	1,530,000		22.50	34,425,000	
WALKWAY WEDGE FDN:	306,000		5.50	1,683,000	
HEEL SLAB:	0		35.00	0	0
TOE SLAB:	0		0.00	0	0
FLUID ON CHANNEL SILL:	0		35.00	9,918,000	
FLUID ON WALKWAY SILL:	90,000		29.00	2,610,000	
FLUID ON D/S WEDGE:	342,000		3.33	604,167	
FLUID ON TOE:	181,250		0.00	0	
UPLIFT FORCE (U1):	-3,045,000		17.50	51,465,333	
UPLIFT FORCE (U2):	-1,268,750		23.33	29,604,167	
FLUID HORIZ FORCE (H):		3,509,000	14.67		
RESISTING FLUID FORCE:		1,044,000	8.00	8,352,000	
SUMTOTAL AT BASE (V,MR,MO):	7,399,400	2,465,000		246,078,917	134,357,000

**STABILITY RESULTS:**

FRICITION FORCE (W*TAN(PHI)) =	3,895,576 LB	D*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	- COHESION * BASE AREA
NET SLIDING FORCE =	2,465,000 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.58 > 1.0?	(FRICTION + COHESION) / (NET SLIDING)
ECCENTRICITY (E=L/2-(MR-MO)/V) =	1.83 > 1.0?	OVERTURNING MOMENT / (RELATIVE TO CL)
BEARING PRESSURE = V/L(1-6*E/L)	2.40	
MAX BEARING PRESS =	5145 PSF	
MIN BEARING PRESS =	2145 PSF	
VOLUME OF CONCRETE =	2,736 CY	

**TRWD Isolation Gate Structure**

**Unusual Load Condition – Max Water Level**

**(File I2 MAX-NoDrain-Pile TRWD.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. Maximum water level at El 544.0 on driving side.
3. Tailwater at El 520.0 on resisting side.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004  
*BDA*

CHECKED BY: — —

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

DESIGN PARAMETERS (INPUT):

DIMENSIONS & WEIGHTS (INPUT):

GATE STRUCTURE:		FACTOR OF SAFETY (FS):	1.33
FLOOD ELEV (FE):	544 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	35 DEGREES
TAILWATER ELEV (TE):	520 FT	ACTUAL SOIL COHESION (CN):	0 PSF
TOP OF PIER ELEV (PE):	557 FT	FLUID PRESS. (EFP):	62.5 PCF
FDN BASE EL (BE):	496 FT	CONC. UNIT WGT (CUW):	150 PCF
PIER LENGTH (PL):	25 FT		
PIER THICKNESS (PT):	7.33 FT		
NO. OF CONC. PIERS (PN):	3		
UPPER STRUCTURE OUTLINE (USO):	98 FT		
UPSTREAM FACE TO GATE CTR LINE (GCL):	13 FT		

RESULTING DESIGN VALUES & DIMENSIONS:

CHANNEL, GATE:		DESIGN FRICTION ANGLE (PHID):	27.77 DEGREES
GATE WIDTH (CGW):	24 FT	DESIGN COHESION (CND):	0 PSF
SILL ELEV (CSE):	518 FT	UPLIFT AT HEEL (UH):	3000 PSF
GATE WEIGHT (CGWGT):	15,000 LBS	UPLIFT AT TOE (UT):	1500 PSF

WALKWAY GATE:

GATE WIDTH (WGW):	12 FT	CONCRETE WEDGE HEIGHT & LGTH (WH):	10 FT
SILL ELEV (WSE):	530 FT	(WH = CSE-BE-TTH)	
GATE WEIGHT (WGWT):	5,000 LBS	FDN LENGTH (L):	35 FT
ADDL HEEL WIDTH (HW):	0 FT	(L = HW + PL + WH + TW)	
HEEL THICKNESS (HTH):	0 FT	FDN WIDTH (B):	58 FT
ADDL TOE WIDTH (TW):	0 FT	(B = CGW + WGW + PN*PT)	
TOE THICKNESS (TT):	12 FT		

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2421-42275-PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: TBDIA DATE: 12/20/04

**STABILITY ANALYSIS:**

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOR: LB	RESISTING MOMENT: LB-FEET	OVERTURNING MOMENT: LB-FEET
CHANNEL GATE:	15,000		22.00	330,000	
WALKWAY GATE:	5,000		22.00	110,000	
CONCRETE PIERS:	3,217,500		22.50	72,393,750	
UPPER STRUCTURE:	1,058,400		22.50	23,814,000	
CHANNEL BLOCK FDN:	3,795,000		22.50	85,387,500	
CHANNEL WEDGE FDN:	1,173,000		5.50	6,455,500	
WALKWAY BLOCK FDN:	1,530,000		22.50	34,425,000	
WALKWAY WEDGE FDN:			5.50	1,683,000	
WALKWAY SLAB:	3,066,000		35.00	0	
HEEL SLAB:	0		0.00	0	
TOR SLAB:	0		35.00	0	
FLUID ON WHEEL:	0		29.00	9,918,000	
FLUID ON CHANNEL SLAB:	342,000		29.00	2,610,000	
FLUID ON WALKWAY SLAB:	90,000		3.33	604,167	
FLUID ON D'S WEDGE:	181,250		0.00	0	
FLUID ON TOR:	0		17.50	53,287,500	
UPLIFT FORCE (U1):	-3,045,000		0.00	35,525,000	
UPLIFT FORCE (U2):	-1,522,500		23.33	66,816,000	
FLUID HORZ FORCE (H1):		4,176,000	16.00	8,352,000	
FLUID HORZ FORCE (H2):		1,044,000	8.00		
RESISTING FLUID FORCE:				246,078,917	155,628,500
SUBTOTAL AT BASE (V,MR,MO) =	7,145,650	3,132,000			

**STABILITY RESULTS:**

FRICITION FORCE (V*TAN(PHIID)) =	3,761,983 LB	= U* WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*1.4*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	3,132,000 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.20 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.58 > 1.0?	
HCENTRICITY ( $B_{L/2}^2 - (MR-MO)/V$ ) =	4.84 (RELATIVE TO C1.)	
BEARING PRESSURE = $V/L(1 + 6 * E/L)$	64442 PSF	
MAX BEARING PRESS =	598 PSF	
MIN BEARING PRESS =	2,736 CY	
VOLUME OF CONCRETE =		

**TRWD Isolation Gate Structure**

**Extreme Load Condition - Seismic**

**(File I3 SEISMIC-NoDrain-Pile TRWD.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. Normal pool level at El 525.0 on driving side.
3. Tailwater at El 520.0 on resisting side.
4. Horizontal ground acceleration = 0.05 g.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275 PRSTR.DCS

DESIGNED BY: WCS  
BDA  
DATE: 12/18/2004

GATE STRUCTURE STABILITY (W/ UPLIFT)  
NORMAL POOL ELEVATION WITH SEISMIC (EXTREME CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:  
FLOOD ELEV (FE) : 525 FT  
TAILWATER ELEV (TE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 496 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 7.33 FT  
NO. OF CONC PIERS (PN) : 3  
UPPER STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

**DESIGN PARAMETERS (INPUT):**

GATE STRUCTURE:  
ACTUAL SOIL FRICTION ANGLE (PHI) : 35 DEGREES  
ACTUAL SOIL COHESION (CN) : 0 PSF  
FLUID PRESS (EFP) : 62.5 PCF  
CONC UNIT WGT (CUW) : 150 PCF  
SEISMIC COEFFICIENT (A) : 0.05 q

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:  
GATE WIDTH (CGW) : 24 FT  
SILL ELEV (CSE) : 518 FT  
GATE WEIGHT (CGWT) : 15,000 LBS

WALKWAY GATE:  
GATE WIDTH (NGW) : 12 FT  
SILL ELEV (NSE) : 530 FT  
GATE WEIGHT (WGWT) : 5,000 LBS

ADDL. HEEL WIDTH (HW) : 0 FT  
HEEL THICKNESS (HTH) : 0 FT  
ADDL. TOE WIDTH (TW) : 0 FT  
TOE THICKNESS (TTH) : 12 FT

DESIGN FRICTION ANGLE (PHD) : 32.46 DEGREES  
DESIGN COHESION (CND) : 0 PSF  
UPLIFT AT HEEL (UH) : 1813 PSF  
UPLIFT AT TOE (UT) : 1500 PSF

FDN LENGTH (L) : 35 FT  
(L = HW + PL + WH + TW)  
FDN WIDTH (B) : 58 FT  
(B = CGW + WGWT + PN \* PT)

**SEISMIC PARAMETERS:**

SEISMIC INERTIA DUE TO MASS = SUM(DL) \* A  
ASSUMED CENTROID OF MASS = 0.4\*(TE-BE)  
SEISMIC FLUID FORCE (PER WESTERGAARD) = 0.67\*51\*A\*(TE-BE)^2  
FLUID FORCE RESULTANT ABOVE BASE = 0.4\*(TE-BE)  
OR 0.4\*(TE-BE)

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS  
CHECKED BY: BDH — DATE: 12/10/04

#### STABILITY ANALYSIS:

WEIGHT <sup>a</sup> :	LAT. FORCE:	ARM TO TOE:	RESISTING MOMENT:	OVERTURNING MOMENT:
CHANNEL GATE:	1,6,000 LB	22.00	330,000	
WALKWAY GATE:	5,000	22.00	110,000	
CONCRETE PIERS:	3,217,500	22.50	72,393,750	
UPPER STRUCTURE:	1,058,400	22.50	23,814,000	
CHANNEL BLOCK FDN:	3,795,000	22.50	85,387,500	
CHANNEL WEDGE FDN:	1,173,000	5.50	6,451,500	
WALKWAY BLOCK FDN:	1,530,000	22.50	34,425,000	
WALKWAY WEDGE FDN:	306,000	5.50	1,683,000	
HEEL SLAB:	0	35.00	0	
TOE SLAB:	0	0.00	0	
FLUID ON HEEL:	0	35.00	0	
FLUID ON CHANNEL STILE:	342,000	29.00	9,918,000	
FLUID ON WALKWAY SILL:	90,000	29.00	2,610,000	
FLUID ON D/S WEDGE:	181,250	3.33	604,167	
FLUID ON TOE:	0	0.00	0	
UPLIFT FORCE (U1):	-3,045,000	17.50	53,287,500	
UPLIFT FORCE (U2):	-317,187	23.33	7,401,042	
FLUID HORIZ FORCE (H):			14,735,021	
RESISTING FLUID FORCE:				
SEISMIC INERTIA FORCE:				
SEISMIC FLUID FORCE U/S:				
SEISMIC FLUID FORCE D/S:				
SUBTOTAL AT BASE (V, MR, MO)	8,350,962	1,037,728	246,078,917	88,991,555

#### STABILITY RESULTS:

FRICTION FORCE (V*TAN(ΦILL))	5,315,824 LB	= $U * (\text{WEIGHT CONC} + \text{GATES} + \text{WATER} - \text{UPLIFT})$
COHESION FORCE (CND*L*θ)	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	1,037,728 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	5.12 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	2.77 > 1.0?	
ECCENTRICITY ( $E=L/2 - (MR\text{-MO})/V$ ) =	-1.31 (RELATIVE TO CL)	
BEARING PRESSURE =	$V/L(1 - 6^{\circ}\theta/E)$	
MAX BEARING PRESS =	3189 PSF	
MIN BEARING PRESS =	5038 PSF	
VOLUME OF CONCRETE =	2,736 CY	

**Section 5**

**Trinity Point Isolation Gate Structures-**

**Mass Concrete Foundation**

**Trinity Point Isolation Gate Structure**

**Usual Load Condition - SPF**

**(File I1 SPF-NoDrain-Mass TPoint.XLS)**

1. Mass concrete foundation on rock.
2. Sliding Factor of Safety = 1.50
3. SPF level at El 545.5 on driving side.
4. Tailwater at El 520.0 on resisting side.
5. Friction angle at rock = 35 degrees.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS  
CHECKED BY: BDA — —

GATE STRUCTURE STABILITY (W/ UPLIFT)  
SF = WATER ELEVATION (USUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:	
FLOOD ELEV (FE):	545.5 FT
TAILWATER ELEV (TE):	520 FT
TOP OF PIER ELEV (PE):	557 FT
PON BASE BL (BE):	465 FT
PIER LENGTH (PL):	25 FT
PIER THICKNESS (PT):	8 FT
NO. OF CONC PIERS (PN):	4
UPPER STRUCTURE OUTLINE (USO):	98 FT
UPSTREAM FACE TO GATE CTR LINE (GCL):	13 FT

**DESIGN PARAMETERS (INPUT):**

	FACTOR OF SAFETY (FS):	1.5 DEGREES
ACTUAL SOIL FRICTION ANGLE (PHI):	35	DEGREES
ACTUAL SOIL COHESION (CN):	0 PSF	
FLUID PRESSURE (EFP):	62.5 PSF	
CONC UNIT WGT (CUW):	150 PSF	

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:	
GATE WIDTH (CGW):	24 FT
STILL ELEV (CSE):	518 FT
GATE WEIGHT (CGWT):	15,000 LBS
WALKWAY GATES:	
GATE WIDTH - 2 GATES (WGW):	24 FT
SILI. ELEV (WSE):	530 FT
GATE WEIGHT - 2 GATES (WGWT):	10,000 LBS
CONCRETE WEDGE HEIGHT & LTC(H) (WH):	
(WH = CSE-BE-TTH)	3.5 FT
FDN LENGTH (L):	60 FT
(L = HW + PL + WH + TW)	
FDN WIDTH (B):	80 FT
(B = CGW + WGW + PN*PT)	

PROJECT: TIRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: BDA DATE: 12/20/04

#### STABILITY ANALYSIS:

WEIGHT <sup>U</sup> :	LATL FORCE:	ARM TO TOE:	RESISTING MOMENT:
LB	LB	LB	LB
CHANNEL GATE:	15,000	47.00	705,000
WALKWAY GATE:	10,000	47.00	470,000
CONCRETE PIERS:	4,680,000	47.50	222,300,000
UPPER STRUCTURE:	1,411,200	47.50	67,032,000
CHANNEL BLOCK FDN:	11,130,000	47.50	528,675,000
CHANNEL WEDGE FDN:	10,437,000	20.43	213,260,250
WALKWAY BLOCK FDN:	5,850,000	47.50	277,875,000
WALKWAY WEDGE FDN:	4,473,000	20.43	91,397,250
HEEL SLAB:	0	60.00	0
TOE SLAB:	0	0.00	0
FLUID ON HEEL:	0	60.00	18,468,000
FLUID ON CHANNEL SLILL:	342,000	54.00	9,720,000
FLUID ON WALKWAY SLILL:	180,000	54.00	0
FLUID ON D/S WEDGE:	3,062,500	11.67	35,729,167
FLUID ON TOE:	0	0.00	0
UPLIFT FORCE (U1):	-16,500,000	39.00	495,000,000
UPLIFT FORCE (U2):	-3,825,000	40.00	153,000,000
FLUID HORTZ FORCE (H):	-16,200,625	26.83	434,716,771
RESISTING FLUID FORCE:	-7,562,500	18.33	138,645,833
SUBTOTAL AT BASE (V,MR,MO)=	21,265,700	8,638,125	1,604,277,500 1,082,716,771

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI)) =	9,926,936 LB	= U* (WEIGHT CONC + GATES + WATER UPLIFT)
COHESION FORCE (CND*L*) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	8,638,125 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO :	1.15 >1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.48 >1.0?	
ECCENTRICITY (B=L/2 - (MR-MO)/VI) =	5.47 (RELATIVE TO CL)	
BEARING PRESSURE : V/L(1+6*B/L)		
MAX BEARING PRESS =	6856 PSF	
MIN BEARING PRESS =	2005 PSF	
VOLUME OF CONCRETE :	9,378 CY	

**Trinity Point Isolation Gate Structure**  
**Unusual Load Condition - Max Water Level**

**(File I2 MAX-NoDrain-Mass TPoint.XLS)**

1. Mass concrete foundation on rock.
2. Sliding Factor of Safety = 1.33
3. Maximum water level at El 549.5 on driving side.
4. Tailwater at El 520.0 on resisting side.
5. Friction angle at rock = 35 degrees.

PROJECT: TWND FLOOD GATE CONTOUR, STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCE

DATE: 12/18/2004

*BDA*  
DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:  
FLOOD ELEV (FE) : 549.5 FT  
TAILWATER ELEV (TE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
PEN BASE EL (BRE) : 465 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 8 FT  
NO. OF CONC PIERS (PN) : 4  
UPPER STRUCTURE OUTLINE (UBO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

**DESIGN PARAMETERS (INPUT):**

GATE STRUCTURE:  
ACTUAL SOIL FRICTION ANGLE (PHI) : 35 DEGREES  
ACTUAL SOIL COHESION (CN) : 0 PSF  
FLUID PRESS (EFP) : 62.5 PSF  
CONC UNIT WGT (CUW) : 150 PSF

CHANNEL GATE:  
GATE WIDTH (CGW) : 24 FT DESIGN FRICTION ANGLE (PHID) : 21.7° DEGREES  
SILL ELEV (CSE) : 518 FT DESIGN COHESION (CND) : 0 PSF  
GATE WEIGHT (WGWT) : 15,000 LBS UPLIFT AT HEEL (UH) : 5281 PSF  
UPLIFT AT TOE (UT) : 3438 PSF

WALKWAY GATES:  
GATE WIDTH - 2 GATES (NGW) : 24 FT CONCRETE WEDGE HEIGHT & LENGTH (WH) : 35 FT  
SILL ELEV (NSR) : 530 FT (WH = CSE-BE-TTH)  
GATE WEIGHT 2 GATES (WGWT) : 10,000 LBS FDN LENGTH (L) : 60 FT  
ADL HEEL WIDTH (HW) : 0 FT (L = HW + PL + WH + TR)  
HEEL THICKNESS (HTH) : 0 FT FDN WIDTH (B) : 80 FT  
ADL TOE WIDTH (TW) : 0 FT (B = CGW + NGW + TN\*PT)  
TOE THICKNESS (TTH) : 18 FT

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:  
GATE WIDTH (CGW) : 24 FT DESIGN FRICTION ANGLE (PHID) : 21.7° DEGREES  
SILL ELEV (CSE) : 518 FT DESIGN COHESION (CND) : 0 PSF  
GATE WEIGHT (WGWT) : 15,000 LBS UPLIFT AT HEEL (UH) : 5281 PSF  
GATE WEIGHT (WGWT) : 15,000 LBS UPLIFT AT TOE (UT) : 3438 PSF

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDA —  
DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LAT'L FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: 705,000	OVERTURNING MOMENT: 705,000
CHANNEL GATE:	15,000		47.00		
WALKWAY GATE:	10,000		47.00		
CONCRETE PIERS:	4,680,000		47.50	222,300,000	
UPPER STRUCTURE:	1,411,200		47.50		67,032,000
CHANNEL BLOCK FDN:	11,130,000		47.50		528,675,000
CHANNEL WEDGE FDN:	10,437,000		20.43		213,260,250
WALKWAY BLOCK FDN:	5,850,000		47.50		277,875,000
WALKWAY WEDGE FDN:	4,473,000		20.43		91,397,250
HEEL SLAB:	0		60.00		0
TOE SLAB:	0		0.00		0
FLUID ON HEEL:	0		60.00		0
FLUID ON CHANNEL SILL:	342,000		54.00		18,468,000
FLUID ON WALKWAY SILL:	180,000		54.00		9,720,000
FLUID ON D/S WEDGE:	3,062,500		11.67		35,729,167
FLUID ON 'OE':	0		0.00		0
UPLIFT FORCE ('U1'):	-16,500,000		30.00		495,000,000
UPLIFT FORCE ('U2'):	-4,425,000		40.00		177,000,000
FLUID HORIZONTAL FORCE ('H'):			28.17		502,792,604
RESISTING FLUID FORCE:			17,850,625		
			-7,562,500		
SUBTOTAL AT BASE (V,MR,MO) =	20,665,700	10,288,125	18.33	138,645,833	
				1,604,277,500	1,174,792,604

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI'D)) =	10,879,909 LB	U*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	10,288,125 LB	DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO	1.06 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.37 > 1.0?	
ECCENTRICITY (E=L/2 - (MR-MO)/V) =	9.22 (RELATIVE TO CL)	
BEARING PRESSURE = V/L (1+-6 E/L)	8274 PSF	
MAX BEARING PRESS -	337 PSF	
MIN BEARING PRESS -	9,378 CF	
VOLUME OF CONCRETE =		

**Trinity Point Isolation Gate Structure (with Drains)**

**Unusual Load Condition – Max Water Level**

**(File I2 MAX-Drain-Mass TPoint.XLS)**

1. Mass concrete foundation on rock, with foundation drainage system.
2. Maximum water level at El 549.5 on driving side.
3. Tailwater at El 520.0 on resisting side.
4. Drains 33 percent effective, 10-ft downstream of headwall.

PROJECT: TIRAD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-422/5-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDA — —

DATE: 12/18/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LIVER: (UNUSUAL CONDITION)

DESIGN PARAMETERS (INPUT):

DIMENSIONS & WEIGHTS (INPUT):

GATE STRUCTURE:		FACTOR OF SAFETY (FS) :	1.33
FLOOD ELEV (FE) :	549.5 FT	ACTUAL SOIL FRICTION ANGLE (PHI) :	35 DEGREES
TAILWATER ELEV (TE) :	520 FT	ACTUAL SOIL COHESION (CN) :	0 PSF
TOP OF PIER ELEV (PE) :	557 FT	FLUID PRESS (ISFP) :	62.5 PCF
FDN BASE EL (BE) :	465 FT	CONC UNIT WGT (CUW) :	150 PCF
PIER LENGTH (PL) :	25 FT	DRAIN EFFICIENCY (DE) :	0.33
PIER THICKNESS (PT) :	8 FT	DRAIN DIMENSION FROM HEADWALL (DD) :	10 FT
NO. OF CONC PIERS (PN) :	4		
UPPER STRUCTURE OUTLINE (USO) :	98 FT		
UPSTREAM FACE TO GATE CTR LINE (GCL) :	13 FT		

RESULTING DESIGN VALUES & DIMENSIONS:

CHANNEL GATE:		DESIGN FRICTION ANGLE (PHID) :	27.77 DEGREES
GATE WIDTH (CGW) :	24 FT	DESIGN COHESION (CND) :	0 PSF
SILL ELEV (CSE) :	518 FT	UPLIFT AT HEEL (UH) :	5281 PSF
GATE WEIGHT (CGWGWT) :	15,000 LBS	UPLIFT AT TOE (UT) :	3438 PSF
		UPLIFT AT DRAIN (UD) :	4460 PSF
WALKWAY GATES:		CONCRETE WEDGE HEIGHT & LGHT (WH) :	33 FT
GATE WIDTH - 2 GATES (WGW) :	24 FT	(WH = CSE-BE-TTH)	
SILL ELEV (WSE) :	530 FT	FDN LENGTH (Ld) :	58 FT
GATE WEIGHT - 2 GATES (WGNGT) :	10,000 LBS	(Ld = HW + PL + WH + TW)	
ADDL HEEL WIDTH (HW) :	0 FT	FDN WIDTH (B) :	80 FT
HEEL THICKNESS (HTH) :	0 FT	(B = CGW + WGW + PN* PT)	
ADDL TOE WIDTH (TW) :	0 FT		
TOE THICKNESS (TTH) :	20 FT		

PROJECT: TIRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDA — —

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT:	LATL FORCE:	ARM TO TOE:	RESISTING MOMENT:
CHANNEL GATE:	15,000 LB		45.00	675,000
WALKWAY GATE:	10,000		45.00	450,000
CONCRETE PIERS:	4,680,000		45.50	212,940,000
UPPER STRUCTURE:	1,411,200		45.50	64,209,600
CHANNEL BLOCK FDN:	11,130,000		45.50	506,415,000
CHANNEL WEDGE FDN:	10,117,800		19.04	192,602,718
WALKWAY BLOCK FDN:	5,850,000		45.50	266,175,000
WALKWAY WEDGE FDN:	4,336,200		19.04	82,544,022
HEEL SLAB:	0		58.00	0
TOE SLAB:	0		0.00	0
FLUID ON HEEL:	0		58.00	17,784,000
FLUID ON CHANNEL STLL:	342,000		52.00	9,360,000
FLUID ON WALKWAY STLL:	180,000		11.00	29,947,500
FLUID ON D/S WEDGE:	2,722,500		0.00	0
FLUID ON TOE:	0		24.00	316,800,000
UPLIFT FORCE (U1):	-13,200,000		32.00	62,811,807
UPLIFT FORCE (U2):	*1,962,869		53.00	189,096,930
UPLIFT FORCE (U3):	-3,567,862		54.67	17,961,770
UPLIFT FORCE (U4):	.328,569		28.17	502,792,604
FLUID HORIZ FORCE (H):		17,850,625		
RESISTING FLUID FORCE:		-7,562,500		
SUMTOTAL AT BASE (V, MR, MO)	21,735,400	10,288,125		1,521,748,673 1,039,462,871

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI)) =	11,443,076 LB	U*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	COHESION * BASE AREA
NET SLIDING FORCE =	10,288,125 LB	DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO :	1.11 >1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) :	1.40 >1.0?	
ECCENTRICITY (E=L/2-(MR-MO)/V) =	9.11 (RELATIVE TO CL.)	
REARING PRESSURE = V/L(1+6*E/L)		
MAX BEARING PRESS =	9100 PSF	
MIN BEARING PRESS =	269 PSF	
VOLUME OF CONCRETE =	9,265 CY	

**Section 6**

**Trinity Point Isolation Gate Structures-**

**RCC Foundation**

**Trinity Point Isolation Gate Structure**

**Usual Load Condition - SPF**

**(File I1 SPF-NoDrain-RCC TPoint.XLS)**

1. Concrete structure on roller compacted concrete foundation to rock.
2. Stability at top of RCC.
3. Sliding Factor of Safety = 1.50
4. SPF level at El 545.5 on driving side.
5. Tailwater at El 520.0 on resisting side.
6. Friction angle on RCC = 45 degrees.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275~PRSTR.DCS

DESIGNED BY: WES

DATE: 12/18/2004  
CHECKED BY: BDA  
DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
SFPE WATER ELEVATION (USUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:	
FLOOD ELEV (FE):	545.5 FT
TAILWATER ELEV (TE):	520 FT
TOP OF PIER ELEV (PE):	557 FT
FDN BASE EL (BE):	509 FT
PIER LENGTH (PL):	25 FT
PIER THICKNESS (PT):	8 FT
NO. OF CONC PIERS (PN):	4
UPPER STRUCTURE OUTLINE (USO):	98 FT
UPSTREAM FACE TO GATE CTR LINE (GCL):	13 FT

**DESIGN PARAMETERS (INPUT):**

GATE STRUCTURE:	FACTOR OF SAFETY (FS):	1.5
FLOOD ELEV (FE):	ACTUAL SOIL FRICTION ANGLE (PHI):	45 DEGREES
TAILWATER ELEV (TE):	ACTUAL SOIL COHESION (CN):	0 PSF
TOP OF PIER ELEV (PE):	FLUID PRESS (FEP):	62.5 PSF
FDN BASE EL (BE):	CONC UNIT WGT (CUW):	150 PSF

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:	
GATE WIDTH (CGW):	24 FT
STILL ELEV (CSE):	518 FT
GATE WEIGHT (CGWGT):	15,000 LBS

DESIGN FRICTION ANGLE (PHD):	33.69 DEGREES
DESIGN COHESION (CND):	0 PSF
UPLIFT AT HEEL (UH):	2281 PSF
UPLIFT AT TOE (UT):	688 PSF

**WALKWAY GATES:**

GATE WIDTH - 2 GATES (WGW):	24 FT
STILL ELEV (WSE):	530 FT
GATE WEIGHT - 2 GATES (WGWT):	10,000 LBS

CONCRETE WEDGE HEIGHT & LGTH (WH):	9 FT
(WH = CGW-BE-TTH)	34 FT
FDN LENGTH (L):	(L = HW + PL + WH + TW)
FDN WIDTH (B):	80 FT
{B = CGW + WGW + TN*PT}	

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: BDJ DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATERAL FORCE: LB	ARM TO TOE: FT	RESISTING MOMENT: FT-LB
CHANNEL GATE:	15,000		21.00	315,000
WALKWAY GATE:	10,000		21.00	210,000
CONCRETE PTERS:	4,660,000		21.50	100,620,000
UPPER STRUCTURE:	1,411,200		21.50	30,340,800
CHANNEL BLOCK FDN:	1,390,000		21.50	40,635,000
CHANNEL WEDGE FDN:	340,200		6.03	2,051,406
WALKWAY BLOCK FDN:	1,890,000		21.50	40,635,000
WALKWAY WEDGE FDN:	145,800		6.03	879,174
WALKWAY WEDGE FDN:	0		34.00	0
HEEL SLAB:	0		0.00	0
TOE SLAB:	0		34.00	0
FLUID ON HEEL:	0		28.00	9,576,000
FLUID ON CHANNEL SILL:	342,000		28.00	5,040,000
FLUID ON WALKWAY SILL:	180,000		3.00	607,500
FLUID ON D/S WEDGE:	202,500		0.00	0
FLUID ON TOE:	0		17.00	31,790,000
UPLIFT FORCE (U1):	1,870,000		17.00	49,130,000
UPLIFT FORCE (U2):	-2,167,500		12.17	40,522,604
FLUID HORIZONTAL FORCE (H):			22.67	
RESISTING FLUID FORCE:			3.67	
SUBTOTAL AT BASE (V,MR,MO)	7,069,200	3,028,125	232,019,047	121,442,604

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI)) =	4,712,800 LB	= U*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	3,028,125 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.56 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.91 > 1.0?	
ECCENTRICITY ( $E=L/2 - (MR-MO)/V$ ) =	1.36 (RELATIVE TO CL)	
BEARING PRESSURE = $V/L(1+6*E/L)$		
MAX BEARING PRESS = 3222 PSF		
MIN BEARING PRESS = 1976 PSF		
VOLUME OF CONCRETE = 2,557 CY		

**Trinity Point Isolation Gate Structure  
Unusual Load Condition - Max Water Level**

**(File I2 MAX-NoDrain-RCC TPoint.XLS)**

1. Concrete structure on roller compacted concrete foundation to rock.
2. Stability at top of RCC.
3. Sliding Factor of Safety = 1.33
4. Maximum water level at El 549.5 on driving side.
5. Tailwater at El 520.0 on resisting side.
6. Friction angle on RCC = 45 degrees.

PROJECT: TRWD - FLOOD GATE CONTROL, STRUCTURE

CHARGE NO.: 2521 42275-FRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004  
BDA

CHECKED BY: — —

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL, TO TOP OF LVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:  
FLOOD ELEV (FE) : 549.5 FT  
TAILWATER ELEV (TE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 509 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 8 FT  
NO. OF CONC PIERS (PN) : 4  
UPPER STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

**DESIGN PARAMETERS (INPUT):**

FACTOR OF SAFETY (FS) : 1.33  
ACTUAL SOIL FRICTION ANGLE (PHI) : 45 DEGREES  
ACTUAL SOIL COHESION (CN) : 0 PSF  
FLUID PRESS (EFP) : 62.5 PCF  
CONC UNIT WGT (CUW) : 150 PCF

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL, GATE:  
GATE WIDTH (CGW) : 24 FT  
STILL ELEV (CSB) : 518 FT  
GATE WEIGHT (CCGWGT) : 15,000 LBS

DESIGN FRICTION ANGLE (PHD) : 36.94 DEGREES  
DESIGN COHESION (CND) : 0 PSF  
UPLIFT AT HEEL (UH) : 2531 PSF  
UPLIFT AT TOE (UT) : 688 PSF

**WALKWAY GATES:**

GATE WIDTH - 2 GATES (WGM) : 24 FT  
STILL ELEV (WSR) : 530 FT  
GATE WEIGHT 2 GATES (WGWT) : 10,000 LBS

CONCRETE WEDGE HEIGHT & LGTH (WH) : 9 FT  
(WH = CSH BF TTH)  
FDN LENGTH (L) : 34 FT  
(L = HW + PL + VH + TW)  
FDN WIDTH (B) : 80 FT  
(B = CGW + WGW + PN \* PT)

ADDL HEEL WIDTH (HW) : 0 FT

HEEL THICKNESS (HTH) : 0 FT

ADDL TOE WIDTH (TW) : 0 FT

TOE THICKNESS (TH) : 0 FT

PROJECT: TRWU - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-4227-PRSTR.DCS

DESIGNED BY: WCS

CHECKED BY: BDA - DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT:	LATL FORCE:	ARM TO TOE:	RESISTING MOMENT:	OVERTURNING MOMENT:
CHANNEL GATE:	15,000 LB		21.00	315,000	
WALKWAY GATE:	10,000		21.00	210,000	
CONCRETE PIERS:	4,680,000		21.50	100,620,000	
UPPER STRUCTURE:	1,411,200		21.50	30,340,800	
CHANNEL BLOCK FDN:	1,890,000		21.50	40,635,000	
CHANNEL WEDGE FDN:	340,200		6.03	2,051,406	
WALKWAY BLOCK FDN:	1,890,000		21.50	40,635,000	
WALKWAY WEDGE FDN:	145,800		6.03	879,174	
HEEL SLAB:	0		34.00	0	
TOE SLAB:	0		0.00	0	
FLUID ON CHANNEL SILL:	0		34.00	9,576,000	
FLUID ON WALKWAY SILL:	342,000		28.00	5,040,000	
FLUID ON WALKWAY SILL:	180,000		3.00	607,500	
FLUID ON D/S WEDGE:	202,500		0.00	0	
FLUID ON TOE:	0		17.00	31,790,000	
UPLIFT FORCE (U1):	-1,870,000		22.67	56,836,667	
UPLIFT FORCE (U2):	-2,507,500		13.50	55,358,438	
FLUID HORTZ FORCE (H):		4,100,625	3.67	1,109,167	
RESISTING FLUID FORCE:		-302,500			
SUBTOTAL AT BASE (V,MR,MO):	6,729,200	3,798,125	232,019,047	143,985,104	

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI))	5,059,549 LB	= U* (WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	3,798,125 LB	DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.33 > 1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.61 > 1.0?	
ECCENTRICITY (E=L/2 - (MR-MO)/V) =	3.92 (RELATIVE TO CL)	
Bearing Pressure =	V/l,(1+ 6*E/L)	
MAX BEARING PRESS =	4184 PSF	
MIN BEARING PRESS =	764 PSF	
VOLUME OF CONCRETE =	2,557 CY	

**Trinity Point Isolation Gate Structure**

**Unusual Load Condition - Max Water Level**

**(File I2 MAX-NoDrain-RCC-Base TPoint.XLS)**

1. Concrete structure on roller compacted concrete foundation to rock.
2. Stability at base of RCC (approximate).
3. Sliding Factor of Safety = 1.33
4. Maximum water level at El 549.5 on driving side.
5. Tailwater at El 520.0 on resisting side.
6. Friction angle at rock = 35 degrees.

PROJECT #: 1'RWD 1'FLOOD GATE CONTROL STRUCTURE

CHARGE NO. : 2521-42275-PRSTR.DCS

DESIGNED BY : WCS

DATE: 12/18/2004  
CHECKED BY: ESDf  
DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

DIMENSIONS & WEIGHTS (INPUT) :

GATE STRUCTURE:  
FLOOD ELEV (FE) : 549.5 FT  
TAILWATER ELEV (TE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 465 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PN) : 8 FT  
NO. OF CONC PIERS (PN) : 4  
UPPER STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

DESIGN PARAMETERS (INPUT) :

FACTOR OF SAFETY (FS) : 1.33 DEGREES  
ACTUAL SOIL FRICTION ANGLE (PHI) : 35 DEGREES  
ACTUAL SOIL COHESION (CN) : 0 PSF  
FLUID PRESS (EFFP) : 62.5 PCF  
CONC UNIT WGT (CUW) : 150 PCF

RESULTING DESIGN VALUES & DIMENSIONS :

CHANNEL GATE:  
GATE WIDTH (CGW) : 24 FT  
SILL ELEV (CSE) : 518 FT  
GATE WEIGHT (CGWGT) : 15,000 LBS

DESIGN FRICTION ANGLE (PHD) : 27.71 DEGREES  
DESIGN COHESION (CND) : 0 PSF  
UPLIFT AT HEEL (UH) : 5281 PSF  
UPLIFT AT TOE (UT) : 3438 PSF

WALKWAY GATES:  
GATE WIDTH (2GATES) : 24 FT  
STILL ELEV (WSE) : 530 FT  
GATE WEIGHT (2GATES) : 10,000 LBS  
ADDL. REEL WIDTH (HW) : 2 FT  
HNL. THICKNESS (HTH) : 44 FT  
ADDL. TOE WIDTH (TW) : 0 FT  
TOE THICKNESS (TTH) : 20 FT

CONCRETE: WEDGE HEIGHT & LENGTH (WH) : 33 FT  
(WH = CSE-BE-TTH)  
FDN LENGTH (L) : 60 FT  
(L = HW + PL + WH + TW)  
FDN WIDTH (B) : 80 FT  
(B = CGW + WGW + PN\*FT)



**Section 7**

**Trinity Point Isolation Gate Structures-**

**Pile Foundation**

**Trinity Point Isolation Gate Structure**

**Usual Load Condition - SPF**

**(File I1 SPF-NoDrain-Pile TPoint.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. SPF level at El 545.5 on driving side.
3. Tailwater at El 520.0 on resisting side.

PROJECT: 'IRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DATE: 12/18/2004

DESIGNED BY: WCS

DATE: 12/10/04

CHECKED BY: DBD

GATE STRUCTURE STABILITY (W/ UPLIFT)  
SFPE WATER ELEVATION (USUAL CONDITION)

DIMENSIONS & WEIGHTS (INPUT):

GATE STRUCTURE:  
FLOOD ELEV (FE) : 545.5 FT  
TAILWATER ELEV (TE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 509 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 8 FT  
NO. OF CONC PIERS (PN) : 4  
UPPER STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

DESIGN PARAMETERS (INPUT):

FACTOR OF SAFETY (FS) : 1.33  
ACTUAL SOIL FRICTION ANGLE (PHI) : 35 DEGREES  
ACTUAL SOIL COHESION (CN) : 0 PSF  
FLUID PRESS (FFP) : 62.5 PCF  
CONC UNIT WGT (CUW) : 150 PCF

RESULTING DESIGN VALUES & DIMENSIONS:

CHANNEL GATE:  
GATE WIDTH (CGW) : 24 FT  
SILL ELEV (CSE) : 518 FT  
GATE WEIGHT (CGWGT) : 15,000 LBS

DESIGN FRICTION ANGLE (PHID) : 27.77 DEGREES  
DESIGN COHESION (CND) : 0 PSF  
UPLIFT AT HEEL (UHL) : 2281 PSF  
UPLIFT AT TOE (UT) : 688 PSF

WALKWAY GATES:  
GATE WIDTH - 2 GATES (WGW) : 24 FT  
STILL ELEV (WSE) : 530 FT  
GATE WEIGHT = 2 GATES (WGWT) : 10,000 LBS  
ADDL HEEL WIDTH (HW) : 4 FT  
HEEL THICKNESS (HTH) : 3 FT  
ADDL TOE WIDTH (TW) : 2 FT  
TOE THICKNESS (TTW) : 3 FT

(WH) : 6 FT  
(WHL = CSE - BE \* TTH)  
FDN LENGTH (L) : 37 FT  
(L = HW + PL + WH + TW)  
FDN WIDTH (B) : 80 FT  
(B = CGW + WGW + PN \* PT)

PROJECT #: TRWD Flood Gate Control Structure

CHARGE NO.: 2421-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: A. B. D. A.

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-F	OVERTURNING MOMENT: LB-F
CHANNEL GATE:	15,000		20.00	300,000	
WALKWAY GATES:	10,000		20.00	200,000	
CONCRETE PIERS:	4,680,000		20.50	95,940,000	
UPPER STRUCTURE:	1,411,200		20.50	28,929,600	
CHANNEL BLOCK FDN:	1,890,000		20.50	38,745,000	
CHANNEL WEDGE FDN:	302,400		5.51	1,666,224	
WALKWAY BLOCK FDN:	1,890,000		20.50	38,745,000	
WALKWAY WEDGE FDN:	129,400		5.51	714,096	
HEEL SLAB:	144,000		35.00	5,040,000	
TOE SLAB:	72,000		1.00	72,000	
FLUID ON HEEL:	670,000		35.00	23,450,000	
FLUID ON CHANNEL SILL:	342,000			9,234,000	
FLUID ON WALKWAY SILL:	180,000		27.00	4,860,000	
FLUID ON D/S WEDGE:	90,000		4.00	360,000	
FLUID ON TOE:	80,000		1.00	80,000	
UPLIFT FORCE (U1):	-2,035,000		1.850		37,647,500
UPLIFT FORCE (U2):	-2,358,750		2.67		58,182,500
FLUID HORIZ. FORCE (H):		3,330,625	12.17		40,522,604
RESISTING FLUID FORCE:		302,500	3.67		
SUBTOTAL AT BASE (V,MR,MO) =	7,512,450	3,028,125		249,445,087	136,352,604

#### STABILITY RESULTS:

FRICITION FORCE (V*TANIPHID)	3,955,093 LB	= U*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	COHESION * BASE AREA
NET SLIDING FORCE	3,028,125 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.31 >1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO)	1.63 >1.0?	
ECCENTRICITY ( $R_{el}/2 = (MR-MO)/V$ )	3.45 (RELATIVE TO CL)	
BEARING PRESSURE = $V/(1+(1+6*E/L))$		
MAX BEARING PRESSURE	3956 PSF	
MIN BEARING PRESSURE	1120 PSF	
VOLUME OF CONCRETE	2,597 CY	

**Trinity Point Isolation Gate Structure**  
**Unusual Load Condition – Max Water Level**  
**(File I2 MAX-NoDrain-Pile TPoint.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. Maximum water level at El 549.5 on driving side.
3. Tailwater at El 520.0 on resisting side.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275 PRSTR, DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: BDA DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:	549.5 FT	FACTOR OF SAFETY (FS) :	1.33
FLOOD ELEV (FE) :	520 FT	ACTUAL SOIL FRICTION ANGLE (PHI) :	35 DEGREES
TAILWATER ELEV (TW) :	557 FT	ACTUAL SOIL COHESION (CN) :	0 PSF
TOP OF PIER ELEV (PE) :	509 FT	FLUID PRESS (EFP) :	62.5 PCF
FDN BASE EL (BE) :	25 FT	CONC UNIT WGT (CUW) :	150 PCF
PIER LENGTH (EL) :	8 FT		
PIER THICKNESS (PT) :	4 FT		
NO. OF CONC PIERS (PN) :	4		
UPPER STRUCTURE OUTLINE (USO) :	98 FT		
UPSTREAM FACE TO GATE CTR LINE (GCL) :	13 FT		

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:	24 FT	DESIGN FRICTION ANGLE (PHID) :	27.77 DEGREES
GATE WIDTH (CGW) :	518 FT	DESIGN COHESION (CND) :	0 PSF
SILL ELEV (CSE) :	15,000 LBS	UPLIFT AT HEEL (UH) :	2531 PSF
GATE WEIGHT (CGWGT) :		UPLIFT AT TOE (UT) :	688 PSF
WALKWAY GATES:			
GATE WIDTH - 2 GATES (WGW) :	24 FT	CONCRETE WEDGE HEIGHT & LGTH (WH) :	6 FT (WH = CSE-BE-TTH)
STILL ELEV (WSE) :	530 FT	FDN LENGTH (L) :	37 FT
GATE WEIGHT - 2 GATES (WGWT) :	10,000 LBS	(L = HW + PL + WH + TW)	
ADDL HEEL WIDTH (HW) :	4 FT	FDN WIDTH (B) :	80 FT
HEEL THICKNESS (HTH) :	3 FT	(B = CGW + WGW + DN* PT)	
ADDL TOE WIDTH (TW) :	2 FT		
TOE THICKNESS (TTH) :	3 FT		

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: TB24

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESTING MOMENT: 300,000	OVERTURNING MOMENT: 200,000
CHANNEL GATE:	15,000		20.00	95,940,000	28,929,600
WALKWAY GATE:	10,000		20.00	38,745,000	20.50
CONCRETE PIERS:	4,680,000		20.50	1,666,224	1,411,200
UPPER STRUCTURE:			20.50	38,745,000	1,890,000
CHANNEL BLOCK FDN:	1,411,200		20.50	38,745,000	302,400
CHANNEL WEDGE FDN:	1,890,000		5.51	38,745,000	1,890,000
WALKWAY BLOCK FDN:	302,400		20.50	38,745,000	129,600
WALKWAY WEDGE FDN:	129,600		5.51	714,096	144,000
HEEL SLAB:	144,000		35.00	5,040,000	72,000
TOE SLAB:	72,000		1.00	72,000	750,000
FLUID ON HEEL:			35.00	26,250,000	750,000
FLUID ON CHANNEL SILL:	342,000		27.00	9,234,000	342,000
FLUID ON WALKWAY SILL:	180,000		27.00	4,860,000	180,000
FLUID ON D/S WEDGE:			4.00	360,000	90,000
FLUID ON TOE:	80,000		1.00	80,000	80,000
UPLIFT FORCE (U1):	-2,035,000		18.50	37,647,500	
UPLIFT' FORCE (U2):	2,728,750		24.67	67,309,167	
FLUID HORIZONTAL FORCE (H):			13.50	55,358,438	
RESISTING FLUID FORCE:			3.67		
SUMTOTAL AT BASE (V,MR,MO)	7,222,450	3,798,125			
			252,245,087	160,315,104	

#### STABILITY RESULTS:

FRICTION FORCE ( $V \cdot \tan(\phi_H)$ )	3,802,416 LB	$= U \cdot (\text{WEIGHT CONC + GATES + WATER - UPLIFT})$
COHESION FORCE ( $CND \cdot L \cdot B$ )	0 LB	$= \text{COHESION * BASE AREA}$
NET SLIDING FORCE	3,798,125 LB	$= \text{DRIVING FORCES MINUS ACTIVE RESISTING FORCES}$
SLIDING RATIO	>1.0?	$= (\text{FRICTION} + \text{COHESION}) / (\text{NET SLIDING})$
OVERTURNING RATIO ( $(MR/MO)_{\text{rel}}$ )	1.57 >1.0?	
ECCENTRICITY ( $(E-L/2 - (MR-MO)/V)$ )	5.77 (RELATIVE TO CI.)	
BEARING PRESSURE	$V/L(1 + -6 \cdot F/L)$	
MAX BEARING PRESS	4,724 PSF	
MIN BEARING PRESS	156 PSF	
VOLUME OF CONCRETES	2,597 CY	

**Trinity Point Isolation Gate Structure**

**Extreme Load Condition - Seismic**

**(File I3 SEISMIC-NoDrain-Pile TPoint.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. Normal pool level at El 525.0 on driving side.
3. Tailwater at El 520.0 on resisting side.
4. Horizontal ground acceleration = 0.05 g.

PROJECT: TRWD - FLOOD GATE CONTROL, STRUCTURE

CHARGE NO.: 2521-42275-PRSTR, DCS

DATE: 12/18/2004

DESIGNED BY: WCS

DATE: 12/20/04

CHECKED BY: 1204

**GATE STRUCTURE STABILITY (W/ UPLIFT)**  
**NORMAL POOL ELEVATION WITH SEISMIC (EXTREME CONDITION)**

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:	
FLOOD ELEV (FE):	525 FT
SILL ELEV (TE):	520 FT
TALIMATER ELEV (TB):	557 FT
TOP OF PIER ELEV (PE):	509 FT
FDN BASE EL (BE):	25 FT
PIER LENGTH (PL):	8 FT
PIER THICKNESS (PT):	4 FT
NO. OF CONC PIERS (PN):	98 FT
UPPER STRUCTURE OUTLINE (USO):	13 FT
UPSTREAM FACE TO GATE CTR LINE (GCL):	

**CHANNEL GATE:**

GATE WIDTH (CGW):	24 FT
STILL ELEV (CSE):	518 FT
GATE WEIGHT (CGWGT):	15,000 LBS

**WALKWAY GATES:**

GATE WIDTH - 2 GATES (WG):	34 FT
SILL ELEV (WSE):	530 FT
GATE WEIGHT (WGWT):	10,000 LBS
ADDL REEL WIDTH (HW):	4 FT
HEEL THICKNESS (HTH):	3 FT
ADDL TOE WIDTH (TW):	2 FT
TOE THICKNESS (TH):	3 FT

**DESIGN PARAMETERS (INPUT):**

1.1	
FACTOR OF SAFETY (FS):	1.1
ACTUAL SOIL FRICTION ANGLE (PHI):	35 DEGREES
ACTUAL SOIL COHESION (Cf):	0 PSF
FLUID PRESS (EFF):	62.5 PCF
CONC UNIT WGT (CUW):	150 PCF
SEISMIC COEFFICIENT (A):	0.05 g

**RESULTING DESIGN VALUES & DIMENSIONS:**

DESIGN FRICTION ANGLE (PHD):	32.46 DEGREES
DESIGN COHESION (CND):	0 PSF
UPLIFT AT HEEL (UR):	1000 PSF
UPLIFT AT TOE (UT):	688 PSF

**SEISMIC PARAMETERS:**

$$\begin{aligned} \text{SEISMIC INERTIA DUE TO MASS} &= \text{SUM}(DL) * A \\ \text{ASSUMED CENTROID OF MASS} &= 0.4 * (PE-BE) \\ \text{SEISMIC FLUID FORCE (PER WESTERGAARD)} &= 0.67 * 51 * A * (FE-BE)^2 \\ \text{FLUID FORCE RESULTANT ABOVE BASE} &= 0.4 * (FE-BE) \\ \text{OR } 0.4 * (TE-BE) \end{aligned}$$

PROJECT: TRWD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: BDD DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LAT. FORCE: LB	ARM TO 'TOE': LB	RESISTING MOMENT: LB-FEET	OVERTURNING MOMENT: LB-FEET
CHANNEL GATE:	15,000		20.00	300,000	
WALKWAY GATE:	10,000		20.00	200,000	
CONCRETE PIERS:	4,680,000		20.50	95,940,000	
UPPER STRUCTURE:	1,411,200		20.50	28,929,600	
CHANNEL BLOCK FDN:	1,890,000		20.50	38,745,000	
CHANNEL WEDGE FDN:	302,400		5.51	1,666,224	
WALKWAY BLOCK FDN:	1,890,000		20.50	38,745,000	
WALKWAY WEDGE FDN:	129,600		5.51	714,096	
WALKWAY WEDGE FDN:	144,000		35.00	5,040,000	
HEEL SLAB:	72,000		1.00	72,000	
TOE SLAB:	260,000		35.00	9,100,000	
FLUID ON HEEL:	260,000		27.00	9,234,000	
FLUID ON CHANNEL STIL:	342,000		27.00	4,860,000	
FLUID ON WALKWAY STIL:	180,000		4.00	360,000	
FLUID ON D/S WEDGE:	90,000		1.00	80,000	
FLUID ON TOE:	80,000		18.50	37,647,500	
UPLIFT FORCE (U1):	2,035,000		24.67	11,408,333	
UPLIFT FORCE (U2):	-462,500		5.33	3,413,333	
FLUID HORIZ. FORCE (H):			3.67	1,109,167	
RESISTING FLUID FORCE:					
SEISMIC INERTIA FORCE:					
SEISMIC FLUID FORCE U/S:					
SEISMIC FLUID FORCE D/S:					
SUBTOTAL AT BASE: (V, MR, MO) =	8,998,700	854,554		235,095,087	62,387,947

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHID)) =	5,728,143 LB	= $U^*$ (WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE ((CND*L*B)) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	854,554 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	6.70 > 1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	3.77 > 1.0?	
ACCENTRICITY ( $E=L/2 - (MR-MO)/V$ ) =	.69 (RELATIVE TO C1.)	
BEARING PRESSURE = $V/L(1+e/E/L)$		
MAX BEARING PRESS = 2699 PSF		
MIN BEARING PRESS = 3381 PSF		
VOLUME OF CONCRETE = 2,597 CY		

# **Section 8**

## **Clear Fork Isolation Gate Structures-**

### **Mass Concrete Foundation**

**Clear Fork Isolation Gate Structure**

**Usual Load Condition - SPF**

**(File I1 SPF-NoDrain-Mass CFork.XLS)**

1. Mass concrete foundation on rock.
2. Sliding Factor of Safety = 1.50
3. SPF level at El 552.5 on driving side.
4. Tailwater at El 520.0 on resisting side.
5. Friction angle at rock = 35 degrees.

PROJECT: TRND - FLOOD GATE CONTROL, STRUCTURE

CHARGE NO.: 2521-42275 PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004  
BDA

CHECKED BY: \_\_\_\_\_

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
SPF WATER ELEVATION (USUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:  
FLOOD ELEV (FE) : 552.5 FT  
TAILWATER ELEV (TE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 487 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 7.33 FT  
NO. OF CONC PIERS (PN) : 3  
UPPER STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACH TO GATE CTR LINE (GCL) : 13 FT

**DESIGN PARAMETERS (INPUT):**

GATE STRUCTURE:  
ACTUAL SOIL FRICTION ANGLE (PHI) : 35 DEGREES  
ACTUAL SOIL COHESION (CN) : 0 PSF  
FLUID PRESS (EFD) : 62.5 PSF  
CONC UNIT WGT (CUW) : 150 PCF

CHANNEL GATE:  
GATE WIDTH (CGW) : 24 FT  
STILL ELEV (CSR) : 518 FT  
GATE WEIGHT (CGWT) : 15,000 LBS

**DESIGN VALUES & DIMENSIONS:**  
DESIGN FRICTION ANGLE (PHID) : 25.02 DEGREES  
DESIGN COHESION (CND) : 0 PSF  
UPLIFT AT HEEL (UH) : 4094 PSP  
UPLIFT AT TOE (UT) : 2063 PSF

WALKWAY GATE:  
GATE WIDTH (NGW) : 12 FT  
STILL ELEV (NSE) : 530 FT  
GATE WEIGHT (WGWT) : 5,000 LBS  
ADDL HEEL WIDTH (HW) : 20 FT  
HEEL THICKNESS (HTH) : 25 FT  
ADDL TOE WIDTH (TW) : 20 FT  
TOE THICKNESS (TTH) : 25 FT

CONCRETE WEDGE HEIGHT & LENGTH (WH) : 6 FT  
(WH = CSE-BE-TTH)  
FDN LENGTHS (L) : 71 FT  
L = RW + PL + WH + TW  
FDN WIDTH (B) : 58 FT  
(B = CGW + WSW + PN\*FW)

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PKSTR-DCS

DESIGNED BY: WCS

CHECKED BY: Bon — DATE: 12/20/04**STABILITY ANALYSIS:**

	WEIGHT: LB	LATERAL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-FEET	OVERTURNING MOMENT: LB-FEET
CHANNEL GATE:	15,000		38.00	570,000	
WALKWAY GATE:	5,000		38.00	190,000	
CONCRETE PIERS:	3,217,500		38.50	123,873,750	
UPPER STRUCTURE:	1,058,400		38.50	40,748,400	
CHANNEL BLOCK PDN:	5,347,500		38.50	205,878,750	
CHANNEL WEDGE PDN:	1,159,200		23.11	26,788,284	
WALKWAY BLOCK PDN:	1,935,000		38.50	74,497,500	
WALKWAY WEDGE PDN:	302,400		23.11	6,988,248	
HEEL SLAB:	4,350,000		61.00	265,350,000	
TOE SLAB:	4,350,000		10.00	43,500,000	
FLUID ON CHANNEL SILL:	2,936,250		61.00	179,111,250	
FLUID ON WALKWAY SILL:	342,000		45.00	15,390,000	
FLUID ON D/S WEDGE:	90,000		45.00	4,050,000	
FLUID ON TOE:	65,250		22.00	1,435,500	
UPLIFT FORCE (U1):	580,000		10.00	5,800,000	
UPLIFT FORCE (U2):	-8,493,375		35.50		
FLUID HORIZONTAL FORCE (H):	-4,182,344		47.33		
RESISTING FLUID FORCE:			21.83		
SUMTOTAL AT BASE (V, MR, MO) =	13,077,781	5,802,266	-1,973,812	11.00	21,711,937
					1,015,883,619
					669,256,789

**STABILITY RESULTS:**

FRICITION FORCE ( $V \cdot \tan(\phi_{HID})$ ) =	6,104,774 LB	= $U^*$ (WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE ( $CND \cdot L \cdot B$ ) =	0 LB	COHESION * BASE AREA
NET SLIDING FORCE =	5,802,266 LB	DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.05 > 1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO ( $MR/MO$ ) =	1.52 > 1.0?	
ECCENTRICITY ( $E_L/2 - (MR-MO)/V_L$ ) =	0.39 (RELATIVE TO CL)	
BEARING PRESSURE = $V/L(1+6 \cdot E/L)$		
MAX BEARING PRESS = 5590 PSF		
MIN BEARING PRESS = 762 PSF		
VOLUME OF CONCRETE = 5,363 CY		

**Clear Fork Isolation Gate Structure**  
**Unusual Load Condition - Max Water Level**

**(File I2 MAX-NoDrain-Mass CFork.XLS)**

1. Mass concrete foundation on rock.
2. Sliding Factor of Safety = 1.33
3. Maximum water level at El 556.5 on driving side.
4. Tailwater at El 520.0 on resisting side.
5. Friction angle at rock = 35 degrees.

PROJECT: TRW1 - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTRK.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDF —

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:	
FLOOD ELEV (WF):	556.5 FT
TAILWATER ELEV (TE):	520 FT
TOP OF PIER ELEV (PE):	557 FT
FDN BASE EL (BRE):	487 FT
PIER LENGTH (PL):	25 FT
PIER THICKNESS (PT):	7.33 FT
NO. OF CONC PIERS (PN):	3
UPSTREAM FACE TO GATE CTR LINE (GCL):	98 FT
UPSTREAM FACE TO GATE CTR LINE (GCL):	13 FT

**DESIGN PARAMETERS (INPUT):**

GATE STRUCTURE:	
FLOOD ELEV (WF):	556.5 FT
TAILWATER ELEV (TE):	520 FT
TOP OF PIER ELEV (PE):	557 FT
FDN BASE EL (BRE):	487 FT
PIER LENGTH (PL):	25 FT
PIER THICKNESS (PT):	7.33 FT
NO. OF CONC PIERS (PN):	3
UPSTREAM FACE TO GATE CTR LINE (GCL):	98 FT
UPSTREAM FACE TO GATE CTR LINE (GCL):	13 FT

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:	
GATE WIDTH (CGW):	24 FT
SILL ELEV (CSE):	518 FT
GATE WEIGHT (CGWGT):	15,000 LBS
DESIGN FRICTION ANGLE (PHI):	27.7° DEGREES
DESIGN COHESION (CND):	0 PSF
UPLIFT AT HEEL (UH):	4344 PSF
UPLIFT AT TOE (UT):	2063 PSF
WALKWAY GATE:	
GATE WIDTH (WGW):	12 FT
STILL ELEV (WSE):	530 FT
GATE WEIGHT (WGWT):	5,000 LBS
CONCRETE WEDGE HEIGHT & LGTH (WH):	6 FT
(WH = CSE-BE-TTH)	
FDN LENGTH (L):	71 FT
(L = HW + PL + WH + TW)	
FDN WIDTH (B):	58 FT
(B = CGW + WGW + PN*PT)	

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: TBDH

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL. FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-FT
CHANNEL GATE:	15,000		38.00	570,000
WALKWAY GATE:	5,000		38.00	190,000
CONCRETE PIERS:	3,217,500		38.50	123,873,750
UPPER STRUCTURE:	1,058,400		38.50	40,748,400
CHANNEL BLOCK FDN:	5,347,500		38.50	205,878,750
CHANNEL WEDGE FDN:	1,159,200		23.11	26,788,284
WALKWAY BLOCK FDN:	1,935,000		38.50	74,497,500
WALKWAY WEDGE FDN:	302,400		23.11	6,988,248
HEEL SLAB:	4,350,000		61.00	265,350,000
TOE SLAB:	4,350,000		10.00	43,500,000
FLUID ON CHANNEL SILL:	3,226,250		61.00	196,801,250
FLUID ON CHANNEL SILL:	342,000		45.00	15,390,000
FLUID ON WALKWAY SILL:	90,000		45.00	4,050,000
FLUID ON D/S WEDGE:	65,250		22.00	1,435,500
FLUID ON TOE:	580,000		10.00	5,800,000
UPLIFT FORCE (U1):	-8,493,375		35.50	301,514,812
UPLIFT FORCE (U2):	-4,697,094		47.33	222,329,104
FLUID HORIZ FORCE (H):		8,754,828	23.17	202,820,185
RESISTING FLUID FORCE:		-1,973,812	11.00	
SUBTOTAL AT BASE (V,MR,MO) =	12,853,031	6,781,016	1,033,573,619	726,664,102

#### STABILITY RESULTS:

FRICITION FORCE (V*UAN (PHID)) =	6,766,759 LB	U* (WEIGHT CONC + GATES + WATER - UPLIFT*)
COHESION FORCE (CND)*L*P) =	0 LB	: COHESION * BASE AREA
NET SLIDING FORCE :	6,781,016 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO :	1.00 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.42 > 1.0?	
ECCECTRICITY (B=L/2 * (MR/MO) /V) =	11.62 (RELATIVE TO C1.)	
BEARING PRESSURE = V/L(1+ 6/E/L)	6187 PSF	
MAX BEARING PRESS =	56 PSF	
MIN BEARING PRESS =	5,363 CY	
VOLUME OF CONCRETE =		

**Clear Fork Isolation Gate Structure (with Drains)**

**Unusual Load Condition - Max Water Level**

**(File I2 MAX-Drain-Mass CFork.XLS)**

1. Mass concrete foundation on rock, with foundation drainage system.
2. Maximum water level at El 556.5 on driving side.
3. Tailwater at El 520.0 on resisting side.
4. Drains 33 percent effective, 10-ft downstream of headwall.

PROJECT: 'URWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: TBDA —

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:	
FLOOD ELEV (FE):	556.5 FT
TAILWATER ELEV (TE):	520 FT
TOP OF PIER ELEV (PE):	557 FT
FDN BASE EL (BE):	487 FT
PIER LENGTH (PL):	25 FT
PIER THICKNESS (PT):	7.33 FT
NO. OF CONC PIERS (PN):	3
UPPER STRUCTURE OUTLINE (USO):	98 FT
UPSTREAM FACE TO GATE CTR LINE (GCL):	13 FT

**DESIGN PARAMETERS (INPUT):**

CHANNEL GATE:	
GATE WIDTH (COW):	24 FT
SILL, ELEV (CSE):	518 FT
GATE WEIGHT (CGWT):	15,000 LBS
WALKWAY GATE:	
GATE WIDTH (WGW):	12 FT
SILL, ELEV (WSE):	530 FT
GATE WEIGHT (WGWT):	5,000 LBS
ADDL. HEEL WIDTH (HW):	
HEEL THICKNESS (HTH):	16 FT
ADDL. TOE WIDTH (TW):	25 FT
TOE THICKNESS (TTH):	20 FT

RESULTING DESIGN VALUES & DIMENSIONS:	
DESIGN FRICTION ANGLE (PHID):	27.77 DEGREES
DESIGN COHESION (CND):	0 PSF
UPLIFT AT HEEL (UH):	4344 PSF
UPLIFT AT TOE (UT):	2063 PSF
UPLIFT AT DRAIN (UD):	2998 PSF
CONCRETE WEDGE HEIGHT & LENGTH (WH):	
(WH CSE-BE-TTH)	6 FT
FDN LENGTH (L):	
(L HW + PL + WH + TW)	67 FT
FDN WIDTH (B):	
(B = CGW + WGW + DN*PT)	58 FT

PROJEC<sup>TM</sup>: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: TBD DATE: 12/18/04

#### STABILITY ANALYSIS:

	WEIGHT <sup>1</sup> LB	LATE <sup>2</sup> FORCE; LB	ARM TO TOE; LB	RESISTING MOMENT; LB-F	OVERTURNING MOMENT; LB-F
CHANNEL GATE:	15,000		38.00	570,000	
WALKWAY GATE:	5,000		38.00	190,000	
CONCRETE PIERS:	3,217,500		36.50	123,873,750	
UPPER STRUCTURE:	1,058,400		36.50	40,748,400	
CHANNEL BLOCK FDN:	5,347,500		38.50	205,878,750	
CHANNEL WEDGE FDN:	1,159,200		23.11	26,788,284	
WALKWAY BLOCK FDN:	1,935,000		38.50	74,497,500	
WALKWAY WEDGE FDN:	3,302,400		23.11	6,988,248	
HEEL SLAB:	3,480,000		59.00	205,320,000	
TOE SLAB:	4,350,000		10.00	43,500,000	
FLUID ON HEEL:	2,581,000		59.00	152,279,000	
FLUID ON CHANNEL SLAB:	342,000		45.00	15,390,000	
FLUID ON WALKWAY SLAB:	90,000		45.00	4,050,000	
FLUID ON D/S WEDGE:	65,250		22.00	1,435,500	
FLUID ON TOE:	580,000		10.00	5,800,000	
UPLIFT FORCE (U1):	-4,904,625		20.50	100,544,812	
UPLIFT FORCE (U2):	1,112,087		27.33	30,397,033	
UPLIFT FORCE (U3):	-4,520,701		54.00	24,4,117,867	
UPLIFT FORCE (U4):	-1,014,837		58.33	59,198,818	
FLUID HORIZONTAL FORCE (H):		8,754,828	23.17	202,820,185	
RESISTING FLUID FORCE:		-1,973,812	11.00	21,711,917	
SUBTOTAL AT BASE (V, MR, MO) :	12,976,000	6,781,016		929,021,369	637,078,715

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI)) =	6,831,499 LB	U* (WEIGHT CONC + GATES + WATER - UPLIFT) COHESION * BASE AREA
COHESION FORCE (CND*L*H) =	0 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
NET <sup>3</sup> SLIDING FORCE =	6,781,016 LB	= (FRICTION + COHESION) / (NET SLIDING)
SLIDING RATIO =	1.01 > 1.0?	
OVERTURNING RATIO (MR/MO) =	1.46 > 1.0?	
ECCENTRICITY (B=L/2 - (MR-MO)/V) =	11.00 (RELATIVE TO C1.)	
BEARING PRESSURE = V/1:(1+6*E/L)		
MAX BEARING PRESSURE =	6629 PSF	
MIN BEARING PRESSURE =	49 PSF	
VOLUME OF CONCRETE =	5,148 CY	

**Section 9**

**Clear Fork Isolation Gate Structures-**

**RCC Foundation**

**Clear Fork Isolation Gate Structure**

**Usual Load Condition - SPF**

**(File I1 SPF-NoDrain-RCC CFork.XLS)**

1. Concrete structure on roller compacted concrete foundation to rock.
2. Stability at top of RCC.
3. Sliding Factor of Safety = 1.50
4. SPF level at El 552.5 on driving side.
5. Tailwater at El 520.0 on resisting side.
6. Friction angle on RCC = 45 degrees.

PROJECT: "TRW1" - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521 42275-PRSTR.DCS

DESIGNED BY: WCS

CHECKED BY: BDA - - - DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
SPF: WATER ELEVATION (USUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:  
FLOOD ELEV (FE) : 552.5 FT  
TAILWATER ELEV (TPE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 504 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 7.33 FT  
NO. OF CONC PIERS (PN) : 3  
UPPER STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

**DESIGN PARAMETERS (INPUT):**

FACTOR OF SAFETY (FS) : 1.5  
ACTUAL SOIL FRICTION ANGLE (PHI) : 45 DEGREES  
ACTUAL SOIL COHESION (CN) : 0 PSF  
FLUID PRESSURE (EFF) : 62.5 PSF  
CONC UNIT WGT (CUW) : 150 PSF

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL, GATE:  
GATE WIDTH (CGW) : 24 FT  
SILL ELEV (CSE) : 518 FT  
GATE WEIGHT (CGWGT) : 15,000 LBS

DESIGN FRICTION ANGLE (PHD) : 33.69 DEGREES  
DESIGN COHESION (CND) : 0 PSF  
UPLIFT AT HEEL (UH) : 3031 PSF  
UPLIFT AT TOE (UT) : 1000 PSF

WALKWAY GATE:  
GATE WIDTH (WG) : 12 FT  
SILL ELEV (WSE) : 530 FT  
GATE WEIGHT (WGWT) : 5,000 LBS  
CONCRETE WEDGE HEIGHT & LENGTH (WH) : 6 FT  
(WH = CSE-BE-TTH)  
FDN LENGTH (L) : 69 FT  
(L = HW + PL + WH + TW)  
FDN WIDTH (B) : 58 FT  
(B = CGW + WG + PN\* PT)

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

CHECKED BY: BDH DATE: 12/10/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	HATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-FT	OVERTURNING MOMENT: LB-FT
CHANNEL GATE:	15,000		30.00	450,000	
WALKWAY GATE:	5,000		30.00	150,000	
CONCRETE PIERS:	3,217,500		30.50	98,133,750	
UPPER STRUCTURE:	1,058,400		30.50	32,281,200	
CHANNEL BLOCK FDN:	2,415,000		30.50	73,657,500	
CHANNEL WEDGE FDN:	455,400		15.28	6,957,684	
WALKWAY BLOCK FDN:	1,170,000		30.50	35,685,000	
WALKWAY WEDGE FDN:	118,800		15.28	1,815,048	
HEEL SLAB:	1,809,600		56.00	101,337,600	
TOE SLAB:	835,200		6.00	5,011,200	
FLUID ON CHANNEL SILL:	3,817,125		56.00	213,759,000	
FLUID ON WALKWAY SILL:	342,000		37.00	12,654,000	
FLUID ON D/S WEDGE:	90,000		37.00	3,330,000	
FLUID ON TOE:	65,250		14.00	913,500	
UPLIFT FORCE (U1):	348,000		6.00	2,088,000	
UPLIFT FORCE (U2):	-4,002,000		34.50		138,069,000
FLUID HORIZONTAL FORCE (H1):	-4,064,531		46.00		186,968,437
RESISTING FLUID FORCE:		4,263,453	16.17		68,925,826
SUBTOTAL AT BASE: (V, MR, MO):	7,695,744	3,799,453	5.33	2,474,667	
				590,698,149	393,963,263

#### STABILITY RESULTS:

FRICITION FORCE ( $V \cdot \tan(\phi)$ ) =	5,130,496 LB	= $U \cdot (\text{WEIGHT CONC + GATES + WATER UPLIFT})$
COHESION FORCE ( $CND \cdot L \cdot B$ ) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	3,799,453 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.35 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.50 > 1.0?	
ECCENTRICITY ( $E = L/2$ (MR-MO) / V) =	8.94 (RELATIVE TO CL)	
BEARING PRESSURE =	V/L(1+ $-6 \cdot E/L$ )	
MAX BEARING PRESS =	3417 PSF	
MIN BEARING PRESS =	429 PSF	
VOLUME OF CONCRETE =	2,716 CY	

**Clear Fork Isolation Gate Structure**  
**Unusual Load Condition - Max Water Level**  
**(File I2 MAX-NoDrain-RCC CFork.XLS)**

1. Concrete structure on roller compacted concrete foundation to rock.
2. Stability at top of RCC.
3. Sliding Factor of Safety = 1.33
4. Maximum water level at El 556.5 on driving side.
5. Tailwater at El 520.0 on resisting side.
6. Friction angle on RCC = 45 degrees.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521 42275-PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004  
CHECKED BY: 13D4 DATE: 12/18/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:		FACTOR OF SAFETY (FS) :	1.33
FLOOD ELEV (FE) :	556.5 FT	ACTUAL SOIL FRICTION ANGLE (PHI) :	45 DEGREES
TAIWATER ELEV (TE) :	520 FT	ACTUAL SOIL COHESION (CN) :	0 PSF
TOP OF PIER ELEV (PE) :	557 FT	FLUID PRESS (EFP) :	62.5 PCF
FUN BASE EL (BE) :	504 FT	CONC UNIT WGT (CUW) :	150 PCF
PIER LENGTH (PL) :	25 FT		
PIER THICKNESS (PT) :	7.33 FT		
NO. OF CONC PIERS (PN) :	3		
UPPER STRUCTURE OUTLINE (USO) :	98 FT		
UPSTREAM FACE TO GATE CTR LINE (GCL) :	13 FT		

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL, GATE:		DESIGN FRICTION ANGLE (PHID) :	36.94 DEGREES
GATE WIDTH (CGW) :	24 FT	DESIGN COHESION (CND) :	0 PSF
SILL ELEV (CSE) :	518 FT	UPLIFT AT HEEL (UH) :	3281 PSF
GATE WEIGHT (CGWGWT) :	15,000 LBS	UPLIFT AT TOE (UT) :	1000 PSF

**WALKWAY GATE:**

GATE WIDTH (WG) :	12 FT	CONCRETE WEDGE HEIGHT & LENGTH (WH) :	6 FT
SILL ELEV (WSE) :	530 FT	(WH = CSE BE-TTH)	69 FT
GATE WEIGHT (WGWGWT) :	5,000 LBS	FDN LENGTH (L) :	
ADDL HEEL WIDTH (HW) :	26 FT	(L = WH + PL + WH + TW)	
HEEL THICKNESS (HTH) :	8 FT	FDN WIDTH (B) :	58 FT
ADDL TOE WIDTH (TW) :	12 FT	(B = CSEW + WG + PN*PT)	
TOE THICKNESS (TTH) :	8 FT		

PROJECT: TRWD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR, DCSS

DESIGNED BY: WCS

CHECKED BY: BDA DATE: 12/20/04**STABILITY ANALYSIS:**

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOR: LB	RESISTING MOMENT: LB-FT	OVERTURNING MOMENT: LB-FT
CHANNEL GATE:	15,000		30.00	450,000	
WALKWAY GATE:	5,000		30.00	150,000	
CONCRETE PIERS:	3,217,500		30.50	98,133,750	
UPPER STRUCTURE:	1,058,400		30.50	32,281,200	
CHANNEL BLOCK FDN:	2,415,000		30.50	73,657,500	
CHANNEL WEDGE FDN:	455,000		15.28	6,957,684	
WALKWAY BLOCK FDN:	1,170,000		30.50	35,685,000	
WALKWAY WEDGE FDN:	118,800		15.28	1,815,048	
HHEEL SLAB:	1,809,600		56.00	101,337,600	
TOE SLAB:	835,200		6.00	5,011,200	
FLUID ON CHANNEL SHELL:	4,194,125		56.00	234,871,000	
FLUID ON CHANNEL SHELL:	342,000		37.00	12,654,000	
FLUID ON WALKWAY SHELL:	90,000		37.00	3,330,000	
FLUID ON D/S WEDGE:	65,250		14.00	913,500	
FLUID ON TOR:	348,000		6.00	2,088,000	
UPLIFT FORCE (U1):	-4,002,000		34.50		
UPLIFT FORCE (U2):	-4,564,781		46.00		
FLUID HORIZONTAL FORCE (FH):			17.50		
RESISTING FLUID FORCE:		4,995,703	5.33	2,474,667	
SUBTOTAL AT BASE (V,MR,MO)=	7,572,494	4,531,703		611,810,149	435,473,742

**STABILITY RESULTS:**

FRICITION FORCE (V*TAN(PHID))=	5,693,604 LB	= U* (WEIGHT CONC + GATES + WATER + UPLIFT)
COHESION FORCE (CND*1.*B):	0 LB	COHESION * BASE AREA
NEW SLIDING FORCE	4,531,703 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.26 >1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO):	1.40 >1.0?	
ECCENTRICITY (E=L/2 *(MR MO) /V):	1.1.21 (RELATIVE TO C.L.)	
BEARING PRESSURE : V/L ( $\frac{1}{4} * 6 * E/L$ )	3737 PSF	
MAX BEARING PRESS =	3737 PSF	
MIN BEARING PRESS =	47 PSF	
VOLUME OF CONCRETE =	2,736 CY	

**Clear Fork Isolation Gate Structure**

**Unusual Load Condition - Max Water Level**

**(File I2 MAX-NoDrain-RCC-Base CFork.XLS)**

1. Concrete structure on roller compacted concrete foundation to rock.
2. Stability at base of RCC (approximate).
3. Sliding Factor of Safety = 1.33
4. Maximum water level at El 556.5 on driving side.
5. Tailwater at El 520.0 on resisting side.
6. Friction angle at rock = 35 degrees.

PROJECT: 'TRWD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WES

DATE: 12/18/2004

CHECKED BY: BDA —

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:			FACTOR OF SAFETY (FS):	1.33
FLOOD ELEV (FE):	556.5	FT	ACTUAL SOIL FRICTION ANGLE (PHI):	35 DEGREES
TOTAL WATER ELEV (TE):	520	FT	ACTUAL SOIL COHESION (CN):	0 PSF
TOP OF PIER ELEV (PE):	557	FT	FLUID PRESSURE (EFP):	62.5 PCF
PIER BASE EL (BE):	487	FT	CONC UNIT WGT (CUW):	150 PCF
PIER LENGTH (PL):	25	FT		
PIER THICKNESS (PT):	7.33	FT		
NO. OF CONC PIERS (PN):	3			
UPPER STRUCTURE OUTLINE (USO):	98	FT		
UPSTREAM FACE TO GATE CTR LINE (GCL):	13	FT		

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:		DESIGN FRICTION ANGLE (PHD):	27.77 DEGREES	
GATE WIDTH (CGW):	24	FT		
STILL HEAD (CSH):	518	FT	DESIGN COHESION (CND):	0 PSF
GATE WEIGHT (CGWT):	15,000	LBS	UPLIFT AT HEEL (UR):	4344 PSF
			UPLIFT AT TOE (UT):	2063 PSF
WALKWAY GATE:				
GATE WIDTH (WG):	12	FT	CONCRETE WEDGE HEIGHT & LENGTH (WH):	19 FT
STILL HEAD (WSH):	530	FT	(WH = CSE - RE - TH)	
GATE WEIGHT (WGWT):	5,000	LBS	PDN LENGTH (L):	81.5 FT
ADDL REEL WIDTH (HW):	26	FT	(L = HW + PL + WH + TN)	
REEL THICKNESS (HTH):	25	FT	PDN WIDTH (B):	58 FT
ADDL TOE WIDTH (TW):	11.5	FT	(B = CGW + WG)	
TOE THICKNESS (TH):	12	FT		

PROJECT: TRWD - FLOOD GATE CONTROL, STRUCTURE

CHARGE NO.: 2521-42275-FRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004  
CHECKED BY: BDA — DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	NATL FORCE: LB	ARM TO TOE:	RESTING MOMENT:	OVERTURNING MOMENT:
CHANNEL GATE:	15,000		42.50	637,500	
WALKWAY GATE:	5,000		42.50	212,500	
CONCRETE PIERS:	3,217,500		43.00	138,352,500	
UPPER STRUCTURE:	1,058,400		43.00	45,511,200	
CHANNEL BLOCK FDN:	5,347,500		43.00	229,942,500	
CHANNEL WEDGE FDN:	2,818,650		22.43	63,214,453	
WALKWAY BLOCK FDN:	1,935,000		43.00	83,205,000	
WALKWAY WEDGE FDN:	735,300		22.43	16,490,727	
HEEL SLAB:	5,655,000		68.50	387,367,500	
TOE SLAB:	1,200,600		5.75	6,903,450	
FLUID ON HEEL:	4,194,125		68.50	287,297,562	
FLUID ON CHANNEL SILL:	342,000		49.50	16,929,000	
FLUID ON WALKWAY SILL:	90,000		49.50	4,455,000	
FLUID ON D/S WEDGE:	654,312		17.83	11,668,573	
FLUID ON TOE:	875,437		5.75	5,033,766	
UPLIFT FORCE (U1):	-9,749,437		40.75	397,289,578	
UPLIFT FORCE (U2):	5,391,734		54.33	292,950,901	
FLUID HORIZ FORCE (H):	8,754,828		23.17	202,820,185	
RESISTING FLUID FORCE:	1,973,812		11.00	21,711,937	
SUBTOTAL AT BASE (V, MR, MO)	13,002,653	6,781,016		1,318,933,169	893,060,664

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHID)) =	6,845,531 LB	= U*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (GND*L*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	6,781,016 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	1.01 >1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.48 >1.0?	
ECCENTRICITY (E=L/2-(MR-MO)/VI) =	8.00 (RELATIVE TO CJ.)	
BEARING PRESSURE = V/L(1+-6*E/L)		
MAX BEARING PRESS = 4370 PSF		
MIN BEARING PRESS = 1131 PSF		
VOLUME OF CONCRETE = 5,424 CY		

**Section 10**

**Clear Fork Isolation Gate Structures-**

**Pile Foundation**

**Clear Fork Isolation Gate Structure**

**Usual Load Condition - SPF**

**(File I1 SPF-NoDrain-Pile CFork.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. SPF level at El 552.5 on driving side.
3. Tailwater at El 520.0 on resisting side.

PROJECT: TRWD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDH

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)

SPE WATER ELEVATION (USUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:  
FLOOD ELEV (FE) : 552.5 FT  
TALLWATER ELEV ('FE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 506 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 7.33 FT  
NO. OF CONC PIERS (PN) : 3  
UPSTREAM STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

**DESIGN PARAMETERS (INPUT):**

FACTOR OF SAFETY (FS) : 1.33  
ACTUAL SOIL FRICTION ANGLE (PHI) : 35 DEGREES  
ACTUAL SOIL COHESION (Cn) : 0 PSF  
FLUID PRESSURE (EFP) : 62.5 PSF  
CONC UNIT WGT (CTW) : 150 PSF

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GAP: 24 FT DESIGN FRICTION ANGLE (PHITD) : 27.77 DEGREES  
GATE WIDTH (CGW) : 518 FT DESIGN COHESION (CND) : 0 PSF  
STILL ELEV (CSE) : 15,000 LBS UPLIFT AT HEEL (UH) : 2906 PSF  
GATE WEIGHT (CGWGT) :  
  
WALKWAY GATE:  
GATE WIDTH (WGW) : 12 FT CONCRETE WEDGE HEIGHT & LENGTH (WH) : 6 FT  
STILL ELEV (WSE) : 530 FT (WH = CSE BL - RTTH)  
GATE WEIGHT (WGWT) : 5,000 LBS FDN LENGTH (L) : 48 FT  
  
ADDL HEEL WIDTH (HW) : 0 FT (L = HW + PL + WH + TW)  
HEEL THICKNESS (HTH) : 0 FT FDN WIDTH (B) : 58 FT  
ADDL TOE WIDTH (TW) : 17 FT (B = CGW + CGW + PN\*PT)  
TOE THICKNESS (TT) : 6 FT

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

BDH DATE: 12/18/2004

CHECKED BY: \_\_\_\_\_ DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-F	OVERTURNING MOMENT: LB-F
CHANNEL GATE:	15,000		35.00	525,000	
WALKWAY GATE:	5,000		35.00	175,000	
CONCRETE PIERS:	3,217,500		35.50	114,221,250	
UPPER STRUCTURE:	1,058,400		35.50	37,513,200	
CHANNEL BLOCK FDN:	2,070,000		35.50	73,485,000	
CHANNEL WEDGE FDN:	372,600		20.34	7,578,684	
WALKWAY BLOCK FDN:	1,080,000		35.50	38,340,000	
WALKWAY WEDGE FDN:	97,200		20.34	1,977,048	
HEEL SLAB:	0		48.00	0	
TOE SLAB:	887,400		8.50	7,542,900	
FLUID ON HEEL:	0		48.00	0	
FLUID ON CHANNEL SILL:	342,000		42.00	14,364,000	
FLUID ON WALKWAY SILL:	90,000		42.00	3,780,000	
FLUID ON D/S WEDGE:	65,250		19.00	1,239,750	
FLUID ON TOE:	493,000		8.50	4,190,500	
UPLIFT FORCE (U1):	-2,436,000		24.00	58,464,000	
UPLIFT FORCE (U2):	2,827,500		32.00	90,480,000	
FLUID HORIZ FORC (H):			15.50	60,745,711	
RESISTING FLUID FORCE:			4.67		
SUBTOTAL AT BASE (V,MR,MO)	4,529,850	3,563,828	306,650,165	209,689,711	

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PH1)) =	2,384,838 LB	U*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*V) =	0 LB	COHESION * BASE AREA
NET SLIDING FORCE =	3,563,828 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	0.67 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.46 > 1.0?	
OVERCENTRICITY (E=L/2 * (MR-MO)/V) =	2.60 (RELATIVE TO CL)	
BEARING PRESSURE = V/L(1+6*E/L)		
MAX BEARING PRESS = 2155 PSF		
MIN BEARING PRESS = 1099 PSF		
VOLUME OF CONCRETE = 2,169 CY		

**Clear Fork Isolation Gate Structure**  
**Unusual Load Condition – Max Water Level**

**(File I2 MAX-NoDrain-Pile CFork.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. Maximum water level at El 556.5 on driving side.
3. Tailwater at El 520.0 on resisting side.

PROJECT: 'TRWD' - FLOOD GATE CONTROL STRUCTURE:

CHARGE NO.: 2521-422/5-PRSTR.DCS

DATE: 12/18/2004

DESIGNED BY: WCS

CHECKED BY: BDH — — —

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

DIMENSIONS & WEIGHTS (INPUT):

GATE STRUCTURE:			
FLOOD ELEV (FE):	556.5 FT	FACTOR OF SAFETY (FS):	1.33
TAILWATER ELEV (TW):	520 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	35 DEGREES
TOP OF PIER ELEV (PE):	557 FT	ACTUAL SOIL COHESION (Cn):	0 PSF
FDN BASE EL (BB):	506 FT	FLUID PRESS (EFP):	62.5 PCF
PIER LENGTH (PL):	25 FT	CONC UNIT WGT (CwU):	150 PCF
PIER THICKNESS (PT):	7.33 FT		
NO. OF CONC PIERS (PN):	3		
UPPER STRUCTURE OUTLINE (USO):	98 FT		
UPSTREAM FACE TO GATE CTR LINE (GCL):	13 FT		

DESIGN PARAMETERS (INPUT):

CHANNEL GATE:			
GATE WIDTH (CGW):	24 FT	DESIGN FRICTION ANGLE (PHD):	27.77 DEGREES
SILL ELEV (CSF):	518 FT	DESIGN COHESION (CND):	0 PSF
GATE WEIGHT (CGWGT):	15,000 LBS	UPLIFT AT HEEL (UH):	3156 PSF
		UPLIFT AT TOE (UT):	875 PSF
WALKWAY GATE:			
GATE WIDTH (WGW):	12 FT	CONCRETE WEDGE HEIGHT & LENGTH (WH):	6 FT
SILL ELEV (WSE):	530 FT	(WH = CSE * BE / TTH)	
GATE WEIGHT (WGWT):	5,000 LBS	FDN LENGTH (L):	48 FT
		(L = HW + PL + WH + TW)	
ADDL HEEL WIDTH (HW):	0 FT	FDN WIDTH (B):	58 FT
HEEL THICKNESS (HTH):	0 FT	(B = CGW + WGW + PN * PT)	
ADDL TOE WIDTH (TW):	17 FT		
TOE THICKNESS (TTH):	6 FT		

PROJECT #: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: Bou DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT:	LATL FORCE:	ARM TO TOE:	ARM TO TOE:	RESISTING MOMENT:	OVERTURNING MOMENT:
CHANNEL GATE:	15,000	1,8	LB	35.00	525,000	
WALKWAY GATE:	5,000			35.00	175,000	
CONCRETE PIERS:	3,217,500			35.50	114,221,250	
UPPER STRUCTURE:	1,058,400			35.50	37,573,200	
CHANNEL BLOCK FDN:	2,070,000			35.50	73,485,000	
CHANNEL WEDGE FDN:	372,600			20.34	7,578,684	
WALKWAY BLOCK FDN:	1,080,000			35.50	38,340,000	
WALKWAY WEDGE FDN:	97,200			20.34	1,977,048	
HEEL SLAB:	0			48.00	0	
TOE SLAB:	887,400			8.50	7,542,900	
FLUID ON CHANNEL STILL:	0	342,000		42.00	14,364,000	
FLUID ON WALKWAY SILL:	90,000			42.00	3,780,000	
FLUID ON D/S WEDGE:	65,250			19.00	1,239,750	
FLUID ON TOE:	493,000			8.50	4,190,500	
UPLIFT FORCE (U1):	-2,436,000			24.00	58,464,000	
UPLIFT FORCE (U2):	-3,175,500			32.00	101,616,000	
FLUID HORIZONTAL FORCE (H):		4,622,328		16.83		
RESISTING FLUID FORCE:		-355,250		4.67	1,657,833	
SUBTOTAL AT BASE (V, MR, MO) =	4,181,850	4,267,078		306,650,165	237,889,190	

#### STABILITY RESULTS:

FRICITION FORCE (V*WAN(BFD)):	2,201,626 LB	= U * (WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*D):	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	4,267,078 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	0.52 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.29 > 1.0?	
ECCENTRICITY (E=L/2 - (MR-MO)/VI) =	7.56 (RELATIVE TO CT)	
BEARING PRESSURE = V/L (1+6*K/L)	2921 PSF	
MAX BEARING PRESS =	83 PSF	
MIN BEARING PRESS =	2,169 CY	
VOLUME OF CONCRETE =		

**Clear Fork Isolation Gate Structure**

**Extreme Load Condition - Seismic**

**(File I3 SEISMIC-NoDrain-Pile CFork.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. Normal pool level at El 525.0 on driving side.
3. Tailwater at El 520.0 on resisting side.
4. Horizontal ground acceleration = 0.05 g.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR, DCS

DESIGNED BY: WCS

CHECKED BY: BDH

DATE: 12/18/2004  
DATE: 12/20/04

**GATE STRUCTURE STABILITY (W/ UPLIFT)  
NORMAL POOL ELEVATION WITH SEISMIC (EXTREME CONDITION)**

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:	
FLOOD ELEV (FE) :	525 FT
TOTAL WATER ELEV (TF) :	520 FT
TOP OF PIER ELEV (PE) :	557 FT
PIER BASE EL. (BE) :	506 FT
PIER LENGTH (PL) :	25 FT
PIER THICKNESS (PT) :	7.33 FT
NO. OF CONC PIERS (PN) :	3
UPPER STRUCTURE OUTLINE (USO) :	98 FT
UPSTREAM FACE TO GATE CTR LINE (GCL) :	13 FT

**DESIGN PARAMETERS (INPUT):**

FACTOR OF SAFETY (FS) :	1.1
ACTUAL SOIL FRICTION ANGLE (PHI) :	35 DEGREES
ACTUAL SOIL COHESION (Cv) :	0 PSF
FLUID PRESS (EFP) :	62.5 PCF
CONC UNIT WGT (CUW) :	150 PCF
SEISMIC COEFFICIENT (A) :	0.05 g

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL, GATE:	
GATE WIDTH (CGW) :	24 FT
SILL ELEV (CSR) :	518 FT
GATE WEIGHT (CGWT) :	15,000 LBS
WALKWAY GATE:	
GATE WIDTH (WGW) :	12 FT
SILL ELEV (WGS) :	530 FT
GATE WEIGHT (WGWT) :	5,000 LBS
ADDL REEL WIDTH (HW) :	
HEEL THICKNESS (HTH) :	0 IN
TOE THICKNESS (TTH) :	17 FT
TOE THICKNESS (TTH) :	6 FT

CONCRETE WEDGE HEIGHT & LGTH (WH) : 6 FT  
(WH = CSE-BE \* TTH)  
FLD LENGTH (L) : 4.8 FT  
(L = HW + PL + WH + TW)  
FLD WIDTH (B) : 5.8 FT  
(B = CGW + WGW + PN\*FW)

**SEISMIC PARAMETERS:**

$$\begin{aligned} \text{SEISMIC INERTIA DUE TO MASS} &= \text{SUM(DL)} * A \\ \text{ASSUMED CENTROID OF MASS} &= 0.4 * (\text{PE}-\text{BE}) \\ \text{SEISMIC FLUID FORCE (VER WESTERGAARD)} &= 0.67 * 51 * A * (\text{PE}-\text{BE})^2 \\ \text{FLUID FORCE RESULTANT ABOVE BAST} &= 0.4 * (\text{PE}-\text{BE}) \\ \text{OR } 0.4 * (\text{TF}-\text{BE}) \end{aligned}$$

PROJECT: TWWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PWR, DCIS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDF

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-F	OVERTURNING MOMENT: LB-F
CHANNEL GATE:	15,000		35,00	525,000	
WALKWAY GATE:	5,000		35,00	175,000	
CONCRETE PIERS:	3,217,500		35,50	114,221,250	
UPPER STRUCTURE:	1,059,400		35,50	37,573,200	
CHANNEL BLOCK FDN:	2,070,000		35,50	73,485,000	
CHANNEL WEDGE FDN:	372,600		20,34	7,578,684	
WALKWAY BLOCK FDN:	1,080,000		35,50	38,340,000	
WALKWAY WEDGE FDN:	97,200		20,34	1,977,048	
HEEL SLAB:	0	48,00	8,50	7,542,900	
TOE SLAB:	887,400		48,00	0	
FLUID ON HEEL:	0		42,00	14,364,000	
FLUID ON CHANNEL SILL:	342,000		42,00	3,780,000	
FLUID ON WALKWAY SILL:	90,000		19,00	1,239,750	
FLUID ON D/S WEDGE:	65,250		8,50	4,190,500	
FLUID ON TOE:	493,000		24,00	58,464,000	
UPLIFT FORCE (U1):	-2,436,000		32,00	13,920,000	
UPLIFT FORCE (U2):	-435,000		4,67	4,143,979	
FLUID HORIZ FORCE (H):		654,312	6,33	1,657,833	
RESISTING FLUID FORCE:		-355,250			
SEISMIC INERTIA FORCE:		395,785	20	8,074,014	
SEISMIC FLUID FORCE U/S:		617	7,6	4,687	
SEISMIC FLUID FORCE D/S:		335	5,6	1,875	
SUBTOTAL AT BASE (V, MR, MO)	6,922,350	695,799	306,650,165	64,608,556	

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI))	4,406,438 LB	= U*(WEIGHT CONC + GATES + WATER = UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	COHESION * BASE AREA
NET SLIDING FORCE =	695,799 LB	DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	6.33 >1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	3.62 >1.0?	
ECCENTRICITY (E=L/2 - (MR-MO)/V) =	-8.08 (RELATIVE TO C.L.)	
BEARING PRESSURE = V/L (1+6*E/L)	-24 PSF	
MAX BEARING PRESS =	4997 PSF	
MIN BEARING PRESS =	2,169 CY	
VOLUME OF CONCRETE =		

# **Section 11**

## **Stability Analyses for Abutment Structures**

## **TRWD Abutment Structures**

### **Unusual Load Condition – Max Water Level**

**(Files: MAX-Abut-E TRWD.XLS & MAX-Abut-W TRWD.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. Maximum water level at El 544.0 on driving side.
3. Tailwater below base on resisting side.
4. Balanced soil pressures neglected for preliminary design.

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: TBDH DATE: 12/20/04

GATE ABUTMENT STRUCTURE STABILITY  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

DIMENSIONS & WEIGHTS (INPUT):

GATE ABUTMENT STRUCTURE:					
FLOOD ELEV (FE):	\$44	FT	ACTUAL SOIL FRICTION ANGLE (PHI):	1.33	DEGREES
TAILWATER ELEV (TE):	\$20	FT	ACTUAL SOIL COHESION (CN):	28	PSF
TOP OF DECK ELEV (TDE):	\$57	FT	FLUID PRESS (EFP):	0	PSF
FDN BASE EL. (BE):	\$26	FT	CONC UNIT WGT (CUW):	62.5	PCF
DECK WIDTH (DW):	25	FT	CONTAINED SOIL WGT (CSW):	150	PCF
HEADWALL THICKNESS (HWT):	2	FT		110	PCF
BUTTRESS WALL THICKNESS (BWT):	2	FT			
NO. OF BUTTRESS WALLS (NB):	3				
TOP SLAB THICKNESS (TS):	1.5	FT	RESULTING DESIGN VALUES & DIMENSIONS:		
HOTOM SHAB THICKNESS (HST):	3	FT			
STRUCTURE LENGTH (B):	53	FT	DESIGN FRICTION ANGLE (PHD):	21.79	DEGREES
ADDL HEEL WIDTH (HW):	0	FT	( PHD = ARCTAN(TAN(PHI)/FS) )		
HEEL THICKNESS (HTH):	0	FT	DESIGN COHESION (CND):	0	PSF
ADDL TOE WIDTH (TW):	0	FT	( CND / CN / FS )		
TOE THICKNESS (TTW):	0	FT	UPLIFT AT HEEL (UH):	1125	PSF

DESIGN PARAMETERS (INPUT):

GATE ABUTMENT STRUCTURE:					
FLOOD ELEV (FE):	\$44	FT	ACTUAL SOIL FRICTION ANGLE (PHI):	1.33	DEGREES
TAILWATER ELEV (TE):	\$20	FT	ACTUAL SOIL COHESION (CN):	28	PSF
TOP OF DECK ELEV (TDE):	\$57	FT	FLUID PRESS (EFP):	0	PSF
FDN BASE EL. (BE):	\$26	FT	CONC UNIT WGT (CUW):	62.5	PCF
DECK WIDTH (DW):	25	FT	CONTAINED SOIL WGT (CSW):	150	PCF
HEADWALL THICKNESS (HWT):	2	FT		110	PCF
BUTTRESS WALL THICKNESS (BWT):	2	FT			
NO. OF BUTTRESS WALLS (NB):	3				
TOP SLAB THICKNESS (TS):	1.5	FT	RESULTING DESIGN VALUES & DIMENSIONS:		
HOTOM SHAB THICKNESS (HST):	3	FT			
STRUCTURE LENGTH (B):	53	FT	DESIGN FRICTION ANGLE (PHD):	21.79	DEGREES
ADDL HEEL WIDTH (HW):	0	FT	( PHD = ARCTAN(TAN(PHI)/FS) )		
HEEL THICKNESS (HTH):	0	FT	DESIGN COHESION (CND):	0	PSF
ADDL TOE WIDTH (TW):	0	FT	( CND / CN / FS )		
TOE THICKNESS (TTW):	0	FT	UPLIFT AT HEEL (UH):	1125	PSF

$$\text{FDN LENGTH (L)} : \frac{(L - HW + DW + TW)}{25} \text{ FT}$$

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTK, DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: B.D.U. DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-F	OVERTURNING MOMENT: LB-F
HEADWALL:	373, 650		24.00	8,967, 600	
BUTTRESS WALLS (1):	596, 250		12.50	7,453, 125	
BUTTRESS WALLS (2):	0		0.00	0	
TOP SLAB:	298, 125		12.50	3,726, 563	
BOTTOM SLAB:	596, 250		12.50	7,453, 125	
HEEL, SLAB:	0		25.00	0	
TOE SLAB:	0		0.00	0	
FLUID ON HEEL:	0		25.00	0	
FLUID ON TOE:	0		0.00	0	
UPLIFT FORCE (U1):	0		12.50	0	
UPLIFT FORCE (U2):	.745, 313		16.67	12,421, 875	
FLUID HORIZ FORCE (H):			6.00	3,219, 750	
RESISTING FLUID FORCE:		536, 625	2.00	0	
SUBTOTAL, AT BASE (V, MR, MO)	1,118, 963	536, 625		27,600, 413	15,641, 625

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(ΦHD)) =	447, 341 LB	= U*(WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	COHESION * BASE AREA
NET SLIDING FORCE =	536, 625 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	0.83 > 1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.76 > 1.0?	
H:CENTRICITY (E=L/2-(MR-MO)/V) =	1.81 (RELATIVE TO CL)	
BEARING PRESSURE = V/(1.(1+6*E/L))		
MAX BEARING PRESS = 1212 PSF		
MIN BEARING PRESS = 477 PSF		
VOLUME OF CONCRETE = 460 CY		

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY:

DATE: 12/20/04

GATE ABUTMENT STRUCTURE STABILITY  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE ABUTMENT STRUCTURE:				
FLOOD ELEV (FE):	544	FT	ACTUAL SOIL FRICTION ANGLE (PHI):	1.33 DEGREES
TAILWATER ELEV (TE):	520	FT	ACTUAL SOIL COHESION (CN):	28 PSF
TOP OF DECK ELEV (TDE):	557	FT	FLUID PRESS (EFP):	0 PSF
FDN BASE EL (BE):	526	FT	CONC UNIT WGT (CUW):	62.5 PCF
DECK WIDTH (DW):	25	FT	CONTAINED SOIL WGT (CSW):	150 PCF
HEADWALL THICKNESS (HWT):	2	FT		110 PCF
BUTTRESS WALL THICKNESS (BWT):	2	FT		
NO. OF BUTTRESS WALLS (NB):	2	FT		
TOP SLAB THICKNESS (TST):	1.5	FT		
BOTTOM SLAB THICKNESS (BST):	3	FT		
STRUCTURE LENGTH (L):	26	FT		
ADDL HEEL WIDTH (HW):	0	FT	DESIGN FRICTION ANGLE (PHID):	21.79 DEGREES
HEEL THICKNESS (HTH):	0	FT	( PHID = ARCTAN(TAN(PHI)/FS) )	
ADDL TOE WIDTH (TW):	0	FT	DESIGN COHESION (CND):	0 PSF
TOE THICKNESS (TTW):	0	FT	( CND = CN / FS )	

**DESIGN PARAMETERS (INPUT):**

GATE ABUTMENT STRUCTURE:				
FLOOD ELEV (FE):	544	FT	FACTOR OF SAFETY (FS):	1.33
TAILWATER ELEV (TE):	520	FT	ACTUAL SOIL FRICTION ANGLE (PHI):	28 DEGREES
TOP OF DECK ELEV (TDE):	557	FT	ACTUAL SOIL COHESION (CN):	0 PSF
FDN BASE EL (BE):	526	FT	FLUID PRESS (EFP):	62.5 PCF
DECK WIDTH (DW):	25	FT	CONC UNIT WGT (CUW):	150 PCF
HEADWALL THICKNESS (HWT):	2	FT	CONTAINED SOIL WGT (CSW):	110 PCF
BUTTRESS WALL THICKNESS (BWT):	2	FT		
NO. OF BUTTRESS WALLS (NB):	2	FT		
TOP SLAB THICKNESS (TST):	1.5	FT		
BOTTOM SLAB THICKNESS (BST):	3	FT		
STRUCTURE LENGTH (L):	26	FT		
ADDL HEEL WIDTH (HW):	0	FT	DESIGN FRICTION ANGLE (PHID):	21.79 DEGREES
HEEL THICKNESS (HTH):	0	FT	( PHID = ARCTAN(TAN(PHI)/FS) )	
ADDL TOE WIDTH (TW):	0	FT	DESIGN COHESION (CND):	0 PSF
TOE THICKNESS (TTW):	0	FT	( CND = CN / FS )	

**RESULTING DESIGN VALUES & DIMENSIONS:**

GATE ABUTMENT STRUCTURE:				
FLOOD ELEV (FE):	544	FT	FACTOR OF SAFETY (FS):	1.33
TAILWATER ELEV (TE):	520	FT	ACTUAL SOIL FRICTION ANGLE (PHI):	28 DEGREES
TOP OF DECK ELEV (TDE):	557	FT	ACTUAL SOIL COHESION (CN):	0 PSF
FDN BASE EL (BE):	526	FT	FLUID PRESS (EFP):	62.5 PCF
DECK WIDTH (DW):	25	FT	CONC UNIT WGT (CUW):	150 PCF
HEADWALL THICKNESS (HWT):	2	FT	CONTAINED SOIL WGT (CSW):	110 PCF
BUTTRESS WALL THICKNESS (BWT):	2	FT		
NO. OF BUTTRESS WALLS (NB):	2	FT		
TOP SLAB THICKNESS (TST):	1.5	FT		
BOTTOM SLAB THICKNESS (BST):	3	FT		
STRUCTURE LENGTH (L):	26	FT		
ADDL HEEL WIDTH (HW):	0	FT	DESIGN FRICTION ANGLE (PHID):	21.79 DEGREES
HEEL THICKNESS (HTH):	0	FT	( PHID = ARCTAN(TAN(PHI)/FS) )	
ADDL TOE WIDTH (TW):	0	FT	DESIGN COHESION (CND):	0 PSF
TOE THICKNESS (TTW):	0	FT	( CND = CN / FS )	

FDN LENGTH (L):  
( L = HW + DW + TW ) : 25 FT

PROJECT: 'TRWD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275 PRSTR, DCS

DESIGNED BY: Wes

CHECKED BY: TBDW — —

DATE: 12/18/2004  
12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOP: LB	RESISTING MOMENT: LB	OVERTURNING MOMENT: LB
HEADWALL:	174,900		24.00	4,197,600	
BUTTRESS WALLS (1):	397,500		12.50	4,968,750	
BUTTRESS WALLS (2):	0		0.00	0	
TOP SLAB:	146,250		12.50	1,828,125	
BOTTOM SLAB:	292,500		12.50	3,656,250	
HEEL SLAB:	0		25.00	0	
'TOE' SLAB:	0		0.00	0	
FLUID ON HEEL:	0		25.00	0	
FLUID ON TOE:	0		0.00	0	
UPLIFT FORCE (U1):	0		12.50	0	
UPLIFT FORCE (U2):	-365,625		16.67	6,093,750	
FLUID HORIZ FORCE (H):		263,250	6.00		
RESISTING FLUID FORCE:		0	-2.00	0	
SUBTOTAL AT BASE: (V, MR, MO) =	645,525	263,250		14,650,725	7,673,250

#### STABILITY RESULTS:

FRICTION FORCE (V*TAN(PHI)) =	258,069 LB	U * (WEIGHT CONC + GATES + WATER = UPLIFT)
COHESION FORCE (CND*V*B)	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	263,250 LB	= DRYING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	0.98 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.91 > 1.0?	
ECCENTRICITY (E=L/2-(MR-MO)/V) =	1.69 (RELATIVE TO CL)	
BEARING PRESSURE =	V/L(1+.6*E/L)	
MAX BEARING PRESS =	1396 PSF	
MIN BEARING PRESS =	590 PSF	
VOLUME OF CONCRETE =	250 CY	

## **Trinity Point Abutment Structures**

### **Unusual Load Condition – Max Water Level**

**(File: MAX-Abut-E & W TPoint.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. Maximum water level at El 549.5 on driving side.
3. Tailwater below base on resisting side.
4. Balanced soil pressures neglected for preliminary design.

## PROJECT": TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275- PRS'R. DC'S

THE JOURNAL OF CLIMATE

DESIGNED BY: WCs DATE: 12/18/2004  
CHECKED BY: TBD DATE: 12/20/04

GATE ABUTMENT STRUCTURE STABILITY  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

DIMENSIONS & WEIGHTS (IN PWT) :

GATE ABUTMENT STRUCTURE:	
FLOOD ELEV (FE) :	
TAILWATER ELEV (TE) :	
TOP OF DECK ELEV (TDE) :	
FDN BASE EL (BEE) :	
DECK WIDTH (DW) :	
HEADWALL THICKNESS (HW) :	
BUTTERESS WALL THICKNESS (BWT) :	
NO. OF BUTTERESS WALLS (NWB) :	
TOP SLAB THICKNESS (BST) :	
BOTTOM SLAB THICKNESS (BTS) :	
STRUCTURE LENGTH (B) :	
ADDL HEEL WIDTH (HW) :	
HEEL THICKNESS (HTH) :	
ADDL TOE WIDTH (TW) :	
TOE THICKNESS (TTW) :	

## DESIGN PARAMETERS (INPUT):

ACTUAL SOIL COHESION (CN) :	FACTOR OF SAFETY (FS) :
ACTUAL SOIL FRICTION ANGLE (PHI) :	
CONTAINED SOIL WGT (CSW) :	FLUID PRESS (EFP) :
CONC UNIT WGT (CUW) :	

BUILDING DESIGN VARIANCE & DIMENSIONS:

```

DESIGN FRICTION ANGLE (PHID) : 21.79 DEGREES
( PHID = ARCTAN (TAN (PHI) / FS ) )
DESIGN COHESION (CND) : 0 PSF
( CND = CN / FS )
UPLIFT AT HEEL (UH) : 14.69 PSF
( UH = (FE-BE) * EFP )
UPLIFT AT TOE (UT) : 0 PSF
( UT = (FE-BE) * EFP )

```

FDN LENGTH (L) :  $L = H_W + D_W + T_W$

PROJECT: 'TRWD FLOOD GATE CONTROL STRUCTURE'

CHARGE NO.: 2521-42275-PHSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004  
CHECKED BY: TD  
DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-FEET	OVERTURNING MOMENT: LB-FEET
HEADWALL:	143,100		30.00	4,293,000	
BUTTRESS WALLS (1):	397,500		18.50	7,353,750	
BUTTRESS WALLS (2):	44,100		4.00	176,488	
TOP SLAB:	123,750		18.50	2,289,375	
BOTTOM SLAB:	247,500		18.50	4,578,750	
HEEL SLAB:	0		31.00	0	
TOE SLAB:	59,400		3.00	178,200	
FLUID ON HEEL:	0		31.00	0	
FLUID ON TOE:	0		3.00	0	
UPLIFT FORCE (U1):	0		15.50	0	
UPLIFT FORCE (U2):	500,844		20.67	10,350,771	
FLUID HORIZ FORCE (H):		379,672	7.83	2,974,096	
RESISTING FLUID FORCE:		0	-2.00	0	
SUBTOTAL, AT BASE (V, MR, MO) =	514,506	379,672		18,869,563	13,324,867

#### STABILITY RESULTS:

FRICITION FORCE (V*VAN(PHID))	205,690 LB	= U* (WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	379,672 LB	: DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	0.54 > 1.0?	= (FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.42 > 1.0?	
HCCENTRICITY (E=L/2 (MR-MO) / V) =	4.72 (RELATIVE TO CL)	
BEARING PRESSURE = V/L (1+6*E/L)		
MAX BEARING PRESS = 1444 PSF		
MIN BEARING PRESS = 65 PSF		
VOLUME OF CONCRETE = 251 CY		

## **Clear Fork Abutment Structures**

### **Unusual Load Condition – Max Water Level**

**(Files: MAX-Abut-E CFork.XLS & MAX-Abut-W CFork.XLS)**

1. Concrete structure on battered steel H-piles to rock.
2. Maximum water level at El 556.5 on driving side.
3. Tailwater below base on resisting side.
4. Balanced soil pressures neglected for preliminary design.

PROJECT: TIRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-FRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: TBDIA DATE: 2/20/04

GATE ABUTMENT STRUCTURE STABILITY  
MAXIMUM WATER LEVEL TO TOP OF LHEVF. (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE ABUTMENT STRUCTURE:				
FLOOD ELEV (FE):	556.5 FT			
TAILWATER ELEV (TE):	520 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	28 DEGREES	
TOP OF DECK ELEV (TDE):	557 FT	ACTUAL SOIL COHESION (CN):	0 PSF	
FDN BASE EL (BE):	526 FT	FLUID PRESS (BFP):	62.5 PCF	
DECK WIDTH (DW):	25 FT	CONC UNIT WGT (CUW):	150 PCF	
HEADWALL THICKNESS (HWT):	2 FT	CONTAINED SOIL WGT (CSW):	110 PCF	
BUTTRESS WALL THICKNESS (BWT):	3 FT			
NO. OF BUTTRESS WALLS (NB):	4			
TOP SLAB THICKNESS (TST):	1.5 FT			
BOTTOM SLAB THICKNESS (BSL):	6 FT			
STRUCTURE LENGTH (B):	80 FT			
ADDL HEEL WIDTH (HW):	12 FT	DESIGN FRICTION ANGLE (PHD):	21.79 DEGREES	
HEEL THICKNESS (HTH):	6 FT	( PHD = ARCTAN(TAN(PHI)/FS) )		
ADDL TOE WIDTH (TW):	10 FT	DESIGN COHESION (CND):	0 PSF	
TOE THICKNESS (TTH):	6 FT	( CND = CN / FS )		

**DESIGN PARAMETERS (INPUT):**

GATE ABUTMENT STRUCTURE:				
FLOOD ELEV (FE):	556.5 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	1.33 DEGREES	
TAILWATER ELEV (TE):	520 FT	ACTUAL SOIL COHESION (CN):	0 PSF	
TOP OF DECK ELEV (TDE):	557 FT	FLUID PRESS (BFP):	62.5 PCF	
FDN BASE EL (BE):	526 FT	CONC UNIT WGT (CUW):	150 PCF	
DECK WIDTH (DW):	25 FT	CONTAINED SOIL WGT (CSW):	110 PCF	
HEADWALL THICKNESS (HWT):	2 FT			
BUTTRESS WALL THICKNESS (BWT):	3 FT			
NO. OF BUTTRESS WALLS (NB):	4			
TOP SLAB THICKNESS (TST):	1.5 FT			
BOTTOM SLAB THICKNESS (BSL):	6 FT			
STRUCTURE LENGTH (B):	80 FT			
ADDL HEEL WIDTH (HW):	12 FT	DESIGN FRICTION ANGLE (PHD):	21.79 DEGREES	
HEEL THICKNESS (HTH):	6 FT	( PHD = ARCTAN(TAN(PHI)/FS) )		
ADDL TOE WIDTH (TW):	10 FT	DESIGN COHESION (CND):	0 PSF	
TOE THICKNESS (TTH):	6 FT	( CND = CN / FS )		

**RESULTING DESIGN VALUES & DIMENSIONS:**

GATE ABUTMENT STRUCTURE:				
FLOOD ELEV (FE):	556.5 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	21.79 DEGREES	
TAILWATER ELEV (TE):	520 FT	( PHI = ARCTAN(TAN(PHI)/FS) )		
TOP OF DECK ELEV (TDE):	557 FT	DESIGN COHESION (CND):	0 PSF	
FDN BASE EL (BE):	526 FT	( CND = CN / FS )		
DECK WIDTH (DW):	25 FT	UPLIFT AT HEEL (UH):	1906 PSF	
HEADWALL THICKNESS (HWT):	2 FT	( UH = (FH BE) * EFP )		
BUTTRESS WALL THICKNESS (BWT):	3 FT	UPLIFT AT TOE (UT):	0 PSF	
NO. OF BUTTRESS WALLS (NB):	4	( UT = (TE-BE) * FFP )		
TOP SLAB THICKNESS (TST):	1.5 FT			
BOTTOM SLAB THICKNESS (BSL):	6 FT			
STRUCTURE LENGTH (B):	80 FT			
ADDL HEEL WIDTH (HW):	12 FT			
HEEL THICKNESS (HTH):	6 FT			
ADDL TOE WIDTH (TW):	10 FT			
TOE THICKNESS (TTH):	6 FT			

FDN LENGTH (L): 47 FT  
(L = HW + DW + TW)

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275=PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDA

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATERAL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-FEET	OVERTURNING MOMENT: LB-FEET
HEADWALL:	479,400		34.00	16,299,600	
BUTTRESS WALLS (1):	1,051,500		22.50	23,793,750	
BUTTRESS WALLS (2):	193,500		6.67	1,290,645	
TOP SLAB:	450,000		22.50	10,125,000	
BOTTOM SLAB:	1,800,000		22.50	40,500,000	
HEMI SLAB:	864,000		41.00	35,424,000	
TOE SLAB:	120,000		5.00	3,600,000	
FLUID ON INLEI	1,470,000		41.00	60,270,000	
FLUID ON TOW	0		5.00	0	
UPLIFT FORCE (U1):	0		23.50	112,290,833	
UPLIFT FORCE (U2):	3,583,750		31.33	23,643,854	
FLUID HORZ FORCE (H):		2,325,625	10.17		
RESISTING FLUID FORCE:		0	-2.00	0	
SUBTOTAL, AT BASE (V, MR, MO):	3,450,650	2,325,625		191,302,995	135,934,688

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(Φ11))	1,379,506 LB			
COHESION FORCE (CND*LB)	0 LB			
NET SLIDING FORCE	2,325,625 LB			= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	0.59 > 1.0?			(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO):	1.41 > 1.0?			
ECCENTRICITY ( $E_b/2 = (MR \cdot MO)/V$ ) =	7.45 (RELATIVE TO CL)			
BEARING PRESSURE V/L(1+6*E/L)				
MAX BEARING PRESS =	1791 PSF			
MIN BEARING PRESS =	44 PSF			
VOLUME OF CONCRETE =	1,374 CY			

PROJECT: TRWD - FLOOD GATE CONTROL, STRUCTURE

CHARGE NO.: 2521-42275 PRSTR, JCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: PDA DATE: 12/20/04

GATE ABUTMENT STRUCTURE STABILITY  
MAXIMUM WATER LEVEL TO TOP OF LIVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE ABUTMENT STRUCTURE:	
FLOOD ELEV (FE):	556.5 FT
TAILWATER ELEV (TE):	520 FT
TOP OF DECK ELEV (TDE):	557 FT
FTN BASE BL (BB):	526 FT
DECK WIDTH (DW):	25 FT
HEADWALL THICKNESS (HWT):	2 FT
BUTTRESS WALL THICKNESS (BWT):	3 FT
NO. OF BUTTRESS WALLS (NB):	2
TOP SLAB THICKNESS (TST):	1.5 FT
BOTTOM SLAB THICKNESS (BST):	6 FT
STRUCTURE LENGTH (L):	23 FT
ADDL HEEL WIDTH (HW):	12 FT
HEEL THICKNESS (HTH):	6 FT
ADDL TOE WIDTH (TW):	8 FT
TOE THICKNESS (TT):	6 FT

**DESIGN PARAMETERS (INPUT):**

GATE ABUTMENT STRUCTURE:	FACTOR OF SAFETY (FS):	1.33
FLOOD ELEV (FE):	ACTUAL SOIL FRICTION ANGLE (PHI):	28 DEGREES
TAILWATER ELEV (TE):	ACTUAL SOIL COHESION (CN):	0 PSF
TOP OF DECK ELEV (TDE):	FLUID PRESS (FFP):	62.5 PCF
FTN BASE BL (BB):	CONC UNIT WGT (CW):	150 PCF
DECK WIDTH (DW):	CONTAINED SOIL WGT (CSW):	110 PCF

**RESULTING DESIGN VALUES & DIMENSIONS:**

STRUCTURE LENGTH (L):	DESIGN FRICTION ANGLE (PHD):	21.79 DEGREES
	( PHD = ARCTAN(TAN(PHI) / FS) )	
	DESIGN COHESION (CND):	0 PSF
	( CND = CN / FS )	
	UPLIFT AT HEEL (UH):	1906 PSF
	( UH = (FF-BE) * FFP )	
	UPLIFT AT TOE (UT):	0 PSF
	( UT = (FF-BE) * FFP )	

$$\text{FDN LENGTH (L)} : \quad 45 \text{ FT} \\ (L = TW + DW + TW)$$

PROJECT: TRWD - FLOOD GATE, CONTROL, STRUCTURE

CHARNO NO. : 2521-42275; PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: BDA DATE: 12/20/04

**STABILITY ANALYSIS:**

	WEIGHT: LB	LATERAL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB	OVERTURNING MOMENT: LB
HEADWALL:			32.00	3,835,200	
BUTTRESS WALLS(1):	119,850		20.50	10,839,375	
BUTTRESS WALLS(2):	528,750		5.34	413,006	
TOP SLAB:	77,400		20.50	2,652,188	
BOTTOM SLAB:	129,375		20.50	10,608,750	
HEEL SLAB:	517,500		39.00	9,687,600	
TOE SLAB:	248,400		4.00	662,400	
FLUID ON HEEL:	165,600		39.90	16,482,375	
FLUID ON TOE:	422,625		4.00	0	
UPLIFT FORCE (U1):	0		22.50	29,594,531	
UPLIFT FORCE (U2):	0		30.00	6,797,608	
FLUID HORIZ FORCE (H):	-986,484	668,617	10.17	0	
RESISTING FLUID FORCE:		0	2.00		
SUBTOTAL AT BASE (V,MR,MO):	1,223,016	668,617		55,180,894	36,392,139

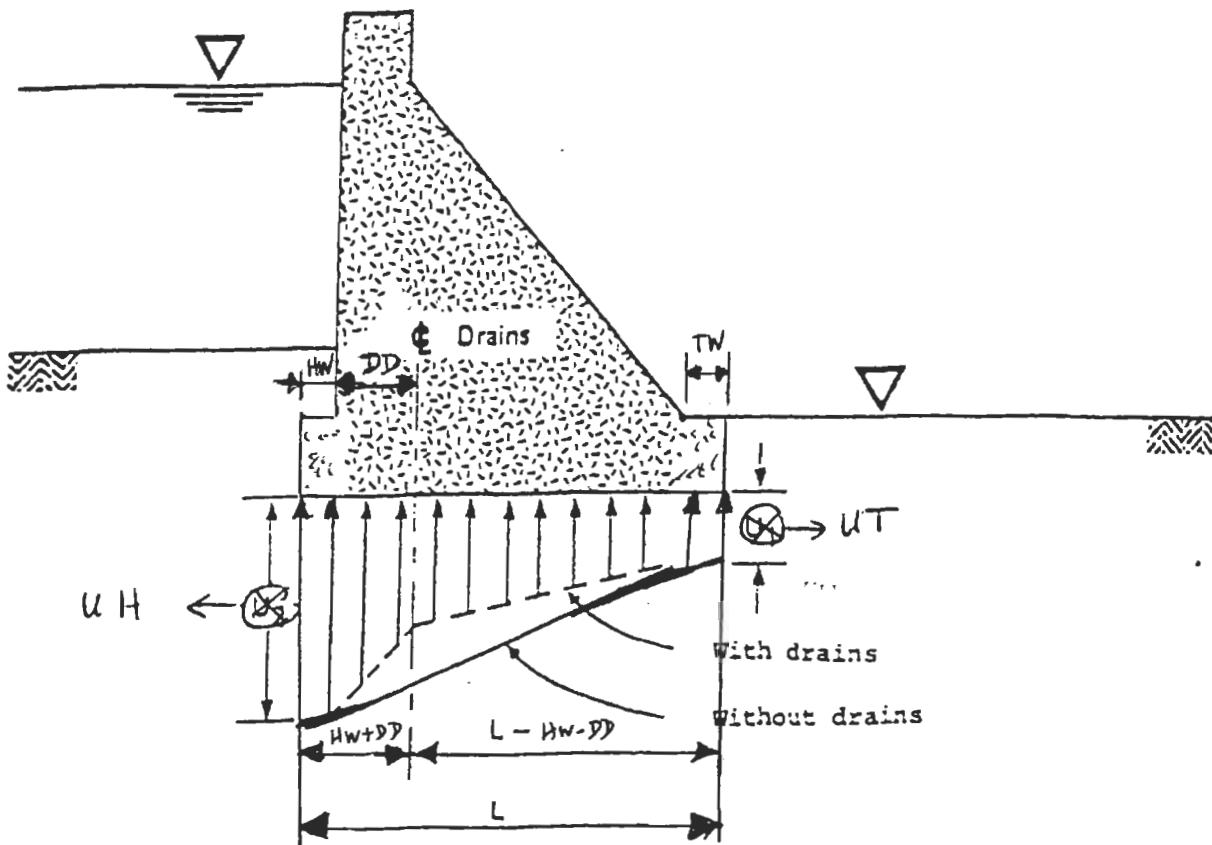
**STABILITY RESULTS:**

FRICITION FORCE (V*TAN(PHID)) =	488,939 LB	= U* (WEIGHT CONC + GATES + WATER - UPLIF <sup>t</sup> )
COHESION FORCE ((ND)1.1B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	668,617 LB	: DRIVING FORCES MINUS ACTIVE RESISTING FORCES
SLIDING RATIO =	0.73 > 1.0?	(FRICTION + COHESION) / (NET SLIDING)
OVERTURNING RATIO (MR/MO) =	1.52 > 1.0?	
ECCENTRICITY (E=L/2-(MR-MO)/V) =	7.14 (RELATIVE TO CL.)	
BEARING PRESSURE = V/I.(1+6*E/L)		
MAX BEARING PRESS :	2306 PSF	
MIN BEARING PRESS =	57 PSF	
VOLUME OF CONCRETE	441 CY	

# **Section 12**

## **Cell Formulas for Excel Spreadsheets**

## **CELL FORMULAS FOR EXCEL SPREADSHEETS**



$$UT + R \frac{L - HW - DD}{L} (UH - UT)$$

$$\text{Pressure Head at Drains} = U_1 + R \left( \frac{L - x}{L} \right) (U_2 - U_1)$$

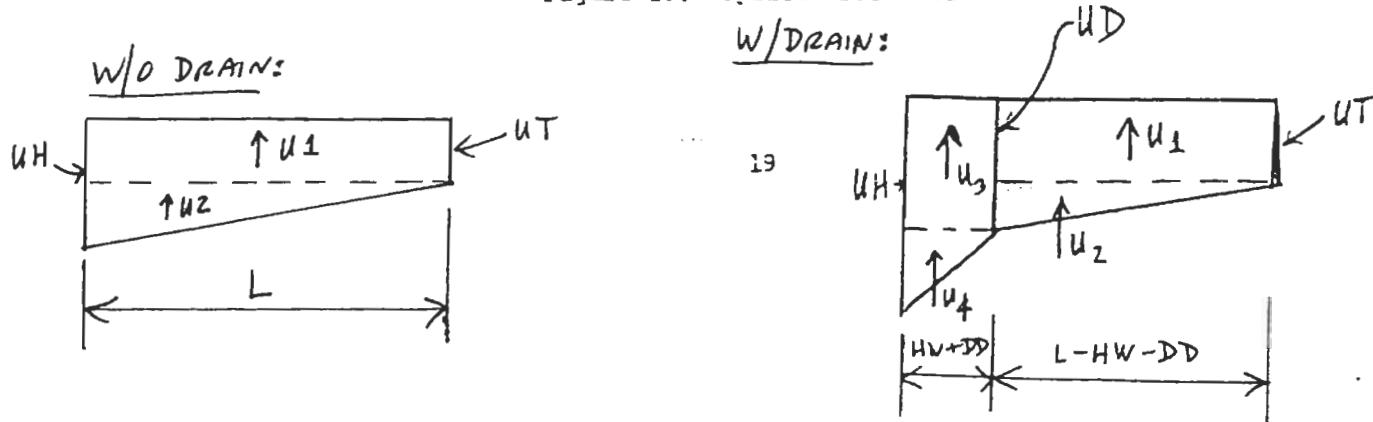
$UT$  (X) = Pressure Head at Toe

$UH$  (X) = Pressure Head at Heel

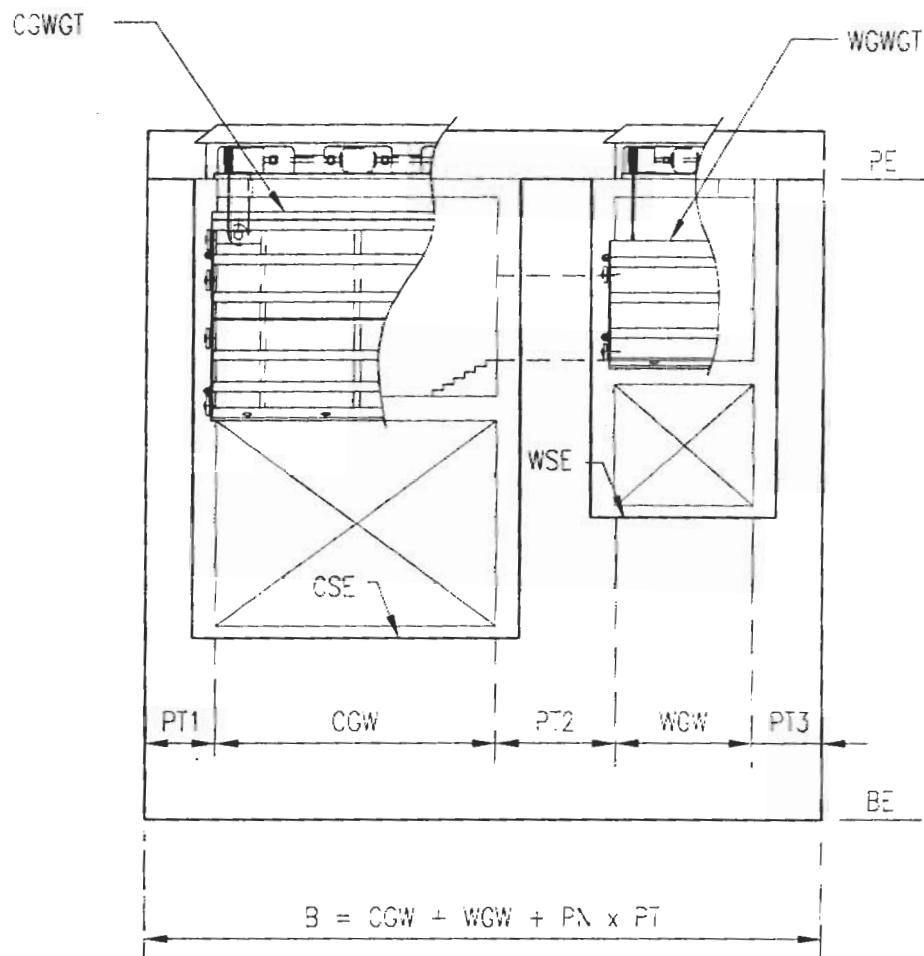
$R$  = Constant  $\{100 - (25\% \rightarrow 50\%) \}$

$$\text{SAY } R = \frac{100 - 33}{100} = 0.67$$

Figure 10. Uplift Pressures



**Gate Structure Stability Analysis (No Drains)**  
**Excel Spreadsheet with Cell Formulas Displayed**



$$PT = \frac{PT1 + PT2 + PT3}{3} = \text{AVERAGE PIER THICKNESS}$$

PN = NO. OF PIERS

## LONGITUDINAL SECTION

1/16"=1'-0"

SCALE: 1/16 " = 1'-0"

1'0 8' 16' 24'



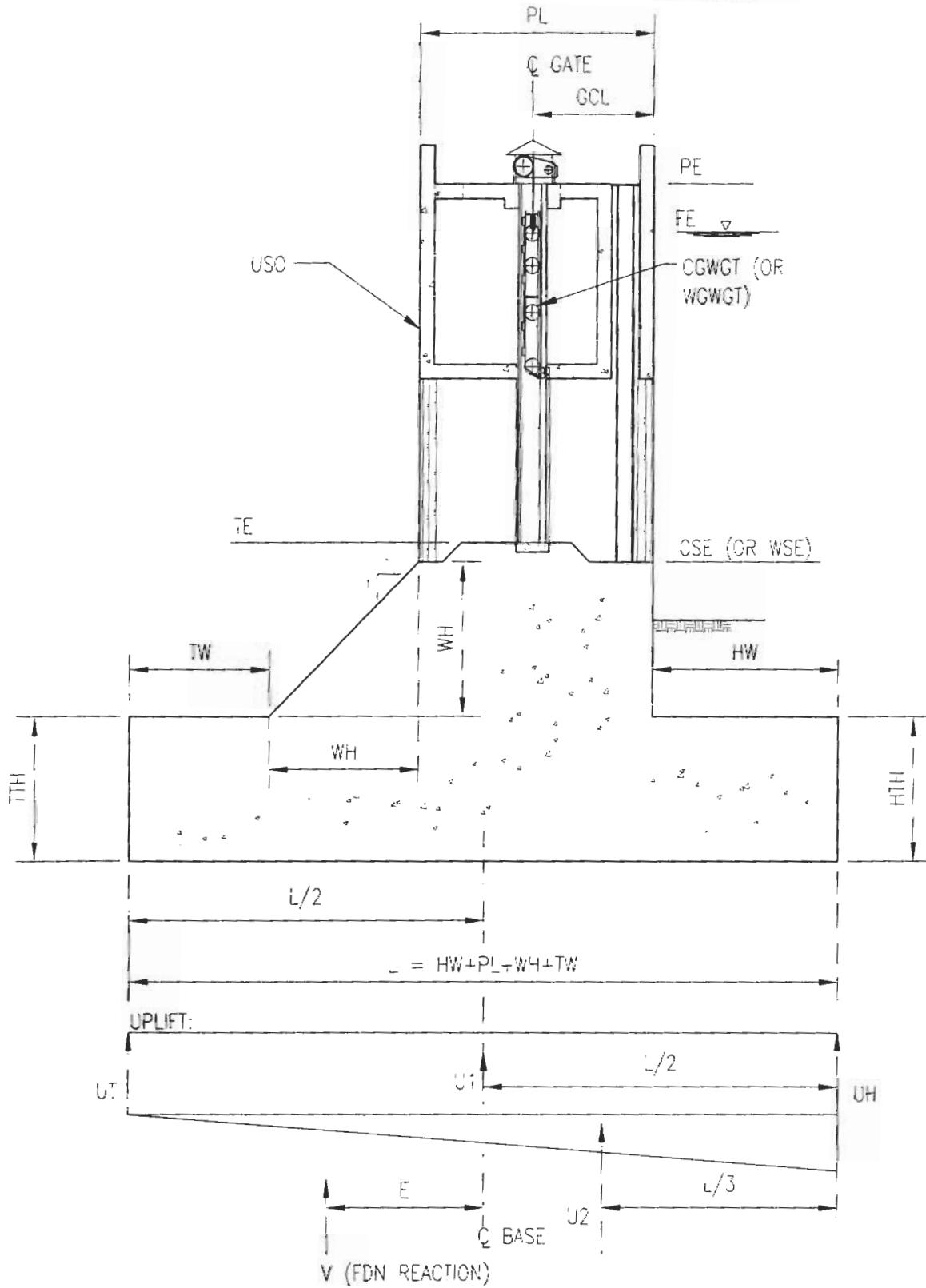
FORT WORTH CENTRAL CITY  
PRELIMINARY DESIGN

CELL NAMES  
GATE STRUCTURE I

**CDM**

DATE 12-21-04

FIGURE No. B-1



## TRANSVERSE SECTION (NO DRAIN)

1/16" = 1'-0"

SCALE: 1/16" = 1'-0"  
8' 15' 24'



FORT WORTH CENTRAL CITY  
PRELIMINARY DESIGN

**CDM**

CELL NAMES  
GATE STRUCTURE II

DATE 12-21-04

FIGURE No. B-2

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521 42275-FRSUR.DCS

DESIGNED BY: WES

CHECKED BY: — — —

DATE: 12/18/2004

DATE: — — —

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:

FLOOD ELEV (FEE): 556.5  
TAILWATER ELEV (TE): 520  
TOP OF PIER ELEV (PE): 557  
FDN BASE EL (BE): 487  
PIER LENGTH (PL): 25  
PIER THICKNESS (PT): 7.333333333  
NO. OF CONC PIERS (PN): 3  
UPPER STRUCTURE OUTLINE (USO): 98  
UPSTREAM FACE TO GATE CTR LINE (GCL): 13

CHANNEL GATE:

GATE WIDTH (CGW): 24  
SILL ELEV (CGSE): 518  
GATE WEIGHT (CGWGT): 15000

WALKWAY GATE:

GATE WIDTH (WGW): 12  
SILL ELEV (WSE): 530  
GATE WEIGHT (WGWT): 5000

ADDL HEEL WIDTH (HW): 20  
HEEL THICKNESS (HTH): 25  
ADDL TOE WIDTH (TW): 20  
TOE THICKNESS (TTT): 25

**DESIGN PARAMETERS ( INPUT ) :**

FACTOR OF SAFETY (FS) : 1.33  
 ACTUAL SOIL FRICTION ANGLE (PHI) : 35  
 ACTUAL SOIL COHESION (CN) : 0  
 FLUID PRESS (EFP) : 62.5  
 CONC UNIT WGT (CUW) : 150

DEGREES  
 PSF  
 PCF  
 PCF

**RESULTING DESIGN VALUES & DIMENSIONS :**

DESIGN FRICTION ANGLE (PHI) :	DEGREES (A TAN (TAN (RADIAN (PHI) ) / FS) )	DEGREES
DESIGN COHESION (CND) :	=CN/FS	PSF
UPLIFT AT HEEL (UH) :	=(FE-BE)*EFP	PSF
UPLIFT AT TOE (UT) :	=(TE-BE)*EFP	PSF
CONCRETE WEDGE HEIGHT & LGTH (WH) :	=CSR-BE-TTH	Ft
FDN LENGTH (L) :	=HW+PL+WH+1'2"	Ft
FDN WIDTH (B) :	=CGW+WGW+PN*P <sup>T</sup>	Ft
(B = CGW + WGW + PN* P <sup>T</sup> )		

```

=A1
=A3
=A5
=A7

DATE: =C5
DATE: : C/

```

### STABILITY ANALYSIS:

WEIGHT:	LATL FORCE:
LB	LB
CHANNEL GATE: =CGWGT	
WALKWAY GATE: =WGWT	
CONCRETE PIERS: =(PE-CSE)*PL*PN*PT*CW	
UPPER STRUCTURE: =USO*2*(CGW+WGW)*CW	
CHANNEL BLOCK FDN: =(CSE-BE)*PL*(CGW+PN*PT)*CW	
CHANNEL WEDGE FDN: =(WH*WH/2+TH*WH)*(CGW+PN*PT)*CW	
WALKWAY BLOCK FDN: =(WSE-BE)*PL*WGW*CW	
WALKWAY WEDGE FDN: =(WH*WH/2+TH*WH)*(WGW)*CDW	
HEEL SLAB: =HW*B*HTH*CW	
TOE SLAB: =TW*B*TTH*CW	
FLUID ON HEEL: =HW*B*(FE-BE*HTH)*EFP	
FLUID ON CHANNEL STIL: =(GCL-1)*(19)*CGW*EFP	
FLUID ON WALLWAY STIL: =(GCL-1)*(10)*WGW*EFP	
FLUID ON D/S WEDGE: =WH*WH/2*B*EFP	
FLUID ON TOE: =TW*B*(TF BE-TTH)*EFP	
UPLIFT FORCE (U1): =-UT*L*B	
UPLIFT FORCE (U2): =-0.5*(UH-UT)*L*B	
FLUID HORIZ FORCE (H):	
RESISTING FLUID FORCE:	
SUBTOTAL AT BASE (V,MR,MC) = =SUM(H13:H31)	
<b>= SUM(I13:I31)</b>	

### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHD)) = =V*TAN(RADIANS(PHD))	LB
COHESION FORCE (CND*L*B) = =CND*L*B	LB
NET SLIDING FORCE = =133	LB
SLIDING RATIO = =(H37+H38)/H39	>1.0?
OVERTURNING RATIO (MR/MO) = =MR/MO	
ECCENTRICITY (E=L/2-(MR-MO)/V) = =(L/2)-((MR-MO)/V)	
BEARING PRESSURE = V/L(1+6*E/L)	
MAX BEARING PRESS = =V/L*(1+6*H42/L)/B	
MIN BEARING PRESS = =V/L*(1-6*H42/L)/B	
VOLUME OF CONCRETE = =(SUM(H15:H22)/150)/27	

(RELATIVE TO CL)

```

ARM TO TOL:
=LN*MN-GCL
=L-HW-GCL
=L-HW-PL/2
=L-HW-PL/2
=L-HW-PL/2
=IF(H18=0,"", (WH*WH/2 * (TW+WH*0.67) + TTH*WH* (TW+WH/2)) / (WH*WH/2+TTH*WH))
=IF(H20=0,"", (WH*WH/2 * (TW+WH*0.67) + TTH*WH* (TW+WH/2)) / (WH*WH/2+TTH*WH))
=L-HW/2
=TW/2
=L-HW/2
=L-HW-(GCL-1)/2
=L-HW-(GCL-1)/2
=TW+WH/3
=TW/2
=L/2
=2*L/3
=(FE-BE)/3
=(TE-BE)/3

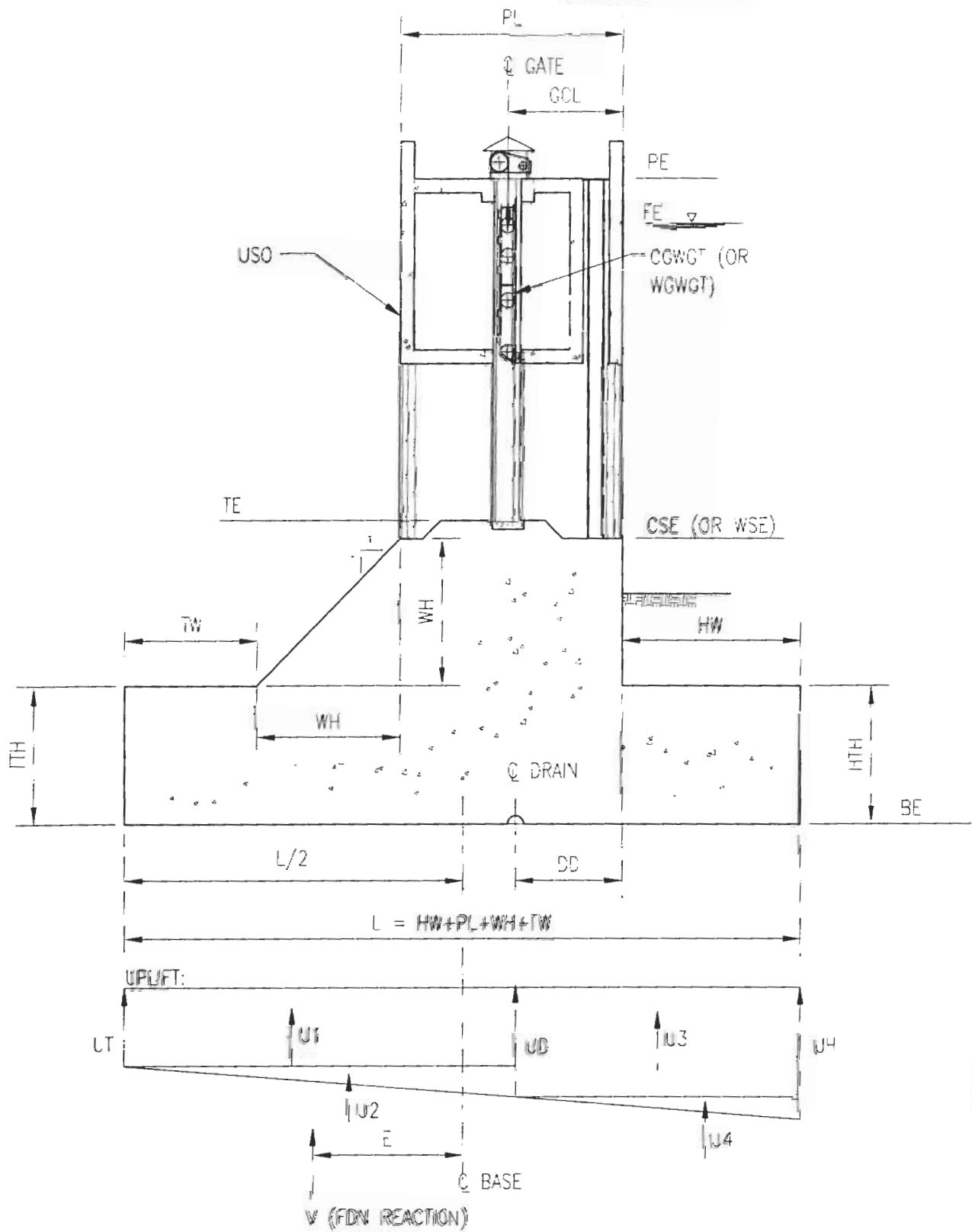
RESISTING
MOMENT:
=H13*J13
=H14*J14
=H15*J15
=H16*J16
=H17*J17
=H18*J18
=H19*J19
=H20*J20
=H21*J21
=H22*J22
=H23*J23
=H24*J24
=H25*J25
=H26*J26
=H27*J27
=-H28*J28
=-H29*J29
=H*J30
=SUM(K13:F31)
=SUM(L13:L31)

OVERTURNING
MOMENT:

```

$L \cdot (WEIGHT \cdot CONC + GATES + WATER - UPLIFT)$   
 COHESION \* BASE AREA  
 = DRIVING FORCES MINUS ACTIVE RESISTING FORCES  
 $= (FRICTION + COHESION) / (\text{NET SLIDING})$

**Gate Structure Stability Analysis (with Drains)**  
**Excel Spreadsheet with Cell Formulas Displayed**



TRANSVERSE SECTION (WITH DRAIN)

1/16"=1'-0"

SCALE: 1/16 " = 1'-0"

1' 0" 3' 16' 24'



FORT WORTH CENTRAL CITY  
PRELIMINARY DESIGN

CELL NAMES  
GATE STRUCTURE III

**CDM**

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: \_\_\_\_\_

DATE: \_\_\_\_\_

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

**GATE STRUCTURE:**

FLOOD ELEV (FE):	556.5	FT'
TAILWATER ELEV (TE):	520	FT
TOP OF PIER ELEV (PE):	557	FT
FDN BASE EL (BE):	48'	FT
PIER LENGTH (PL):	25	FT'
PIER THICKNESS (PT):	14.3333333333	FT'
NO. OF CONC PIERS (PN):	3	
UPSTREAM FACE TO GATE CTR LINE (GCL):	98	FT
		FT

**CHANNEL GATE:**

GATE WIDTH (CGW):	24	FT'
SILL ELEV (CSE):	518	FT
GATE WEIGHT (CGWGT):	150000	LBS

**WALKWAY GATE:**

GATE WIDTH (WGW):	12	FT
SILL ELEV (WSE):	530	FT
GATE WEIGHT (WGWT):	50000	LBS

ADDL HEEL WIDTH (HW): 16  
HEEL THICKNESS (HTH): 25  
ADDL TOE WIDTH (TW): 20  
TOE THICKNESS (TTH): 25

**DESIGN PARAMETERS (INPUT):**

FACTOR OF SAFETY (FS) : 1.3  
 ACTUAL SOIL FRICTION ANGLE (PHI) : 35  
 ACTUAL SOIL COHESION (CN) : 0  
 FLUID PRESS (EFP) : 62.5  
 CONC UNIT WGT (CUW) : 150  
 DRAIN EFFICIENCY (DE) : 0.33  
 DRAIN DIMENSION FROM HEADWALL (DD) : 10

DEGREES  
 PSF  
 PCP  
 PCF  
 FT

**RESULTING DESIGN VALUES & DIMENSIONS:**

DESIGN FRICTION ANGLE (PHD) : =DEGREES(ATAN(TAN(RADIANS(PHI)) / FS))  
 DESIGN COHESION (CND) : =CN/FS  
 UPLIFT AT NEEL (UH) : =(FE-BE)\*EFP  
 UPLIFT AT TOE (UT) : =(TE-BE)\*EFP  
 UPLIFT AT DRAIN (UD) : =UT\*(1-DE)\*( (L\_HN-ID) / L ) \* (UH-UT)  
 CONCRETE WEDGE HEIGHT & LGTH (WH) : =CSE-BE-TTH  
 EDN LENGTH (L) : =HN+PL+WH+TW  
 EDN WIDTH (B) : =CGW+WGW+PN\*PT  
 (WH = CSH-BE-TTH)  
 (L = HW + PL + WH + TW)  
 (B = CGW + WGW + PN\*PT)

DEGREES  
 PSF  
 PCP  
 PCF  
 FT

```

=A1
=A3
=A5
=A7

DATE: =C5
DATE: C/I

```

### STABILITY ANALYSIS: WEIGHT:

```

LATL FORCE: LB
CHANNEL GATE: =CGWGT
WALKWAY GATE: =WGWT
CONCRETE PIERS: =(PE-CSE)*PL*IN*PT*CUN
UPPER STRUCTURE: =USO*2*(CGW*WCW)*CUN
CHANNEL BLOCK FDN: =(CSE-BE)*PL*(CGW+PN*PI)*CUN
CHANNEL WEDGE FDN: =(WH*WH/2+TH*WI)*(CGW+PN*PT)*CUN
WALKWAY BLOCK FDN: =(WSE-BE)*(PL)*WGW*CUN
WALKWAY WEDGE FDN: =(WH*WH/2+TH*WH)*(WSR)*CUN
HEEL SLAB: =HW*B*HTH*CUN
TOE SLAB: =TW*B*TTH*CUN
FLUID ON HEEL: =HW*B*(FE-BE-TH)*EFP
FLUID ON CHANNEL SILL: =(GCL-L)*(19)*CGW*EFP
FLUID ON WALKWAY SILL: =(GCL-L)*(10)*WGW*EFP
FLUID ON D/S WEDGE: =WH*WH/2*B*EFP
FLUID ON TOE: =TW*B*(TE-BE-TH)*EFP
UPLIFT FORCE (U1): =UT*(L-HW-DD)*B
UPLIFT FORCE (U2): =0.5*(UD-UT)*(1-HW-DD)*B
UPLIFT FORCE (U3): =UD*(HW-DD)*B
UPLIFT FORCE (U4): =-0.5*(UH-DD)*(HW+DD)*B
FLUID HORIZ FORCE (H): RESISTING FLUID FORCE:
SUBTOTAL AT BASE (V,MR,MO) = SUM(H13:H33)

```

### STABILITY RESULTS:

```

FRICTION FORCE (V*TAN(PHTD)) = V*TAN(RADTANS(PHTD))
COHESION FORCE (CND*L*B) = CND*L*B
NET SLIDING FORCE = 135
SLIDING RATIO = (H39+H40)/H41
OVERTURNING RATIO (MR/MO) = MR/MO
ECCENTRICITY (E=L/2-(MR-MO)/V) = (L/2)-(MR-MO)/V
BEARING PRESSURE = V/L(1+6*E/L)
MAX BEARING PRESS = V/L*(1+6*H44/L)/B
MIN BEARING PRESS = V/L*(1-6*H44/L)/B
VOLUME OF CONCRETE = (SUM(H15:H22)/150)/27

```

LB  
LB  
LB  
>1.0?  
>1.0?  
(RELATIVE TO CI.)  
PSF  
PSF  
CY

## ARM TO TOE :

```

=L-HW-GCL
=L-HW-GCL
=L-HW-PL/2
=L-HW-PL/2
=L-HW-PL/2
=L-HW-PL/2
=TP(H18=0,"", (WH*WH/2 * (TW+WH*0.67) * TTH*WH * (TW*WH/2)) / (WH*WH/2 + TTH*WH))
=TP(H20=0,"", (WH*WH/2 * (TW+WH*0.67) * TTH*WH * (TW+WH/2)) / (WH*WH/2 + TTH*WH))
=TW/2
=L-HW/2
=L-RW/2
=L-HW-(GCL-3)/2
=L-HW-(GCL-1)/2
=TW*WH/3
=TW/2
=(L-HW-DD)/2
=2*(L-HW-DD)/3
=L-(HW-DD)/2
=2*(HW*DD)/3+(L-HW-DD)
=(FE-BE)/3
=(TE-BE)/3

```

RESISTING  
MOMENT :

```

=H13*J13
=H14*J14
=H15*J15
=H16*J16
=H17*J17
=H18*J18
=H19*J19
=H20*J20
=H21*J21
=H22*J22
=H23*J23
=H24*J24
=H25*J25
=H26*J26
=H27*J27
=H28*J28
=H29*J29
=-H30*J30
=-H31*J31
=R*J32
=-1.33*J33

```

SUM(K13:K33)

```

= U * (WEIGHT* CONC + GATES + WATER - UPLIFT)
= COHESION * BASE AREA
= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
≈ (FRICTION + COHESION) / (NET SLIDING)

```

SUM(L13:L33)

OVERTURNING  
MOMENT :

**Gate Structure Seismic Analysis**  
**Excel Spreadsheet with Cell Formulas Displayed**

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: \_\_\_\_\_

DATE: \_\_\_\_\_

GATE STRUCTURE STABILITY (W/ UPLIFT)  
NORMAL POOL ELEVATION WITH SEISMIC (EXTREME CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

**GATE STRUCTURE:**

FLOOD ELEV (FE):	525	FT
TAILWATER ELEV (TE):	520	FT
TOP OF PIER ELEV (PE):	557	FT
FDN BASE EL (BE):	506	FT
PIER LENGTH (PL):	25	FT
PIER THICKNESS (PT):	7.3333333333	FT
NO. OF CONC PIERS (PN):	3	
UPPER STRUCTURE OUTLINE (USO):	98	FT
UPSTREAM FACE TO GATE CTR LINE (GCL):	13	FT

**CHANNEL GATE:**

GATE WIDTH (CGW):	24	FT
STILL ELEV (CSE):	518	FT
GATE WEIGHT (CCGGWT):	15000	LBS

**WALKWAY GATE:**

GATE WIDTH (WG):	12	FT
STILL ELEV (WSE):	530	FT
GATE WEIGHT (WGWT):	5000	LBS

ADDL HEEL WIDTH (HW):	0	FT
HEEL THICKNESS (HTH):	0	FT
ADDL TOE WIDTH (TW):	17	FT
TOE THICKNESS (TTH):	6	FT

**DESIGN PARAMETERS (INPUT):**

ACTUAL, SOIL FRICTION ANGLE (PHI) :	35	DEGREES
ACTUAL SOIL COHESION (CND) :	0	PSF
FLUID PRESS (EFF) :	62.5	PCF
CONC UNIT WGT (CON) :	150	PCF
SEISMIC COEFFICIENT (A) :	0.05	G

**RESULTING DESIGN VALUES & DIMENSIONS:**

DESIGN FRICTION ANGLE (PHID) : = DEGREES ATAN (TAN (PHI) / FS)	DEGREES
DESIGN COHESION (CND) : = CN / FS	PSF
UPLIFT AT HEEL (UH) : = (FE - BE) * EFP	PSF
UPLIFT AT TOE (UT) : = (TE - BE) * EFP	PSF

CONCRETE WEIGHT & LENGTH (WH) : = CSB * BE - TWH	WT
FDN LENGTH (L) : = HW + PI * WH + TW	(WH = CSE BE - TWH) WT
FDN WIDTH (B) : = CEN + WGW + PN * PT	(L = HW + PL + WH + TW) WT (B = CGW + WGW + PN * PT)

**SEISMIC PARAMETERS:**

SEISMIC INERTIA DUE TO MASS = SIM (DL) \* A  
ASSUMED CENTROID OF MASS = 0.4 \* (FE - BE)  
SEISMIC FLUID FORCE (PER WESTERGAARD) = 0.67 \* 51 \* A \* (FE - BE) ^ 2  
FLUID FORCE RESULTANT ABOVE BASE 0.4 \* (FE - BE)  
OR 0.4 \* (TE - BE)

=A1  
=A3  
=A5  
=A7

DATE: =C5  
DATE: =C7

#### STABILITY ANALYSIS:

##### WEIGHT:

LB LATL FORCE:  
LB

```

CHANNEL GATE: =CGNGT
WALKWAY GATE: =WGNGT
CONCRETE PIERS: =(PE-CSE)*PL*PN*PT*CW
UPPER STRUCTURE: =USO*2*(CGW+WG)*CW
CHANNEL BLOCK FDN: =(CSE-BE)*PL*(CGW+PN*PT)*CW
CHANNEL WEDGE FDN: =(WH*WH/2+PTH*WH)*(CGW+PN*PT)*CW
WALKWAY BLOCK FDN: =(WSE-BE)*(PL)*(WG)*CW
WALKWAY WEDGE FDN: =(WH*WH/2+PTH*WH)*(WG)*CW
HEEL SLAB: =HW*B*TH*CW
TOE SLAB: =TW*B*TH*CW
FLUID ON HEEL: =HW*B*(FE-BE-HTH)*EFP
FLUID ON CHANNEL STL: =(GCL-1)*(1.9)*CGN*EFP
FLUID ON WALKWAY STL: =(GCL-1)*(1.0)*GN*EFP
FLUID ON D/S MEDGE: =WH*WH/2*B*EFP
FLUID ON TOE: =TW*B*(TE-BE-TTH)*EFP
UPLIFT FORCE (U1): =-UT*L*B
UPLIFT FORCE (U2): =-0.5*(UR-OT)*L*B
FLUID HORIZ FORCE (H): =B*(FE-BE)^2*EFP/2)
RESISTING FLUID FORCE: =SUM((H13:H120)*A
SEISMIC INERTIA FORCE: = 0.67*51*A*(FE-BE)^2
SEISMIC FLUID FORCE US: = 0.67*51*A*(TE-BE)^2
SEISMIC FLUID FORCE DS: =SUM(H13:H34)

SUBTOTAL AT BASE (V,MR,MO) = =SUM(H13:H34)


```

#### STABILITY RESULTS:

```

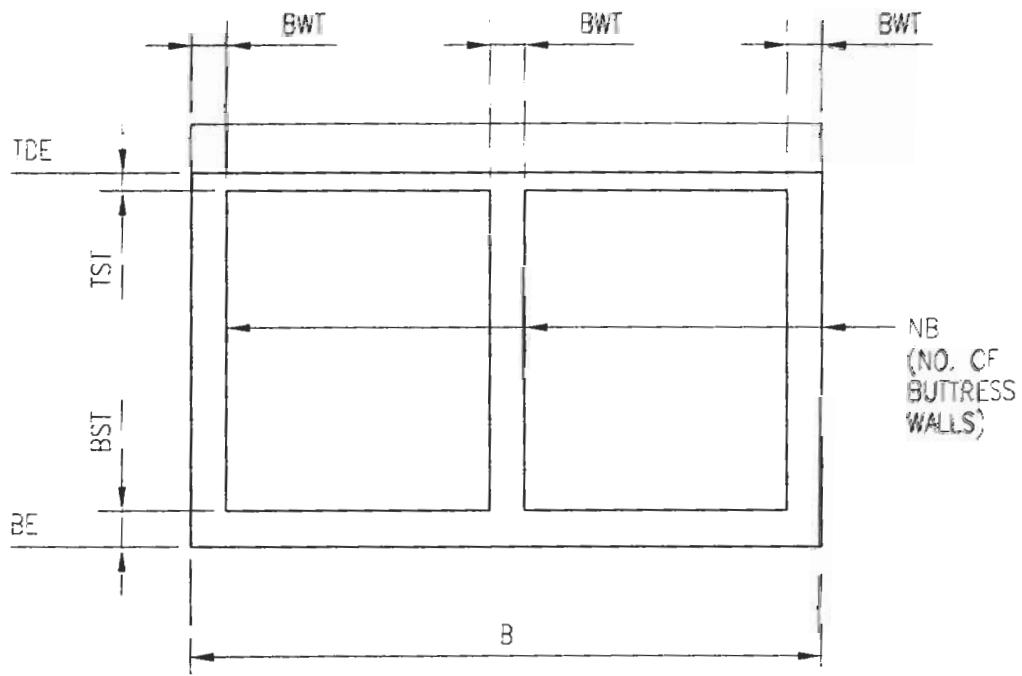
FRICTION FORCE (V*TAN(PHID)) = =V*TAN(RADIANS(PHID))
COHESION FORCE (CND*L*B) = =CND*L*B
NET SLIDING FORCE = 136
SLIDING RATIO = =(H40+H41)/H42 > 1.0?
OVERTURNING RATIO (MR/MO) = =MR/MO > 1.0?
ECCENTRICITY (E-L/2-(MR-MO)/V) = =(L/2) ((MR-MO)/V) (RELATIVE TO CL)
BEARING PRESSURE = V/L1,-6*E/L
MAX BEARING PRESS = =V/L*(1+6*H45/L)/B
MIN BEARING PRESS = =V/L*(1-6*H45/L)/B
VOLUME OF CONCRETE = =(SUM(H15:H22)/150)/27

```

ARM TO TOE:	RESISTING MOMENT:	OVERTURNING MOMENT:
$=L \cdot HW \cdot GCL$	$=H13 \cdot J13$	
$=L \cdot HW \cdot GCL$	$=H14 \cdot J14$	
$=L \cdot HW \cdot PL / 2$	$=H15 \cdot J15$	
$=L \cdot HW \cdot PL / 2$	$=H16 \cdot J16$	
$=L \cdot HW \cdot PL / 2$	$=H17 \cdot J17$	
$=TW \cdot WH / 2 \cdot (WH \cdot WH / 2 \cdot (TW + WH * 0.67) + TTH \cdot WH \cdot (TW + WH / 2)) / (WH \cdot WH / 2 + TW \cdot WH)$	$=H18 \cdot J18$	
$=TW \cdot WH / 2 \cdot (WH \cdot WH / 2 \cdot (TW + WH * 0.67) + TTH \cdot WH \cdot (TW + WH / 2)) / (WH \cdot WH / 2 + TW \cdot WH)$	$=H19 \cdot J19$	
$=TW \cdot WH / 2 \cdot (WH \cdot WH / 2 \cdot (TW + WH * 0.67) + TTH \cdot WH \cdot (TW + WH / 2)) / (WH \cdot WH / 2 + TW \cdot WH)$	$=H20 \cdot J20$	
$\geq LF(H20 - 0, **, (WH \cdot WH / 2 \cdot (TW + WH * 0.67) + TTH \cdot WH \cdot (TW + WH / 2)) / (WH \cdot WH / 2 + TW \cdot WH))$	$=H21 \cdot J21$	
$=L \cdot HW / 2$	$=H22 \cdot J22$	
$=TW / 2$	$=H23 \cdot J23$	
$=L \cdot HW / 2$	$=H24 \cdot J24$	
$=L \cdot HW - (GCL - 1) / 2$	$=H25 \cdot J25$	
$=L \cdot HW - (GCL - 1) / 2$	$=H26 \cdot J26$	
$=TW \cdot WH / 3$	$=H27 \cdot J27$	
$=TW / 2$	$=H28 \cdot J28$	
$=1 / 2$	$=H29 \cdot J29$	
$=2 ** / 3$	$=H * J30$	
$=(FE - BE) / 3$	$=I31 \cdot J31$	
$(PE - BE) / 3$	$=I32 \cdot J32$	
$=0.4 * (PE - BE)$	$=I33 \cdot J33$	
$=0.4 * (FE - BE)$	$=I34 \cdot J34$	
$=0.4 * (TE - BE)$		
	$=SUM(K13 : K34)$	$=SUM(L13 : L34)$

$\geq U * (\text{WEIGHT CONC} + \text{GATES} + \text{WATER} - \text{UPLIFT})$   
 $= \text{COHESION} * \text{BASE AREA}$   
 $= \text{DRIVING FORCE MINUS ACTIVE RESISTING FORCES}$   
 $(\text{FRICTION} + \text{COHESION}) / (\text{NET SLIDING})$

**Abutment Structure Stability Analysis**  
**Excel Spreadsheet with Cell Formulas Displayed**



## LONGITUDINAL SECTION

1/16"=1'-0"

SCALE: 1/16 " = 1'-0"  
10' 8' 16' 24'

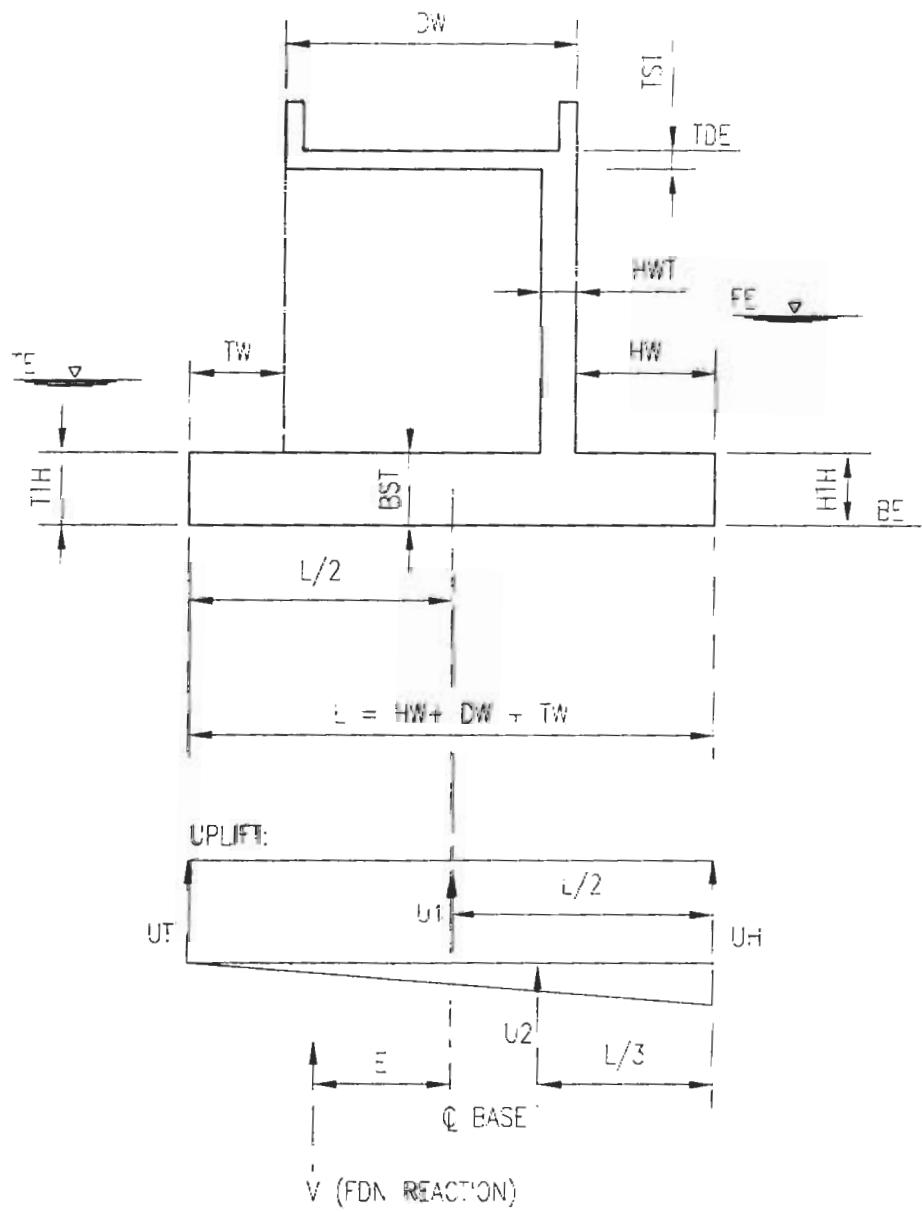


FORT WORTH CENTRAL CITY  
PRELIMINARY DESIGN

CELL NAMES  
ABUTMENT STRUCTURE I

**CDM**

DATE 12-21-04 FIGURE No. B-4



## TRANSVERSE SECTION

1/16"=1'-0"

SCALE: 1/16 "=1'-0"  
1'0" 8' 16' 24'



FORT WORTH CENTRAL CITY  
PRELIMINARY DESIGN

CELL NAMES  
ABUTMENT STRUCTURE II

**CDM**

DATE 12-21-04 FIGURE No. B-5

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: \_\_\_\_\_

DATE: \_\_\_\_\_

GATE ABUTMENT STRUCTURE STABILITY  
MAXIMUM WATER LEVEL TO TOP OF NAVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

**GATE ABUTMENT STRUCTURE:**

FLOOD ELEV (FE):	556.5	FT
TAILWATER ELEV (TE):	520	FT
TOP OF DECK ELEV (TDE):	557	FT
FDN BASE EL (BE):	526	FT
DECK WIDTH (DW):	2.5	FT
HEADWALL THICKNESS (HWT):	2	FT
BUTTRESS WALL THICKNESS (BWT):	3	FT
NO. OF BUTTRESS WALLS (NB):	4	
TOP SLAB THICKNESS (TST):	1.5	FT
BOTTOM SLAB THICKNESS (BST):	6	FT
STRUCTURE LENGTH (B):	80	FT

ADDL. HEEL WIDTH (HW):	12	FT
HEEL THICKNESS (HTH):	6	FT
ADDL. TOE WIDTH (TW):	10	FT
TOE THICKNESS (TTH):	6	FT

**DESIGN PARAMETERS (INPUT) :**

FACTOR OF SAFETY (FS) :	1.33	DEGREES
ACTUAL SOIL FRICTION ANGLE (PHI) :	28	PSF
ACTUAL SOIL COHESION (CN) :	0	PCF
FLUID PRESS (EFF) :	62.5	PCP
CONC UNIT WGT (CUW) :	150	PCF
CONTAINED SOIL WGT (CSW) :	110	

**RESULTING DESIGN VALUES & DIMENSIONS :**

DESIGN FRICTION ANGLE (PHID) :	=DEGREES(ATAN(TAN(RADIANS(PHI))/FS))	DEGREES
	( PHID = ARCTAN(TAN(PHI)/FS) )	
DESIGN COHESION (CND) :	=CN/FS	PSF
	( CND = CN / FS )	
UPLIFT AT HEEL (UH) :	=(FE-BE)*EFP	PSF
	( UH = (FE-BE) * EFP )	
UPLIFT AT TOE (UT) :	=IF((TE-BE)<0,0,(TE-BE)*EFP)	PSF
	( UT = (TE-BE) * EFP )	

FDN LENGTH (L) : =HW+DW+TW

(L = HW + DW + TW)

FT

=A1  
=A3  
=A5  
=A7

DATE: =C5  
DATE: =C7

#### STABILITY ANALYSIS:

WEIGHT:  
LB

```

HEADWALL: =(TDE-TST-BE-BST)*HWT*(B-BWT*NE)*CUN
BUTTRESS WALLS (1): =(TDE-TST-BE-BST)*BWT*NE*DWT*CUN
BUTTRESS WALLS (2): = 0.5 * (TDE-TST-2-BE-BST)*BWT*NB*TWT*CUN
TOP SLAB: =TST*B*DWT*CUN
BOTTOM SLAB: =BST*B*DWT*CUN
HEEL SLAB: =HW*HTH*B*CUN
TOE SLAB: =TW*TTH*B*CUN
FLUID ON HEEL: =HW*B*(FE-BB-HTH)*EFP
FLUID ON TOE: =IF(BE>TE, 0, TW*B*(TE-BE-TTH)*EFP)
UPLIFT FORCE (U1): =-UT*L*B
UPLIFT FORCE (U2): = -0.5 * (UH*UT) * L^13
FLUID HORIZ FORCE (H):  

RESISTING FLUID FORCE:  

SUBTOTAL AT BASE (V, MR, MO) = =SUM(H113:H26)

```

#### STABILITY RESULTS:

```

FRIC'UTON FORCE (V*TAN(PHID)) = V*TAN(RAD)ANS (PHID) )
COHESION FORCE (CND*L*B) = CND*L*B
NET SLIDING FORCE = I28
SLIDING RATIO = =(H34:H35)/H36
OVERTURNING RATIO (MR/MO) = =MR/MO
ECCENTRICITY (E=L/2-(MR-MO)/V) = =(L/2) ((MR MO)/V)
BEARING PRESSURE = V/I,(1+6*E/L)
MAX BEARING PRESS = =V/L*(1+6*E/L)/B
MIN BEARING PRESS = =V/L*(1-6*E/L)/B
VOLUME OF CONCRETE =SUM(H14:H20)/150/27

```

ARM TO TOE:	$=DW*TW-HWT/2$ $=DW/2*TW$ $=0.667*TW$ $=DW/2-TW$ $=DW/2+TW$ $=DW+TW+HW/2$ $=TW/2$ $=DW+TW+HW/2$ $=TW/2$ $=L/2$ $=2*L/3$ $=(FE-BE)/3$ $=(TE-BE)/3$	RESISTING MOMENT:	$=H14*J14$ $=H15*J15$ $=H16*J16$ $=H17*J17$ $=H18*J18$ $=H19*J19$ $=H20*J20$ $=H21*J21$ $=H22*J22$ $=-H23*J23$ $=-H24*J24$ $=H*J25$	OVERTURNING MOMENT:	$=SUM(K13:K26)$ $=SUM(L13:L26)$
-------------	---	----------------------	--	------------------------	------------------------------------

$= U * (\text{WEIGHT CONC} + \text{GATES} + \text{WATER} - \text{UPLIFT})$   
 $= \text{COHESION} * \text{BASE AREA}$   
 $= \text{DRIVING FORCES MINUS ACTIVE RESISTING FORCES}$   
 $= (\text{FRICTION} + \text{COHESION}) / (\text{NET SLIDING})$

# **Section 13**

## **Design of H-Piles (Manual Calculations)**

CLIENT TRWD JOB NO. 42275 COMPUTED BY BDA  
PROJECT GATE STR DATE 11-15-04  
DETAIL PILE CAPACITY CHECKED BY HCK

PAGE NO.

## STEEL PILE CAPACITY

ASSUME:

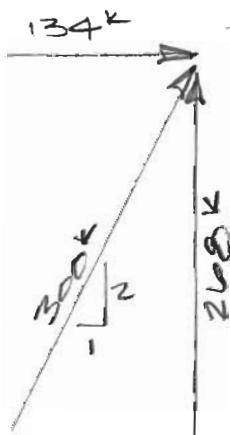
HP 14 x 102

MAX STRESS = 10.0 ksi

AREA = 30 in<sup>2</sup>

$$\therefore P_{max} = 30 \text{ in}^2 (10.0 \text{ ksi}) = 300 \text{ k}$$

FOR A 2:1 BATTER



CLIENT	TRWD	JOB NO.	42275	COMPUTED BY	BDA
PROJECT	GATE STR	DATE CHECKED	11-19-04	DATE	11-15-04
DETAIL	TRWD	CHECKED BY	NW	PAGE NO.	

Rev. 12-21-04

STEEL PILE LAYOUT

ASSUME:

HP14 x 102 PILES

FIND BATTER ANGLE

FROM MAX LOAD CONDITIONS - TRWD GATE

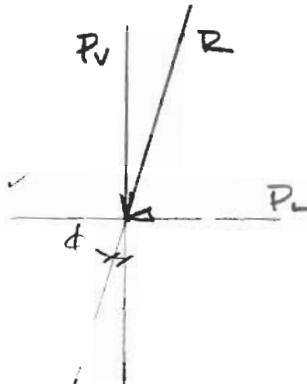
$$P_v = 7146 \text{ k}$$

$$P_u = 3132 \text{ k}$$

$$\tan \phi = \frac{3132 \text{ k}}{7146 \text{ k}} = 0.438$$

$$1/0.438 = 2.3$$

USE 1H : 2.5 V



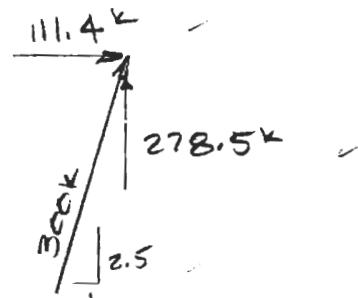
HP14 x 102

CAPACITY

MAX STRESS = 10 ksi

$$A = 30 \text{ in}^2$$

$$P_{max} = 300 \text{ k}$$



CLIENT: TRWD  
PROJECT: GATE STR  
DETAIL: TRWD

JOB NO. 42275  
DATE CHECKED 11-19-04  
CHECKED BY MCK

COMPUTED BY BDA  
DATE 11-15-04  
PAGE NO.

Rev. 12-21-04

### STEEL PILE LAYOUT

NUMBER OF PILES REQ'D

BATTERED

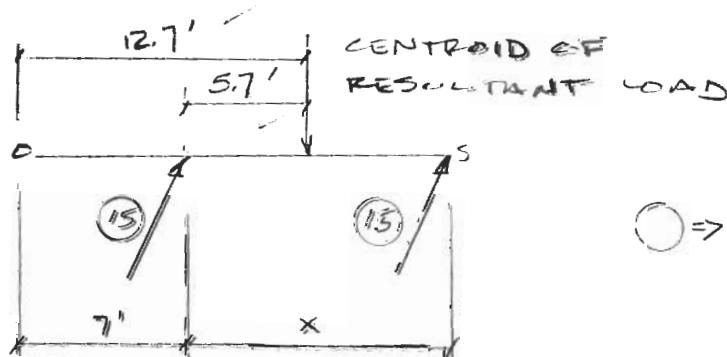
$$\frac{3132 \text{ k}}{111.4 \text{ k/PILE}} = 28.1 \text{ PILES}$$

$$\frac{7146 \text{ k}}{278.5 \text{ k/PILE}} = 25.7 \text{ PILES}$$

SAY USE 30 PILES -

### PILE LOCATION

MAX LOAD CONDITION  $L = 35' - 0'' \quad \ell = 4.84'$   
(TRWD GATE)



$$15(5.7) = 15(x + 7 - 12.7)$$

$$85.5 = 15x + 105 - 190.5$$

$$x = 11.4'$$

CLIENT TRWD  
 PROJECT GATE STR  
 DETAIL TRWD

JOB NO. 42275  
 DATE CHECKED 11-19-04  
 CHECKED BY WCR

COMPUTED BY BDA  
 DATE 11-15-04  
 PAGE NO.

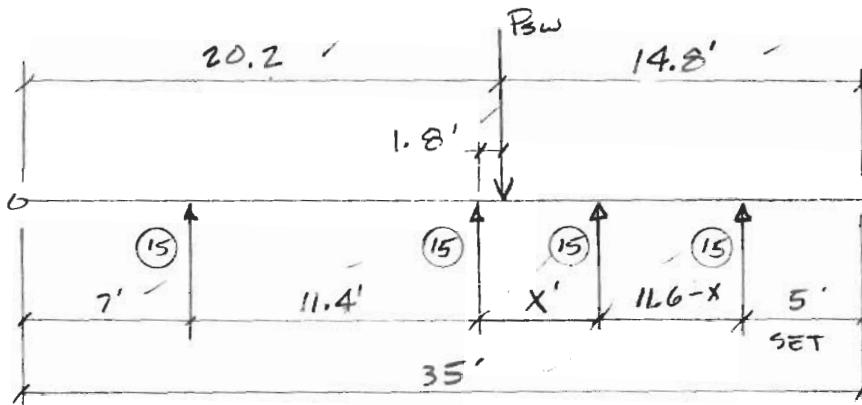
Rev. 12-21-04

### STEEL PILE LAYOUT

#### PILE LOCATION

LOW WATER - MAXIMUM SELF WT.

$$P_{sw} = 11,100 \text{ K} \quad e = 2.73'$$



ABOUT  $P_{sw}$

$$15(13.2') + 15(1.8') = 15(x - 1.8') + 15(9.8')$$

$$198 + 27.0 = 15x - 27.0 + 147$$

$$x = 7.0$$

4-ROWS OF 15 PILES EACH

$$\frac{58'}{15} = 3.87' \text{ SAY } 3\frac{1}{8}'' \text{ SPACING}$$

$$4 \times 15 \times 278.5'' = 16,710'' > 11,100'' \text{ OK}$$

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDF

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:			FACTOR OF SAFETY (FS):	1.33
FLOOD ELEV (FE):	496 FT		ACTUAL SOIL FRICTION ANGLE (PHI):	35 DEGREES
TAILWATER ELEV (TE):	496 FT		ACTUAL SOIL COHESION (CN):	0 PSF
TOP OF PIER ELEV (PE):	557 FT		FLUID PRESS (FPP):	0 PCF
FDN BASE EL (BE):	496 FT		CONC UNIT WGT (CUN):	15.0 PCF
PIER LENGTH (PL):	25 FT			
PIER THICKNESS (PT):	7.33 FT			
NO. OF CONC PIERS (PN):	3			
UPPER STRUCTURE OUTLINE (USO):	98 FT			
TREMAP FACE TO GATE CTR LINE (GCL):	13 FT			

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:		DESIGN FRICTION ANGLE (PHD):	27.77 DEGREES
GATE WIDTH (CGW):	24 FT	DESIGN COHESION (CND):	0 PSF
SILL ELEV (CSE):	518 FT		
GATE WEIGHT (CGWGT):	15,000 LBS		

WALKWAY GATE:		CONCRETE WEDGE HEIGHT & LGTH (WH):	10 FT
GATE WIDTH (WGW):	12 FT	(WH = CSF-BE * TH)	
SILL ELEV (WSE):	530 FT	FDN LENGTH (L):	3.5 FT
GATE WEIGHT (WGWT):	5,000 LBS	(L = HW + PL + WH + TW)	
ADDL HEEL WIDTH (HW):	0 FT	FDN WIDTH (B):	5.8 FT
HEEL THICKNESS (HTH):	0 FT	(B = CGW + WSW + LN * PT)	
ADDL TOE WIDTH (TW):	0 FT		
TOE THICKNESS (TTW):	12 FT		

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO. : 2521-42275-PRSTR, DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: TBOA —

DATE: 12/20/04

**STABILITY ANALYSIS:**

	WEIGHT: LB	LNL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB	OVERTURNING MOMENT: LB
CHANNEL GATE:	15,000		22.00	330,000	
WALKWAY GATE:	5,000		22.00	110,000	
CONCRETE PIERS:	3,217,500		22.50	72,393,750	
UPPER STRUCTURE:	1,058,400		22.50	23,814,000	
CHANNEL BLOCK FDN:	3,795,000		22.50	85,387,500	
CHANNEL WEDGE FDN:	1,173,000		5.50	6,451,500	
WALKWAY BLOCK FDN:	1,530,000		22.50	34,425,000	
WALKWAY WEDGE FDN:	306,000		5.50	1,683,000	
HEEL SLAB:	0		35.00	0	
TOE SLAB:	0		0.00	0	
SUBTOTAL AT BASE (V, MR, MO) =	11,099,900	0	0	224,594,750	0

**STABILITY RESULTS:**

$$\begin{aligned} \text{ECCENTRICITY } (E=L/2-(MR-MO)/V) &= -2.73 \text{ (RELATIVE TO CL)} \\ \text{BEARING PRESSURE } &= V/I, (1+6*F/L) \\ \text{MAX BEARING PRESS } &= 2905 \text{ PSF} \\ \text{MIN BEARING PRESS } &= 8031 \text{ PSF} \\ \text{VOLUME OF CONCRETE } &= 2,736 \text{ CY} \end{aligned}$$

CLIENT TRWD  
 PROJECT GATE STR  
 DETAIL TRINITY POINT

JOB NO. 42275  
 DATE CHECKED 11-19-04  
 CHECKED BY HG

COMPUTED BY BDA  
 DATE 11-15-04  
 PAGE NO. \_\_\_\_\_

*Rev. 12-21-04*

### STEEL PILE LAYOUT

ASSUME:

HP 14 x 102 PILES

FIND BATTERED ANGLE

FROM MAX LOAD CONDITIONS - TRINITY PT. GATE

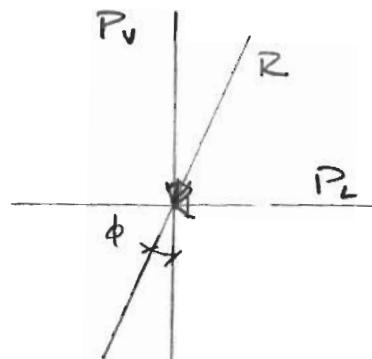
$$P_v = 7223 \text{ k}$$

$$P_L = 3798 \text{ k}$$

$$\tan \phi = \frac{3798 \text{ k}}{7223 \text{ k}} = 0.524$$

$$1/0.524 = 1.90$$

use 1H:2V



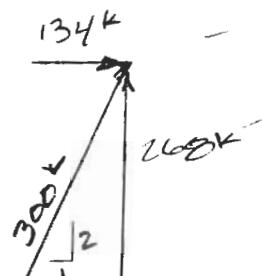
HP 14 x 102

CAPACITY

MAX STRESS = 10 ksi

$$A = 30 \text{ in}^2$$

$$P_{max} = 300 \text{ k}$$



CLIENT	TRWUD	JOB NO.	42275	COMPUTED BY	BDA
PROJECT	GATE STR	DATE CHECKED	11-19-04	DATE	11-15-04
DETAIL	TRINITY POINT	CHECKED BY	JLG	PAGE NO.	

Rev. 12-21-04

STEEL PILE LAYOUT

NUMBER OF PILES REQ'D  
BATTERED

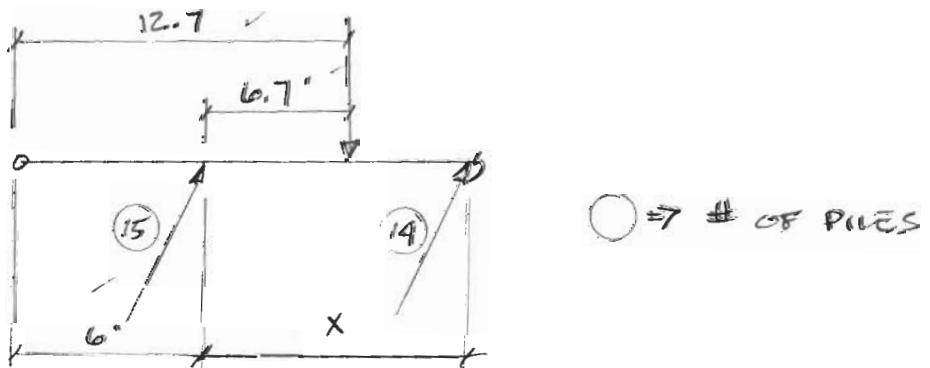
$$\frac{3798 \text{ k}}{134 \text{ k/pile}} = 29 \text{ PILES}$$

$$\frac{7223 \text{ k}}{268 \text{ k/pile}} = 27 \text{ PILES}$$

∴ USE 29 PILES  
(USE 30)

## PILE LOCATION

MAX LOAD CONDITION  $L = 37' - 0''$   $e = 5.77''$



$$15(6.7') = 14(x + 6' - 12.7')$$

$$100.5' = 14x + 84' - 177.8$$

$$x = 13.9' \checkmark$$

SAY 14.0'

**CDM**CLIENT TRWD  
PROJECT GATE STR  
DETAIL TRINITY POINTJOB NO. 42275  
DATE CHECKED 11-19-04  
CHECKED BY WVCOMPUTED BY BDA  
DATE 11-15-04  
PAGE NO. 1

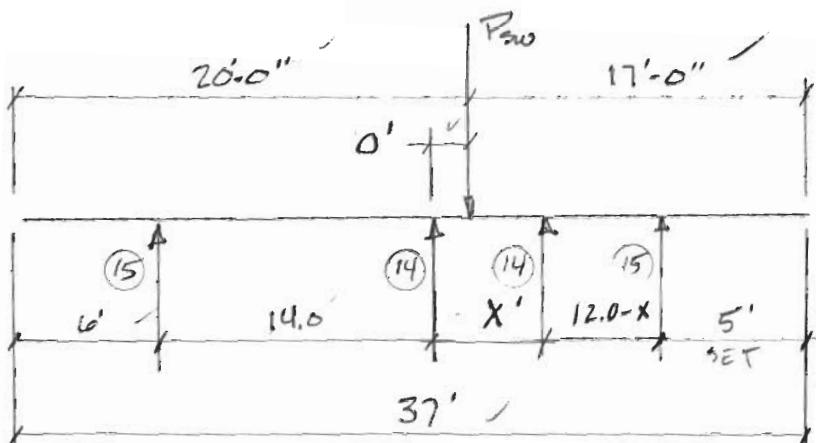
Rev. 12-21-04

STEEL PILE LAYOUT

## PILE LOCATION

LOW WATER - MAXIMUM SELF WT.

$$P_{sw} = 10,544.2^k \quad e = 1.45'$$

ABOUT  $P_{sw}$ 

$$15(14.0') + 14(8') = 14(X + 0') + 15(12')$$

$$210' = 14X + 180'$$

$$X = 2.1' \checkmark$$

USE MIN SPA = 3.5'

$$80 X = 3.5'$$

SAY USE 30 PILES:

4 ROWS OF 15 EACH

$$\frac{80'}{15} = 5.33' \quad \text{SAY } 5'-3" \text{ OC}$$

$$4 \times 15 \times 268^k = 16,080.^k > 10,544.^k \text{ OK}$$

PROJECT #: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO. : 2521-42275-PRSTR, DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: TBDY

DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:  
FLOOD ELEV (PE) : 549.5 FT  
TALLWATER ELEV (TE) : 520 FT  
TOP OF PIER ELEV (PE) : 557 FT  
FDN BASE EL (BE) : 509 FT  
PIER LENGTH (PL) : 25 FT  
PIER THICKNESS (PT) : 8 FT  
NO. OF CONC PIERS (PN) : 4  
UPPER STRUCTURE OUTLINE (USO) : 98 FT  
UPSTREAM FACE TO GATE CTR LINE (GCL) : 13 FT

**DESIGN PARAMETERS (INPUT):**

GATE STRUCTURE:  
ACTUAL SOIL, FRICTION ANGLE (PHI) : 1.33 DEGREES  
ACTUAL SOIL COHESION (CN) : 35 PSF  
FLUID PRESS (EFF) : 0 PCF  
CONC UNIT WGT (COW) : 150 PCF

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:  
GATE WIDTH (CGW) : 24 FT  
STILL ELEV (CSE) : 518 FT  
GATE WEIGHT (CGWGT) : 11,000 LBS

WALKWAY GATES:  
GATE WIDTH - 2 GATES (WGW) : 24 FT  
SILL ELEV (WSE) : 530 FT  
GATE WEIGHT = 2 GATES (WGWT) : 10,000 LBS

CONCRETE WEDGE HEIGHT & LGHT (WH) : 6 FT  
(WH = CSE-BE TTII)  
FDN LENGTH (L) : 37 FT  
(L = HW + PL + WH + TW)  
FDN WIDTH (B) : 80 FT  
(B = CGW + WGW + PN\* PT)

ADDL TEEL WIDTH (HW) : 4 FT  
HEFL THICKNESS (HTH) : 3 FT  
ADDL TOE WIDTH (TW) : 2 FT  
TOP THICKNESS (TTI) : 3 FT

PROJECT: TWWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR, DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: IBD4 DATE: 12/20/04

**STABILITY ANALYSIS:**

	WEIGHT: LB	LAWL FORCH: LB	ARM TO TOE:	RESISTING MOMENT: LB
CHANNEL GATE:	15,000		20.00	300,000
WALKWAY GATE:	10,000		20.00	200,000
CONCRETE PLEERS:	4,680,000		20.50	95,940,000
UPPER STRUCTURE:	1,411,200		20.50	28,929,600
CHANNEL BLOCK FDN:	1,890,000		20.50	38,745,000
CHANNEL WEDGE FDN:	302,400		5.51	1,666,224
WALKWAY BLOCK FDN:	1,890,000		20.50	38,745,000
WALKWAY WEDGE FDN:	129,600		5.51	714,096
HEEL SLAB:	144,000		35.00	5,040,000
TOE SLAB:	72,000		1.00	72,000
SUHTOTAL AT BASE (V,MR,MO) :	10,544,200	0	210,351,920	0

**STABILITY RESULTS:**

ECCENTRICITY ( $E=L/2-(MR-MO)/V$ ) : 1.41, (RELATIVE TO CL)  
BEARING PRESSURE =  $V/l_c(1+6*E/l_c)$   
MAX BEARING PRESS = 2725 PSF  
MIN BEARING PRESS = 4400 PSF  
VOLUME OF CONCRETE = 2,597 CY

CLIENT TRW D  
 PROJECT GATE STR  
 DETAIL CLEAR FORK

JOB NO. 42275  
 DATE CHECKED 11-15-04  
 CHECKED BY HJH

COMPUTED BY BDA  
 DATE 11-15-04  
 PAGE NO.

Rev. 12-21-04

### STEEL PILE LAYOUT

ASSUME:

HP 14 x 102

FIND BATTER ANGLE

FROM MAX LOAD CONDITIONS - CLEAR FICK GATE

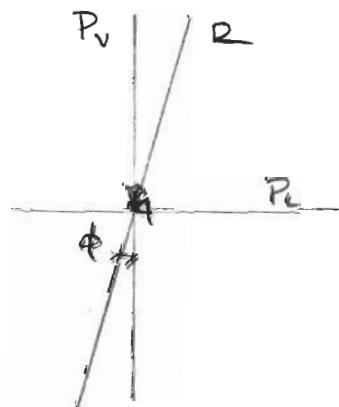
$$P_v = 4182 \text{ k}$$

$$P_e = 4267 \text{ k}$$

$$\tan \phi = \frac{4267 \text{ k}}{4182 \text{ k}} = 1.02$$

$$1/1.02 = 0.98$$

USE 1H:2V



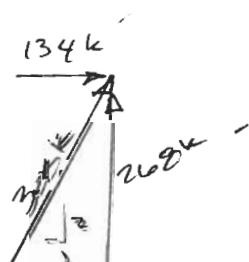
HP 14 x 102

CAPACITY

MAX STRESS = 10 ksi

$$A = 30 \text{ in}^2$$

$$P_{max} = 300 \text{ k}$$



NO. OF PILES

$$4182 \text{ k} / 268 \text{ k/pile} = 16 \text{ piles}$$

$$4267 \text{ k} / 134 \text{ k/pile} = 32 \text{ piles}$$

→ USE  
32 PILES

CLIENT TRWD  
 PROJECT GATE STR  
 DETAIL CLEAR FORK

JOB NO. 42275  
 DATE CHECKED 11-19-04  
 CHECKED BY HBR

COMPUTED BY BDA  
 DATE 11-16-04  
 PAGE NO. 1

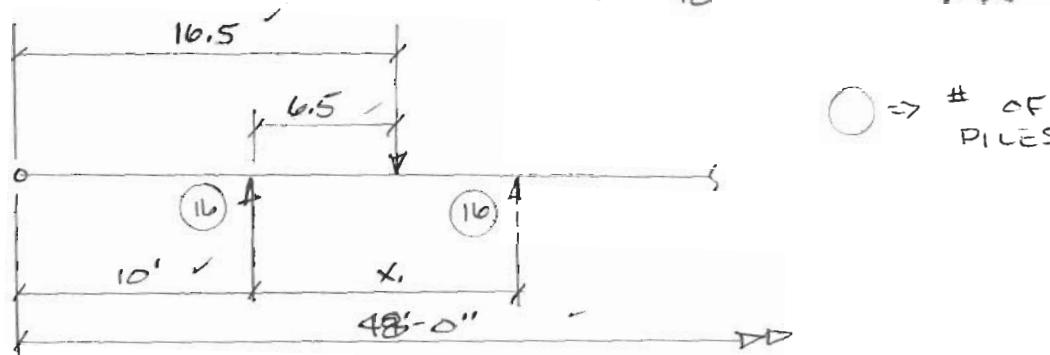
Rev. 12-21-04

### STEEL PILE LAYOUT

MAX NO DRAIN PILE CASE

MAX LOAD CONDITION

$$L = 48'-0'' \quad e = 7.56' \quad$$



$$16(6.5') = 16(x_1 + 10 - 16.5')$$

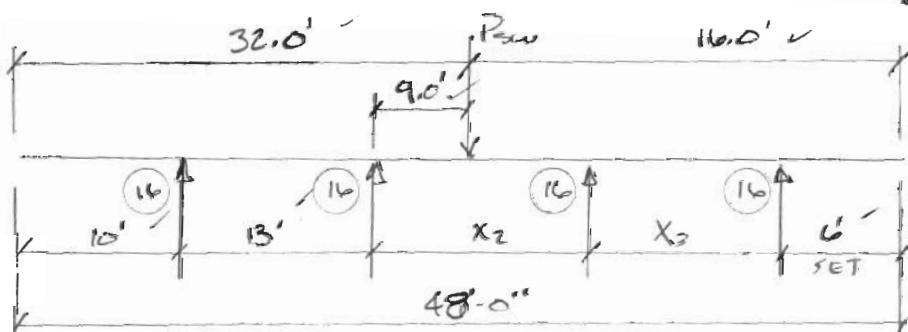
$$104 = 16x_1 + 160 - 264$$

$$x_1 = 13.0'$$

### PILE LOCATION

LOW WATER - MAXIMUM SELF WT. CASE

$$P_{sw} = 8803 \text{ KIPS} \quad e = 7.97'$$



$$16(22.0') + 16(9.0') = 16(x_2 - 9.0') + 16(10.0')$$

$$352 + 144 = 16x_2 - 144 + 160$$

$$x_2 = 30.0'$$

IF  $x_2 = 30'$  THEN THE TOTAL SUM OF LENGTH  
 BETWEEN PILES IS GREATER THAN  $\underline{\underline{48 \text{ in}}}$  ✓

STEEL PILE LAYOUT

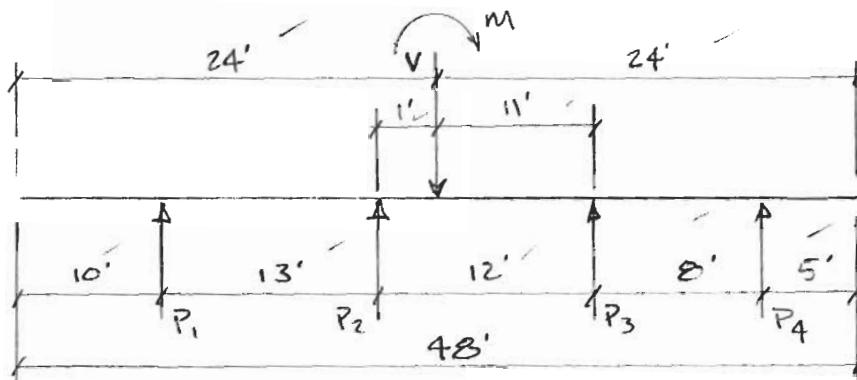
## SELF WEIGHT CONDITION

$$\text{TOTAL WEIGHT} = 8803.1 \text{ k}$$

ECCENTRICITY = 7.97F REL TO C OF STRUCT.

$\therefore$  MOMENT ON PILE GROUP

$$M_p = 8803.1 \text{ k} (7.97F) = 70,161 \text{ F-k}$$



## MOMENT EFFECTS AT PILES

$$P_1 = \frac{70,161 \text{ F-k} (14')}{(14')^2 + (1.0')^2 + (11')^2 + (19')^2} = 1447 \text{ k}$$

$$P_2 = \frac{70,161 \text{ F-k} (1.0')}{(14')^2 + (1')^2 + (11')^2 + (19')^2} = 103 \text{ k}$$

$$P_3 = \frac{70,161 \text{ F-k} (11')}{(14')^2 + (1')^2 + (11')^2 + (19')^2} = 1137 \text{ k}$$

$$P_4 = \frac{70,161 \text{ F-k} (19')}{(14')^2 + (1')^2 + (11')^2 + (19')^2} = 1963 \text{ k}$$

## MAXIMUM CASE

$$P_4 \Rightarrow 1963 \text{ k} / 16 \text{ PILES/ROW} = 122.7 \text{ k/PILE}$$

$$P_{\text{tot}/N} = 8803 \text{ k} / 16 (4) = 137.5 \text{ k/PILE}$$

$$\text{MAX LOAD ON PILE} = 122.7 \text{ k} + 137.5 \text{ k} = 260.2 \text{ k/PILE}$$

260 k < 268 k CAPACITY  $\therefore$  OK

4 ROWS OF 16 PILES EACH =  $\frac{58}{16} = 3.63$  SAY 3'-6" SPACING

PROJECT: TKWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHECKED BY: RBH DATE: 12/20/04

GATE STRUCTURE STABILITY (W/ UPLIFT)  
MAXIMUM WATER LEVEL TO TOP OF LEVEE (UNUSUAL CONDITION)

**DIMENSIONS & WEIGHTS (INPUT):**

GATE STRUCTURE:			FACTOR OF SAFETY (FS) :	1.33
FLOOD ELEV (FE):	506 FT		ACTUAL SOIL, FRICTION ANGLE (PHI) :	35 DEGREES
TAILWATER ELEV (TE):	506 FT		ACTUAL SOIL COHESION (CN) :	0 PSF
TOP OF PIER ELEV (PE):	557 FT		FLUID PRESS (EFP) :	0 PCF
FDN BASE EL (BE):	506 FT		CONC UNIT WGT (CUW) :	150 PCF
PIER LENGTH (PL):	25 FT			
PIER THICKNESS (PT):	7.33 FT			
NO. OF CONC PIERS (PN):	3			
UPPER STRUCTURE OUTLINE (USO):	98 FT			
TREMAP FACE TO GATE CTR LINE (GCL):	13 FT			

**RESULTING DESIGN VALUES & DIMENSIONS:**

CHANNEL GATE:		DESIGN FRICTION ANGLE (PH1) :	27.77 DEGREES
GATE WIDTH (CGW):	24 FT	DESIGN COHESION (CND) :	0 PSF
SILL ELEV (CSE):	518 FT		
GATE WEIGHT (CGWGT):	15,000 LBS		

WALKWAY GATE:		CONCRETE WEDGE HEIGHT & LGTH (WH) :	6 FT
GATE WIDTH (WGW):	12 FT	(WH = CSE-BE-TTH)	
SILL ELEV (WSE):	530 FT	FDN LENGTH (L) :	48 FT
GATE WEIGHT (WGWT):	5,000 LBS	(L = HW + FL + WH + TW)	
ADDL HEEL WIDTH (HW):	0 FT	FDN WIDTH (B) :	58 FT
HEEL THICKNESS (HTH):	0 FT	(B = CGW + WGW + PN*PT)	
ADDL TOE WIDTH (TW):	17 FT		
TOE THICKNESS (TTH):	6 FT		

PROJECT: TRWD - FLOOD GATE CONTROL, STRUCTURE

CHARGE NO.: 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BDH

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: IN	RESISTING MOMENT: IN-LB	OVERTURNING MOMENT: IN-LB
CHANNEL GATE:	15,000	35.00		525,000	
WALKWAY GATE:	5,000	35.00		175,000	
CONCRETE PIERS:	3,217,500	35.50		114,221,250	
UPPER STRUCTURE:	1,058,400	35.50		37,573,200	
CHANNEL BLOCK FDN:	2,070,000	35.50		73,485,000	
CHANNEL WEDGE FDN:	372,600	20.34		7,578,684	
WALKWAY BLOCK FDN:	1,080,000	35.50		38,340,000	
WALKWAY WEDGE FDN:	97,200	20.34		1,977,048	
HEEL SLAB:	0	48.00		0	
TOE SLAB:	887,400	8.50		7,542,900	
SUBTOTAL AT BASE (V,MR,MO) =	8,803,100	0		281,418,082	0

#### STABILITY RESULTS:

ECCENTRICITY ( $E=L/2 - (MR \cdot MO)/V$ ) =  $-7.9'$  (RELATIVE TO CL)  
BEARING PRESSURE =  $V/L(1+-6*E/L)$   
MAX BEARING PRESS = 13 PSF  
MIN BEARING PRESS = 6311 PSF  
VOLUME OF CONCRETE = 2,169 CY

be necessary. If the resultant load does not coincide with the center of gravity of the area of the footing, the computation of the soil pressures becomes a problem involving bending on an unsymmetrical section. Theoretically, eq. 20.7 is not applicable even though the entire base may be in compression. However, unless the footing is greatly unsymmetrical, the errors involved in using eq. 20.7 are tolerable for design. The subject of bending on unsymmetrical sections has received adequate treatment elsewhere.

### 20.7. Moment on Pile Footings

The reactions exerted by piles beneath a footing subject to moment are calculated in a manner similar to that described in the preceding articles concerning the pressure under soil-supported footings. Pile caps, such as those shown in Fig. 20.5 and Fig. 20.6, are commonly

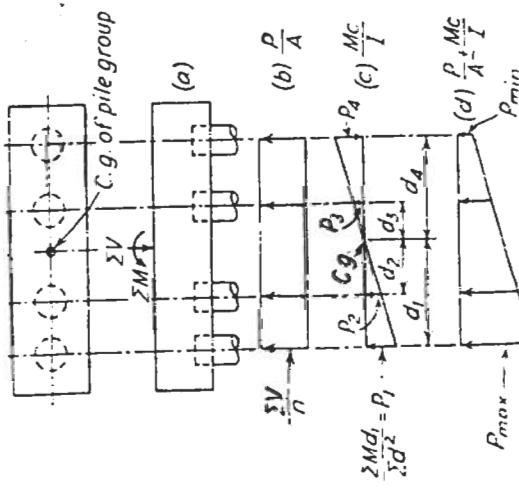


Fig. 20.5. Computation of pile reaction.

assumed to act as rigid structures. A planar distribution of the vertical settlement of the piles follows as a result of this assumption. Finally, if the ratio of reaction to settlement is assumed to be constant, the loads in the piles vary in the same planar fashion. Neither the assumption of the rigid cap nor the supposition that reaction is directly proportional to settlement is strictly valid, but each is generally considered sufficiently accurate for the purposes of design. The analysis of a moment-resistant group of piles is illustrated in

*Foundation Engineering by Peck, Hanson, and Thornburn*

Fig. 20.5. If there were no moment and  $\Sigma V$  acted through the center of gravity of the four piles, the loads in the piles would be as shown in *b*. On the other hand, if there were no resultant vertical force and only  $\Sigma M$  acted on the group of piles, the loads would be as shown in *c*.

The loads shown in *d* represent the total reaction and are the sums of those in *b* and *c*. The same loads would have been produced by  $\Sigma V$  acting eccentrically at a distance *e* to the left of the center of gravity.

From statics, it is evident that the resisting moment of the reactions furnished by the piles, Fig. 20.5*c*, must equal the applied moment,  $\Sigma M$ . The following equation expresses this relationship if resisting moments at the junctions of the piles and the cap either do not exist or are disregarded.

$$\Sigma M = P_1 d_1 + P_2 d_2 + P_3 d_3 + P_4 d_4 \quad 20.8a$$

If the variation in pile reactions shown in *c* is assumed to be linear, then

$$P_1/d_1 = P_2/d_2 = P_3/d_3 = P_4/d_4 \quad 20.8b$$

or

$$P_2 = P_1 d_2/d_1; \quad P_3 = P_1 d_3/d_1; \quad P_4 = P_1 d_4/d_1$$

Substituting these values of  $P_2$ ,  $P_3$ , and  $P_4$  in eq. 20.8a, we have

$$\Sigma M = P_1 d_1^2/d_1 + P_1 d_2^2/d_1 + P_1 d_3^2/d_1 + P_1 d_4^2/d_1, \quad 20.8b$$

Solving for  $P_1$ ,

$$P_1 = \frac{\Sigma M d_1}{d_1^2 + d_2^2 + d_3^2 + d_4^2} = \frac{\Sigma M d_1}{\Sigma d^2} \quad 20.9$$

Similarly, the part of the load on any other pile due to moment may be computed by means of eq. 20.9 if  $d_1$  is replaced by the distance from the pile to the center of gravity of the group.

The total reaction on any pile, found by adding the load shown in Fig. 20.5*c* to that in *b*, may be expressed in the form of eq. 20.10.

$$P = \frac{\Sigma V}{n} \pm \frac{\Sigma M d}{\Sigma d^2} \quad 20.10$$

where  $P$  = total pile reaction resulting from moment and direct load

$\Sigma V$  = sum of vertical loads acting on the foundation

$\Sigma M$  = sum of moments about the center of gravity of the group.  $\Sigma M$  is sometimes expressed as  $\Sigma V e$ .

$n$  = number of piles in the group

$d$  = distance from the center of gravity of the group to pile in question  
 $\Sigma d^2$  = sum of the squares of the distances to each pile from the center of gravity of the group

Inspection of eq. 20.10 reveals that it is no more than a special form of the basic formula for stress on a section or for pressure beneath a soil-supported footing when either is subjected simultaneously to direct load and moment. The number of piles  $n$  is sub-

$$\Sigma d^2 \text{ (one row)} = \frac{s^2}{12} n_1 (n_1^2 - 1) \quad 20.12$$

where  $s$  = spacing of piles in the row  
 $n_1$  = number of piles in the row

#### 20.8. Piles Subjected to Tension

Ordinarily the piles beneath a footing are expected to act in compression and only nominal provision is made to anchor them to the footing. This condition exists whenever all the pile reactions computed in accordance with eq. 20.10 and 20.11 are positive. If some of the reactions are negative but the piles are not anchored to the cap, the situation is analogous to that described in Arts. 20.3 and 20.5 which deal with footings having only part of their bases in compression. If the piles corresponding to the negative reactions cannot resist the tensile forces, the compression in the other piles is increased.

On the other hand, piles are often used specifically to resist tensile forces beneath several common types of structures such as towers, gas storage tanks, and tall stacks. Beneath such structures the tensile forces are usually temporary and are almost always caused by the moment due to wind. Under these conditions, if the piles are capable of withstand tension and are adequately anchored to the cap, the loads in each pile may be computed by means of eq. 20.10 and 20.11.

**20.9. Illustrative Design. DP D-4. Bridge Pier**  
 Most groups of piles contain several rows. Furthermore, moment about both axes is not uncommon. Equation 20.11 applies to these conditions.

$$P = \frac{\Sigma I}{n} \pm \frac{\Sigma M_1 d_1}{\Sigma d_1^2} \pm \frac{\Sigma M_2 d_2}{\Sigma d_2^2} \quad 20.11$$

The subscript of the moment  $M$  denotes the centroidal axis about which the moment acts. The subscript of the distance indicates the centroidal axis to which the distance from the pile is measured. These symbols are shown in Fig. 20.6.

If the moments have the directions shown in Fig. 20.6, it is apparent that pile  $A$  carries the greatest load whereas pile  $B$  carries the least. Both  $\Sigma M_1$  and  $\Sigma M_2$  increase the reaction at  $A$  and decrease that at

$B$ . Thus, it is possible to select by inspection the proper signs in the application of eq. 20.11 to any pile.

The determination of  $\Sigma d^2$  for large groups of piles may be considerably simplified by the use of eq. 20.12 which applies to a single row of piles with equal spacing.

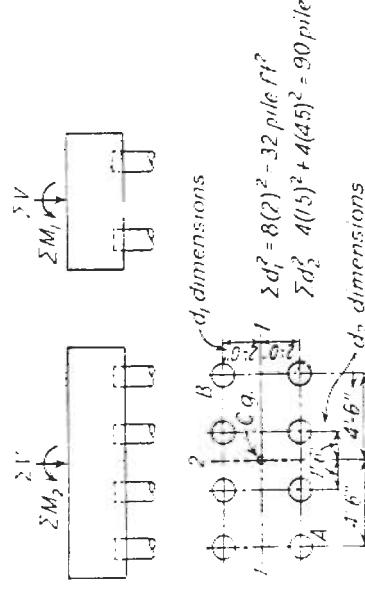


Fig. 20.6. Group of piles subjected to direct load and to moments about both axes.

stituted for the area, and the term  $\Sigma d^2$  replaces the moment of inertia of the area. For this reason  $\Sigma d^2$  is sometimes called the moment of inertia of the group of piles. The analogy between the terms of the two equations is shown in Fig. 20.5.

Most groups of piles contain several rows. Furthermore, moment about both axes is not uncommon. Equation 20.11 applies to these conditions.

The base of a bridge pier is a common example of a footing subjected to vertical loads together with moment about both axes. The vertical loads are due to the dead weight and live load of the superstructure and to the weight of the pier itself. Moments and shears on the foundation are produced by horizontal forces such as centrifugal force and those due to traction, nosing, wind, current, and ice. For the most unfavorable combination of these loadings, the allowable soil pressure or pile reaction beneath the base is commonly increased from 25 to 50 per cent above the value permitted under dead plus live load.

CLIENT TRWD  
 PROJECT GATE STR  
 DETAIL ABUTMENTS

JOB NO. 42275  
 DATE CHECKED 12-21-04  
 CHECKED BY MH

COMPUTED BY BDA  
 DATE 12-20-04  
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MAXIMUM LOAD  
ABUTMENT SUMMARY

		LENGTH	WEIGHT	LAT. FORCE
①	CFORK E	80'	3451 k	2326 k
②	CFORK W	23'	1223 k	669 k
③	T. POINT E/W	22'	515 k	380 k
④	TRWD E	53'	1119 k	537 k
⑤	TRWD W	26'	646 k	264 k

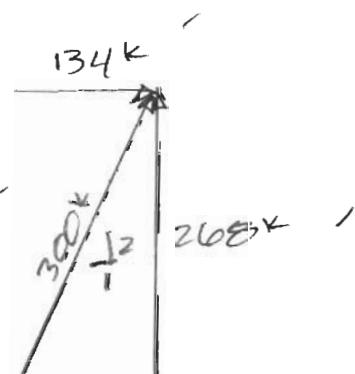
GROUPING OF SIM. LATERAL LOADING

COMPARISON STUDY	①	CFORK E	2326 k
	② ④	CFORK W + TRWD E	669 k (max)
	③ ⑤	TPOINT E/W + TRWD W	380 k (max)

ASSUME A 1H:2V BATTER

HP 14 x 102

$$P_{max} = 300 k$$



CLIENT TRWD  
 PROJECT GATE STR  
 DETAIL ABUTMENTS

JOB NO. 42275  
 DATE CHECKED 12-21-04  
 CHECKED BY TBP

COMPUTED BY BDA  
 DATE 12-20-04  
 PAGE NO.

### NUMBER OF PILES REQ'D

#### ① CFORK E

$$\text{LAT} \quad \frac{2326 \text{ k}}{134 \text{ k/PILE}} = 18 \text{ PILES} \quad 1 \text{ ROW}$$

$$\text{VERT} \quad \frac{3451 \text{ k}}{268 \text{ k/PILE}} = 13 \text{ PILES} \quad 1 \text{ ROW}$$

$$\text{SELF WT} \quad \frac{5565 \text{ k}}{268 \text{ k/PILE}} = 21 \text{ PILES TOTAL}$$

PROVIDE 2 ROWS OF  $\frac{18}{2}$  PILES

$$\frac{80'}{18} = 4.44' \text{ say } 4'-4" \text{ SPACING}$$

#### ② CFORK W & TRWD E

$$\text{LAT} \quad \frac{669 \text{ k}}{134 \text{ k/PL}} = 5 \text{ PILES /ROW}$$

$$\text{VERT} \quad \frac{1865 \text{ k}}{268 \text{ k/PL}} = 7 \frac{3}{4} \text{ PILES /ROW}$$

$$\text{SELF WT} \quad \frac{1787 \text{ k}}{268 \text{ k/PL}} = 7 \text{ PILES TOTAL}$$

PROVIDE 2 ROWS OF  $\frac{7}{2}$  PILES AT TRWD E

$$\text{CFORK W: VERT} = \frac{1223}{268} = 5 \text{ PILES} \rightarrow \frac{53'}{7} = 7\frac{1}{7}' \text{ say } 7\frac{1}{7}' \text{ SPACING}$$

PROVIDE 2 ROWS OF 5 PILES AT CFORK W

$$\frac{23'}{5} = 4.6' \text{ say } 4\frac{1}{2}' \text{ SPACING}$$

CLIENT TRWD  
 PROJECT GATE STR.  
 DETAIL ABUTMENTS

JOB NO. 42275  
 DATE CHECKED 12-21-04  
 CHECKED BY ZKZ

COMPUTED BY BDA  
 DATE 12-20-04  
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NUMBER OF PILES REQ'D

③ T-POINT E/W & TRWD W

~~$\text{LAT} \frac{380 \text{ k}}{134 \text{ k/pl}} = 3 \text{ PILES/ROW}$~~

~~$\text{VERT} \frac{646}{268 \text{ k/pl}} = 2 \text{ PILES/ROW}$~~

~~$\text{SELF WT} \frac{1016 \text{ k}}{268 \text{ k/pl}} = 4 \text{ PILES TOTAL}$~~

SAY PROVIDE 2 ROWS OF 5 PILES (MIN)

④ TRWD E

~~$\frac{22'}{5} = 4.4' \text{ SAY } 4.4'' \text{ SPACING AT T-POINT}$~~

~~$\text{LAT} \frac{537 \text{ k}}{134 \text{ k/pl}} = 4 \text{ PILES } \frac{26'}{5} = 5.2' \text{ SAY } 5.2'' \text{ SPACING AT TRWD W}$~~

~~$\text{VERT} \frac{1117 \text{ k}}{268 \text{ k/pl}} = 5 \text{ PILES}$~~

~~$\text{SELF WT} \frac{1865 \text{ k}}{268 \text{ k/pl}} = 7 \text{ PILES}$~~

PROVIDE 2 ROWS OF 7 PILES

⑤ TRWD W

~~$\text{LAT} \frac{264 \text{ k}}{134 \text{ k/pl}} = 2 \text{ PILES}$~~

~~$\text{VERT} \frac{646 \text{ k}}{268 \text{ k/pl}} = 3 \text{ PILES}$~~

~~$\text{SELF WT} \frac{1012 \text{ k}}{268 \text{ k/pl}} = 4 \text{ PILES}$~~

PROVIDE 2 ROWS OF 5 PILES (MIN)

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-FRSTR, DCS

DESIGNED BY: WCS DATE: 12/18/2004

CHCKED BY: BDA DATE: 12/20/04

GATE ABUTMENT STRUCTURE  
SELF-WEIGHT

**DIMENSIONS & WEIGHTS (INPUT):**

GATE ABUTMENT STRUCTURE:			
FLOOD ELEV (FE):	526 FT	FACTOR OF SAFETY (FS):	1.33
TAILWATER ELEV (TE):	520 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	28 DEGREES
TOP OF DECK ELEV (TDE):	557 FT	ACTUAL SOIL COHESION (CN):	0 PSF
FDN BASE EL (BE):	526 FT	FLUID PRESS (FPP):	0 PCF
DECK WIDTH (DW):	25 FT	CONC UNIT WGT (CW):	150 PCF
HEARWALL THICKNESS (HTW):	2 FT	CONTAINED SOIL WGT (CSW):	110 PCF
BUTTRESS WALL THICKNESS (BWT):	3 FT		
NO. OF BUTTRESS WALLS (NB):	4		
TOP SLAB THICKNESS (TST):	1.5 FT		
BOTTOM SLAB THICKNESS (BST):	6 FT		
STRUCTURE LENGTH (L):	80 FT		
ADDL HEEL WIDTH (HW):	12 FT	DESIGN FRICTION ANGLE (PHID):	21.19 DEGREES
HEEL THICKNESS (HTH):	6 FT	( PHID = ARCTAN(TAN(PH1) / FS) )	
ADDL TOE WIDTH (TW):	10 FT	DESIGN COHESION (CND):	0 PSF
TOE THICKNESS (TTH):	6 FT	{ CND = CN / FS }	

**DESIGN PARAMETERS (INPUT):**

GATE ABUTMENT STRUCTURE:			
FLOOD ELEV (FE):	526 FT	FACTOR OF SAFETY (FS):	1.33
TAILWATER ELEV (TE):	520 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	28 DEGREES
TOP OF DECK ELEV (TDE):	557 FT	ACTUAL SOIL COHESION (CN):	0 PSF
FDN BASE EL (BE):	526 FT	FLUID PRESS (FPP):	0 PCF
DECK WIDTH (DW):	25 FT	CONC UNIT WGT (CW):	150 PCF
HEARWALL THICKNESS (HTW):	2 FT	CONTAINED SOIL WGT (CSW):	110 PCF
BUTTRESS WALL THICKNESS (BWT):	3 FT		
NO. OF BUTTRESS WALLS (NB):	4		
TOP SLAB THICKNESS (TST):	1.5 FT		
BOTTOM SLAB THICKNESS (BST):	6 FT		
STRUCTURE LENGTH (L):	80 FT		
ADDL HEEL WIDTH (HW):	12 FT	DESIGN FRICTION ANGLE (PHID):	21.19 DEGREES
HEEL THICKNESS (HTH):	6 FT	( PHID = ARCTAN(TAN(PH1) / FS) )	
ADDL TOE WIDTH (TW):	10 FT	DESIGN COHESION (CND):	0 PSF
TOE THICKNESS (TTH):	6 FT	{ CND = CN / FS }	
		UPLIFT AT' HEEL (UHL):	0 PSF
		{ UHL = (FR-BE) * FPP }	
		UPLIFT AT' TOE (UT):	0 PSF
		{ UT = (TE-BE) * FPP }	

DESIGN LENGTH (L): 47 FT  
(L = HW + DW + TW)

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTW, DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: TBDF

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LAWL. FORCE: LB	ARM TO TOE: IN	RESISTING MOMENT: IN-LB	OVERTURNING MOMENT: IN-LB
HEADWALL:	479,400		34.00	16,299,600	
BUTTRESS WALLS (1):	1,057,500		22.50	23,793,750	
BUTTRESS WALLS (2):	1,93,500		6.67	1,296,645	
TOP SLAB:	450,000		22.50	10,125,000	
BOTTOM SLAB:	1,800,000		22.50	40,500,000	
HEEL, SLAB:	864,000		41.00	35,424,000	
TOE SLAB:	720,000		5.00	3,600,000	
FLUID ON HEEL:	0		41.00	0	
FLUID ON TOE:	0		5.00	0	
SUHTOTAL AT BASE (V, MR, MO) =	5,564,400	0	131,032,995	0	

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI)) =	2,224,544 LB	= U* (WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCS (GND*L*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	0 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
RECENTRICITY (E-L/2-(MR-MO)/V) =	.05 (RELATIVE TO CL)	= (FRICTION + COHESION) / (NET SLIDING)
BEARING PRESSURE = V/L(1+-6*E/L)		
MAX BEARING PRESS =	1471 PSF	
MIN BEARING PRESS =	1489 PSF	
VOLUME OF CONCRETE =	1,374 CY	

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR, DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: 1324

DATE: 12/20/04

GATE ABUTMENT STRUCTURE  
SELF-WEIGHT

DIMENSIONS & WEIGHTS (INPUT):

GATE ABUTMENT STRUCTURE:			
FLOOD ELEV (FE):	526 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	1.33 DEGREES
TALLWATER ELEV (TE):	520 FT	ACTUAL SOIL COHESION (CN):	2B PSF
TOP OF DECK ELEV (TDE):	557 FT	FLUID PRESS (EFP):	0 PCF
FDN BASE RL (BE):	526 FT	CONC UNIT WGT (CUW):	150 PCF
DECK WIDTH (DW):	2.5 FT	CONTAINED SOIL WGT (CSW):	110 PCF
HEADWALL THICKNESS (HWT):	2 FT		
BUTTRESS WALL THICKNESS (BWT):	3 FT		
NO. OF BUTTRESS WALLS (NB):	2		
TOP SLAB THICKNESS (TST):	1.5 FT		
BOTTOM SLAB THICKNESS (BST):	6 FT		
STRUCTURE LENGTH (B):	2.3 FT		
ADDL HEEL WIDTH (HW):	12 FT	DESIGN FRICTION ANGLE (PHID):	21.79 DEGREES
HEEL THICKNESS (HTH):	6 FT	( PHID = ARCTAN(TAN(PHI)/FS) )	
ADDL TOE WIDTH (TW):	8 FT	DESIGN COHESION (CND):	0 PSF
TOE THICKNESS (TTW):	6 FT	( CND = CN / FS )	

DESIGN PARAMETERS (INPUT):

GATE ABUTMENT STRUCTURE:			
FLOOD ELEV (FE):	526 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	1.33 DEGREES
TALLWATER ELEV (TE):	520 FT	ACTUAL SOIL COHESION (CN):	2B PSF
TOP OF DECK ELEV (TDE):	557 FT	FLUID PRESS (EFP):	0 PCF
FDN BASE RL (BE):	526 FT	CONC UNIT WGT (CUW):	150 PCF
DECK WIDTH (DW):	2.5 FT	CONTAINED SOIL WGT (CSW):	110 PCF
HEADWALL THICKNESS (HWT):	2 FT		
BUTTRESS WALL THICKNESS (BWT):	3 FT		
NO. OF BUTTRESS WALLS (NB):	2		
TOP SLAB THICKNESS (TST):	1.5 FT		
BOTTOM SLAB THICKNESS (BST):	6 FT		
STRUCTURE LENGTH (B):	2.3 FT		
ADDL HEEL WIDTH (HW):	12 FT	DESIGN FRICTION ANGLE (PHID):	21.79 DEGREES
HEEL THICKNESS (HTH):	6 FT	( PHID = ARCTAN(TAN(PHI)/FS) )	
ADDL TOE WIDTH (TW):	8 FT	DESIGN COHESION (CND):	0 PSF
TOE THICKNESS (TTW):	6 FT	( CND = CN / FS )	
UPLIFT AT HEEL (UH):		UPLIFT AT HEEL (UH):	0 PSF
( UH = (FE-BE) * EFP )		( UH = (FE-BE) * EFP )	
UPLIFT AT TOE (UT):		UPLIFT AT TOE (UT):	0 PSF
( UT = (TE-BE) * EFP )		( UT = (TE-BE) * EFP )	

$$\text{FDN LENGTH} (L) = \frac{(1_e + T_W + D_W + T_W)}{4.5 \text{ FT}}$$

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521 42275 PRSTR, DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: TBD

DATE: 12/20/04

**STABILITY ANALYSIS:**

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB	OVERTURNING MOMENT: LB
HEADWALL:	119,850		32.00	3,835,200	
BUTTRESS WALLS (1):	528,750		20.50	10,339,375	
BUTTRESS WALLS (2):	77,400		5.34	413,006	
TOP SLAB:	129,375		20.50	2,652,188	
BOTTOM SLAB:	517,500		20.50	10,608,750	
HEEL SLAB:	248,400		39.00	9,687,600	
TOE SLAB:	165,600		4.00	662,400	
SUBTOTAL AT BASE: (V, MR, MO) =	1,786,875	0	38,698,519	0	

**STABILITY RESULTS:**

$$\begin{aligned} \text{FRICTION FORCE } (V * \tan(\phi)) &= 714,360 \text{ LB} \\ \text{COHESION FORCE } (\gamma_{CD} * L * B) &= 0 \text{ LB} \\ \text{NET SLIDING FORCE} &= 0 \text{ LB} \\ \text{ECCENTRICITY } (E-L/2 - (MR-MO)/V) &= .84 \text{ (RELATIVE TO CL)} \\ \text{BEARING PRESSURE} &= V/L(1 + -6 * E/L) \\ \text{MAX BEARING PRESS} &= 1920 \text{ PSF} \\ \text{MIN BEARING PRESS} &= 1532 \text{ PSF} \\ \text{VOLUME OF CONCRETE} &= 441 \text{ CY} \end{aligned}$$

$$\begin{aligned} &= U * (\text{WEIGHT CONC + GATES + WATER - UPLIFT}) \\ &= \text{COHESION * BASE AREA} \\ &= \text{DRIVING FORCES MINUS ACTIVE RESISTING FORCES} \\ &= \{\text{FRICTION + COHESION}\} / (\text{NET SLIDING}) \end{aligned}$$

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-422/5-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: B Doy

DATE: 12/20/04

GATE ABUTMENT STRUCTURE  
SELF-WEIGHT

DIMENSIONS & WEIGHTS (INPUT):

GATE ABUTMENT STRUCTURE:			
FLOOD ELEV (FE):	526 FT	ACTUAL SOIL FRICTION ANGLE (PHI):	1.33 DEGREES
TALL WATER ELEV (TE):	520 FT	ACTUAL SOIL COHESION (CN):	0 PSF
TOP OF DECK ELEV (TDE):	557 FT	FLUID PRESS (FFP):	0 PCF
FDN BASH EL (BE):	526 FT	CONC UNIT WGT (CUW):	150 PCF
DECK WIDTH (DW):	25 FT	CONTAINED SOIL WGT (CSW):	110 PCF
HEADWALL THICKNESS (HWT):	2 FT		
BUTTRESS WALL THICKNESS (BWT):	2 FT		
NO. OF BUTTRESS WALLS (NB):	2		
TOP SLAB THICKNESS (TST):	1.5 FT	RESULTING DESIGN VALUES & DIMENSIONS:	
BOTTOM SLAB THICKNESS (BST):	3 FT		
STRUCTURE LENGTH (B):	22 FT	DESIGN FRICTION ANGLE (PHID):	21.79 DEGREES
ADDL HEEL WIDTH (HW):	0 FT	{ PHID = ARCTAN(TAN(PHI)/FS) }	
HEEL THICKNESS (HTH):	0 FT	DESIGN COHESION (CND):	0 PSF
ADDL TOE WIDTH (TW):	6 FT	{ CND = CN / FS }	
TOE THICKNESS (TTH):	3 FT	UPLIFT AT HEEL (UH):	0 PSF
		{ UH = (FE-BE) * FFP }	
		UPLIFT AT TOE (UT):	0 PSF
		{ UT = (TE BE) * FFP }	

FDN LENGTH (L): 31 FT  
(L = LW + DW + TW)

DESIGN PARAMETERS (INPUT):

FACTOR OF SAFETY (FS):	1.33
ACTUAL SOIL FRICTION ANGLE (PHI):	2.8 DEGREES
ACTUAL SOIL COHESION (CN):	0
FLUID PRESS (FFP):	0
CONC UNIT WGT (CUW):	150
CONTAINED SOIL WGT (CSW):	110
DESIGN FRICTION ANGLE (PHID):	21.79 DEGREES
{ PHID = ARCTAN(TAN(PHI)/FS) }	
DESIGN COHESION (CND):	0 PSF
{ CND = CN / FS }	
UPLIFT AT HEEL (UH):	0 PSF
{ UH = (FE-BE) * FFP }	
UPLIFT AT TOE (UT):	0 PSF
{ UT = (TE BE) * FFP }	

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275, PRSTR, DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: 7304

DATE: 12/20/cy

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: IN	RESISTING MOMENT: IN-LB	OVERTURNING MOMENT: IN-LB
HEADWALL:	143,100		30.00	4,293,000	
BUTTRESS WALLS (1):	397,500		18.50	7,353,750	
BUTTRESS WALLS (2):	44,100		4.00	176,488	
TOP SLAB:	123,750		18.50	2,289,375	
BOTTOM SLAB:	247,500		18.50	4,578,750	
HEEL SLAB:	0		31.00	0	
TOE SLAB:	59,400		3.00	178,200	
SUBTOTAL AT BASE: (V,MR,MO) =	1,015,350	0	18,869,563	0	

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHID)) =	405,918 LB	= U* (WEIGHT* CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	0 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
ECCENTRICITY (E=L/2 - (MR MO)/V) =	-3.08 (RELATIVE TO CL)	= (FRICTION + COHESION) / (NET SLIDING)
BEARING PRESSURE V/L, (1+ -6*E/L)		
MAX BEARING PRESS =	600 PSF	
MIN BEARING PRESS =	2378 PSF	
VOLUME OF CONCRETE =	251 CY	

PROJECT: TRWD FLOOD GATE CONTROL, STRUCTURE

CHARGE NO.: 2521-42275, PRSTR, DCIS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: J. S. H.

DATE: 12/20/04

GATE ABUTMENT STRUCTURE  
SELF-WEIGHT

DIMENSIONS & WEIGHTS (INPUT):

GATE ABUTMENT STRUCTURE:	
FLOOD ELEV (FE):	526 FT
TAILWATER ELEV (TW):	520 FT
TOP OF DECK ELEV (TDE):	557 FT
FDN BASE EL (BE):	526 FT
DECK WIDTH (DW):	25 FT
HEADWALL THICKNESS (HWT):	2 FT
BUTTRESS WALL THICKNESS (BWT):	2 FT
NO. OF BUTTRESS WALLS (NB):	3
TOP SLAB THICKNESS (TST):	1.5 FT
BOTTOM SLAB THICKNESS (BST):	3 FT
STRUCTURE LENGTH (B):	53 FT

GATE ABUTMENT STRUCTURE:	
FLOOD ELEV (FE):	526 FT
TAILWATER ELEV (TW):	520 FT
TOP OF DECK ELEV (TDE):	557 FT
FDN BASE EL (BE):	526 FT
DECK WIDTH (DW):	25 FT
HEADWALL THICKNESS (HWT):	2 FT
BUTTRESS WALL THICKNESS (BWT):	2 FT
NO. OF BUTTRESS WALLS (NB):	3
TOP SLAB THICKNESS (TST):	1.5 FT
BOTTOM SLAB THICKNESS (BST):	3 FT
STRUCTURE LENGTH (B):	53 FT

ADDL. HEEL WIDTH (IRW):	0 FT
HEEL THICKNESS (HTH):	0 FT
ADDL. TOE WIDTH (ITW):	0 FT
TOE THICKNESS (TTW):	0 FT

DESIGN PARAMETERS (INPUT):

ACTUAL SOIL FRICTION ANGLE (PHI):	1.33 DEGREES
ACTUAL SOIL COHESION (Cn):	28 PSF
FLUID PRESS (EFP):	0 PCF
CONC UNIT WGT (CW):	150 PCF
CONTAINED SOIL WGT (CSW):	110 PCF

RESULTING DESIGN VALUES & DIMENSIONS:

DESIGN FRICTION ANGLE (PHID):	21.79 DEGREES
( PHID = ARCTAN(TAN(PHI) / FS) )	
DESIGN COHESION (CND):	0 PSF
( CND = CN / FS )	
UPLIFT AT HEEL (UH):	0 PSF
( UH = (FE-BE) * EFP )	
UPLIFT AT TOE (UT):	0 PSF
( UT = (TE-BE) * EFP )	

FDN LENGTH (L): 25 FT  
(L = HW + DW + TW)

PROJECT: TRWD - FLOOD GATE CONTROL STRUCTURE

CHARGE NO. : 2521-42275-PRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004  
Troy

CHECKED BY: PSD

**STABILITY ANALYSIS:**

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB-F	OVERTURNING: MOMENT: LB-F
HEADWALL:	373,650		24.00	8,967,600	
BUTTRESS WALLS (1):	596,250		12.50	7,453,125	
BUTTRESS WALLS (2):	0		0.00	0	
TOP SLAB:	298,125		12.50	3,726,563	
BOTTOM SLAB:	596,250		12.50	7,453,125	
HEEL SLAB:	0		25.00	0	
TOE SLAB:	0		0.00	0	
SUBTOTAL AT BASE (V,MR,MO) =	1,864,275	0	27,600,413	0	

**STABILITY RESULTS:**

FRICITION FORCE (V\*TAN(ΦHID)) = 745,303 LB  
COHESION FORCE (CND\*1.7B) = 0 LB  
NET SLIDING FORCE = 0 LB

ECCENTRICITY ( $E=L/2-(MR-MO)/V$ ) =  $\sqrt{1/(1+6*E/L)}$  (RELATIVE TO CL)  
BEARING PRESSURE =  $V/(1/(1+6*E/L))$   
MAX BEARING PRESS = 629 PSF  
MIN BEARING PRESS = 2185 PSF  
VOLUME OF CONCRETE = 460 CY

$U * (\text{WEIGHT CONC} + \text{GATES} + \text{WATER} - \text{UPLIFT})$   
= COHESION \* BASE AREA  
= DRIVING FORCES MINUS ACTIVE RESISTING FORCES  
= (FRICTION + COHESION) / (NET SLIDING)

PROJECT: TRWD F1.0010 GATE CONTROL STRUCTURE

CHARGE NO.: 2521-42275-PRSTR, DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: Terry

DATE: 12/20/04

GATE ABUTMENT STRUCTURE  
SELF-WEIGHT

DIMENSIONS & WEIGHTS (INPUT):

GATE ABUTMENT STRUCTURE:  
FLOOD ELEV (FE): 526 FT  
TAILWATER ELEV (TE): 520 FT  
TOP OF DECK ELEV (TDE): 557 FT  
FDN BASE EL (BE): 526 FT  
DECK WIDTH (DW): 25 FT  
HEADWALL THICKNESS (HWT): 2 FT  
BUTTRESS WALL THICKNESS (BWT): 2 FT  
NO. OF BUTTRESS WALLS (NR): 2  
TOP SLAB THICKNESS (TST): 1.5 FT  
BOTTOM SLAB THICKNESS (BST): 3 FT  
STRUCTURE LENGTH (B): 26 FT

DESIGN PARAMETERS (INPUT):  
FACTOR OF SAFETY (FS): 1.33  
ACTUAL SOIL FRICTION ANGLE (PHI): 28 DEGREES  
ACTUAL SOIL COHESION (CN): 0 PSF  
FLUID PRESS (EFP): 0 PCF  
CONC UNIT WGT (CDW): 150 PCF  
CONTAINED SOIL WGT (CSW): 110 PCF

RESULTING DESIGN VALUES & DIMENSIONS:

DESIGN FRICTION ANGLE (PHD): 21.79 DEGREES  
( PHD = ARCTAN(TAN(PHI)/FS) )  
DESIGN COHESION (CND): 0 PSF  
( CND = CN / FS )  
UPLIFT AT HEEL (UH): 0 PSF  
( UH = (FE-BE) \* EFP )  
UPLIFT AT TOE (UT): 0 PSF  
( UT = (TE-BE) \* EFP )

$$\text{FDN LENGTH (L)} : \frac{(L - HW + DW + TW)}{FT}$$

PROJECT: TKWD FLOOD GATE CONTROL STRUCTURE

CHARGE NO.: 2521 42275 TRSTR.DCS

DESIGNED BY: WCS

DATE: 12/18/2004

CHECKED BY: BBJdt

DATE: 12/20/04

#### STABILITY ANALYSIS:

	WEIGHT: LB	LATL FORCE: LB	ARM TO TOE: LB	RESISTING MOMENT: LB	OVERTURNING MOMENT: LB
HEADWALL:	174,900			24,00	4,197,600
BUTTRESS WALLS (1):	397,500			12,50	4,968,750
BUTTRESS WALLS (2):	0			0,00	0
TOP SLAB:	146,250			12,50	1,828,125
BOTTOM SLAB:	292,500			12,50	3,656,250
HEEL SLAB:	0			25,00	0
TOE SLAB:	0			0,00	0
SUBTOTAL AT BASE (V,MR,M0):-	1,011,150	0	0	14,650,725	0

#### STABILITY RESULTS:

FRICITION FORCE (V*TAN(PHI)) =	404,739 LB	= U* (WEIGHT CONC + GATES + WATER - UPLIFT)
COHESION FORCE (CND*L*B) =	0 LB	= COHESION * BASE AREA
NET SLIDING FORCE =	0 LB	= DRIVING FORCES MINUS ACTIVE RESISTING FORCES
ECCENTRICITY (E=L/2 = (Mr Mo)/V) =	-1.99 (RELATIVE TO CL.)	(FRICTION + COHESION) / (NET SLIDING)
BEARING PRESSURE = V/L (1+ -6*E/L)		
MAX BEARING PRESS =	813 PSF	
MIN BEARING PRESS =	2298 PSF	
VOLUME OF CONCRETE =	250 CY	

# **Section 14**

## **Training Wall Stability Analysis and Design (CTWall Results and Manual Calculations)**

CLIENT TRWD  
 PROJECT FWCC  
 DETAIL TRAINING WALLS

JOB NO. 42275  
 DATE CHECKED 12-20-2004  
 CHECKED BY BDA

COMPUTED BY WCI  
 DATE 11-23-04  
 PAGE NO.  
Rev. 1/18/05

BASED ON PRELIMINARY ANALYSES, PUT TRAINING WALLS ON PILES

(EXCESSIVE FIG. LG. FOR STD. TRAING. WALL)

- ASSUME CHANNEL FILLED IN TO EL 512.0 (min) ✓ w/

BASE OF WALL AT EL 508.0 ✓

- ASSUME GRADE BEHIND WALL AT EL 530 ✓ w/

TOP OF WALL AT EL 533.50 ✓

BASED ON PRELIMINARY CT WALL ANALYSES, USE 6' TOE & 26' TOTAL BASE:

CT WALL RESULTS:

I 1 NL PILE: O.T. RATIO = 1.54, 100% compr., NET LAT. FORCE = 31.9% ✓

I 1 NS PILE: " = 1.10, " , " " " = 15.5% ✓

I 4 CL PILE: " = 2.15, " , " " " = 37.6% ✓

I 4 CS PILE: " = 5.26, " , " " " = 25.3% ✓

{ I 1 FL PILE: " = 1.07, " , " " " = 34.2% ✓

II FS PILE: " = 2.27, " , " " " = 18.2% ✓

CHECK BASE OF STEM FOR LOADS FROM I 4 CL PILE:

DETERMINE EQUIL. LATERAL PRESSURE EL 530 TO 508:

$$\text{EARTH LOAD} : 28.052 = \frac{1}{2} \gamma_e (22')^2 : \gamma_e = 0.116 \checkmark$$

$$\text{SURCHARGE LOAD} : 1.377 = \gamma_s (22')^2 : \gamma_s = 0.0028 \checkmark$$

$$\text{WATER LOAD} : 8.196 = \frac{1}{2} \gamma_w (22')^2 : \gamma_w = 0.034 \checkmark$$

$$V_c \text{ BASE OF STEM} = 0.0028 (18)^2 + \frac{1}{2} (0.116 + 0.034) (18)^2 \\ = 0.907 \\ = 0.094 + 24.30 = 25.2 \%, \checkmark$$

$$V_u = 1.3 \times 1.7 \times 25.2 = 55.7 \%, \checkmark$$

$$\text{TRW } 48'' \text{ AT BASE. } \& V_c = 0.1075 \times 45'' \times 12'' = 58.0 \% > 55.7 \%, \underline{\underline{\text{OK}}} \checkmark$$

$$M_c \text{ BASE OF STEM} = 0.0028 (18)^3/2 + \frac{1}{6} (0.116 + 0.034) (18)^3 = 8.2 + 145.8 \\ = 154.1 \%, \checkmark$$

$$M_u = 1.3 \times 1.7 \times 154 = 340 \checkmark$$

$$A_s = \frac{340}{(0.37 \times 15)} = 1.73 \text{ in}^2/\text{ft} > 1.806, \text{ use } 4.6'' \text{ C BASE OF STEM}$$

CLIENT TRWD  
 PROJECT FWCC  
 DETAIL DRAINING WALLS

JOB NO. 42275 COMPUTED BY MCF  
 DATE CHECKED 12-20-2004 DATE 11-29-04  
 CHECKED BY BDA PAGE NO.

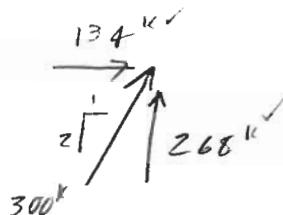
$$K = \frac{340 \times 1000}{(51)^2} = 131^{\vee}, a_n = 4.39^{\vee}$$

$$A_s = \frac{300}{4.39 \times 51} = 1.52 \text{ m}^2/\text{ft} \Rightarrow \# 8 \text{ #6} = 1.58 \text{ m}^2/\text{ft}^{\vee}$$

- USE 4'6" @ BASE OF WALL<sup>v</sup>

PILES: USE HP14x102 @ 2:1 BATTER

$$\frac{134^{\vee}}{38^{\vee}/\text{ft}} = 3.53^{\vee}$$



USE 2 ROWS OF PILES @ 7' SPACING (STAGGERED)

$$\text{DEAD WGT. OF WALL} = \left[ \frac{(2' + 4.5')}{2} \times 21.5' + 4' \times 26' \right] \times 0.150 = 26.1^{\vee}.$$

LOAD ON 2 ROWS OF PILES @ 7' SPACING.

$$\frac{26.1 \times 7'}{2} = 91.4^{\vee} \text{ EACH} << 268^{\vee}$$

SAY PROVIDE 1 ROW OF VERTICAL PILES @ 7' SPACING?

$$\frac{26.1^{\vee} \times 7'}{3} = 60.9^{\vee} / \text{PILE}$$

$$\text{LATERAL LOAD @ BATTERED PILES} = 60.9 \times \frac{134}{268} = 30.5^{\vee} \text{ EACH}$$

→ USE 2 ROWS BATTERED UPSTREAM TO BALANCE LATERAL FORCE

$X_R = 9.53'$  MEASURED FROM TDE:

SAY PILES @ 7' FROM TDE & 12' FROM DE

\*\*\*\*\* Echoprint of Input Data \*\*\*\*\*

Date: \*\*/11/23

Time: 10.47.26

Flood Wall Stability Analysis Using CTWALL  
Filename: I1NPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District  
Wall location:

Training Walls

Computed by: WCS

Structural geometry data:

Elevation of top of stem (ELTS)	=	533.50 ft
Height of stem (HTS)	=	21.50 ft
Thickness top of stem (TTS)	=	1.50 ft
Thickness bottom of stem (TBS)	=	4.00 ft
Dist. of batter at bot. of stem (TBSR)	=	.00 ft
Depth of heel (THEEL)	=	4.00 ft
Distance of batter for heel (BTRH)	=	.00 ft
Depth of toe (TTOE)	=	4.00 ft
Width of toe (TWIDTH)	=	6.00 ft
Distance of batter for toe (BTRT)	=	.00 ft
Width of base (BWIDTH)	=	26.00 ft
Depth of key (HK)	=	.00 ft
Width cf bottom of key (TK)	=	.00 ft
Dist. of batter at bot. of key (BTRK)	=	.00 ft

Structure coordinates:

x (ft)	y (ft)
.00	508.00
.00	512.00
16.00	512.00
18.50	533.50
20.00	533.50
20.00	512.00
26.00	512.00
26.00	508.00

NOTE: X=0 is located at the left-hand side  
of the structure. The Y values correspond  
to the actual elevation used.

Structural property data:

Unit weight of concrete = .150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Unit wt. (kcf)	Moist unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
27.00	.000	.100	.130	.00	530.01	

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	4.00	50.00
2	.00	50.00
3	.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1081.91	546.68
2	-31.91	546.68
3	18.09	530.01

Resisting side soil property data:

Phi (deg)	c (ksf)	Unit wt. (kcf)	Moist unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
27.00	.000	.100	.130	.00	508.00	.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	26.00	508.00
2	526.00	508.00

Foundation property data:

phi for soil-structure interface = 27.00 (deg)  
c for soil-structure interface = .100 (ksf)  
phi for soil-soil interface = 27.00 (deg)  
c for soil-soil interface = .100 (ksf)

Water data:

Driving side elevation = 530.00 ft  
Resisting side elevation = 524.30 ft  
Unit weight of water = .0625 kcf  
Seepage pressures computed by Line of Creep method.

Uniform load data:

Magnitude of load = .10 k/ft

Minimum required factors of safety:

Sliding FS = 1.50

Overspinning = 100.00% base in compression

Crack options:

- o Crack depth is to be calculated
- o Computed cracks \*will\* be filled with water

Strength mobilization factor = .6667

50% of full passive \*is used\* in the overspinning analysis.

Forces on the resisting side \*are used\* in the sliding analysis.

\*Do\* iterate in overspinning analysis.

\*\*\*\*\* Summary of Results \*\*\*\*\*

Flood Wall Stability Analysis Using CTWALL

Project name: TRWD-FWCC

\*\*\*\*\* Satisfied \*\*\*  
\* Overturning \*      Required base in comp. = 100.00 %  
\*\*\*\*\* Actual base in comp. = 100.00 %  
                      Overturning ratio = 1.54

Xr (measured from toe) = 8.67 ft  
Resultant ratio = .3336  
Stem ratio = .2308  
Base pressure at heel = .0025 ksf  
Base pressure at toe = 3.6358 ksf

\*\*\* Warning \*\*\* The maximum available shear along the base of the structure has been exceeded!

\*\*\*\*\* Not Satisfied \*\*\*  
\* Sliding \*      Min. Required = 1.50  
\*\*\*\*\* Actual FS = 1.07

To increase stability try one or a combination of the following:

1. Increase the base width
2. Slope the base of the structure
3. Lower the wall base
4. Add a key

\*\*\*\*\* Output Results \*\*\*\*\*

Date: \*\*/11/23

Time: 10.47.26

Flood Wall Stability Analysis Using CTWALL  
Filename: I1NLPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

\*\*\*\*\*

\*\* Overturning Results \*\*

\*\*\*\*\*

Solution converged in 1 iterations.

SMF used to calculate K's = .6667

Alpha for the SMF = -44.1002

Calculated earth pressure coefficients:

Driving side at rest K = .4886

Driving side at rest Kc = 1.1474

Resisting side at rest K = .0000

Resisting side at rest Kc = .0000

Full passive K calculated for resisting side.

50% of full passive will be used.

Depth of cracking = .00 ft

\*\* Driving side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
=====	
530.00	.0000
508.00	1.2117

Earth pressures:

Elevation (ft)	Pressure (ksf)
=====	
536.04	.0000
530.00	.4500
515.76	1.3363
508.00	1.6203

Surcharge pressures:

Elev. (ft)	Press. (ksf)
536.04	.049
508.00	.049

\*\* Resisting side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
524.30	.0000
508.00	1.0187
508.00	1.0187

\*\* Uplift pressures \*\*

Water pressures:

x-coord. (ft)	Pressure (ksf)
.00	1.2117
26.00	1.0187

\*\* Forces and moments \*\*

Part	Force (kips)		Mom. Arm (ft)	Moment (ft-k)
	Vert.	Horiz.		
<b>Structure:</b>				
Structure weight.....	24.469		-11.00	-269.05
<b>Structure, driving side:</b>				
Moist soil.....	5.475		-19.96	-109.27
Saturated soil.....	39.889		-17.47	-696.70
Water above structure.....	.000		.00	.00
Water above soil.....	.000		.00	.00
External vertical loads....	1.850		-16.75	-30.99
Ext. horz. pressure loads..		.000	.00	.00
Ext. horz. line loads.....		.000	.00	.00
<b>Structure, resisting side:</b>				
Moist soil.....	.000		.00	.00
Saturated soil.....	.000		.00	.00
Water above structure.....	.000		.00	.00
Water above soil.....	4.612		-3.00	-13.84
<b>Driving side:</b>				
Effective earth loads.....		25.548	9.79	249.99
Shear (due to delta).....	.000		.00	.00
Horiz. surcharge effects...		1.370	14.02	19.21
Water loads.....		13.329	7.33	97.73
<b>Resisting side:</b>				
Effective earth loads.....		.000	.00	.00
Water loads.....		-8.303	5.43	-45.12
<b>Foundation:</b>				
Vertical force on base....	-47.299		-8.67	410.21
Shear on base.....		-31.944	.00	.00
Uplift.....	-28.996		-13.37	387.82
<b>** Statics Check **</b>				
SUMS =	.000	.000		.00

Angle of base = .00 degrees

Normal force on base = 47.299 kips

Shear force on base = 31.944 kips

Max. available shear force = 26.700 kips

\*\*\* Warning \*\*\* The maximum available shear along the base of the structure has been exceeded!

Base pressure at heel = .0025 ksf

Base pressure at toe = 3.6358 ksf

Xr (measured from toe) = 8.67 ft

Resultant ratio = .3336

Stem ratio = .2308

Base in compression = 100.00 %

Overturning ratio = 1.54

Volume of concrete = 6.04 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

\*\*\*\*\*
\*\* Sliding Results \*\*
\*\*\*\*\*

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	3.379
2	-8.303	6.462
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	1.2117		
2			.0000	1.2117
2			26.0000	1.0187
3	.0000	.0000		

Points of sliding plane:

Point 1 (left), x = .00 ft, y = 508.00 ft  
 Point 2 (right), x = 26.00 ft, y = 508.00 ft

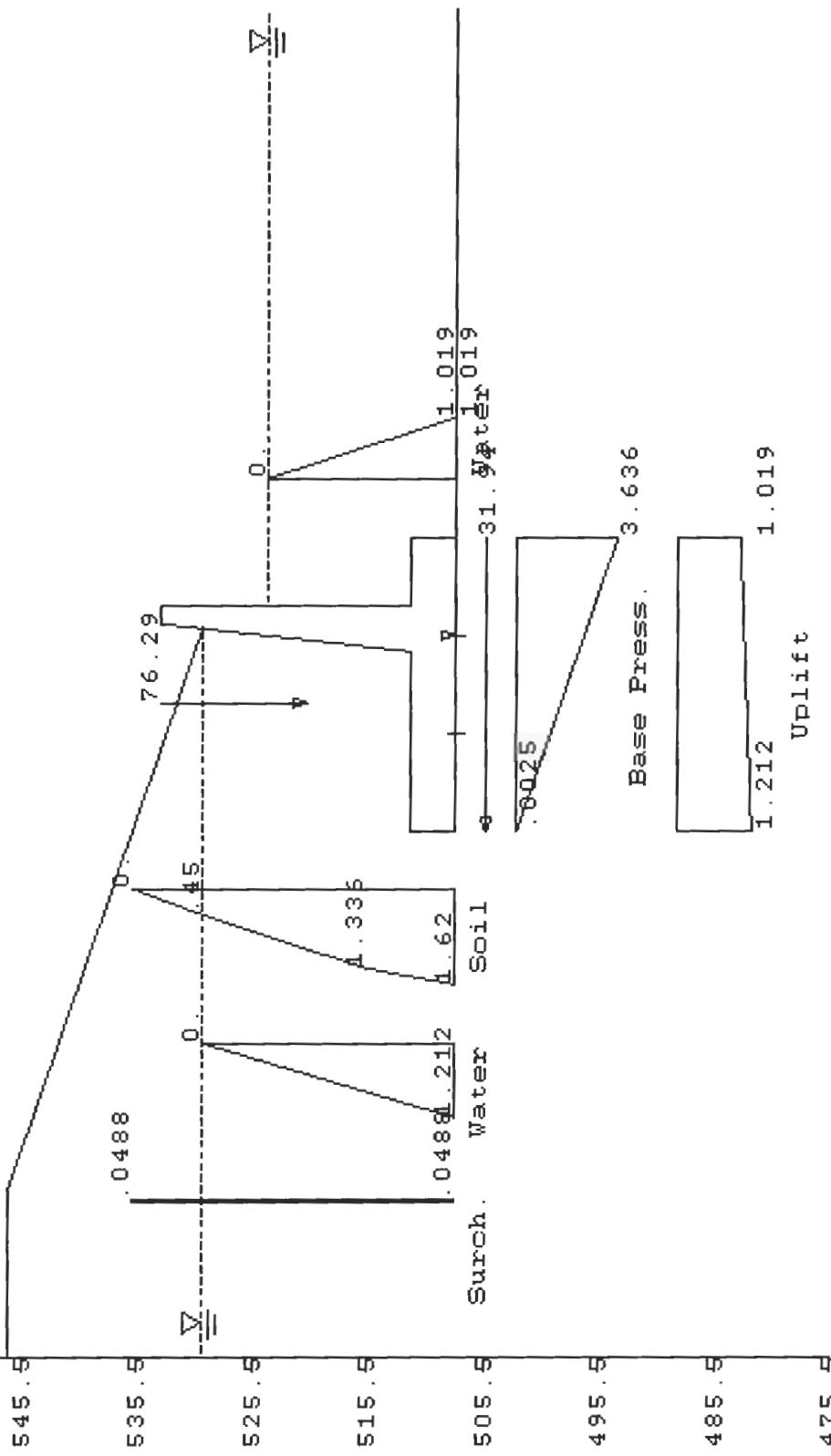
Depth of cracking = .00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-48.862	51.355	54.711	29.212	17.698
2	.000	26.000	69.832	26.000	28.996
3	.000	.000	.000	.000	.000

Wedge number	Net force (kips)
1	-33.348
2	33.348
3	.000
SUM =	.000

Factor of safety =	1.066
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Flood Wall Stability Analysis Using CTWALL  
TRWD-FWCC



\*\*\*\*\* Echoprint of Input Data \*\*\*\*\*

Date: \*\*/11/23

Time: 11.04.55

Flood Wall Stability Analysis Using CTWALL  
Filename: I1NSPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

Structural geometry data:

Elevation of top of stem (ELTS)	=	533.50 ft
Height of stem (HTS)	=	21.50 ft
Thickness top of stem (TTS)	=	1.50 ft
Thickness bottom of stem (TBS)	=	4.00 ft
Dist. of batter at bot. of stem (TBSR)	=	.00 ft
Depth of heel (THEEL)	=	4.00 ft
Distance of batter for heel (BTRH)	=	.00 ft
Depth of toe (TTOE)	=	4.00 ft
Width of toe (TWIDTH)	=	6.00 ft
Distance of batter for toe (BTRT)	=	.00 ft
Width of base (BWIDTH)	=	26.00 ft
Depth of key (HK)	=	.00 ft
Width of bottom of key (TK)	=	.00 ft
Dist. of batter at bot. of key (BTRK)	=	.00 ft

Structure coordinates:

x (ft)	y (ft)
.00	508.00
.00	512.00
16.00	512.00
18.50	533.50
20.00	533.50
20.00	512.00
26.00	512.00
26.00	508.00

NOTE: X=0 is located at the left-hand side  
of the structure. The Y values correspond  
to the actual elevation used.

Structural property data:

Unit weight of concrete = .150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
.00	1.000	.100	.130	.00	530.01

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	4.00	50.00
2	.00	50.00
3	.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1081.91	546.68
2	-31.91	546.68
3	18.09	530.01

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
.00	1.000	.100	.130	508.00	.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	26.00	508.00
2	526.00	508.00

Foundation property data:

phi for soil-structure interface = .00 (deg)  
c for soil-structure interface = 1.000 (ksf)  
phi for soil-soil interface = .00 (deg)  
c for soil-soil interface = 1.000 (ksf)

Water data:

Driving side elevation = 530.00 ft  
Resisting side elevation = 524.30 ft  
Unit weight of water = .0625 kcf  
Seepage pressures computed by Line of Creep method.

Uniform load data:

Magnitude of load = .10 k/ft

Minimum required factors of safety:

Sliding FS = 1.50

Overspinning = 100.00% base in compression

Crack options:

- o Crack \*is\* down to bottom of heel
- o Computed cracks \*will\* be filled with water

Strength mobilization factor = .6667

50% of full passive \*is used\* in the overspinning analysis.

Forces on the resisting side \*are used\* in the sliding analysis.

\*Do\* iterate in overspinning analysis.

\*\*\*\*\* Summary of Results \*\*\*\*\*

Flood Wall Stability Analysis Using CTWALL

Project name: TRWD-FWCC

\*\*\*\*\* \*\*\* Satisfied \*\*\*  
\* Overturning \* Required base in comp. = 100.00 %  
\*\*\*\*\* Actual base in comp. = 100.00 %  
Overturning ratio = 2.10

Xr (measured from toe) = 11.43 ft  
Resultant ratio = .4397  
Stem ratio = .2308  
Base pressure at heel = 1.3075 ksf  
Base pressure at toe = 2.7911 ksf

\*\*\*\*\* \*\*\* Satisfied \*\*\*  
\* Sliding \* Min. Required = 1.50  
\*\*\*\*\* Actual FS = 1.60

\*\*\*\*\* Output Results \*\*\*\*\*

Date: \*\*/11/23

Time: 11.04.55

Flood Wall Stability Analysis Using CTWALL  
Filename: I1NSPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

\*\*\*\*\*

\*\* Overturning Results \*\*

\*\*\*\*\*

Solution converged in 1 iterations.

SMF used to calculate K's = .6667

Alpha for the SMF = -31.6073

Calculated earth pressure coefficients:

Driving side at rest K = 1.0000

Driving side at rest Kc = 2.4441

Resisting side at rest K = .0000

Resisting side at rest Kc = .0000

Full passive K calculated for resisting side.

50% of full passive will be used.

Depth of cracking = 14.94 ft

Crack extends to bottom of base of structure.

\*\* Driving side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
=====	
536.04	.0000
521.11	.9335
508.00	1.1291

Earth pressures:

Elevation (ft)	Pressure (ksf)
=====	
536.04	.0000
521.11	.0000
508.00	.3068

Surcharge pressures:

Elev. (ft)	Press. (ksf)
521.11	.100
508.00	.100

\*\* Resisting side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
524.30	.0000
508.00	1.0187
508.00	.6412

\*\* Uplift pressures \*\*

Water pressures:

x-coord. (ft)	Pressure (ksf)
.00	1.1291
26.00	.6412

\*\* Forces and moments \*\*

Part	Force (kips)	Mom. Arm (ft)	Moment (ft-k)
	Vert.	Horiz.	
<b>Structure:</b>			
Structure weight.....	24.469	-11.00	-269.05
Structure, driving side:			
Moist soil.....	5.475	-19.96	-109.27
Saturated soil.....	39.889	-17.47	-696.70
Water above structure.....	.000	.00	.00
Water above soil.....	.000	.00	.00
External vertical loads....	1.850	-16.75	-30.99
Ext. horz. pressure loads..	.000	.00	.00
Ext. horz. line loads.....	.000	.00	.00
Structure, resisting side:			
Moist soil.....	.000	.00	.00
Saturated soil.....	.000	.00	.00
Water above structure.....	.000	.00	.00
Water above soil.....	4.612	-3.00	-13.84
Driving side:			
Effective earth loads.....	2.010	4.37	8.78
Shear (due to delta).....	.000	.00	.00
Horiz. surcharge effects...	1.311	6.55	8.59
Water loads.....	20.487	10.34	211.84
Resisting side:			
Effective earth loads.....	.000	.00	.00
Water loads.....	-8.303	5.43	-45.11
Foundation:			
Vertical force on base....	-53.282	-11.43	609.09
Shear on base.....	-15.505	.00	.00
Uplift.....	-23.013	-14.19	326.65
<b>** Statics Check **      SUMS = .000      .000      .00</b>			

Angle of base = .00 degrees

Normal force on base = 53.282 kips

Shear force on base = 15.505 kips

Max. available shear force = 26.000 kips

Base pressure at heel = 1.3075 ksf

Base pressure at toe = 2.7911 ksf

Xr (measured from toe) = 11.43 ft

Resultant ratio = .4397

Stem ratio = .2308

Base in compression = 100.00 %

Overturning ratio = 2.10

Volume of concrete = 6.04 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

\*\*\*\*\*
\*\* Sliding Results \*\*
\*\*\*\*\*

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	.000
2	16.270	6.462
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	.0000		
2			.0000	1.3750
2			26.0000	.6412
3	.0000	.0000		

Points of sliding plane:

Point 1 (left), x = .00 ft, y = 508.00 ft  
 Point 2 (right), x = 26.00 ft, y = 508.00 ft

Depth of cracking = 28.04 ft

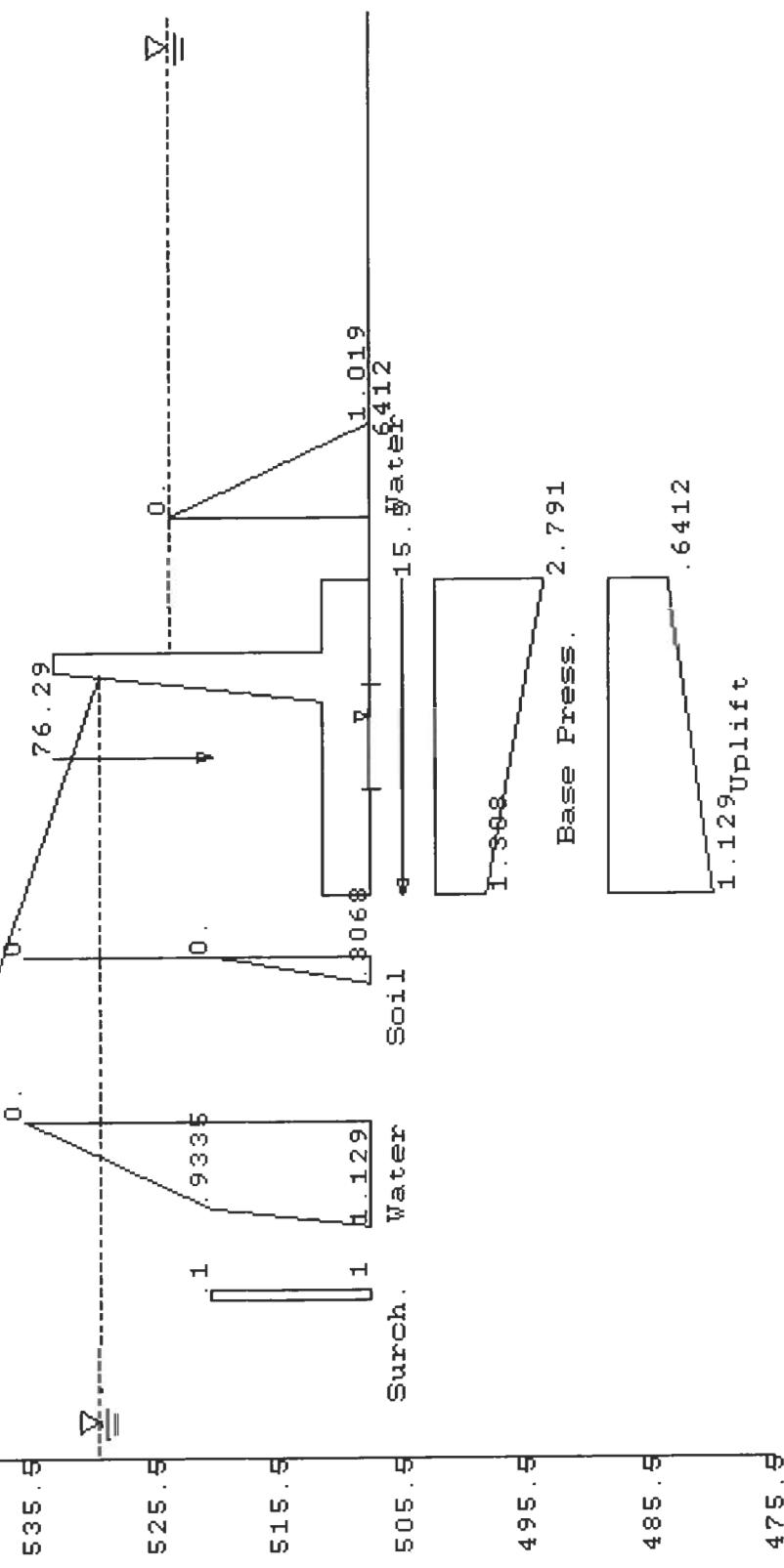
Crack extends to bottom of base of structure.

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	.000	.000	.000	.000	.000
2	.000	26.000	69.832	26.000	26.210
3	.000	.000	.000	.000	.000

Wedge number	Net force (kips)
1	.000
2	.001
3	.000
SUM =	.001

+-----+  
| Factor of safety = 1.598 |  
+-----+

Flood Wall Stability Analysis Using CTWALL  
TRWD-FWCC



\*\*\*\*\* Echoprint of Input Data \*\*\*\*\*

Date: \*\*/11/23

Time: 10.48.50

Flood Wall Stability Analysis Using CTWALL  
Filename: I4CLPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

Structural geometry data:

Elevation of top of stem (ELTS)	=	533.50 ft
Height of stem (HTS)	=	21.50 ft
Thickness top of stem (TTS)	=	1.50 ft
Thickness bottom of stem (TBS)	=	4.00 ft
Dist. of batter at bot. of stem (TBSR)	=	.00 ft
Depth of heel (THEEL)	=	4.00 ft
Distance of batter for heel (BTRH)	=	.00 ft
Depth of toe (TTOE)	=	4.00 ft
Width of toe (TWIDTH)	=	6.00 ft
Distance of batter for toe (BTRT)	=	.00 ft
Width of base (BWIDTH)	=	26.00 ft
Depth of key (HK)	=	.00 ft
Width of bottom of key (TK)	=	.00 ft
Dist. of batter at bot. of key (BTRK)	=	.00 ft

Structure coordinates:

x (ft)	y (ft)
.00	508.00
.00	512.00
16.00	512.00
18.50	533.50
20.00	533.50
20.00	512.00
26.00	512.00
26.00	508.00

NOTE: X=0 is located at the left-hand side  
of the structure. The Y values correspond  
to the actual elevation used.

Structural property data:

Unit weight of concrete = .150 kcf

Driving side soil property data:

Phi (deg)	C (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
27.00	.000	.100	.130	.00	530.01

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	4.00	50.00
2	.00	50.00
3	.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1081.91	546.68
2	-31.91	546.68
3	18.09	530.01

Resisting side soil property data:

Phi (deg)	C (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
27.00	.000	.100	.130	508.00	.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	26.00	508.00
2	526.00	508.00

Foundation property data:

phi for soil-structure interface	=	27.00 (deg)
c for soil-structure interface	=	.100 (ksf)
phi for soil-soil interface	=	27.00 (deg)
c for soil-soil interface	=	.100 (ksf)

Water data:

Driving side elevation	=	530.00 ft
Resisting side elevation	=	508.01 ft
Unit weight of water	=	.0625 kcf
Seepage pressures computed by Line of Creep method.		

Uniform load data:

Magnitude of load	=	.10 k/ft
-------------------	---	----------

Minimum required factors of safety:

Sliding FS = 1.33

Overspinning = 75.00% base in compression

Crack options:

- o Crack depth is to be calculated
- o Computed cracks \*will\* be filled with water

Strength mobilization factor = .6667

50% of full passive \*is used\* in the overspinning analysis.

Forces on the resisting side \*are used\* in the sliding analysis.

\*Do\* iterate in overspinning analysis.

\*\*\*\*\* Summary of Results \*\*\*\*\*

Flood Wall Stability Analysis Using CTWALL

Project name: TRWD-FWCC

\*\*\*\*\* Satisfied \*\*\*  
\* Overturning \*      Required base in comp. = 75.00 %  
\*\*\*\*\* Actual base in comp. = 100.00 %  
                      Overturning ratio = 2.15

Xr (measured from toe) = 9.53 ft  
Resultant ratio = .3667  
Stem ratio = .2308  
Base pressure at heel = .4771 ksf  
Base pressure at toe = 4.2912 ksf

\*\*\* Warning \*\*\* The maximum available shear along the base of the structure has been exceeded!

\*\*\*\*\* Not Satisfied \*\*\*  
\* Sliding \*      Min. Required = 1.33  
\*\*\*\*\* Actual FS = 1.10

To increase stability try one or a combination of the following:

1. Increase the base width
2. Slope the base of the structure
3. Lower the wall base
4. Add a key

\*\*\*\*\* Output Results \*\*\*\*\*

Date: \*\*/11/23

Time: 10.48.50

Flood Wall Stability Analysis Using CTWALL  
Filename: I4CLPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District  
Wall location:

Training Walls

Computed by: WCS

\*\*\*\*\*

\*\* Overturning Results \*\*

\*\*\*\*\*

Solution converged in 1 iterations.

SMF used to calculate K's = .6667

Alpha for the SMF = -44.6301

Calculated earth pressure coefficients:

Driving side at rest K = .4912

Driving side at rest Kc = 1.1308

Resisting side at rest K = .0000

Resisting side at rest Kc = .0000

Full passive K calculated for resisting side.

50% of full passive will be used.

Depth of cracking = .00 ft

\*\* Driving side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
<hr/>	
530.00	.0000
508.00	.7451

Earth pressures:

Elevation (ft)	Pressure (ksf)
<hr/>	
536.04	.0000
530.00	.4480
515.18	1.5189
508.00	1.8580

**Surcharge pressures:**

Elev. (ft)	Press. (ksf)
536.04	.049
508.00	.049

**\*\* Resisting side pressures \*\***

**Water pressures:**

Elevation (ft)	Pressure (ksf)
508.01	.0000
508.00	.0006
508.00	.0006

**\*\* Uplift pressures \*\***

**Water pressures:**

x-coord. (ft)	Pressure (ksf)
.00	.7451
26.00	.0006

\*\* Forces and moments \*\*

Part	Force (kips)		Mom. Arm (ft)	Moment (ft-k)
	Vert.	Horiz.		
<b>Structure:</b>				
Structure weight.....	24.469		-11.00	-269.05
<b>Structure, driving side:</b>				
Moist soil.....	5.475		-19.96	-109.27
Saturated soil.....	39.889		-17.47	-696.70
Water above structure....	.000		.00	.00
Water above soil.....	.000		.00	.00
External vertical loads....	1.850		-16.75	-30.99
Ext. horz. pressure loads..		.000	.00	.00
Ext. horz. line loads.....		.000	.00	.00
<b>Structure, resisting side:</b>				
Moist soil.....	.000		.00	.00
Saturated soil.....	.000		.00	.00
Water above structure....	.000		.00	.00
Water above soil.....	.000		.00	.00
<b>Driving side:</b>				
Effective earth loads.....		28.052	9.54	267.64
Shear (due to delta).....	.000		.00	.00
Horiz. surcharge effects...		1.377	14.02	19.31
Water loads.....		8.196	7.33	60.10
<b>Resisting side:</b>				
Effective earth loads.....		.000	.00	.00
Water loads.....		.000	-.95	.00
<b>Foundation:</b>				
Vertical force on base....	-61.988		-9.53	590.99
Shear on base.....		-37.625	.00	.00
Uplift.....	-9.694		-17.33	167.96
<b>** Statics Check **      SUMS = .000      .000      .00</b>				

Angle of base = .00 degrees

Normal force on base = 61.988 kips

Shear force on base = 37.625 kips

Max. available shear force = 34.185 kips

\*\*\* Warning \*\*\* The maximum available shear along the base of the structure has been exceeded!

Base pressure at heel = .4771 ksf

Base pressure at toe = 4.2912 ksf

Xr (measured from toe) = 9.53 ft

Resultant ratio = .3667

Stem ratio = .2308

Base in compression = 100.00 %

Overspinning ratio = 2.15

Volume of concrete = 6.04 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

\*\*\*\*\*
\*\* Sliding Results \*\*
\*\*\*\*\*

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	3.378
2	.000	1.850
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	.7451		
2			.0000	.7451
2			26.0000	.0006
3	.0000	.0000		

Points of sliding plane:

Point 1 (left), x = .00 ft, y = 508.00 ft  
 Point 2 (right), x = 26.00 ft, y = 508.00 ft

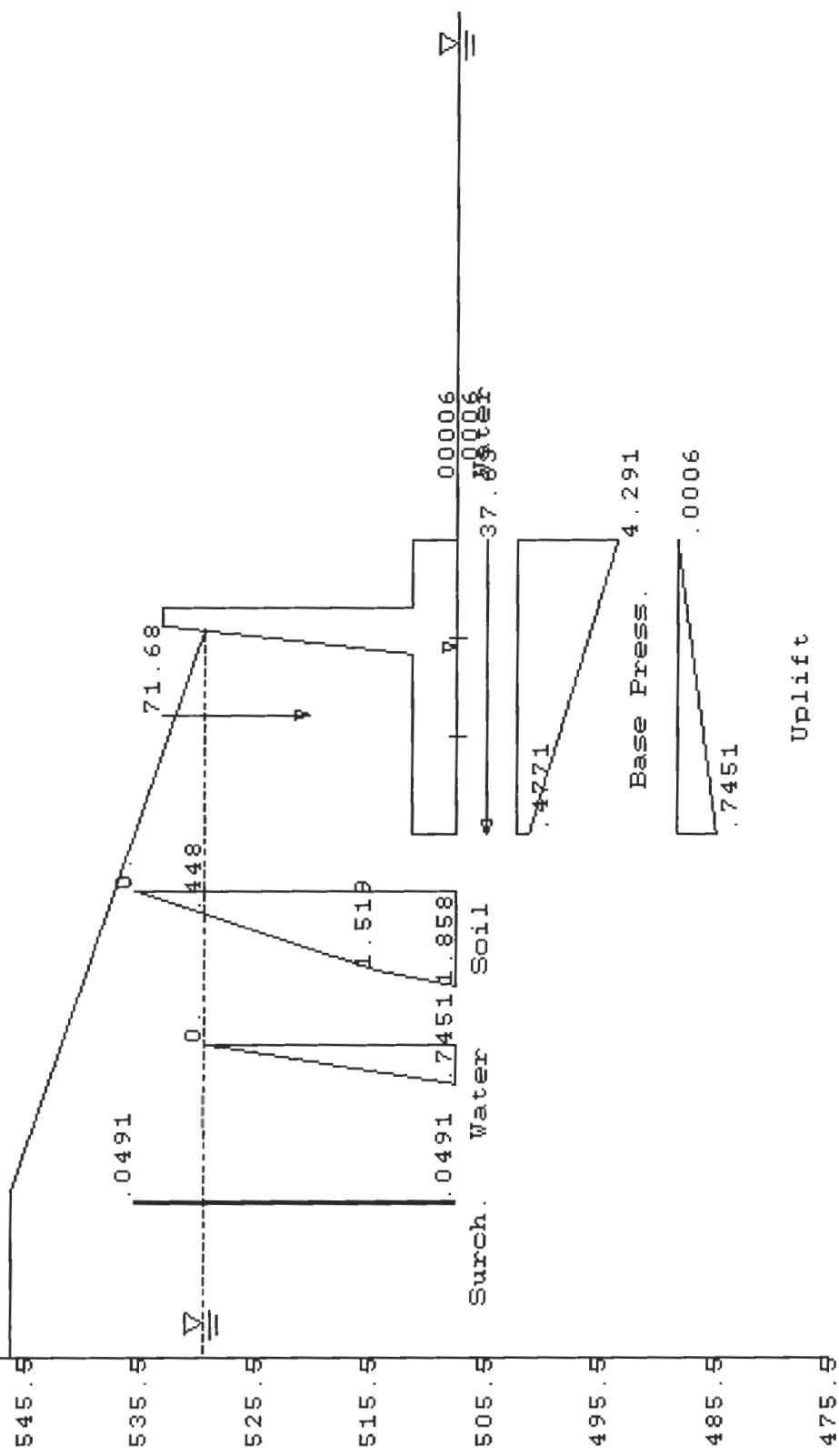
Depth of cracking = .00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-48.867	51.351	54.698	29.209	10.882
2	.000	26.000	69.832	26.000	9.694
3	.000	.000	.000	.000	.000

Wedge number	Net force (kips)
1	-30.964
2	30.964
3	.000
SUM	.000

Factor of safety =	1.104
--------------------	-------

Flood Wall Stability Analysis Using CTWALL  
TRWD-FWCC



\*\*\*\*\* Echoprint of Input Data \*\*\*\*\*

Date: \*\*/11/23

Time: 11.03.16

Flood Wall Stability Analysis Using CTWALL  
Filename: I4CSPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

Structural geometry data:

Elevation of top of stem (ELTS)	=	533.50 ft
Height of stem (HTS)	=	21.50 ft
Thickness top of stem (TTS)	=	1.50 ft
Thickness bottom of stem (TBS)	=	4.00 ft
Dist. of batter at bot. of stem (TBSR)	=	.00 ft
Depth of heel (THEEL)	=	4.00 ft
Distance of batter for heel (BTRH)	=	.00 ft
Depth of toe (TTOE)	=	4.00 ft
Width of toe (TWIDTH)	=	6.00 ft
Distance of batter for toe (BTRT)	=	.00 ft
Width of base (BWIDTH)	=	26.00 ft
Depth of key (HK)	=	.00 ft
Width of bottom of key (TK)	=	.00 ft
Dist. of batter at bot. of key (BTRK)	=	.00 ft

Structure coordinates:

x (ft)	y (ft)
.00	508.00
.00	512.00
16.00	512.00
18.50	533.50
20.00	533.50
20.00	512.00
26.00	512.00
26.00	508.00

NOTE: X=0 is located at the left-hand side  
of the structure. The Y values correspond  
to the actual elevation used.

Structural property data:

Unit weight of concrete = .150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
.00	1.000	.100	.130	.00	530.01

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	4.00	50.00
2	.00	50.00
3	.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1081.91	546.68
2	-31.91	546.68
3	18.09	530.01

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
.00	1.000	.100	.130	508.00	.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	26.00	508.00
2	526.00	508.00

Foundation property data:

phi for soil-structure interface = .00 (deg)
c for soil-structure interface = 1.000 (ksf)
phi for soil-soil interface = .00 (deg)
c for soil-soil interface = 1.000 (ksf)

Water data:

Driving side elevation = 530.00 ft
Resisting side elevation = 508.01 ft
Unit weight of water = .0625 kcf
Seepage pressures computed by Line of Creep method.

Uniform load data:

Magnitude of load = .10 k/ft
------------------------------

Minimum required factors of safety:

Sliding FS = 1.33

Overspinning = 75.00% base in compression

Crack options:

- o Crack \*is\* down to bottom of heel
- o Computed cracks \*will\* be filled with water

Strength mobilization factor = .6667

50% of full passive \*is used\* in the overspinning analysis.

Forces on the resisting side \*are used\* in the sliding analysis.

\*Do\* iterate in overspinning analysis.

\*\*\*\*\* Summary of Results \*\*\*\*\*

Flood Wall Stability Analysis Using CTWALL

Project name: TRWD-FWCC

\*\*\*\*\*                    \*\*\* Satisfied \*\*\*  
\* Overturning \*       Required base in comp. = 75.00 %  
\*\*\*\*\*                    Actual base in comp. = 100.00 %  
                          Overturning ratio = 5.26

Xr (measured from toe) = 13.05 ft  
Resultant ratio = .5020  
Stem ratio = .2308  
Base pressure at heel = 2.9973 ksf  
Base pressure at toe = 2.9277 ksf

\*\*\*\*\*                    \*\*\* Not Satisfied \*\*\*  
\* Sliding \*            Mir. Required = 1.33  
\*\*\*\*\*                    Actual FS = 1.06

To increase stability try one or a combination  
of the following:

1. Increase the base width
2. Slope the base of the structure
3. Lower the wall base
4. Add a key

\*\*\*\*\* Output Results \*\*\*\*\*

Date: \*\*/11/23

Time: 11.03.16

Flood Wall Stability Analysis Using CTWALL  
Filename: I4CSPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

\*\*\*\*\*

\*\* Overturning Results \*\*

\*\*\*\*\*

Solution converged in 1 iterations.

SMF used to calculate K's = .6667

Alpha for the SMF = -31.6073

Calculated earth pressure coefficients:

Driving side at rest K = 1.0000

Driving side at rest Kc = 2.4441

Resisting side at rest K = .0000

Resisting side at rest Kc = .0000

Full passive K calculated for resisting side.

50% of full passive will be used.

Depth of cracking = 14.94 ft

Crack extends to bottom of base of structure.

\*\* Driving side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
=====	
536.04	.0000
521.11	.9335
508.00	.7879

Earth pressures:

Elevation (ft)	Pressure (ksf)
=====	
536.04	.0000
521.11	.0000
508.00	.8795

Surcharge pressures:

Elev. (ft)	Press. (ksf)
521.11	.100
508.00	.100

\*\* Resisting side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
508.01	.0000
508.00	.0006
508.00	-.3770

\*\* Uplift pressures \*\*

Water pressures:

x-coord. (ft)	Pressure (ksf)
.00	.7879
26.00	-.3770

\*\* Forces and moments \*\*

Part	Force (kips)		Mom. Arm (ft)	Moment (ft-k)
	Vert.	Horiz.		
<b>Structure:</b>				
Structure weight.....	24.469		-11.00	-269.05
Structure, driving side:				
Moist soil.....	5.475		-19.96	-109.27
Saturated soil.....	39.889		-17.47	-696.70
Water above structure.....	.000		.00	.00
Water above soil.....	.000		.00	.00
External vertical loads....	1.850		-16.75	-30.99
Ext. horz. pressure loads..		.000	.00	.00
Ext. horz. line loads.....		.000	.00	.00
Structure, resisting side:				
Moist soil.....	.000		.00	.00
Saturated soil.....	.000		.00	.00
Water above structure.....	.000		.00	.00
Water above soil.....	.000		.00	.00
Driving side:				
Effective earth loads.....		5.763	4.37	25.17
Shear (due to delta).....	.000		.00	.00
Horiz. surcharge effects...		1.311	6.55	8.59
Water loads.....		18.251	11.07	202.07
Resisting side:				
Effective earth loads.....		.000	.00	.00
Water loads.....		.000	-508.00	.00
Foundation:				
Vertical force on base.....	-77.024		-13.05	1005.23
Shear on base.....		-25.325	.00	.00
Uplift.....	5.342		-25.28	-135.06

=====  
\*\* Statics Check \*\*      SUMS =      .000      .000      .00

Angle of base        =      .00 degrees

Normal force on base =      77.024 kips

Shear force on base =      25.325 kips

Max. available shear force =      26.000 kips

Base pressure at heel =      2.9973 ksf

Base pressure at toe =      2.9277 ksf

Xr (measured from toe) =      13.05 ft

Resultant ratio        =      .5020

Stem ratio            =      .2308

Base in compression    =      100.00 %

Overturning ratio     =      5.26

Volume of concrete =      6.04 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

\*\*\*\*\*
\*\* Sliding Results \*\*
\*\*\*\*\*

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	.000
2	24.573	1.850
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	.0000		
2			.0000	1.3750
2			26.0000	-.3770
3	.0000	.0000		

Points of sliding plane:

Point 1 (left), x = .00 ft, y = 508.00 ft  
 Point 2 (right), x = 26.00 ft, y = 508.00 ft

Depth of cracking = 28.04 ft

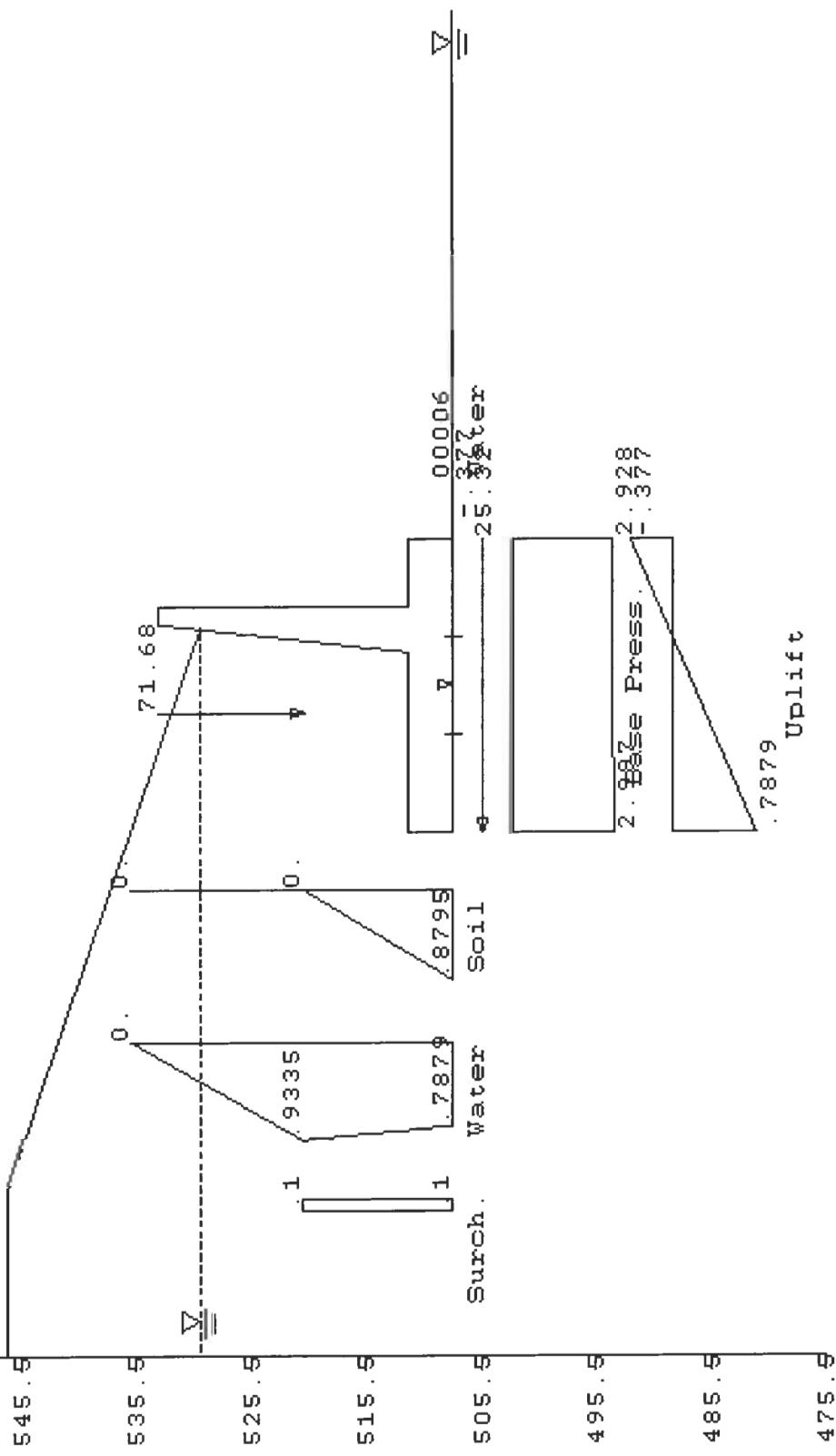
Crack extends to bottom of base of structure.

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	.000	.000	.000	.000	.000
2	.000	26.000	69.832	26.000	12.974
3	.000	.000	.000	.000	.000

Wedge number	Net force (kips)
1	.000
2	.000
3	.000
SUM =	.000

Factor of safety = 1.058
--------------------------

Flood Wall Stability Analysis Using CTWALL  
TRWD-FWCC



\*\*\*\*\* Echoprint of Input Data \*\*\*\*\*

Date: \*\*/01/17

Time: 10.59.43

Flood Wall Stability Analysis Using CTWALL  
Filename: I1FLPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

Structural geometry data:

Elevation of top of stem (ELTS)	=	533.50 ft
Height of stem (HTS)	=	21.50 ft
Thickness top of stem (TTS)	=	1.50 ft
Thickness bottom of stem (TBS)	=	4.00 ft
Dist. of batter at bot. of stem (TBSR)	=	.00 ft
Depth of heel (THEEL)	=	4.00 ft
Distance of batter for heel (BTRH)	=	.00 ft
Depth of toe (TTOE)	=	4.00 ft
Width of toe (TWIDTH)	=	6.00 ft
Distance of batter for toe (BTRT)	=	.00 ft
Width of base (BWIDTH)	=	26.00 ft
Depth of key (HK)	=	.00 ft
Width of bottom of key (TK)	=	.00 ft
Dist. of batter at bot. of key (BTRK)	=	.00 ft

Structure coordinates:

x (ft)	y (ft)
.00	508.00
.00	512.00
16.00	512.00
18.50	533.50
20.00	533.50
20.00	512.00
26.00	512.00
26.00	508.00

NOTE: X=0 is located at the left-hand side  
of the structure. The Y values correspond  
to the actual elevation used.

Structural property data:

Unit weight of concrete = .150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
27.00	.000	.100	.130	.00	530.01

Driving side soil geometry:

Soil point	Batter (in:lft)	Distance (ft)
1	4.00	50.00
2	.00	50.00
3	.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1081.91	546.68
2	-31.91	546.68
3	18.09	530.01

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:lft)
27.00	.000	.100	.130	508.00	.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	26.00	508.00
2	526.00	508.00

Foundation property data:

phi for soil-structure interface	=	27.00 (deg)
c for soil-structure interface	=	.100 (ksf)
phi for scil-soil interface	=	27.00 (deg)
c for soil-soil interface	=	.100 (ksf)

Water data:

Driving side elevation	=	530.00 ft
Resisting side elevation	=	519.00 ft
Unit weight of water	=	.0625 kcf
Seepage pressures computed by Line of Creep method.		

Minimum required factors of safety:

Sliding FS = 1.50

Overturning = 100.00% base in compression

Crack options:

- o Crack depth is to be calculated
- o Computed cracks \*will\* be filled with water

Strength mobilization factor = .6667

50% of full passive \*is used\* in the overturning analysis.

Forces on the resisting side \*are used\* in the sliding analysis.

\*Do\* iterate in overturning analysis.

\*\*\*\*\* Summary of Results \*\*\*\*\*

Flood Wall Stability Analysis Using CTWALL

Project name: TRWD-FWCC

\*\*\*\*\*                    \*\*\* Satisfied \*\*\*  
\* Overturning \*       Required base in comp. = 100.00 %  
\*\*\*\*\*                    Actual base in comp. = 100.00 %  
                          Overturning ratio = 1.67

Xr (measured from toe) = 8.82 ft  
Resultant ratio = .3392  
Stem ratio = .2308  
Base pressure at heel = .0670 ksf  
Base pressure at toe = 3.7592 ksf

\*\*\* Warning \*\*\* The maximum available shear along the base of the structure has been exceeded!

\*\*\*\*\*                    \*\*\* Not Satisfied \*\*\*  
\* Sliding \*       Min. Required = 1.50  
\*\*\*\*\*                    Actual FS = 1.05

To increase stability try one or a combination of the following:

1. Increase the base width
2. Slope the base of the structure
3. Lower the wall base
4. Add a key

\*\*\*\*\* Output Results \*\*\*\*\*

Date: \*\*/01/17

Time: 10.59.43

Flood Wall Stability Analysis Using CTWALL  
Filename: I1FLPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

\*\*\*\*\*

\*\* Overturning Results \*\*

\*\*\*\*\*

Solution converged in 1 iterations.

SMF used to calculate K's = .6667

Alpha for the SMF = -43.8621

Calculated earth pressure coefficients:

Driving side at rest K = .4874

Driving side at rest Kc = 1.1551

Resisting side at rest K = .0000

Resisting side at rest Kc = .0000

Full passive K calculated for resisting side.

50% of full passive will be used.

Depth of cracking = .00 ft

\*\* Driving side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
530.00	.0000
508.00	1.0599

Earth pressures:

Elevation (ft)	Pressure (ksf)
536.04	.0000
530.00	.4509
516.01	1.3707
508.00	1.6903

\*\* Resisting side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
<hr/>	
519.00	.0000
508.00	.6875
508.00	.6875

\*\* Uplift pressures \*\*

Water pressures:

x-coord. (ft)	Pressure (ksf)
<hr/>	
.00	1.0599
26.00	.6875

\*\* Forces and moments \*\*

Part	Force (kips)		Mom. Arm (ft)	Moment (ft-k)
	Vert.	Horiz.		
<hr/>				
Structure:				
Structure weight.....	24.469		-11.00	-269.05
Structure, driving side:				
Moist soil.....	5.475		-19.96	-109.27
Saturated soil.....	39.889		-17.47	-696.70
Water above structure.....	.000		.00	.00
Water above soil.....	.000		.00	.00
External vertical loads....	.000		.00	.00
Ext. horz. pressure loads..		.000	.00	.00
Ext. horz. line loads.....		.000	.00	.00
Structure, resisting side:				
Moist soil.....	.000		.00	.00
Saturated soil.....	.000		.00	.00
Water above structure.....	.000		.00	.00
Water above soil.....	2.625		-3.00	-7.88
Driving side:				
Effective earth loads.....		26.365	9.72	256.31
Shear (due to delta).....	.000		.00	.00
Horiz. surcharge effects...		.000	.00	.00
Water loads.....		11.659	7.33	85.51
Resisting side:				
Effective earth loads.....		.000	.00	.00
Water loads.....		-3.781	3.67	-13.87
Foundation:				
Vertical force on base.....	-49.741		-8.82	438.64
Shear on base.....		-34.243	.00	.00
Uplift.....	-22.716		-13.92	316.29
<hr/>				
** Statics Check **	SUMS =	.000	.000	.00

Angle of base = .00 degrees  
Normal force on base = 49.741 kips  
Shear force on base = 34.243 kips  
Max. available shear force = 27.944 kips

\*\*\* Warning \*\*\* The maximum available shear along the base of the structure has been exceeded!

Base pressure at heel = .0670 ksf  
Base pressure at toe = 3.7592 ksf

Xr (measured from toe) = 8.82 ft  
Resultant ratio = .3392  
Stem ratio = .2308  
Base in compression = 100.00 %  
Overturning ratio = 1.67

Volume of concrete = 6.04 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

\*\*\*\*\*

\*\* Sliding Results \*\*

\*\*\*\*\*

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	.000
2	-3.781	2.625
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	1.0599		
2			.0000	1.0599
2			26.0000	.6875
3	.0000	.0000		

Points of sliding plane:

Point 1 (left), x = .00 ft, y = 508.00 ft  
Point 2 (right), x = 26.00 ft, y = 508.00 ft

Depth of cracking = .00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-48.938	51.296	54.519	29.178	15.463
2	.000	26.000	69.832	26.000	22.716
3	.000	.000	.000	.000	.000

Wedge number	Net force (kips)
1	-30.475
2	30.475
3	.000

=====

SUM = .000

+-----+  
| Factor of safety = 1.047 |  
+-----+

# Flood Wall Stability Analysis Using CTWALL

TRWD-FWCC

555.5

545.5

535.5

525.5

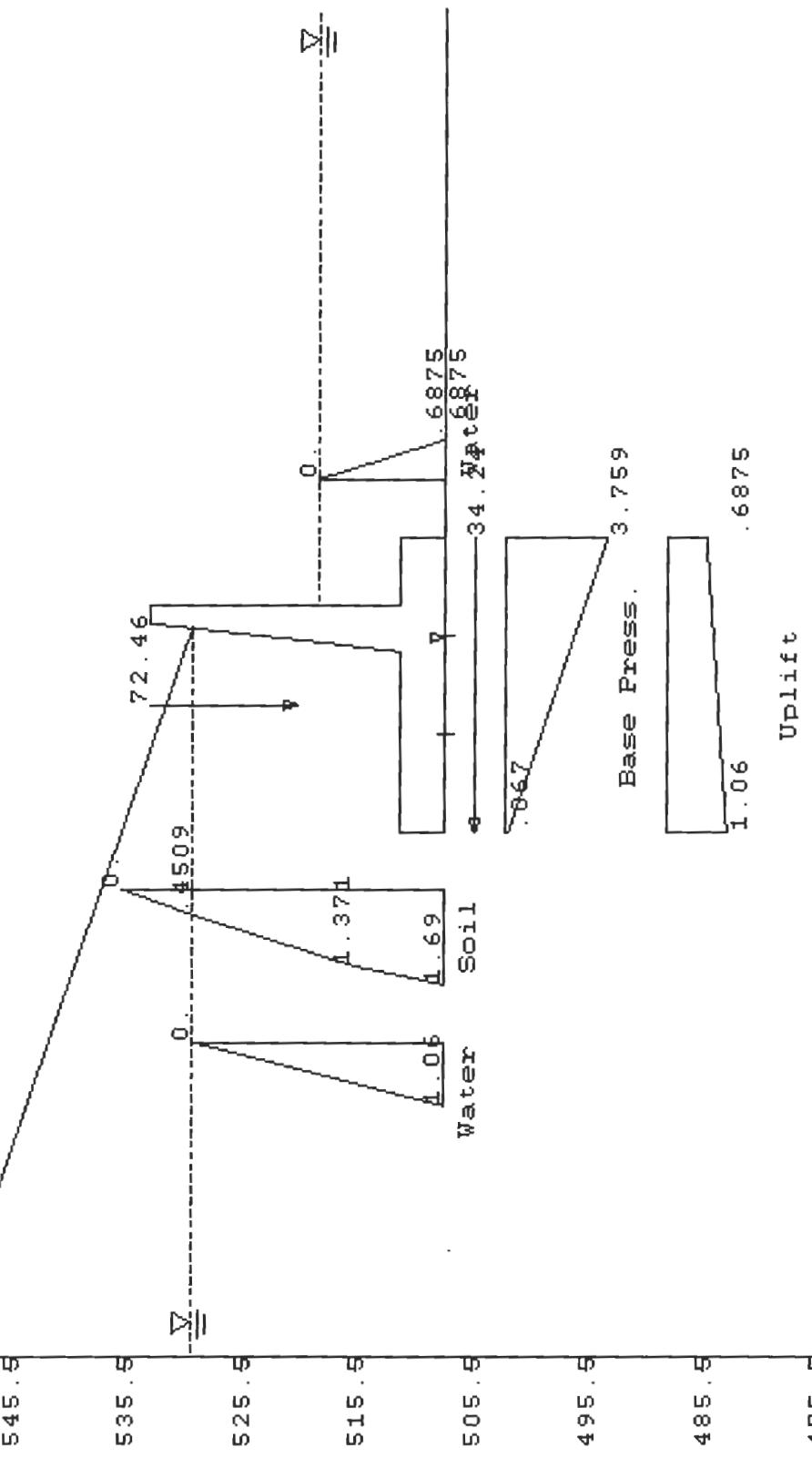
515.5

505.5

495.5

485.5

475.5



\*\*\*\*\* Echoprint of Input Data \*\*\*\*\*

Date: \*\*/01/17

Time: 10.57.07

Flood Wall Stability Analysis Using CTWALL  
Filename: I1FSPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

Structural geometry data:

Elevation of top of stem (ELTS)	=	533.50 ft
Height of stem (HTS)	=	21.50 ft
Thickness top of stem (TTS)	=	1.50 ft
Thickness bottom of stem (TBS)	=	4.00 ft
Dist. of batter at bot. of stem (TBSR)	=	.00 ft
Depth of heel (THEEL)	=	4.00 ft
Distance of batter for heel (BTRH)	=	.00 ft
Depth of toe (TTOE)	=	4.00 ft
Width of toe (TWIDTH)	=	6.00 ft
Distance of batter for toe (BTRT)	=	.00 ft
Width of base (BWIDTH)	=	26.00 ft
Depth of key (HK)	=	.00 ft
Width of bottom of key (TK)	=	.00 ft
Dist. of batter at bot. of key (BTRK)	=	.00 ft

Structure coordinates:

x (ft)	y (ft)
.00	508.00
.00	512.00
16.00	512.00
18.50	533.50
20.00	533.50
20.00	512.00
26.00	512.00
26.00	508.00

NOTE: X=0 is located at the left-hand side  
of the structure. The Y values correspond  
to the actual elevation used.

Structural property data:

Unit weight of concrete = .150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
.00	1.000	.100	.130	.00	530.01

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	4.00	50.00
2	.00	50.00
3	.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1081.91	546.68
2	-31.91	546.68
3	18.09	530.01

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
.00	1.000	.100	.130	508.00	.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	26.00	508.00
2	526.00	508.00

Foundation property data:

phi for soil-structure interface =	.00	(deg)
c for soil-structure interface =	1.000	(ksf)
phi for soil-soil interface =	.00	(deg)
c for soil-soil interface =	1.000	(ksf)

Water data:

Driving side elevation =	530.00	ft
Resisting side elevation =	519.00	ft
Unit weight of water =	.0625	kcf
Seepage pressures computed by Line of Creep method.		

Minimum required factors of safety:

Sliding FS = 1.50

Overspinning = 100.00% base in compression

Crack options:

- o Crack \*is\* down to bottom of heel
- o Computed cracks \*will\* be filled with water

Strength mobilization factor = .6667

50% of full passive \*is used\* in the overspinning analysis.

Forces on the resisting side \*are used\* in the sliding analysis.

\*Do\* iterate in overspinning analysis.

\*\*\*\*\* Summary of Results \*\*\*\*\*

Flood Wall Stability Analysis Using CTWALL

Project name: TRWD-FWCC

\*\*\*\*\*                    \*\*\* Satisfied \*\*\*  
\* Overturning \*       Required base in comp. = 100.00 %  
\*\*\*\*\*                    Actual base in comp. = 100.00 %  
                         Overturning ratio = 2.27

Xr (measured from toe) = 11.12 ft  
Resultant ratio = .4276  
Stem ratio = .2308  
Base pressure at heel = 1.1996 ksf  
Base pressure at toe = 3.0423 ksf

\*\*\*\*\*                    \*\*\* Not Satisfied \*\*\*  
\* Sliding \*       Min. Required = 1.50  
\*\*\*\*\*                    Actual FS = 1.25

To increase stability try one or a combination  
of the following:

1. Increase the base width
2. Slope the base of the structure
3. Lower the wall base
4. Add a key

\*\*\*\*\* Output Results \*\*\*\*\*

Date: \*\*/01/17

Time: 10.57.07

Flood Wall Stability Analysis Using CTWALL  
Filename: I1FSPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

\*\*\*\*\*

\*\* Overturning Results \*\*

\*\*\*\*\*

Solution converged in 1 iterations.

SMF used to calculate K's = .6667

Alpha for the SMF = -30.8493

Calculated earth pressure coefficients:

Driving side at rest K = 1.0000

Driving side at rest Kc = 2.5701

Resisting side at rest K = .0000

Resisting side at rest Kc = .0000

Full passive K calculated for resisting side.

50% of full passive will be used.

Depth of cracking = 28.04 ft

Crack extends to bottom of base of structure.

\*\* Driving side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
=====	
536.04	.0000
520.90	.9465
508.00	1.0218

Earth pressures:

Elevation (ft)	Pressure (ksf)
=====	
536.04	.0000
520.90	.0000
508.00	.3283

\*\* Resisting side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
<hr/>	
519.00	.0000
508.00	.6875
508.00	.3099

\*\* Uplift pressures \*\*

Water pressures:

x-coord. (ft)	Pressure (ksf)
<hr/>	
.00	1.0218
26.00	.3099

\*\* Forces and moments \*\*

Part	Force (kips)		Mom. Arm (ft)	Moment (ft-k)
	Vert.	Horiz.		
<hr/>				
Structure:				
Structure weight.....	24.469		-11.00	-269.05
Structure, driving side:				
Moist soil.....	5.475		-19.96	-109.27
Saturated soil.....	39.889		-17.47	-696.70
Water above structure.....	.000		.00	.00
Water above soil.....	.000		.00	.00
External vertical loads....	.000		.00	.00
Ext. horz. pressure loads..		.000	.00	.00
Ext. horz. line loads.....		.000	.00	.00
Structure, resisting side:				
Moist soil.....	.000		.00	.00
Saturated soil.....	.000		.00	.00
Water above structure.....	.000		.00	.00
Water above soil.....	2.625		-3.00	-7.88
Driving side:				
Effective earth loads.....		2.117	4.30	9.10
Shear (due to delta).....	.000		.00	.00
Horiz. surcharge effects...		.000	.00	.00
Water loads.....		19.860	10.54	209.41
Resisting side:				
Effective earth loads.....		.000	.00	.00
Water loads.....		-3.781	3.67	-13.87
Foundation:				
Vertical force on base....	-55.145		-11.12	613.08
Shear on base.....		-18.196	.00	.00
Uplift.....	-17.313		-15.32	265.17
<hr/>				
** Statics Check **	SUMS =	.000	.000	.00

Angle of base = .00 degrees  
Normal force on base = 55.145 kips  
Shear force on base = 18.196 kips  
Max. available shear force = 26.000 kips

Base pressure at heel = 1.1996 ksf  
Base pressure at toe = 3.0423 ksf

Xr (measured from toe) = 11.12 ft  
Resultant ratio = .4276  
Stem ratio = .2308  
Base in compression = 100.00 %  
Overturning ratio = 2.27

Volume of concrete = 6.04 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

```
*****
** Sliding Results **
*****
```

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	.000
2	20.791	2.625
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	.0000		
2			.0000	1.3750
2			26.0000	.3099
3	.0000	.0000		

Points of sliding plane:

Point 1 (left), x = .00 ft, y = 508.00 ft  
 Point 2 (right), x = 26.00 ft, y = 508.00 ft

Depth of cracking = 28.04 ft

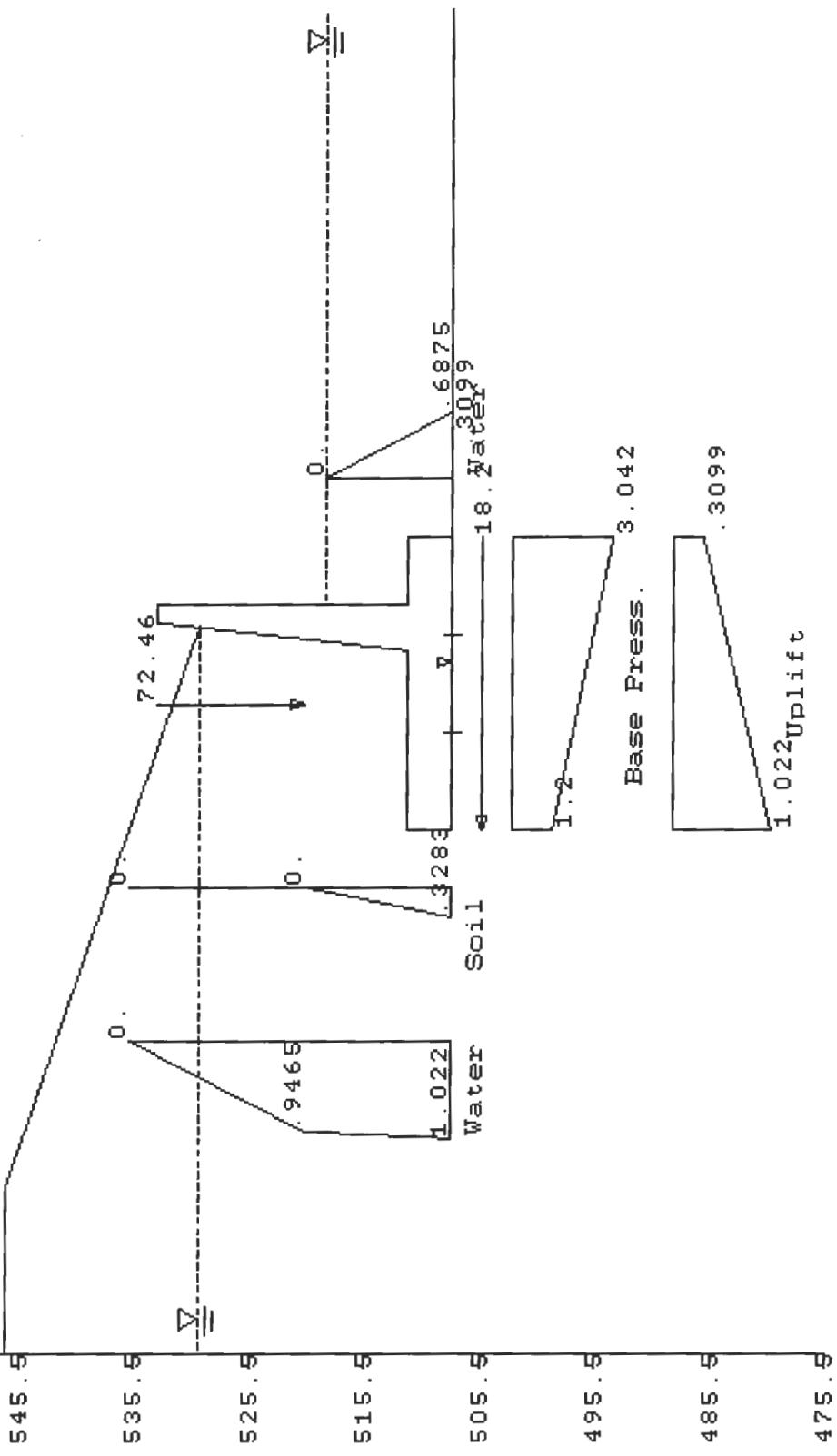
Crack extends to bottom of base of structure.

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	.000	.000	.000	.000	.000
2	.000	26.000	69.832	26.000	21.904
3	.000	.000	.000	.000	.000

Wedge number	Net force (kips)
1	.000
2	.000
3	.000
SUM =	.000

```
+-----+
| Factor of safety = 1.251 |
+-----+
```

Flood Wall Stability Analysis Using CTWALL  
TRWD-FWCC



CLIENT TRWD  
 PROJECT FWCC  
 DETAIL TRAINING WALLS - SEISMIC

JOB NO. 42275  
 DATE CHECKED \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_

COMPUTED BY WLT  
 DATE 1-7-05  
 PAGE NO. \_\_\_\_\_

SEISMIC ANALYSIS

$$\text{USE } K_h = 0.05g$$

$$\Psi = \tan^{-1}(K_h) = 2.86$$

$$K_V = \gamma = \theta = 0^\circ$$

$$\beta = \tan^{-1}\left(\frac{1}{3}\right) = 18.4^\circ$$

$$K_{AE} = \frac{\cos^2(24.85^\circ - 2.86)}{(\cos 2.86)^2 \left[ 1 + \sqrt{\frac{\sin(24.85)(\sin(24.85 - 2.86 - 18.4))}{\cos(18.4)(\cos 2.86)}} \right]^2}$$

$$= \frac{0.860}{0.998 [1.167]^2} = 0.633$$
[3-45]

STATIC:

$$K_A = \frac{\cos^2(24.85)}{\left[ 1 + \sqrt{\frac{\sin(24.85)\sin(24.85 - 18.4)}{\cos(18.4)}} \right]^2}$$

$$= \frac{0.823}{[1.223]^2} = 0.550$$
[3-14]

$$\Delta K_{AE} = 0.633 - 0.550 = 0.083$$

where

$$K_A = \frac{\sin^2(\theta + \phi) \cos \delta}{\sin \theta \sin(\theta - \delta) \left[ 1 + \sqrt{\frac{\sin(\phi + \delta) \sin(\phi - \beta)}{\sin(\theta - \delta) \sin(\theta + \beta)}} \right]^2} \quad [3-12]$$

Examples 1 and 2 in Appendix M and the examples in Appendix N demonstrate the use of Equation 3-12.

(2) When wall friction is neglected ( $\delta = 0$ ), Equation 3-12 reduces to:

$$K_A = \frac{\sin^2(\theta + \phi)}{\sin^2 \theta \left[ 1 + \sqrt{\frac{\sin \phi \sin(\phi - \beta)}{\sin \theta \sin(\theta + \beta)}} \right]^2} \quad [3-13]$$

(3) For the case of no wall friction ( $\delta = 0$ ) and a vertical wall ( $\theta = 90$  degrees),

$$K_A = \frac{\cos^2 \phi}{\left[ 1 + \sqrt{\frac{\sin \phi \sin(\phi - \beta)}{\cos \beta}} \right]^2} \quad [3-14]$$

(4) For the special case of no wall friction, horizontal backfill surface, and a vertical wall, Coulomb's equation for  $K_A$  reduces to:

$$K_A = \frac{1 - \sin \phi}{1 + \sin \phi} = \tan^2 \left( 45^\circ - \frac{\phi}{2} \right) \quad [3-15]$$

which is identical to Rankine's equation for this special case.

(5) As stated in paragraph 3-11c and demonstrated in Figure 3-6 and Appendix E, a developed  $\phi$  angle computed by Equation 3-10 using an SMF of 2/3 can be used in Coulomb's equation to compute an earth pressure coefficient close to that given by the Jaky or Danish Code equations.

For driving (active) wedges (Figure 3-34a),

$$P_{AE} = \frac{1}{2} K_{AE} \gamma (1 - k_v) h^2 \quad [3-44]$$

$$K_{AE} = \frac{\cos^2(\phi - \psi - \theta)}{\cos \psi \cos^2 \theta \cos(\psi + \theta + \delta) \left[ 1 + \sqrt{\frac{\sin(\phi + \delta) \sin(\phi - \psi - \beta)}{\cos(\beta - \theta) \cos(\psi + \theta + \delta)}} \right]^2} \quad [3-45]$$

For resisting (passive) wedges (Figure 3-34b),

$$P_{PE} = \frac{1}{2} K_{PE} \gamma (1 - k_v) h^2 \quad \text{Handwritten note: } h \text{ is height of wall} \quad [3-46]$$

$$K_{PE} = \frac{\cos^2(\phi - \psi + \theta)}{\cos \psi \cos^2 \theta \cos(\psi - \theta + \delta) \left[ 1 - \sqrt{\frac{\sin(\phi - \delta) \sin(\phi - \psi + \beta)}{\cos(\beta - \theta) \cos(\psi - \theta + \delta)}} \right]^2} \quad [3-47]$$

$P_{AE}$  and  $P_{PE}$  are the combined static and dynamic forces due to the driving and resisting wedges, respectively. The equations are subject to the same limitations that are applicable to Coulomb's equations. Definitions of terms are as follows:

$\gamma$  = unit weight of soil

$k_v$  = vertical acceleration in g's

$h$  = height of wall

$\phi$  = internal friction angle of soil

$\psi = \tan^{-1} \left( \frac{k_h}{1 - k_v} \right)$  = seismic inertia angle

$k_h$  = horizontal acceleration in g's

$\theta$  = inclination of wall with respect to vertical (this definition of  $\theta$  is different from  $\theta$  in Coulomb's equations)

$\delta$  = wall friction angle

$\beta$  = inclination of soil surface (upward slopes away from the wall are positive)

**CDM**

CLIENT TRWD  
 PROJECT FWCC  
 DETAIL TRAINING WALLS - SEISMIC

JOB NO. 42275  
 DATE CHECKED \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_

COMPUTED BY Yet  
 DATE 1-7-05  
 PAGE NO. \_\_\_\_\_

## SEISMIC ANALYSIS:

CASE I 3 ELPILE.DAT

$$\text{INERTIA OF CONC WALL PLUS SOIL ABOVE HEEL} = K_h W$$

$$W = 24.469 + (5.475 + 39.889) = 69.83^k$$

$$I_{cs} = 0.05(69.83) = 3.49^k$$

$$P_{AE} = P_A + P_{ws} + \Delta P_{AE}$$

$$= \frac{1}{2} K_A \gamma_b h^2 + \frac{1}{2} \gamma_w h^2 + \frac{1}{2} \Delta K_{AE} \gamma h^2$$

$$= \frac{1}{2}(0.550)\left(\frac{130-62.5}{1000}\right)(25.5)^2 + \frac{1}{2}(0.0625)(25.5)^2$$

$$+ \frac{1}{2}(0.083)(0.130)(25.5)^2$$

$$= \frac{12.07}{P_A} + \frac{20.32}{P_{ws}} + \frac{3.51}{\Delta P_{AE}} = 35.9^k$$

DRIVING WEDGE NET FORCE From CT WALL (F.S. = 1.10):  $32.529^k$

NET ADDL FORCE =  $35.9 + 3.49 - 32.53 = 6.86^k$

$$P_A + P_{ws} = 12.07 + 20.32 = 32.39^k \quad \Delta P_{AE} = 3.51^k$$

TOTAL SEISMIC MOMENT:

$$M_s = (32.39^k)\left(\frac{25.5}{2}\right) + (3.51^k)(0.67 \times 25.5') + (3.49^k)\left(\frac{25.5}{2}'\right)$$

$$= 379.8^k$$

$$\Delta M = 379.8 - \underbrace{(250.55 + 97.73)}_{\text{FROM CT-WALL}} = 31.52^k$$

$$h_e = \frac{31.52^k}{3.51^k} = 9.0'$$

$\therefore$  APPLY  $3.51^k @ 9.0'$  ABOVE BASE = EL 517.0'

CONCLUSION: SEISMIC DRIVING FORCE < MAX. STATIC LATERAL FORCE

= SEISMIC DOES NOT CONTROL

## Water pressures:

Elevation (ft)	Pressure (ksf)
<hr/>	
524.30	.0000
508.00	1.0187
508.00	1.0187

CT WALL - I3E PILE.DAT  
w/o ADDED SURCHARGE LINE LOAD

## \*\* Uplift pressures \*\*

## Water pressures:

x-coord. (ft)	Pressure (ksf)
<hr/>	
.00	1.2117
26.00	1.0187

## \*\* Forces and moments \*\*

Part	Force (kips)		Mom. Arm (ft)	Moment (ft-k)
	Vert.	Horiz.		
<hr/>				
Structure:				
Structure weight.....	<u>24.469</u>		-11.00	-269.05
Structure, driving side:				
Moist soil.....	<u>5.475</u>		-19.96	-109.27
Saturated soil.....	<u>39.889</u>		-17.47	-696.70
Water above structure.....	.000		.00	.00
Water above soil.....	.000		.00	.00
External vertical loads....	.000		.00	.00
Ext. horz. pressure loads..		.000	.00	.00
Ext. horz. line loads.....		.000	.00	.00
Structure, resisting side:				
Moist soil.....	.000		.00	.00
Saturated soil.....	.000		.00	.00
Water above structure.....	.000		.00	.00
Water above soil.....	<u>4.612</u>		-3.00	-13.84
Driving side:				
Effective earth loads.....		<u>25.552</u>	9.81	<u>250.55</u>
Shear (due to delta).....	.000		.00	.00
Horiz. surcharge effects...		.000	.00	.00
Water loads.....		<u>13.329</u>	7.33	<u>97.73</u>
Resisting side:				
Effective earth loads.....		.000	.00	.00
Water loads.....		<u>-8.303</u>	5.43	-45.12
Foundation:				
Vertical force on base.....	<u>-45.449</u>		-8.75	397.88
Shear on base.....		<u>-30.578</u>	.00	.00
Uplift.....	<u>-28.996</u>		-13.37	387.82
<hr/>				
** Statics Check **	SUMS =	.000	.000	.00

\*\*\*\*\*
\*\* Sliding Results \*\*
\*\*\*\*\*

Stationary solution. Static sum of forces.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	.000
2	-8.303	4.612
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	1.2117		
2			.0000	1.2117
2			26.0000	1.0187
3	.0000	.0000		

Points of sliding plane:

Point 1 (left), x = .00 ft, y = 508.00 ft  
 Point 2 (right), x = 26.00 ft, y = 508.00 ft

Depth of cracking = .00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-47.996	52.048	56.926	29.606	17.937
2	.000	26.000	69.832	26.000	28.996
3	.000	.000	.000	.000	.000

Wedge number	Net force (kips)
1	<u>-32.529</u>
2	31.719
3	.000

SUM = -.811

NOTE: Forces are calculated for the FS specified below.

Factor of safety = 1.100
--------------------------

\*\*\*\*\* Echoprint of Input Data \*\*\*\*\*

Date: \*\*/01/07

Time: 11.51.38

Flood Wall Stability Analysis Using CTWALL  
Filename: I3ELPILE.DAT

*w/ seismic surcharge line load*

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

Structural geometry data:

Elevation of top of stem (ELTS)	=	533.50 ft
Height of stem (HTS)	=	21.50 ft
Thickness top of stem (TTS)	=	1.50 ft
Thickness bottom of stem (TBS)	=	4.00 ft
Dist. of batter at bot. of stem (TBSR)	=	.00 ft
Depth of heel (THEEL)	=	4.00 ft
Distance of batter for heel (BTRH)	=	.00 ft
Depth of toe (TTOE)	=	4.00 ft
Width of toe (TWIDTH)	=	6.00 ft
Distance of batter for toe (BTRT)	=	.00 ft
Width of base (BWIDTH)	=	26.00 ft
Depth of key (HK)	=	.00 ft
Width of bottom of key (TK)	=	.00 ft
Dist. of batter at bot. of key (BTRK)	=	.00 ft

Structure coordinates:

x (ft)	y (ft)
.00	508.00
.00	512.00
16.00	512.00
18.50	533.50
20.00	533.50
20.00	512.00
26.00	512.00
26.00	508.00

NOTE: X=0 is located at the left-hand side  
of the structure. The Y values correspond  
to the actual elevation used.

Structural property data:

Unit weight of concrete = .150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
27.00	.000	.100	.130	.00	530.01

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	4.00	50.00
2	.00	50.00
3	.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1081.91	546.68
2	-31.91	546.68
3	18.09	530.01

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
27.00	.000	.100	.130	508.00	.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	26.00	508.00
2	526.00	508.00

Foundation property data:

phi for soil-structure interface	=	27.00 (deg)
c for soil-structure interface	=	.100 (ksf)
phi for soil-soil interface	=	27.00 (deg)
c for soil-scil interface	=	.100 (ksf)

Water data:

Driving side elevation	=	530.00 ft
Resisting side elevation	=	524.30 ft
Unit weight of water	=	.0625 kcf
Seepage pressures computed by Line of Creep method.		

Horizontal line load data:

Elevation (ft)	Force (kips)
517.00	3.51

Minimum required factors of safety:

Sliding FS = 1.10  
Overturning = .10% base in compression

Crack options:

- o Crack depth is to be calculated
- o Computed cracks \*will\* be filled with water

Strength mobilization factor = .6667

50% of full passive \*is used\* in the overturning analysis.

Forces on the resisting side \*are used\* in the sliding analysis.

\*Do\* iterate in overturning analysis.

Forces for sliding are calculated for the REQUIRED FS.

\*\*\*\*\* Summary of Results \*\*\*\*\*

Flood Wall Stability Analysis Using CTWALL

Project name: TRWD-FWCC

\*\*\*\*\* Satisfied \*\*\*  
\* Overturning \*      Required base in comp. =    .10 %  
\*\*\*\*\*                 Actual base in comp. = 80.66 %  
                       Overturning ratio = 1.35

Xr (measured from toe) = 6.99 ft  
Resultant ratio = .2689  
Stem ratio = .2308  
Base pressure at x= 20.97 ft from toe = .0000 ksf  
Base pressure at toe = 4.0466 ksf

\*\*\* Warning \*\*\* The maximum available shear along the base of the structure has been exceeded!

\*\*\*\*\* Satisfied \*\*\*  
\* Sliding \*      Min. Required = 1.10  
\*\*\*\*\*                 Actual FS = 1.10

\*\*\*\*\* Output Results \*\*\*\*\*

Date: \*\*/01/07

Time: 11.51.38

Flood Wall Stability Analysis Using CTWALL  
Filename: I3ELPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

\*\*\*\*\*

\*\* Overturning Results \*\*

\*\*\*\*\*

Solution converged in 5 iterations.

SMF used to calculate K's = .6667

Alpha for the SMF = -43.5082

Calculated earth pressure coefficients:

Driving side at rest K = .4856

Driving side at rest Kc = 1.1670

Resisting side at rest K = .0000

Resisting side at rest Kc = .0000

Full passive K calculated for resisting side.

50% of full passive will be used.

Depth of cracking = .00 ft

\*\* Driving side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
530.00	.0000
508.00	1.3750

Earth pressures:

Elevation (ft)	Pressure (ksf)
536.04	.0000
530.00	.4521
516.39	1.3464
508.00	1.6773

\*\* Resisting side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
<hr/>	
524.30	.0000
508.00	1.0187
508.00	1.0187

\*\* Uplift pressures \*\*

Water pressures:

x-coord. (ft)	Pressure (ksf)
<hr/>	
.00	1.3750
5.03	1.3750
26.00	1.0187

\*\* Forces and moments \*\*

Part	Force (kips)		Mom. Arm (ft)	Moment (ft-k)		
	Vert.	Horiz.				
<hr/>						
Structure:						
Structure weight.....	24.469		-11.00	-269.05		
Structure, driving side:						
Moist soil.....	5.475		-19.96	-109.27		
Saturated soil.....	39.889		-17.47	-696.70		
Water above structure....	.000		.00	.00		
Water above soil.....	.000		.00	.00		
External vertical loads....	.000		.00	.00		
Ext. horz. pressure loads..		.000	.00	.00		
Ext. horz. line loads.....		3.510	9.00	31.59		
Structure, resisting side:						
Moist soil.....	.000		.00	.00		
Saturated soil.....	.000		.00	.00		
Water above structure....	.000		.00	.00		
Water above soil.....	4.612		-3.00	-13.84		
Driving side:						
Effective earth loads.....		26.290	9.75	256.22		
Shear (due to delta).....	.000		.00	.00		
Horiz. surcharge effects...		.000	.00	.00		
Water loads.....		15.125	7.33	110.92		
Resisting side:						
Effective earth loads.....		.000	.00	.00		
Water loads.....		-8.303	5.43	-45.12		
Foundation:						
Vertical force on base....	-42.431		-6.99	296.61		
Shear on base.....		-36.622	.00	.00		
Uplift.....	-32.014		-13.70	438.63		
<hr/>						
** Statics Check **	SUMS =	.000	.000	.00		

Angle of base = .00 degrees  
Normal force on base = 42.431 kips  
Shear force on base = 36.622 kips  
Max. available shear force = 23.717 kips

\*\*\* Warning \*\*\* The maximum available shear along the base of the structure has been exceeded!

Base pressure at x= 20.97 ft from toe = .0000 ksf  
Base pressure at toe = 4.0466 ksf

Xr (measured from toe) = 6.99 ft  
Resultant ratio = .2689  
Stem ratio = .2308  
Base in compression = 80.66 %  
Overturning ratio = 1.35

Volume of concrete = 6.04 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR.  
Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

\*\*\*\*\*
\*\* Sliding Results \*\*
\*\*\*\*\*

Stationary solution. Static sum of forces.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	.000
2	-4.793	4.612
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	1.3750		
2			.0000	1.3750
2			5.0264	1.3750
2			26.0000	1.0187
3	.0000	.0000		

Points of sliding plane:

Point 1 (left), x = .00 ft, y = 508.00 ft  
 Point 2 (right), x = 26.00 ft, y = 508.00 ft

Depth of cracking = .00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-47.777	52.228	57.497	29.708	20.425
2	.000	26.000	69.832	26.000	32.014
3	.000	.000	.000	.000	.000

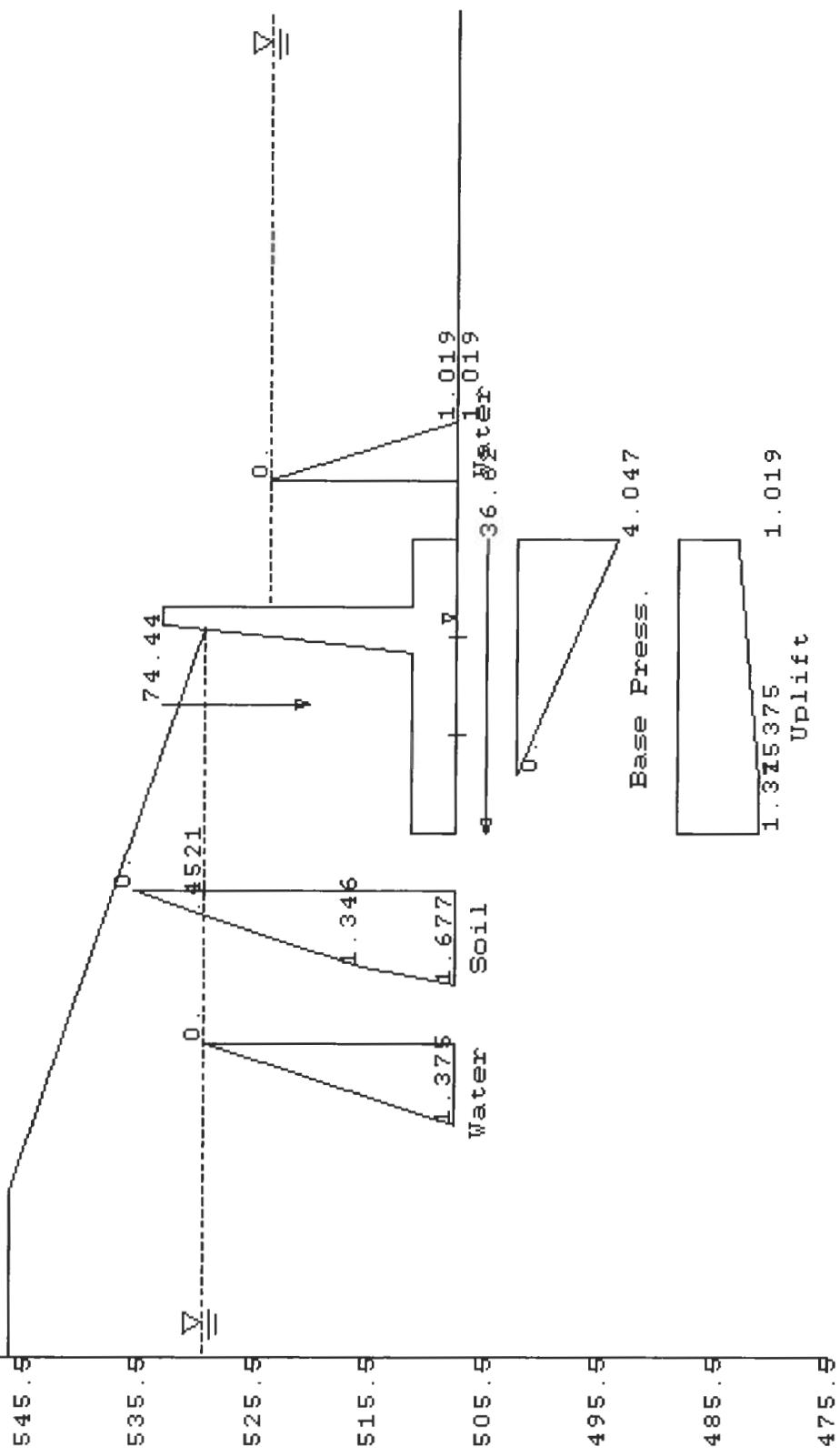
Wedge number	Net force (kips)
--------------	------------------

1	-33.635	→ DRIVING FORCE < 37.6 % PER STATIC ANALYSES
2	26.353	∴ SEISMIC DOES NOT
3	.000	CONTROL
SUM = -7.282		

NOTE: Forces are calculated for the FS specified below.

Factor of safety = 1.100
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Flood Wall Stability Analysis Using CTWALL  
TRWD-FWCC



CLIENT TRWD  
PROJECT FWCC  
DETAIL TRAINING WALLS - SEISMIC

JOB NO. 42275  
DATE CHECKED \_\_\_\_\_  
CHECKED BY \_\_\_\_\_

COMPUTED BY NCB  
DATE 1-7-05  
PAGE NO. \_\_\_\_\_

CASE I3ESPILE.DAT

- FULL CRACK TO BASE OF FOOTING
- SO NEGLECT "DYNAMIC EARTH PRESSURE" & JUST INCLUDE LATERAL INERTIA OF WALL + SOIL ABOVE PTG

$$W = 24,469 + (5,475 + 39,889) = 69,83^k$$

$$I_{cs} = 0.05(69.83) = 3.49^k$$

$$\rightarrow \text{APPLY AT } \frac{25.50'}{2} = 12.75', \text{ SAY } 13.0' \text{ ABOVE BASE}$$

$\rightarrow \text{EL } 521.0$

CONCLUSION = THIS CASE DOES NOT CONTROL DESIGN

Water pressures:

Elevation (ft)	Pressure (ksf)
<hr/>	
524.30	.0000
508.00	1.0187
508.00	.6412

CT WALL : I3ESPIL.E.DAT

w/o ADDED SURCHARGE LINE LOAD

\*\* Uplift pressures \*\*

Water pressures:

x-coord. (ft)	Pressure (ksf)
<hr/>	
.00	1.1317
26.00	.6412

\*\* Forces and moments \*\*

Part	Force (kips)		Mom. Arm (ft)	Moment (ft-k)
	Vert.	Horiz.		
<hr/>				
Structure:				
Structure weight.....	<u>24.469</u>		-11.00	-269.05
Structure, driving side:				
Moist soil.....	<u>5.475</u>		-19.96	-109.27
Saturated soil.....	<u>39.889</u>		-17.47	-696.70
Water above structure.....	<u>.000</u>		.00	.00
Water above soil.....	<u>.000</u>		.00	.00
External vertical loads....	<u>.000</u>		.00	.00
Ext. horz. pressure loads..		<u>.000</u>	.00	.00
Ext. horz. line loads.....		<u>.000</u>	.00	.00
Structure, resisting side:				
Moist soil.....	<u>.000</u>		.00	.00
Saturated soil.....	<u>.000</u>		.00	.00
Water above structure.....	<u>.000</u>		.00	.00
Water above soil.....	<u>4.612</u>		-3.00	-13.84
Driving side:				
Effective earth loads.....		<u>.909</u>	<u>4.30</u>	<u>3.91</u>
Shear (due to delta).....	<u>.000</u>		.00	.00
Horiz. surcharge effects...		<u>.000</u>	.00	.00
Water loads.....		<u>20.568</u>	<u>10.33</u>	<u>212.47</u>
Resisting side:				
Effective earth loads.....		<u>.000</u>	.00	.00
Water loads.....		<u>-8.303</u>	<u>5.43</u>	<u>-45.11</u>
Foundation:				
Vertical force on base....	<u>-51.398</u>		-11.49	590.35
Shear on base.....		<u>-13.175</u>	.00	.00
Uplift.....	<u>-23.047</u>		-14.20	327.24
<hr/>				
** Statics Check **	SUMS =	<u>.000</u>	<u>.000</u>	<u>.00</u>

\*\*\*\*\*
\*\* Sliding Results \*\*
\*\*\*\*\*

Stationary solution. Static sum of forces.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	.000
2	16.270	4.612
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	.0000		
2			.0000	1.3750
2			26.0000	.6412
3	.0000	.0000		

Points of sliding plane:

Point 1 (left), x = .00 ft, y = 508.00 ft  
 Point 2 (right), x = 26.00 ft, y = 508.00 ft

Depth of cracking = 28.04 ft

Crack extends to bottom of base of structure.

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	.000	.000	.000	.000	.000
2	.000	26.000	69.832	26.000	26.210
3	.000	.000	.000	.000	.000

Wedge number	Net force (kips)
1	.000
2	7.367
3	.000
SUM =	7.367

NOTE: Forces are calculated for the FS specified below.

Factor of safety = 1.100
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\*\*\*\*\* Echoprint of Input Data \*\*\*\*\*

Date: \*\*/01/07

Time: 13.05.06

Flood Wall Stability Analysis Using CTWALL

Filename: I3ESPILE.DAT

*w/ SEISMIC SURCHARGE LINE  
LOAD ADDED*

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

Structural geometry data:

Elevation of top of stem (ELTS)	=	533.50 ft
Height of stem (HTS)	=	21.50 ft
Thickness top of stem (TTS)	=	1.50 ft
Thickness bottom of stem (TBS)	=	4.00 ft
Dist. of batter at bot. of stem (TBSR)	=	.00 ft
Depth of heel (THEEL)	=	4.00 ft
Distance of batter for heel (BTRH)	=	.00 ft
Depth of toe (TTOE)	=	4.00 ft
Width of toe (TWIDTH)	=	6.00 ft
Distance of batter for toe (BTRT)	=	.00 ft
Width of base (BWIDTH)	=	26.00 ft
Depth of key (HK)	=	.00 ft
Width of bottom of key (TK)	=	.00 ft
Dist. of batter at bot. of key (BTRK)	=	.00 ft

Structure coordinates:

x (ft)	y (ft)
.00	508.00
.00	512.00
16.00	512.00
18.50	533.50
20.00	533.50
20.00	512.00
26.00	512.00
26.00	508.00

NOTE: X=0 is located at the left-hand side  
of the structure. The Y values correspond  
to the actual elevation used.

Structural property data:

Unit weight of concrete = .150 kcf

Driving side soil property data:

Phi (deg)	C (ksf)	Unit wt. (kcf)	Moist unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
.00	1.000	.100	.130	.00	530.01	

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	4.00	50.00
2	.00	50.00
3	.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1081.91	546.68
2	-31.91	546.68
3	18.09	530.01

Resisting side soil property data:

Phi (deg)	C (ksf)	Unit wt. (kcf)	Moist unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
.00	1.000	.100	.130	508.00	.00	

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	26.00	508.00
2	526.00	508.00

Foundation property data:

phi for soil-structure interface =	.00 (deg)
c for soil-structure interface =	1.000 (ksf)
phi for soil-soil interface =	.00 (deg)
c for soil-soil interface =	1.000 (ksf)

Water data:

Driving side elevation =	530.00 ft
Resisting side elevation =	524.30 ft
Unit weight of water =	.0625 kcf
Seepage pressures computed by Line of Creep method.	

Horizontal line load data:

Elevation (ft)	Force (kips)
521.00	3.49

Minimum required factors of safety:

Sliding FS = 1.10  
Overturning = .10% base in compression

Crack options:

- o Crack \*is\* down to bottom of heel
- o Computed cracks \*will\* be filled with water

Strength mobilization factor = .6667

50% of full passive \*is used\* in the overturning analysis.

Forces on the resisting side \*are used\* in the sliding analysis.

\*Do\* iterate in overturning analysis.

Forces for sliding are calculated for the REQUIRED FS.

\*\*\*\*\* Summary of Results \*\*\*\*\*

Flood Wall Stability Analysis Using CTWALL

Project name: TRWD-FWCC

\*\*\*\*\* Satisfied \*\*\*  
\* Overturning \*      Required base in comp. = .10 %  
\*\*\*\*\* Actual base in comp. = 100.00 %  
                      Overturning ratio = 1.93

Xr (measured from toe) = 10.60 ft  
Resultant ratio = .4078  
Stem ratio = .2308  
Base pressure at heel = .8834 ksf  
Base pressure at toe = 3.0703 ksf

\*\*\*\*\* Satisfied \*\*\*  
\* Sliding \*      Min. Required = 1.10  
\*\*\*\*\* Actual FS = 1.10

\*\*\*\*\* Output Results \*\*\*\*\*

Date: \*\*/01/07

Time: 13.05.06

Flood Wall Stability Analysis Using CTWALL  
Filename: I3ESPILE.DAT

Company name:

CDM

Project name:

TRWD-FWCC

Project location:

Fort Worth, TX / Tarrant Regional Water District

Wall location:

Training Walls

Computed by: WCS

\*\*\*\*\*

\*\* Overturning Results \*\*

\*\*\*\*\*

Solution converged in 1 iterations.

SMF used to calculate K's = .6667

Alpha for the SMF = -30.8493

Calculated earth pressure coefficients:

Driving side at rest K = 1.0000

Driving side at rest Kc = 2.5701

Resisting side at rest K = .0000

Resisting side at rest Kc = .0000

Full passive K calculated for resisting side.

50% of full passive will be used.

Depth of cracking = 28.04 ft

Crack extends to bottom of base of structure.

\*\* Driving side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
=====	
536.04	.0000
520.90	.9465
508.00	1.1317

Earth pressures:

Elevation (ft)	Pressure (ksf)
=====	
536.04	.0000
520.90	.0000
508.00	.1410

\*\* Resisting side pressures \*\*

Water pressures:

Elevation (ft)	Pressure (ksf)
<hr/>	
524.30	.0000
508.00	1.0187
508.00	.6412

\*\* Uplift pressures \*\*

Water pressures:

x-coord. (ft)	Pressure (ksf)
<hr/>	
.00	1.1317
26.00	.6412

\*\* Forces and moments \*\*

Part	Force (kips)		Mom. Arm	Moment
	Vert.	Horiz.	(ft)	(ft-k)
<hr/>				
Structure:				
Structure weight.....	24.469		-11.00	-269.05
Structure, driving side:				
Moist soil.....	5.475		-19.96	-109.27
Saturated soil.....	39.889		-17.47	-696.70
Water above structure.....	.000		.00	.00
Water above soil.....	.000		.00	.00
External vertical loads....	.000		.00	.00
Ext. horz. pressure loads..		.000	.00	.00
Ext. horz. line loads.....		3.490	13.00	45.37
Structure, resisting side:				
Moist soil.....	.000		.00	.00
Saturated soil.....	.000		.00	.00
Water above structure.....	.000		.00	.00
Water above soil.....	4.612		-3.00	-13.84
Driving side:				
Effective earth loads.....		.909	4.30	3.91
Shear (due to delta).....	.000		.00	.00
Horiz. surcharge effects...		.000	.00	.00
Water loads.....		20.568	10.33	212.47
Resisting side:				
Effective earth loads.....		.000	.00	.00
Water loads.....		-8.303	5.43	-45.11
Foundation:				
Vertical force on base....	-51.398		-10.60	544.98
Shear on base.....		-16.665	.00	.00
Uplift.....	-23.047		-14.20	327.24
<hr/>				
** Statics Check **	SUMS =	.000	.000	.00

-16.665

< 37.6%

∴ DOES NOT CONTROL

Angle of base = .00 degrees  
Normal force on base = 51.398 kips  
Shear force on base = 16.665 kips  
Max. available shear force = 26.000 kips

Base pressure at heel = .8834 ksf  
Base pressure at toe = 3.0703 ksf

Xr (measured from toe) = 10.60 ft  
Resultant ratio = .4078  
Stem ratio = .2308  
Base in compression = 100.00 %  
Overturning ratio = 1.93

Volume of concrete = 6.04 cubic yds/ft of wall

NOTE: The engineer shall verify that the computed bearing pressures below the wall do not exceed the allowable foundation bearing pressure, or, perform a bearing capacity analysis using the program CBEAR. Also, the engineer shall verify that the base pressures do not result in excessive differential settlement of the wall foundation.

\*\*\*\*\*
\*\* Sliding Results \*\*
\*\*\*\*\*

Stationary solution. Static sum of forces.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	.000	.000
2	19.760	4.612
3	.000	.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	.0000	.0000		
2			.0000	1.3750
2			26.0000	.6412
3	.0000	.0000		

Points of sliding plane:

Point 1 (left),	$x = .00$ ft,	$y = 508.00$ ft
Point 2 (right),	$x = 26.00$ ft,	$y = 508.00$ ft

Depth of cracking = 28.04 ft

Crack extends to bottom of base of structure.

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	.000	.000	.000	.000	.000
2	.000	26.000	69.832	26.000	26.210
3	.000	.000	.000	.000	.000

Wedge number	Net force (kips)
1	.000
2	3.877
3	.000
SUM =	3.877

NOTE: Forces are calculated for the FS specified below.

Factor of safety = 1.100
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Flood Wall Stability Analysis Using CTWALL  
TRWD-FWCC

