REV. NO.	DESCRIPTION	DESIGNED	CHECKED	APPROVED
A	For Approval	26.10.16 KRC	26.10.16 RR	26.10.16 BRJ

REVISIONS

LARSEN & TOUBRO LIMITED
CONSTRUCTION DIVISION
Water,Smart World & Communication IC

CLIENT:	CONSULTANT :
TELANGANA DRINKING WATER SUPPLY PROJECT, GOVERNMENT OF TELANGANA	

PROJECT :	**Providing drinking water to habitations in Komarambheem-Asifabad Segment in Adilabad District**
SUPPLIER / CONTRACTOR	**L&T CONSTRUCTION Water & Effluent Treatment SBG**

JOB Ref. No. : LE150883

TITLE :

Design Calculations for Thrust block

	NAME	SIGN	DATE
DSGN	KRC		26.10.16
CHKD	RR		26.10.16
APPD	BRJ		26.10.16

DOC./DRG. No.

LE1508 83-C-WS-CW-DC-3055

SIZE: A4 | REV.: A

RELEASED FOR: ☐ PRELIMINARY ☐ INFORMATION ☑ APPROVAL ☐ CONSTRUCTION

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Water & Effulent Treatment IC

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	PIPE DATA:Design of Thrust Block for 90° Horizontal bend		**(Typical)** DI-K9
1)	Size of pipe =		635 dia pipe
2)	Outer diameter of pipe (D_o) =		635 mm
3)	Inner diameter of pipe (D_i) =		605.2 mm
4)	Thickness of pipe shell (T_1) =		9.9 mm
5)	Thickness of cement concrete lining (T_2) =		5 mm
6)	Operating pressure of the pipe (Po) =		1020.27 kN/m^2
7)	Design pressure acting (Pt) = 1.5xPo =		1530.405 kN/m^2
8)	Angle of bend for the design of thrust block (θ) =		90 deg
9)	Minimum depth of top of pipe below ground (D_s) =		1000 mm
10)	C/S area of pipe for inner dia (A_{pi}) =	3.14/4x605.2² =	287665 mm^2
11)	C/S area of pipe for outer dia (A_{po}) =	3.14/4x635² =	316692 mm^2
12)	Density of Pipe Shell Material γ_{steel} =		78.5 kN/m^3
13)	Density of Cement concrete γ_{con} =		24 kN/m^3
14)	Density of water inside the pipe γ_w =		10 kN/m^3
15)	Weight of Pipe per m run =	3.14x0.6251x0.0099x78.5+	
		3.14x0.6102x0.005x24 =	1.76 kN/m
15)	Weight of water inside pipe per m run = $A_{pi}x\gamma_w$ =	0.287665x10 =	2.88 kN/m
	SOIL DATA:		
	1) Angle of internal friction (ϕ)	=	30 °
	2) Unit weight of soil (γ_s)	=	18 kN/m^3
	3) Submerged Unit weight of soil (γ_s')	=	8 kN/m3
	4) Cu = Cohesion in the soil		0 kN/m^2
	5) Ka = Coefficient of active earth pressure		
	= [1-Sin(ϕ)]/[1+Sin(ϕ)]	= [1-Sin(30)]/[1+Sin(30)] =	0.33
	6) Kp = Coefficient of passive earth pressure		
	= [1+Sin(ϕ)]/[1-Sin(ϕ)]	= [1+Sin(30)]/[1-Sin(30)] =	3.00
	7) Ko = Coefficient of earth pressure at rest condition		
	= [1-Sin(ϕ)]	= (1-Sin(30)) =	0.5

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As per soil report	8) Net safe bearing capacity of soil =	100 kN/m^2
IS 456-2000 Cl.20.2	9) Factor of safety against sliding =	1.4
IS 456-2000 Cl.20.1	10) Factor of safety against overturning =	1.4

Figure showing the plan of Thrust Block:

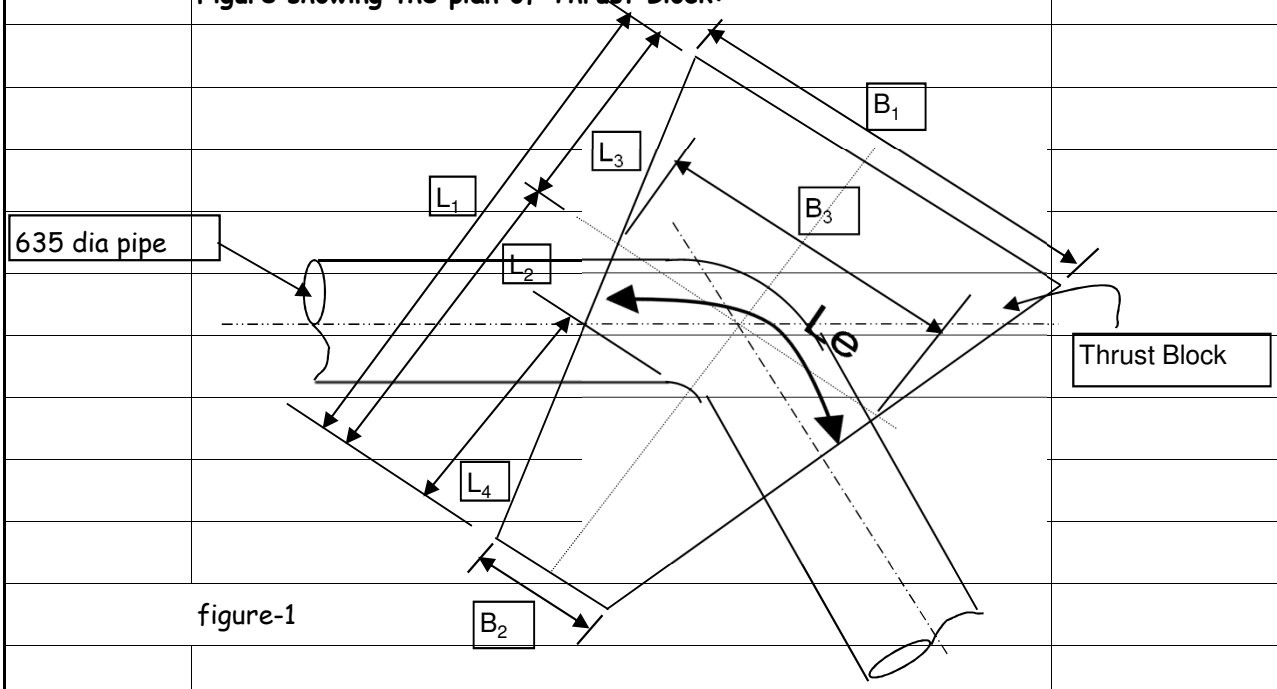

figure-1

Figure showing the elevation of Thrust Block:

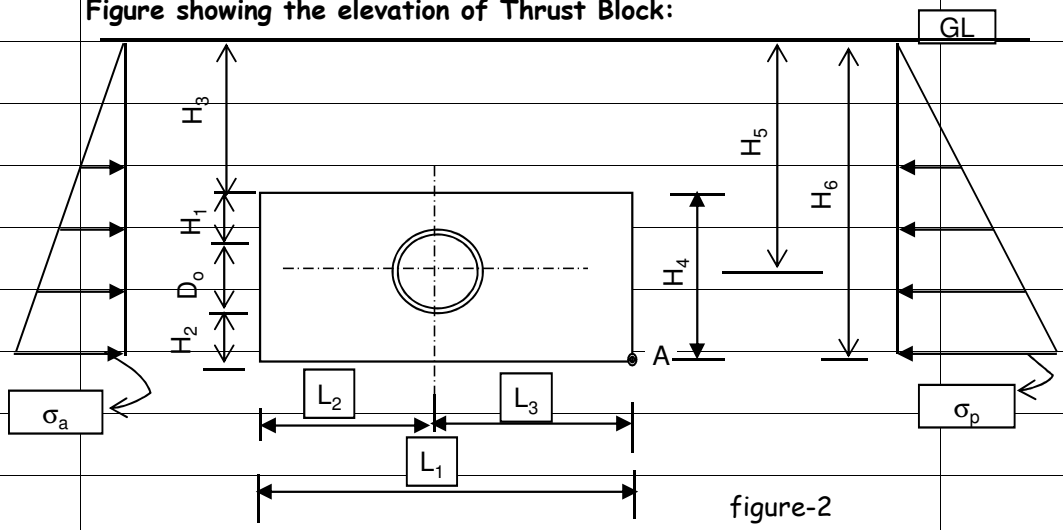

figure-2

Dimensions of thrust block: (refer figure 1 & 2)

1)	Thickness of concrete at the top of the pipe = H_1 =	500 mm

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2)	Thickness of concrete at bottom of the pipe = H_2 =		500 mm
3)	Thickness of concrete at side pipe = L_4 =	2271-635/2=	1954 mm
4)	Width of Thrust Block at thrust face = B_1 =		6000 mm
5)	Width of Thrust Block at other face = B_2 =		1800 mm
6)	Length of Thrust Block L_1 =		3850 mm
7)	Height of soil above the Thrust Block = H_3 =	1000-500 =	500 mm
8)	Height of Thrust Block = $H_4 = H_1+D_o+H_2$ =	500+635+500 =	1635 mm
9)	Height of center of pipe below GL = $H_5 = H_3+H_1+D_o/2$		
	500+500+635/2 =		1317.5 mm
10)	Height of base of TB below GL = $H_6 = H_3+H_4$ =	500+1635 =	2135 mm
11)	Length L_2 (i.e., location of cg of the block) =		2271 mm
12)	Length L_3 (i.e., location of cg of the block) = $L_1 - L_2$ = 3850-2271 =		1579 mm
13)	Width B_3 (i.e., width of block at centre of pipe) =		4278 mm
14)	Length of pipe embeded in concrete = L_e =		
	= $B_3/Cos(\theta/2)$ =		6050 mm
15)	Base area of Thrust Block in contact with soil = A_b =		
	= $(B_1+B_2)/2xL_1$ = (6000+1800)/2x3850 =		15015000 mm^2
16)	Area of thrust face of Thrust Block in contact with soil = A_{f1} =		
	= B_1xH_4 = 6000x1635 =		9810000 mm^2
17)	Area of other face of Thrust Block in contact with soil = A_{f2} =		
	= B_2xH_4 = 1800x1635 =		2943000 mm^2
18)	Total Downward load acting due to thrust Block W_T =		706.39 kN
A)	**<u>Check for factor of safety against sliding</u>**: (refer figure 1 & 2)		
	a) Passive pressure at the top of the block = $P_1 = k_p x \gamma_s x H_3$		
	= 3x18x0.5 =		27 kN/m^2
	Passive pressure at the bottom of the block = $P_2 = k_p x \gamma_s x (H_3+H_4)$		
	= 3x18x(0.5+1.635) =		115.29 kN/m^2
	Passive resistance acting on the Thrust Block =		

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	Rp = $H_4 x B_1 x (P_1+P_2)/2$ = 1.635x6x (27+115.29)/2, =	697.93 kN
	b) Active Pressure acting at the top of the Block = $P_3 = k_a \times \Upsilon_s \times H_3$	
	= 0.33x18x0.5 =	2.97 kN/m^2
	Active pressure at the bottom of the block = $P_4 = k_a x \gamma_s x (H_3+H_4)$	
	= 0.33x18x(0.5+1.635) =	12.68 kN/m^2
	Active resistance acting on the Thrust Block =	
	Ra = $H_4 x B_2 x (P_3+P_4)/2$ = 1.635x1.8x (2.97+12.68)/2, =	23.03 kN
	c) Frictional Resistance acting at the base of Thrust Block =	
	1) Coefficient of friction of soil = μ =	0.3
	2) Calculate Load acting at the base of Thrust Block	
	Weight of empty pipe = 1.76x6.05 =	10.63 kN
	Weight of water inside = 2.88x6.05 =	17.42 kN
	Weight of Concrete = $A_b x H_4 x \gamma'_{con} - A_{po} x L_e x \gamma'_{con}$ =	
	= (15.015x1.635x24) - (0.317x6.05x24) =	543.2 kN
	Weight of soil on top of Thrust Block = ($A_b x H_3 x \gamma\sigma$)=	
	= (15.015x0.5x18) =	135.14 kN
	Total load acting at the base of Thrust Block = W_T =	
	= 10.63+17.42+543.2+135.14 =	706.39 kN
	3) Frictional Resistance acting at the base = $R_f = C + (\mu x W_T)$ =	
	= 0 + (0.3x706.39) =	211.92 kN
	d) Total Horizontal force resisting sliding = $R_h = R_p+R_f$	
	= 697.93+211.92 =	909.85 kN
	f) Horizontal force acting due to pipe bend = F_h =	
	=2x $P_t x A_{pi} x Sin(\theta/2)$ ="2x1530.405x0.288xSin(90/2)=	622.6 kN
	Total Horizontal force acting on the TB (F_{HT}) = F_h+R_a =	
	622.6+23.03 =	645.63 kN
	Factor of Safety Against Sliding = R_h/F_{HT} =	

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	= 909.85/645.63 =	1.41 OK >1.4
B)	**Check for Bearing pressure of soil:**	
	Net Safe Bearing capacity of soil from soil report =	100 kN/m^2
	Gross Safe Bearing capacity of soil at depth of 2.135 m	
	below the ground level = 100+2.135x18 =	138.43 kN/m^2
	Total load acting at the base of thrust block due to weight of	
	concrete and soil on top (pipe full) = W_T =	706.39 kN
	Total load acting at the base of thrust block due to weight of	
	concrete and soil on top (pipe empty) = W_T = 10.63+543.2+135.14=	688.97 kN
	Total base area of Thrust Block = A_b =	15.015 m^2
	Calculate eccentricity at base of thrust block:	
	x = (RM-OTM)/WT = (1567.94-523.91)/706.39 =	1.478 m
	eccentricity(e) = L3-x = 1.579-1.478 =	0.10 m
	(OK) No tension occurs at base as eccentricity < width/6	0.642 m
	Calculate Bearing pressure acting at the base of thrust block	
	Section modulus (to thrust face) (zth) =	10.61 m3
	Section modulus (to other face) (zoth) =	7.38 m3
	P_{max} = WT/Ab+WTxe/zth =	
	= (706.39/15.015)+(706.39x0.1/10.61) =	53.70 kN/m2
		OK <SBC
	Pmin = WT/Ab-WTxe/zoth =	
	= (706.39/15.015)-(706.39x0.1/7.38) =	37.47 kN/m2
		OK No Tension
C)	**Check for Factor of Safety Against Overturning:**	
	a) Overturning moment acting about point A due to water pressure	
	inside = OTM1 = Fhx(Do/2+H2) = 622.6X(0.635/2+0.5) =	508.98 kN-m
	b) Overturning moment acting due to active pressure : OTM2	

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	1) Active Pressure acting on the Thrust Block = Ra	23.03 kN
	2) Center of Gravity of load from base of Thrust Block =	
	= [3xH3+H4]/[2xH3+H4]xH4/3 =	
	= [3x0.5+1.635]/[2x0.5+1.635]x(1.635/3) =	0.65 m
	OTM2 = 23.03x0.648415559772296 =	14.93 kN-m
	Total Overturning moment acting about point A = OTM	
	= OTM1+OTM2 = 508.98+14.93 =	523.91 kN-m
	b) Calculation of Restoring Moment about point A	
	1) Restoring moment due to weight of concrete and soil : RM1	
	Total Weight of concrete & Soil acting at the base = WT =	706.39 kN
	Centre of gravity of Thrust Block From point A = L3=	1.579 m
	Restoring Moment RM1 = 706.39x1.579 =	1115.39 kN-m
	2) Restoring moment due to passive earth pressure of soil RM2	
	RM2 = RpxC.G of base of Thrust block	
	697.93*0.64841! =	452.55 kN-m
	Total Restoring Moment acting about point A =	
	RM = RM1+RM2 +452.55	1567.94 kN-m
	Factor of Safety Against Overturning = RM/OTM =	
	= 1567.94/523.91 =	2.99 OK >1.4