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Determination of the most appropriate area of Thrust block on Tee junction with opposite face having same and different diameter

Rohit Mishra[1], Dr Sunil Kumar[2]
[1]Department of Civil Engineering, HBTU Kanpur, India
[2] Professor in Department of Civil Engineering, HBTU Kanpur, India
Corresponding Author: Rohit Mishra

Abstract : *Thrust block are the concrete block with nominal reinforcement which are provided to prevent the failure of underground laid pipelines due to force generated by moving water or due to surge condition. According to Water Agencies Standards (WAS) (2012) who have reported that Thrust blocks are basically installed on unrestrained pressure pipelines at all tees, wyes, reducers, horizontal bends, ascending vertical bends, and dead-ends, and shall bear directly against fittings and firm, wetted, undisturbed soil .So considering the present situation of water scarcity loss of water or treated water can cause serious problem of water scarcity.*

In the following abstract the optimum area of thrust block is calculated for tee junction with opposite face having same and different diameter. The method used for design is simple by calculating the resultant force and then considering the safe bearing capacity of soil the area of thrust block is calculated. The term safety of factor is taken to consider the case of surge condition .The present study is done in Kanpur Nagar which is situated in India and the following value of pressure is taken from the respective place.

Keywords- *Bearing capacity of soil, Kanpur Nagar, Thrust block, Tee, surge.*

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I. Introduction

In the present situation of the world water became one of the most valuable resources and the importance of this resource is increasing as the amount of clean water is decreasing day by day. Therefore the wise use of water is necessary as it may cost us in long run. The present paper is based on the design of thrust block which are installed at all tees, wyes, reducers, horizontal bends, ascending vertical bends, and dead-ends and design of such Thrust Block on Tee junction and calculate its optimum area is the main objective of this study. For example consider a situation in which a following underground laid pipeline is carrying treated water now suppose a condition of surge due to which the is a sudden increase in internal pressure which produces enough internal force to cause the movement of such pipes .Thrust block work on such places which prevent the movement of such pipeline through its weight and prevents the failure from such condition. According to Gupta S.C et al (2018) who studied the effect of centrifugal force generated in Pithoragarh district in the state of Uttarakhand, India, by moving water in pipeline which produces a horizontal thrust on the pipeline bends or at joints, according to them the resistance offered by Thrust Block contain mainly three component that is

1. Frictional resistance.
2. Passive earth pressure (Lateral resistance of soil).
3. Active earth pressure (Lateral earth pressure).

While Anwar et al. (2016) used genetic algorithm for the design of thrust block for water and waste water industry in Nigeria based on traditional approach by Ductile Iron Pipe Research Association (DIPRA). Traditional method is achieved by choosing the block height such that the calculated block width varies between one and two times the height. Jeyapalan et al**. (**2015) studied the difference in design of thrust blocks for water pipelines and sewer force mains which vary from one pipe material or standard to another just like the design of pipe wall thickness.

II. Materials and Methodology

Thrust Block are simply concrete blocks made up of mixture of cement , sand and aggregate .The minimum grade of concrete used for design of Thrust block is M20 which consist of 1:1.5:3 ratio of cement , sand, aggregate. Talking about the steel Reinforcement HYSD bars are used and minimum amount of reinforcement used is 0.12% of total area.

The method used in design of thrust block is simple by considering the bearing capacity of six types of poorly graded soil that is soft clay, silt, sandy silt, sand ,sandy clay, Hard clay and assuming the standard diameter of pipes which varies from 0.2-0.8m.The pressure value of Pipauri Gram Panchayat Water supply scheme is take which is obtained from Kanpur Jal Nigam .In design of Thrust Block for Tee end with different diameter ,the diameter of opposite face is fluctuated keeping in mind the other side of diameter. Surge is a condition in which there is a sudden increase in internal pressure due to some kind of failure in laid pipeline, the factor of safety is taken keeping in mind the condition of surge.

2.1 Equations

The main objective of the design is to provide a bearing Area (Ab) of the Block that will distribute the force against the soil such that the lateral bearing strength of the soil was not exceeded. Balance condition equation used is

$$2p(\frac{\pi D^2}{4}) \sin(\Theta/2) Sf \leq Sb(b*h) \qquad (1)$$

Where
b= bearing width
h= bearing height
D= Diameter of the pipe
P = Internal Pressure of the liquid
θ= angle of the bend
Sf = Factor of safety
Sb = bearing strength of the soil
The equation (1) can be written as

$$(2p(\frac{\pi D^2}{4}) \sin(\Theta/2) Sf) / Sb = (b*h) \qquad (2)$$

That is (b*h) is the obtained optimum area of the block which should be greater than or equal to the total thrust divided by the bearing area of that respective soil.
The equation (2) is further simplified and written in form

$$Ab = T * Sf/Sb \qquad (3)$$

T= Thrust

The following are general criteria for bearing block design.
1. Bearing surface should, where possible, be placed against undisturbed soil. Where it is not possible, the fill between the bearing surface and undisturbed soil must be compacted to at least 90% Standard Proctor density.
2. Block height (h) should be equal to or less than one-half the total depth to the bottom of the block, (Ht), but not less than the pipe diameter (D).
3. Block height (h) should be chosen such that the calculated block width (b) varies between one and two times the height.

III. Results

3.1 Tee end with opposite face having same diameter

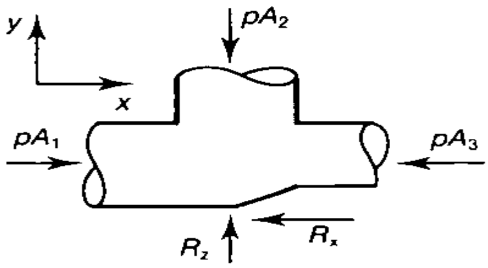

Fig 3.1- Tee junction (x-y) plane

Internal pressure =1000kN/m²

Table-3.1.1 Bearing capacity of Sand=47.88kN/m²

S.NO	Dia of pipe (m)	Thrust (kN)	Area of block(m²)	b (width) (m)	h (height) (m)
1	.20m	31.4	.985	.739	1.33
2	.40m	125.6	3.94	1.479	2.66
3	.50m	196.25	6.158	1.849	3.329
4	.60m	282.6	8.85	2.217	3.99

5	.70m	384.65	12.05	2.587	4.657
6	.80m	502.4	15.73	2.956	5.32

Table-3.1.2 Bearing capacity of Sand=71.82kN/m²

S.NO	Dia of pipe (m)	Thrust (kN)	Area of block(m²)	b (width) (m)	h (height) (m)
1	.20m	31.4	.6558	.6036	1.086
2	.40m	125.6	2.623	1.207	2.172
3	.50m	196.25	4.09	1.507	2.713
4	.60m	282.6	5.90	1.81	3.2588
5	.70m	384.65	8.033	2.112	3.80
6	.80m	502.4	10.49	2.414	4.345

Table-3.1.3 Bearing capacity of Sand=143.64kN/m²

S.NO	Dia of pipe (m)	Thrust (kN)	Area of block(m²)	b (width) (m)	h (height) (m)
1	.20m	31.4	.3279	.4268	.768
2	.40m	125.6	1.311	.853	1.536
3	.50m	196.25	2.049	1.0669	1.92
4	.60m	282.6	2.95	1.28	2.304
5	.70m	384.65	4.016	1.49	2.688
6	.80m	502.4	5.246	1.707	3.073

Table-3.1.4 Bearing capacity of Sand=191.52kN/m²

S.NO	Dia of pipe (m)	Thrust (kN)	Area of block(m²)	b (width) (m)	h (height) (m)
1	.20m	31.4	.2459	.3696	.665
2	.40m	125.6	.9837	.7392	1.33
3	.50m	196.25	1.537	.924	1.663
4	.60m	282.6	2.213	1.108	1.996
5	.70m	384.65	3.012	1.293	2.328
6	.80m	502.4	3.93	1.4785	2.66

Table-3.1.5 Bearing capacity of Sand=287.28kN/m²

S.NO	Dia of pipe (m)	Thrust (kN)	Area of block(m²)	b (width) (m)	h (height) (m)
1	.20m	31.4	.1639	.30	.54
2	.40m	125.6	.6558	.6036	1.086
3	.50m	196.25	1.024	.754	1.358
4	.60m	282.6	1.475	.905	1.6297
5	.70m	384.65	2.008	1.056	1.90
6	.80m	502.4	2.623	1.207	2.172

Table-3.1.6 Bearing capacity of Sand=430.92kN/m²

S.NO	Dia of pipe (m)	Thrust (kN)	Area of block(m²)	b (width) (m)	h (height) (m)
1	.20m	31.4	.109	.2464	.4435
2	.40m	125.6	.4372	.4928	.887
3	.50m	196.25	.683	.616	1.1089
4	.60m	282.6	.9837	.739	1.33
5	.70m	384.65	1.3389	.862	1.55
6	.80m	502.4	1.7488	.9856	1.774

3.2 Tee end with opposite face having different diameter

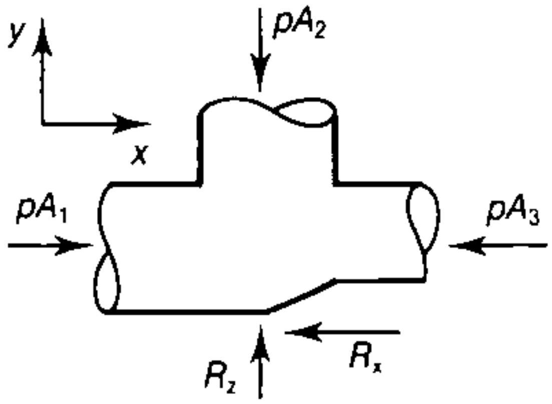

Fig 3.2- Tee junction (x-y) plane

Table- 3.2.1 Tee joint with diameter

d_1=.40m
d_2=.20m
d_3=.20m
Resultant Thrust=99.29kN

S.NO	Types of soil	Area (m^2)	Width (m)	Height (m)	Length (m)	Volume of Block (m^3)
1	Soft clay	3.11	1.31	2.36	2.3	7.128
2	Silt	2.07	1.138	2.049	2.1	4.896
3	Sandy Silt	1.0368	.929	1.11	1.2	1.237
4	Sand	.778	.805	.967	1.0	.778
5	Sandy clay	.518	.657	.789	1.0	.518
6	Hard clay	.3456	.56	.616	1.0	.3456

Table- 3.2.2 Tee joint with diameter

d_1=.60m
d_2=.40m
d_3=.55m
Resultant Thrust=133.48kN

S.NO	Types of soil	Area (m^2)	Width (m)	Height (m)	Length (m)	Volume of Block (m^3)
1	Soft clay	4.18	1.524	2.74	2.8	11.69
2	Silt	2.78	1.319	2.11	2.2	6.122
3	Sandy Silt	1.5	.968	1.549	1.6	2.4
4	Sand	1.045	.933	1.12	1.2	1.254
5	Sandy clay	.696	.768	.914	1.0	.696
6	Hard clay	.4646	.622	.746	1.0	.4646

Table- 3.2.3 Tee joint with diameter

d_1=.70m
d_2=.60m
d_3=.65m
Resultant Thrust=287.5kN

S.NO	Types of soil	Area (m^2)	Width (m)	Height (m)	Length (m)	Volume of Block (m^3)
1	Soft clay	9.006	2.23	4.026	4	35.91
2	Silt	6.06	1.826	3.287	3.5	21.21
3	Sandy Silt	3.0	1.369	2.19	2.1	6.1
4	Sand	2.25	1.11	2.01	2.1	4.685
5	Sandy clay	1.5	.968	1.54	1.6	2.4
6	Hard clay	1.0	.9132	1.09	1.1	1.1

Table- 3.2.4 Tee joint with diameter

d_1=.80m
d_2=.75m
d_3=.75m
Resultant Thrust=445.25kN

S.NO	Types of soil	Area	Width	Height	Length	Volume of

		(m²)	(m)	(m)	(m)	Block (m³)
1	Soft clay	13.94	2.78	5.01	5.0	69.7
2	Silt	9.29	2.27	4.1	4.0	37.16
3	Sandy Silt	4.64	1.6	2.9	3.0	13.92
4	Sand	3.4	1.45	2.33	2.4	8.16
5	Sandy clay	2.32	1.2	1.92	2.0	4.64
6	Hard clay	1.55	.98	1.57	2.0	3.10

IV. Conclusion

It is identified that Thrust block is necessary not only for short term but for long term use for the protection of pipe against unbalanced force generated. If comparative study is done on the area of the block obtained for different types of soil condition once whose bearing capacity is known .The area obtained for soil with low bearing capacity like soft clay, silt is large as compared to the soil with high bearing capacity like Hard clay and Sandy clay which depicts that such types of soils with low bearing capacity is not favourable for design of Thrust block or if further design is needed the design will be not okay from economical point of view. However these types of Blocks are very useful in hilly areas where the change in direction of water produces a centrifugal force so to overcome these types of forces thrust block is really necessary.

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