"Study on the Influence of TBM operation on its behavior in H&V Shield"

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1. Introduction:

The objectives of this study were to run a Sensitivity analysis to understand the influence of a tunnel boring machine on a horizontal and vertical movement shield, and to compare the shield tunneling behaviors between the simulation results and the observed data to verify the model.

A Shield tunneling method is any method in which a solid cylinder or shield is push forward through the ground with the purpose of tunneling construction. This shield is called a Tunnel Boring Machine or TBM.

A Vertical and Horizontal shield is a tunneling machine using two bodies, with cross sections that can be changed continuously from horizontal to vertical multi-circular shape or vice versa, for simultaneous construction of multiple tunnels.

TYPE	CASE	ER	α	E_{3R}	SPT-N value
1	a	1	0	0.5	30
	b	0.75	0	0.5	30
	c	0.5	0	0.5	30
	d	0.25	0	0.5	30
2.1	a	1	0.5	0.5	30
	b	0.75	0.5	0.5	30
	c	0.5	0.5	0.5	30
	d	0.25	0.5	0.5	30
2.2	a	1	1	0.5	30
	b	0.75	1	0.5	30
	c	0.5	1	0.5	30
	d	0.25	1	0.5	30
3	a	0.5	0	0.2	30
	b	0.5	0	0.4	30
	c	0.5	0	0.6	30
	d	0.5	0	0.8	30
4	a	0.5	0	0.5	10
	b	0.5	0	0.5	30
	c	0.5	0	0.5	50

Table 1. Parameters

2. Sensitivity Analisys

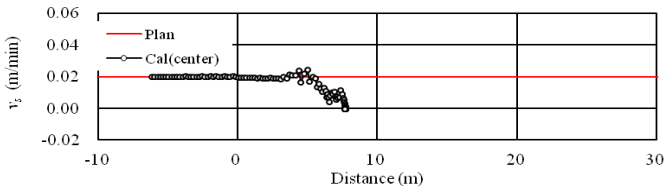
In the other hand, a sensitivity analysis has the objective to make quantitatively clear the characteristics of operational parameters on H&V shield behavior.

The parameters analyzed are on Table 1, which are (from left to right): copy cutter range and copy cutter length, crease angle and pitching angle, jack thrust force and the ground.

2.1 Type 1

For this Type the effective rate was modified.

For the biggest impression was presented on the shield bahavior where we can check that case (d) (presented with the lowest effective rate) stops its results even before the 10



Graph 1. Velocity vs. distance, case (d)

meters distance is reached. This is because the effective rate affects the excavation speed or velocity, the lower the rate, the slowest it becomes, and therefore the distance reached is shorter.

2.2 Type 2

For Type 2, the study was divided in Type 2.1 with an alpha value 0.5 and 2.2 with an alpha value 1. We can appreciate the influence of this value on the crease and pitching angle on Table 2.

α	0	0.5	1
θ_{cv}	θ_{cv}	$0.5\theta_{cv}$	0
ϕ_p	0	$-0.5\theta_{cv}$	$-\theta_{cv}$

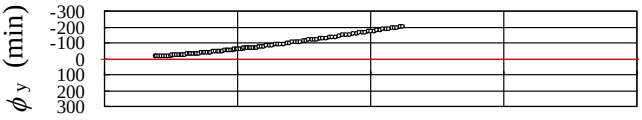
Table 2. Alpha effect on crease (θ_{cv}) and pitching (ϕ_p) angle.

Therefore, ϕ_p (pitching angle) has a tendency to be reduced the higher is the α value. The reduction of the ϕ_p means a change on the vertical angle, and when the machine starts to go upwards, the velocity is reduced, and therefore the distance.

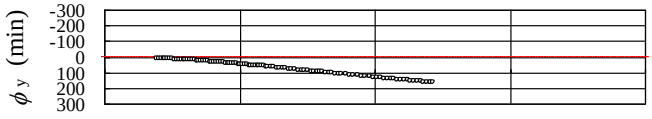
The Crease angle influences the pressure on the front and rear part of the machine, but just on the Right Body, since the Left Body does not present an inclination angle on the vertical direction. The reason for this influence is that this inclination angle, led to a bigger area for the pressure to act.

2.3 Type 3

In case (a), Graph 2, the jack trust value is equal to 0.4, and for Case (b), Graph 3, 0.6 on the left body of the machine. While the force of the right body, was calculated as: 1 minus the force of the left body. Even tough these were the



Graph 2. Case (a)

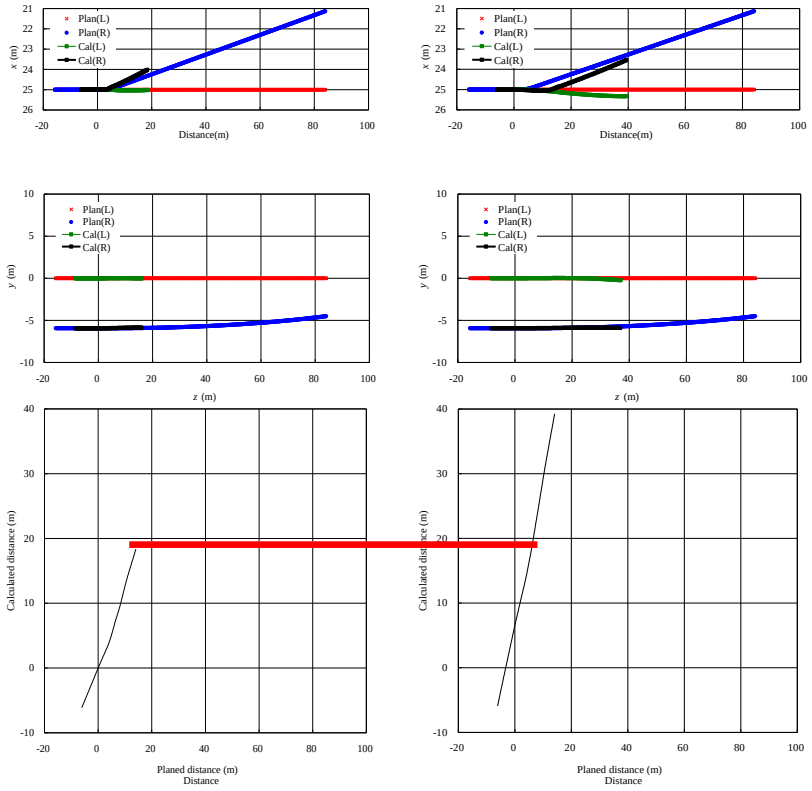


Graph 3. Case (b)

values used on the calculating programs, the real value is in percentage, therefore, when the value 0.6 is mentioned, it actually means a 60% of the jack thrust force maximum capacity.

First of all, we can see that the distance reached in Graph 2 case (b) is larger, but that even in this case, the 20 meters are not reached. The reason was because in order to compensate the jack force and the force acting at the face, the force acting on the periphery was increased, therefore reducing the velocity, the jack force also had an effect on the direction of the machine as we can appreciate on the screen, turning to left when the jack force is bigger on the right body, and vice versa.

2.4 Type 4



Graph 4. Case a) Case b)

Type 4 corresponds to the analysis of the ground parameters. The case (a) on Graph 4 represents a stiff type ground (SPT-N value equal to 30), while the case (b) are the results of doing the analysis on a very stiff type of ground (SPT-N value equal to 50).

Both cases presented a very similar shield behavior. The most significant difference for this parameter is the distance reached, as we can appreciate on the Graph 4, where case (b), with a stiffer ground, duplicated the distance reached. This brings us the conclusion that when the ground is stiffer, the rotation of the machine comes more easily and therefore reaches a longer distance.

3. Conclusions

Of the four principal parameters that were analyzed for this study we can conclude as next:

1) The effective rate of the copy cutter machine is important to reduce the friction generated because of the contact between the machine and the ground. This is important because the friction reduces the velocity.

2) The α value, which only affects the Right body, affects the pressure area due to this inclination. For this reason, a bigger α value means bigger pressure against the tunneling machine, reducing the velocity too.

3) A large jack force is required to increase the velocity. Also, the jack moment is effective for rotating the shield.

4) The stiffness actually helps the machine, permitting the rotation more easily, increasing the velocity ant therefore also the reached distance.

These parameters of the Tunneling Boring Machine, therefore, have an influence on the Horizontal and Vertical shield machine that should be considered in order to optimize the excavation work.