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Effect of Underground Tunnelling by TBM on Foundations of Existing Structures

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Abstract

Underground tunnel construction has been rapidly increasing worldwide. Most of the tunnelling projects are executed in urban areas. The use of tunnelling for utility, such as water supply, sewage disposal and metro rail etc. tunnelling brings a lot of questions with them like managing the site logistics, how to excavate the bores, how to stabilize the soil etc. Due to increase in Industrialization, speed of growth of cities is increasing. This growth resulted in a good future for tackling the problem like water supply, solid waste management, urban infrastructure etc. Traffic and transportation are one of the major issues today. To avoid or to overcome this problem, the underground tunnelling is emerged as a new concept and can help to solve the traffic problem.

This thesis emphasizes on the study of underground tunnel (TBM), below the foundations of existing structures. In this study, a 3D finite element analysis is considered to find the optimum distance required for tunnelling in vertical directions. Also a parametric study is conducted with respect to hard murrum and soft murrum for existing foundations like shallow foundation (Isolated foundation) and raft foundation.

Analysis were carried out using MIDAS GTS NX software for 3D tunnelling and the results were cross checked for allowable deflection by passing tunnel through various depth in accordance with the IS 1904-1984. Optimum depth of tunneling was found out by considering the allowable displacement of existing foundation as per IS Code.

Keywords: *Underground Tunnel, TBM, 3D Tunnelling, Tunnels*

INTRODUCTION

The growth of many cities has resulted in the need for development. As urban space becomes more limited, subsurface structures such as tunnels are becoming more efficient in providing the required development.

Indian cities are growing very rapidly, now Hyderabad and Bangalore are also included in metropolitan cities. Due to increase in industrialization, speed of growth of cities is increased. This growth result in good future and also generates problems like water supply, solid waste management, urban infrastructure etc. Traffic and transportation is one of the major issues today. To avoid this problem, the underground road or the underground tunnelling has emerged as a new concept. By tunnelling, lots of traffic problem will get disappeared.

As the population of country increases day by day this results in increase the number of vehicles which result in traffic congestion, air pollution and traffic accidents. So that there will be the requirement of tunnelling to solve these problem. Transport situation in most Indian metropolitan cities is rapidly deteriorating because of the increasing travel demand and inadequate transportation system. Indian cities of all sizes are facing the crisis of urban transport.

Despite investments in road infrastructure and plans for land use and transport development, all face the problem of congestion traffic accidents and air pollution and the problems continue to grow. Large cities are facing an unprecedented growth of personal vehicles (two wheelers and cars) and in medium and small cities different forms of intermediate public transport provided by informal sector are struggling to meet the mobility demands of city resident. This study considers the method of underground tunnelling and its effect on the foundation of existing structure.

METHODOLOGY

The methodology of this study will be as follows:

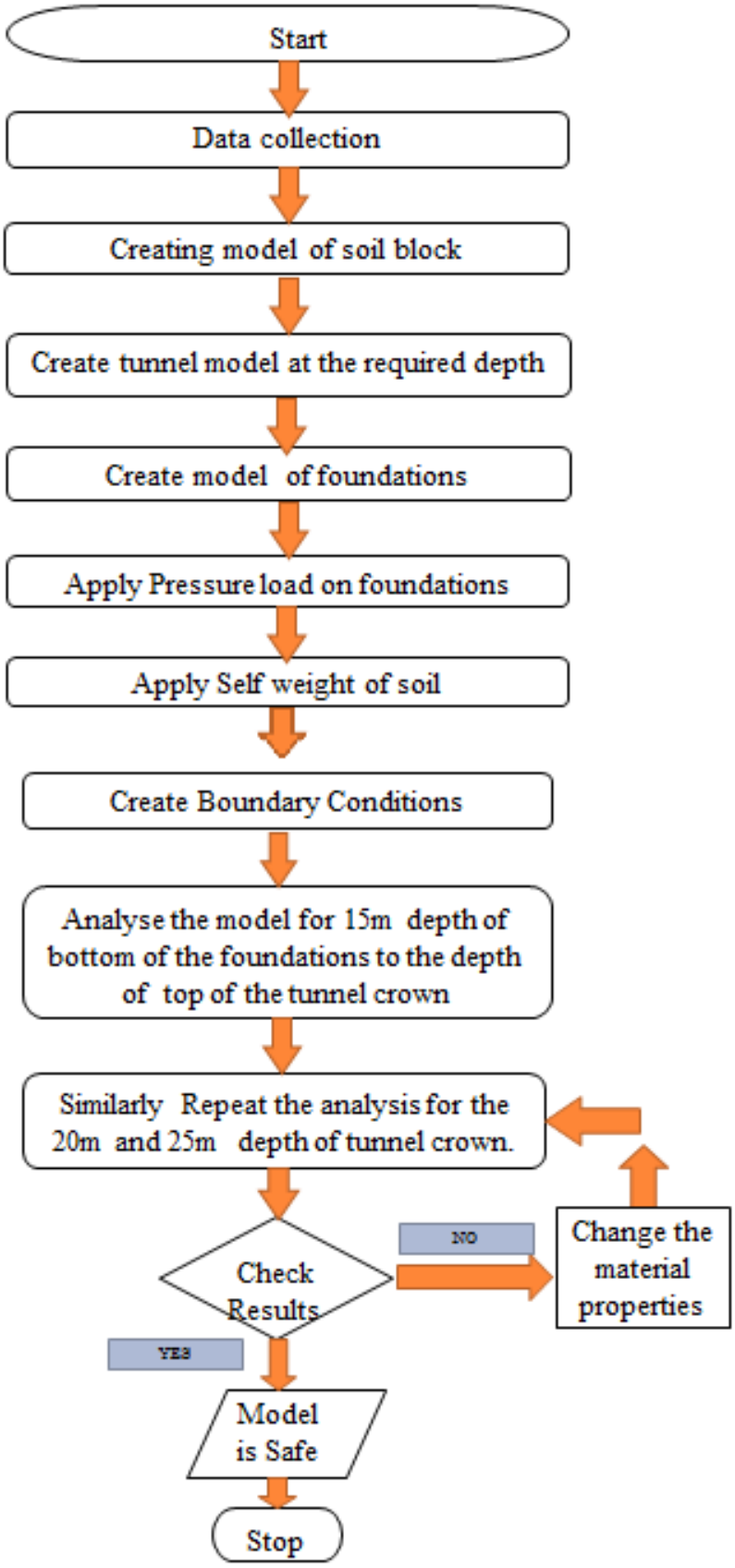


Figure no. 1- Methodology of this Study

MATERIAL PROPERTIES OF GROUND MEDIUM

The material properties of the ground material are given in table below.

Table no. 1- Material properties of ground medium

Strata	Dry unit (γ) wt.(kN/m^3)	Sat. unit wt. (γ_{sat}) (kN/m^3)	Poison's ratio (μ)	Elastic modules (E) (kN/m^2)	Angle of friction (ϕ)	Cohesion (C) (kN/m^2)
Hard murrum	19	20	0.2	150000	39	0
Soft murrum	18	20	0.4	52000	27	0

PROPERTIES OF STRUCTURAL MEDIUM

The material properties of the structural material are given in table below.

Table no. 2- Material properties of structural medium

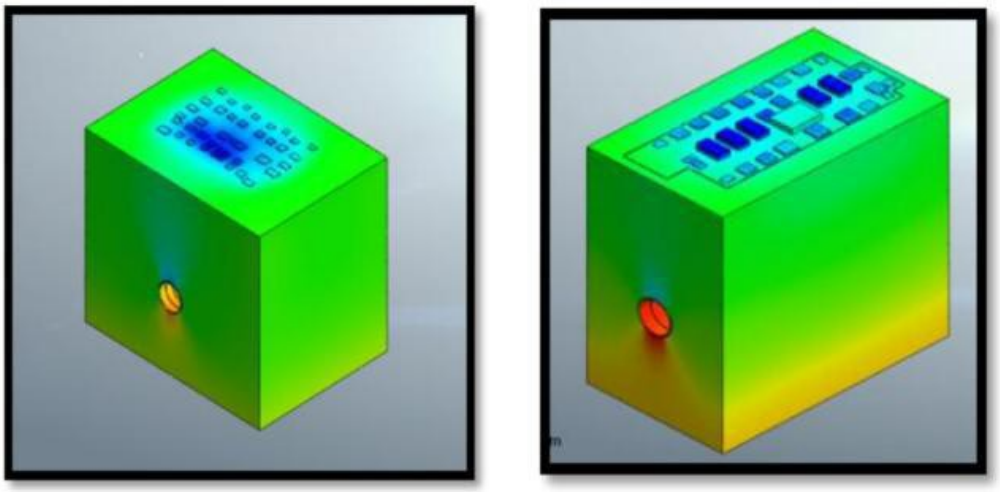
Sr. no.	Material Material	Elastic Modulus E (kN/m^2)	Unit Weight (kN/m^3)
1	Segment	21×10^6	24
2	Steel	20×10^8	78
3	Grout	10×10^6	22.5
4	Concrete (M20)	22.36×10^6	25

SIZE OF MODELS AND LOADING ON FOUNDATIONS

The size of models of shallow (Isolated footing) is 50m x 50m x 40m (B x D x L) and for raft foundation is (30m x 50m x 50m)

Table no. 3- Size of models and loading on foundations

Sr. No.	Types of foundations	Floor (No. of Stories)	Load in Tone	Size of Model (B X DX L) (m)
1	Shallow foundation	B + G + 11 Stories	5995.78	50 X 30 X 40
2	Raft foundation	B + G + 4 Stories	5397.50	30 X 50 X 50



Isolated foundation Raft foundation

Figure no. 2- Size of models and loading on foundations

ANALYSIS WORK

Analysis work flow charts are as follows:

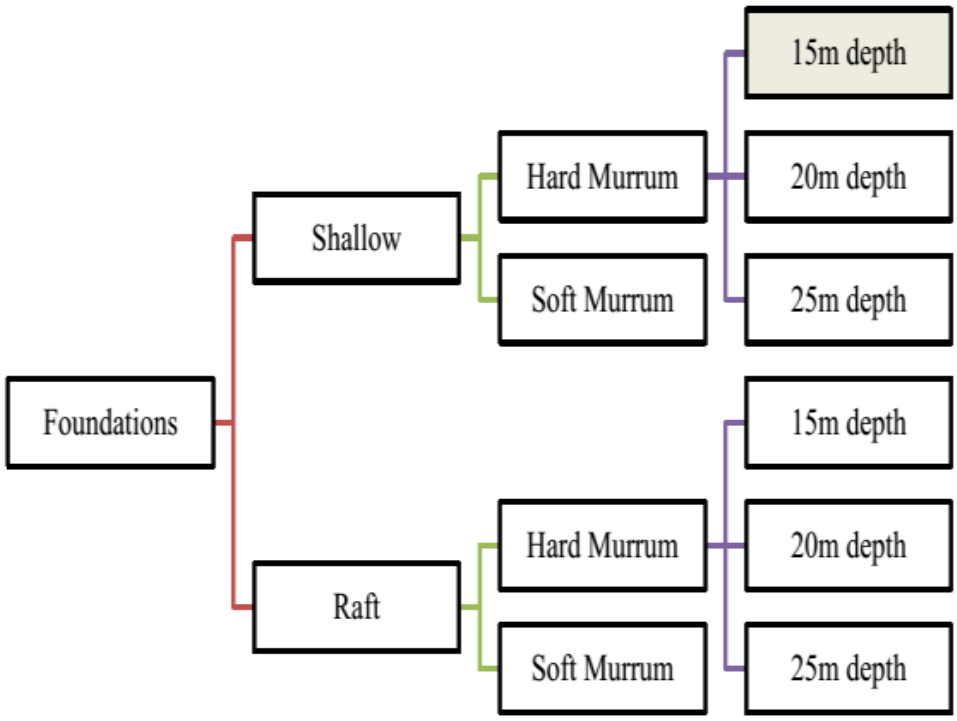


Figure no. 3- Flow chart of Analysis work

DIFFERENT DEPTH OF TUNNEL CROWN

Different depth of tunnel crown is as follows:

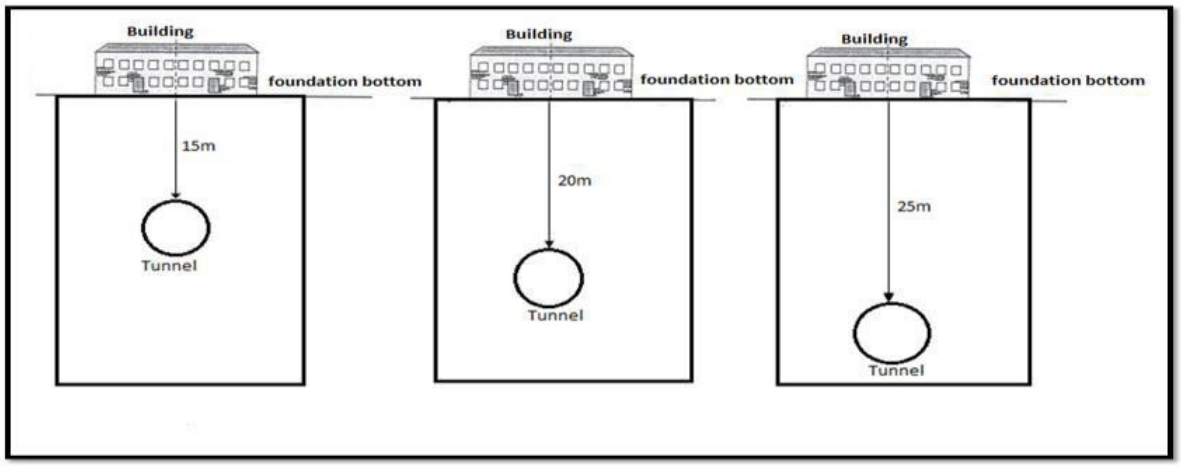


Figure no. 4- Different depth of underground tunnelling, 15m, 20m and 25m

DISPLACEMENT OF FOUNDATIONS BEFORE AND AFTER TUNNELLING

i. For Shallow foundation (Isolated footing)

The before tunnel construction displacement of foundation is less as compare to after tunnel

Table no. 4- Displacement of foundations before and after tunnelling.

Strata	Depth (m)	Before tunnelling (mm)	After tunnelling (mm)
Hard murrum	15	23.48	25.57
	20	14.44	19.35
	25	14.41	18.89
Soft murrum	15	32.53	44.09
	20	25.09	29.38
	25	14.58	28.95

ii. For Raft foundation

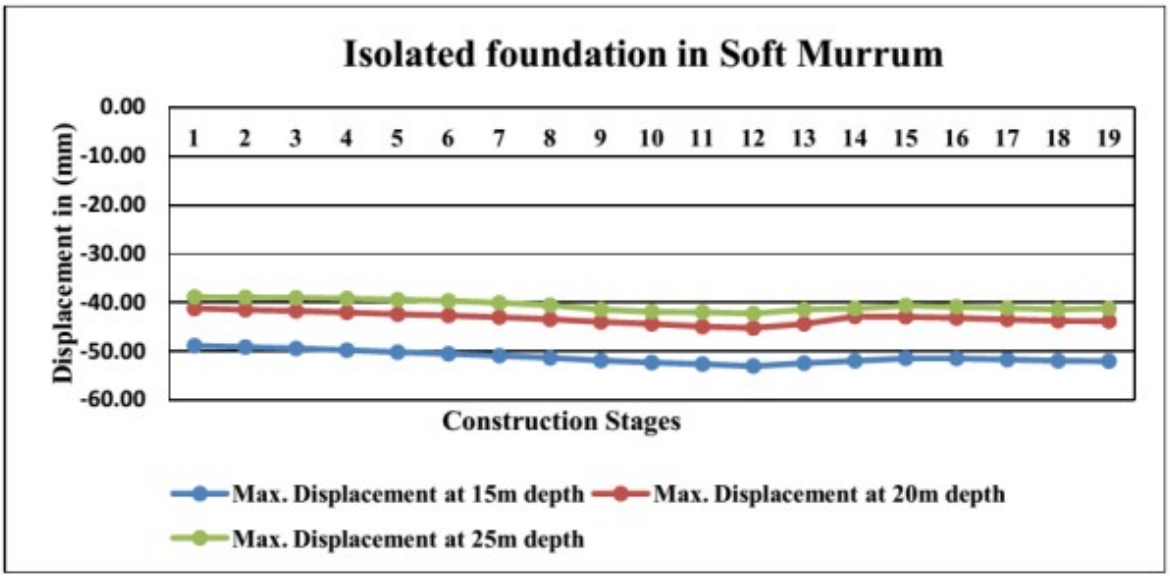
The before tunnel construction displacement of foundation is less as compare to after tunnel construction, in table are as follows:

Table no. 5- Displacement of foundations before and after tunnelling

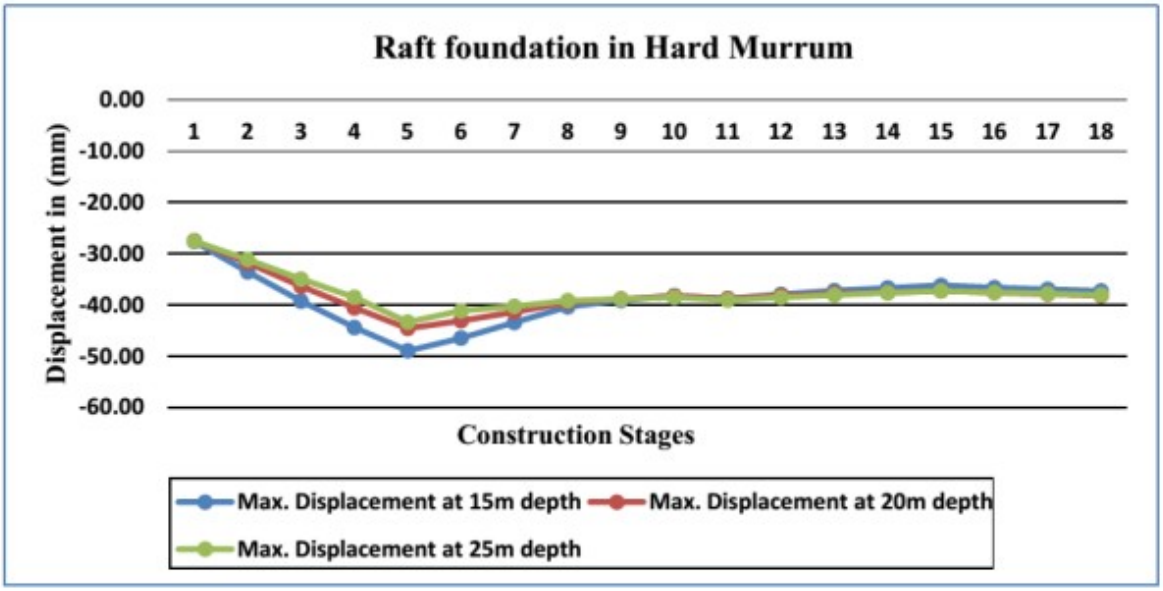
Strata	Depth (m)	Before tunnelling (mm)	After tunnelling (mm)
Hard murrum	15	42.19	46.95
	20	41.30	46.93
	25	41.10	44.55
Soft murrum	15	51.23	60.67
	20	50.73	60.32

RESULTS AND DISCUSSION

In this present study, the results obtained from the 3D analysis of underground tunnel are presented and discussed. Results are obtained from the software for two soil strata, hard murrum and soft murrum for two types of foundations, shallow foundations (Isolated foundation) and Raft foundation. Results tables and graphs are as shown below:



Displacement Vs Construction Stages at depth 15m, 20m and 25m for hard murrum.



Displacement Vs Construction Stages at depth 15m, 20m and 25m for soft murrum.

CONCLUSION

The following are the conclusion of the study.

- The underground tunnel construction is suitable to construct bottom of foundation to the top of the tunnel crown, at 20m depth and below the 20m. It tunnel construct at 15m depth, although it is coming with permissible limit of IS: 1906-1986 but foundation gets disturb.

- The optimum depth (i.e. distance between bottoms of foundation to top of tunnel crown) for tunnelling in hard murrum and soft murrum for shallow foundation is 20m and below.

- In shallow foundation, the maximum displacement occurred for hard murrum, at later construction stage i.e. CS-11. whereas in soft murrum it occurred for construction stage 12

- In raft foundation, settlement and differential settlement are within the permissible limit.

- In raft foundation, the max. displacement occurred for all the strata at the initial construction stage i.e. CS-5

- Before tunnelling, the displacement of existing foundation is less as compared to displacement after tunnelling.

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