DESIGN AND ANALYSIS OF UNDER WATER TUNNEL

(By using Rocscience Phase 2 V8 software)

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Abstract: Tunnels are very important structures which are being used in various construction like in road, railway for defense purpose and laying of pipelines etc. Tunnels have different shapes based on their uses and the ground conditions and the availability of materials. All tunnels have various degrees of complexity depending on function and safety needs or the code requirements at the time of construction, but most tunnels employ one or many functional systems, such as lighting, ventilation, drainage, fire detectors and alarms, fire suppression, communications, and traffic control. With the limited access and confined conditions within a tunnel; the operation, maintenance and inspection of a tunnel must be thoroughly regimented to provide an adequate level of safety for the traveling public. Construction of different types of tunnels include some very basic operations or steps which are to be followed in sequence in order to build or to construct a tunnel. These are known as basic tunneling operations. This tunneling operations may differ in comparison to older times and this modern time. This paper provides information on Underwater Tunnels and various tunneling operations involved to make Underwater Tunnel and also provide information related to old methods of tunneling and new methods of tunneling using ultramodern technology. Some case studies are also there related to the modern technology which are used on Underwater Tunnel construction. Many Underwater Tunnel structures have been experiencing water leakages worldwide. Tunnel structures experiencing water leakages are not only old, but also new in some case. The Concrete Tunnels structures located underwater are generally protected by waterproof membranes as the first defense to prevent water leakages and rebar corrosion. However, once water leakage occurs, the corrosion mechanism is quite different from other concrete structures which are exposed to marine or de-icing salt environments.

Keywords: Underwater Tunnels, Tunneling Operations, Modern Tunneling Operations.

1.1 Introduction: Tunnel Construction for transport courses has gotten progressively significant around the world. Transport has been sped up and ideal insurance is accommodated the climate and the scene. Such countless tunnels are viewed as mechanical showstoppers and governments have regarded tunnels designs as legends. Building a tunnel, notwithstanding, is quite possibly the most perplexing difficulties in the field of structural designing. Tunnels are appealing answers for rail lines, streets, public utilities, and broadcast communications. Since, Overall populace is expanding quickly so the need of fast or speedy transportation to counter this roughly 3/fourth of earth floor which is submerged is to be utilized. This brings about development of submerged tunnels. A submerged tunnel is a section, exhibition, or street underneath a waterway. Submerged tunnels are utilized for interstate deals, railroad, and trams to move sewage, oils, gas, or vehicles and for military and common protection reason. Current submerged tunneling starts by developing an inundated cylinder inside a pre-tunneled channel on the waterway or ocean bottom, to do these pre-assembled areas of steel and solid cylinder are coasted into position and deliberately sunk into the channel. Drenched tunneling is a craft of controlling the extraordinary characteristic power, the water, to do Designing works: "managing" lightness for transportation, "directing" water loads for inundation, and "managing" hydrostatic pressing factor for association.

1.2 Limitation Existing System:

- Immersed tunnels are often partly exposed (usually with some rock materials and natural siltation) on the river/seabed, risking a sunken ship/anchor strike.
- Direct contact with water necessitates careful waterproofing design around the joints.
- The segmental approach requires careful design of the connections, where longitudinal effects and forces must be transferred across.

1.3 Scope and Objective:

1.3.1 SCOPE:

- Due to deficiency of land and quickly developing traffic and populace, different submerged tunneling development methods ought to be executed.
- As submerged tunnels has more limited courses than extensions and streets, it saves our significant time.
- Different materials like oils, gas and drinking water can be all the while moved alongside the traffic course.

- By utilizing trend setting innovations straightforward cylinder can be constructed which gives extremely tasteful and appealing perspective for travelers and vacationer.
- Therefore, making the general venture savvy.

1.3.2 OBJECTIVE: Tunnels can be utilized for conveying cargo and travelers, water, sewage, and so forth Tunnels are more affordable than open cuts past specific profundities. Tunnels abstain from upsetting or meddling with surface life and traffic during development. Tunnels end up being less expensive than scaffolds or open slices to convey public utility administrations like water, sewer, and gas. Possibility of these developments in normal materials, like stone and soil, makes the land conditions assume a significant part in their solidness. Parts of significant significance and that is conclusive for the attainability of a Tunnel project is land conditions, development time and expenses. The motto of this exercise is to give the overall parts of significance in burrows, their sorts, and techniques for burrowing.

Fig: 1 Section of Tunnel.

These are some images of Underwater Tunnel. Their construction procedure is followed by various steps which need to be maintained sequentially.

1.4 The Underwater Tunnel Concept:

- Essentially, a Submerged Tunnels idea comprises of the accompanying components:
- The tunnels tube which gives space to the street and additionally rail route traffic.
- Ties, vertical or skewed fixing the chamber to the seabed at certain isolating.
- Boats mounted on top of the Tunnels and "getting" it to the sea surface.
- Gravity gets on the seabed offering assistance for the ties.
- Shore relationship at the terminations of the Tunnels.

1.5 Design Issues:

For plan of a Submerged Tunnels the accompanying essential contemplations ought to be thought of:

- The cross-segment should give adequate room for traffic, clearing, ventilation, counterbalance, investigation, support, and fix work.
- The game plan ought to be so much that there is no check with transport traffic Tunneling above.
- The Tunnels ought to have a clear static system which can be suitably tended to in the arrangement calculations.
- The joints should have no less strength or decency than the chamber between the joints.
- The design ought to have an adaptable direct in the potential disillusionment modes.
- The getting structure should be redundant.
- The Tunnels ought not be unduly powerless against neighborhood hurt.
- The essential nuances ought to be direct and planned to avoid superfluous pressing factor obsessions.
- The construction ought to be incredible against changes in the static system, assortments in the material properties and utilization.
- The Tunnels should carry on in a worthy manner as to deformations, settlements, and vibration.
- The Tunnels ought to have a satisfactory prosperity against weariness.

1.6 Necessity of Underwater Tunnels:

Economics of Underwater tunneling is a broad question and in general depends on the relative cost of open cut Vs. tunneling. Basically, when depth of cut is over 18 m, tunneling is advisable. From viewpoint of economy and traffic safety, the tunneling operation is desirable under the following conditions.

- To allow rapid and unobstructed transport facilities in big the congested cities.
- To avoid acquisition of valuable land.
- To avid long circuitous routes around a mountain or spur.
- To avoid sliding of open cut sides in softer soils.
- To connect two terminal stations separated by mountain.
- To divert water for generation of power.
- To carry public utility services like oil, gas, water etc. across the stream or a mountain.
- To avoid the steep gradients in mountains and thereby maintain a high speed.
- When the provision of the bridge over the river is costlier and in convenient.
- It is preferred on routes of strategic importance because a tunnel is hidden in ground.
- To save the maintenance cost which is generally lesser for tunnel compared to a bridge and an open cut.

1.7 Disadvantages:

- Immersed tunnels are regularly somewhat uncovered (generally with some stone protective layer and normal siltation) on the waterway/seabed, gambling a submerged boat/anchor strike.
- Direct contact with water requires cautious water sealing plan around the joints.
- The segmental methodology requires cautious plan of the associations, where longitudinal impacts and powers should be moved across.
- Environmental effect of cylinder and submerged dike on existing channel/seabed.

1.8 Causes for Tunnel collapse: Tunnel breakdown can occur for a few reasons, for example, insufficient ground examination, shallow ground conditions, deficient help measures, cost enhancement, unpracticed project workers, lacking management, deferrals of unearthing and backing erection.

- Construction disappointment.
- Ground and Groundwater Conditions.
- Preliminary examination did with no penetrating.
- Probe penetrating was not performed during burrowing.
- No adjustment measures to help an enormous expanding dirt segment prior to impacting.

2. Abbreviations and Acronyms:

The following acronyms and abbreviations are used throughout the chapters of this Undergraduate Thesis and they must be understood according to the specific description given in this section.

2.1 Professional or Academic Organizations

NPRA: Norwegian Public Roads Administration
NTH: Norwegian Institute of Technology
NTNU: Norwegian University of Science and Technology
NFF: Norwegian Tunnelling Society
PMI: Project Management Institute

2.2 Project Management

CSC: Critical Success Criteria
CSF: Critical Success Factors
LCC: Life Cycle Cost
PRM: Project Risk Management
TCO: Total Cost Under Ownership
WBS: Work Breakdown Structure

2.3 Project Risk Management

FM: Failure Mode
RP: Risk Policy
RI: Risk Identification
RA: Risk Assessment / Risk Analysis
RR: Risk Response
RM: Risk Monitoring

2.4 Underground and Tunnelling Projects

D&B: Drill and Blast or Conventional Method

EPB: Earth Pressure Balance Machines
NATM: New Austrian Tunnel Method
TBM: Tunnel Boring Machine

2. RELATED WORKS: In these following research papers, we are observing a good number of similarities with our proposed project works. And they are enunciated bellow on a high note:

2.1 Z. Liu, and C. Zhang (2019) Influence Zone Division and Risk Assessment of Underwater Tunnel Adjacent Constructions, compared with ordinary tunnels, the influence analysis of underwater tunnel adjacent constructions is more complicated. As of now, the observational strategy used to partition the impact zone of the tunnel nearby developments has extraordinary vulnerability. In this way, it is of extraordinary importance for genuine development and configuration to decide the impact zone precisely as indicated by hypothetical estimations. In this paper, in view of the Hoek–Earthy colored nonlinear disappointment rule of rock mass and considering drainage factor, the pressure condition of rock mass around the submerged tunnel nearby developments can be found by elastoplastic hypothesis. At that point joined with the idea of "free zone-bearing zone", the impact zone division technique for submerged tunnel neighboring developments is proposed, and it is applied to the investigation of designing models. Through the concluded hypothetical equations, the impact zone of submerged tunnel nearby development can be partitioned into widely solid, solid, generally solid, feeble, and no influence zones. Comparing the impact zones with the danger levels in the code, diverse control measures are received for various danger levels, which can give certain direction to the plan and development of tunnel in pragmatic designing. some of the major draws are summarized below:

In this paper, in view of the Hoek–Earthy colored disappointment model, the hypothetical investigation is directed on the submerged tunnel nearby development. In light of drainage stream, the impact zone of submerged tunnel contiguous development is separated, at that point impact zones are coordinated with hazard levels in the code. The accompanying ends can be acquired. The versatile plastic pressure condition of the Tunneling stone of submerged tunnel is not the same as that of normal tunnel. The drainage activity can make a specific level of weakening the Tunneling stone, which cannot be disregarded. As per the proposed drafting strategy for the impact zone of submerged tunnel nearby development in this investigation, the impact zone can be separated into widely solid, solid, solid, powerless, and no-sway zones. During the development, measures will be taken dependent on the distinctive impact zone. The impact zones are coordinated with the danger levels, and various countermeasures are taken by various danger levels, which have controlling importance for the site development.

2.2 N. Usamaa and Prof. M. Bhattacharya (July-2020) Comparative Analysis of Underground & Underwater Tunnel. With the urban population increasing, conurbation is getting more and more crowed, traffic jam happens everywhere. In this case, utilization of the underground and underwater space has become an effective way to undertake this set of problems. Tunnel construction is one of the important infrastructure projects, which is vital for enhancing the transportation networks, especially in congested cities. This review project presents a framework for selecting the appropriate tunneling method and transportation network with respect to the induced ground surface settlements. Parameters which have significant influence on the ground surface settlement will also be discussed in this project. This paper will help the contractors, engineers, and designer in selecting appropriate method and estimating the required cost and time for construction of a tunnel. Tunnel development for transport courses is getting progressively significant around the world. Transport is sped up and ideal assurance is accommodated the climate and the scene. Numerous tunnels are viewed as innovative showstoppers and governments have respected tunnel designs as saints. Developing a tunnel, notwithstanding, is quite possibly the most intricate difficulties in the field of structural designing. Tunnel s are alluring answers for rail routes, streets, public utilities, and media communications. Overall populace is expanding quickly so the need of fast or speedy transportation to counter this around 3/fourth of earth floor which is submerged is to be utilized. This brings about development of submerged tunnel. A submerged tunnel is a tunnel s, exhibition, or street underneath a waterway. Submerged tunnels are utilized for expressway deals, railroad, and metros to move sewage, oils, gas, or vehicles and furthermore for military and common guard reason. a portion of the significant draws are summed up underneath:

- The first, least complex and generally clear of the solid tunnel alternatives is the solid component. Each tunnel component is a nonstop construction that goes about as a shaft.
- The segmental structure solid tunnel component was created from the first solid tunnel component to stay away from the requirement for an outer waterproofing layer.
- A variety of the solid supported solid component is to prestress it with perpetual longitudinal prestress. This type of tunnel component can have benefits in decreasing the measure of longitudinal support and the in general compressive pressure it gives keeps an eye on close any breaks in the solid, lessening the probability of spillage.
- The utilization of steel–solid composite sandwich development is a later improvement that has for the most part been advanced in Japan, albeit a great deal of exploration and testing has likewise been completed in the Assembled Realm. The solid is set between the steel plates, so an extremely liquid self-compacting blend is required. Putting this solid and guaranteeing adequate compaction and complete making up for of the shortfall between the plates is one of the fundamental difficulties of this technique.

3.1 Research Methodology:

3.1.1 Characteristics of Underwater Tunnel Projects: This part presents the most applicable attributes of submerged tunnel and it additionally investigations the intricacy that includes the advancement of this class of undertakings. The fundamental highlights identified with the arranging and execution stages for undersea tunnel are brought and dissected, underscoring these viewpoints the spot danger and vulnerability characteristics to be higher, and may contrarily influence the value assessment measure, as appropriately as the assignment generally execution during execution.

3.1.2 The Concept once more Complexity

Submerged tunnel are underground designs, to some degree or totally unearthed in rock or soil that lies beneath open our waterways, for example, oceans, fjords, streams, or lakes. These designs are typically developed to associate metropolitan regions situated far from the terrain or to give mechanical conveniences under the seabed, NFF (2009). An exact occasion of undersea road burrow, developed as period of the public foundation, is appeared in Figure in the accompanying. This parent shows the longitudinal piece of the Frøya Tunnel Undertaking, which was done in Norway somewhere in the range of 1998 and 1999.

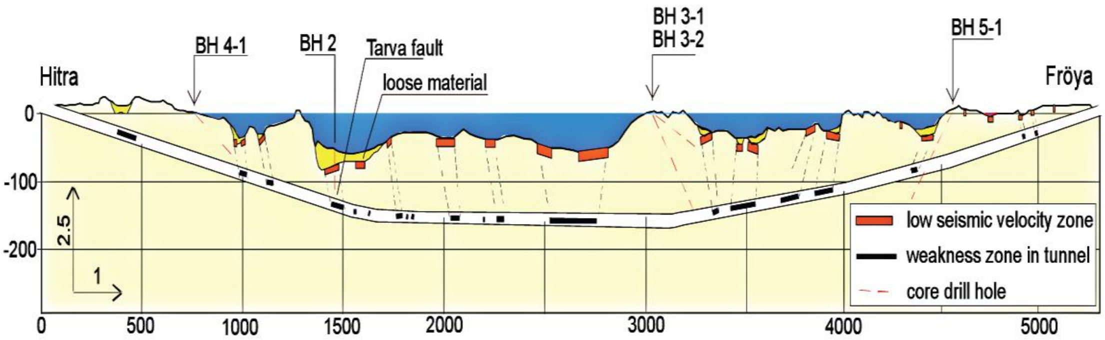

Fig: 2 Longitudinal Section of Tunnel Project (source: NFF (2009)).

Undersea tunnel is convoluted structural designing undertakings that for the most part mean a more elevated level of intricacy and chance than typical floor projects, and moreover with respect to regular tunnel, Pennington (2011). Likewise, and as per NFF (2009), a portion of the segments that make extra testing the improvement of submerged tunnel are as per the following:

- Special methods for region examination are needed, because of the intense district of the tunnel (i.e.: the basic segment is incorporated by water). The present circumstance contributes with more vulnerability in the understanding of the examinations.
- Specific areas of submerged tunnel, for example, inlets or waterways comprise itself issue or shortcoming zones.
- The useful of water inflow is boundless.

3.3 Geographical Examination in Submerged Tunnel: As in any unique improvement try, records gathered going before to the last choice, to go or no longer to go, may likewise add to developed sound premise and establishments to help the dynamic cycle. An all-around upheld dynamic way should verify that the best other options, those with the good cost for the endeavor proprietor and partners, are being chosen and executed. In this sense, land examination is an incredibly significant perspective that adds to more likely evaluate the improvement of undersea tunnel. Given the space of undersea tunnel, challenges respect geographical examinations vogue to be higher than various typical underground tasks. Limitations to get right of section to in the vicinities of things to come burrow arrangement makes extra prohibitive the probabilities to work field examination, which truly add to the charge respects this particular endeavor viewpoint. Thusly, the determination of which pre examination ought to be caused must to consistently consider those that offer additional benefit, all through the advancement of the pre subsidizing stages, Pennington (2011).The above referred to is subsequent with the assessment of NFF (2009), where is underscored that pre examination should be just about as gigantic as could be expected, to ensure that the five star designing decisions are being made (i.e.: burrow arrangement, prevalent stone cover, goal of exhuming techniques), and in this way decline the danger eventually of the development stage. NFF (2009) additionally features that despite the fact that an enormous pre-examination arrangement may likewise be executed, there is consistently a likelihood that real conditions are less good than anticipated. Thusly, pre-examination should be continually assessed in a cognizant and reasonable way, to keep away from inordinate hopefulness in the arranging and amp, graph stage. NFF (2009) underlines that the hopeful understanding of pre-unearthing examinations infers the execution of excellent estimates all through the structure way and it will expand the costs all through the undertaking execution. The geographical examinations to be completed all through the tunnel improvement might be ordered as capacity of when they are performed. As indicated by NFF (2009) the topographical examination may moreover be coordinated into the accompanying classifications:

3.3.1 Feasibility Pre-Investigation: The significant goal of the pre-examination at the practicality fragment is to outfit the foundation for a topographical appraisal of the anticipated specifications to be experienced all through the tunnel execution, thinking about various tunnel options. Pertinent components to be broke down are:

Achievable tunnel arrangements, negligible tunnel overburden, fundamental joints, and practicable deficiency zones. The base examinations to be respected at this stage are:

- Analysis of going before Geographical Examinations.
- Analysis of Flying Photos
- Geological Planning (scale 1: 5.000)
- Soil Cover Examination (when is conceivable)

3.3.2 General Plan Pre-Investigation: At the ordinary diagram is anticipated to supply the foundation for the determination of the authoritative tunnel arrangement. The examination should envelop the amendment of the relative multitude of realities recently gathered and following data should be presented or refreshed:

- Topographic Guides and Elevated Photos
- Soil Cover, Type, Thickness and Profundity.
- Rock Limits and Geography of the On-Shore Zones.
- Bedding and Foliations.
- Joint Example (Thickness, Direction).
- Weakness Zones.
- Hydrology and Hydrogeology.
- Quality of the Stone.
- Geophysical Examination.
- Core Penetrating and distinctive Borehole Examinations.

3.4 The Tunneling Process: When the genuine exhuming of the tunnel is completed, field examinations proceed at the tunnel face. Development examination comprises a center snippet of data for the dynamic interaction in regard to other burrowing exercises, profoundly reliant, of the real stone or soil conditions experienced at the tunnel face. The actions identified with the water control and the conclusive stone help ought to be evaluated and choose, thinking about the genuine boundaries.

estimated at the tunnel face. Some applicable data to be enlisted at the face rock planning is as per the following:

- Rock Stresses and Strength
- Q Esteems
- Lugeon Worth

As the tunnel project progress in its cycle, various cycles are executed to build up the fundamental idea and acquire more practical estimate of the venture scope. All the data gathered as a component of the topographical examination is incorporated, as important contribution, in the designing and plan and venture the executives' measures. The expectations of both will help chiefs to choose the task execution or its scratch-off. The burrowing interaction is characterized in this work as the execution of four (04) distinct exercises,

which are as per the following:

- Excavation
- Ground Water Inflow Control
- Rock Mass Help
- Tunnel Coating

The exercises identified with the burrowing cycle are exceptionally delicate to unsettling influences produced by land and development vulnerabilities. Consequently, unsettling influences, produces in the burrowing interaction, influence significant venture standards, for example, cost, time, or security. As indicated by Isaksson (2002), the principal reason of this significant degree of affectability to unsettling influences is because of sequential nature of the burrowing cycle, which is essentially because of the by the accompanying requirements:

•Limited ability to change work environment area.

•Limited ability to perform equal exercises.

Fig: 3 Ground Water Inflow Control

The water inflow control might be considered as a component of the uncovering interaction, or as a feature of the starter rock support, by and by it has been viewed as applicable to portray independently. This choice is upheld in the high prevalence that water control exercises have for both development and activity of submerged tunnels. As indicated by NFF (2005) the water control in underground designs is essentially because of the accompanying reasons:

- To forestall an unfriendly inside climate during the development and activity of the tunnel.
- To forestall unsatisfactory effect on the outside general climate.
- To keep up hydrodynamic control.

Since the water inflow should be respected endless in submerged tunnels, the main target is the most significant. As indicated by NFF (2011), the administration of water inflow may likewise be performed by applying the accompanying strategies.

- Pre grouting
- Post grouting
- Infiltration
- Face Water Freezing
- Water and Ice Insurance
- Drainage and Water Siphon

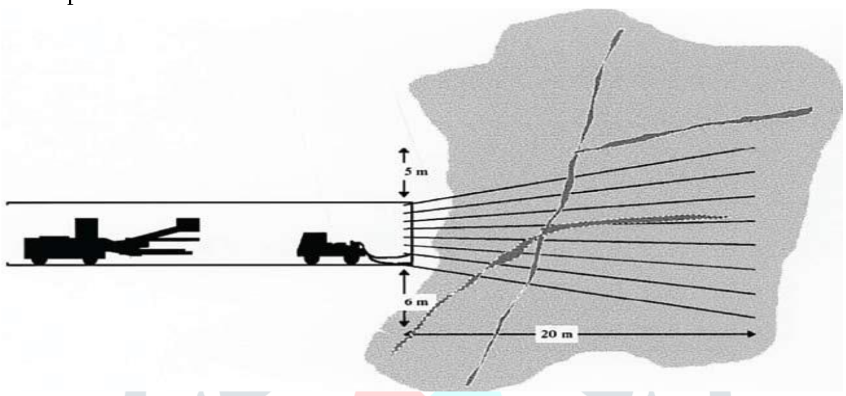

Fig: 4 Contouring

4. Proposed Model:

4.1 A Brief Discussion about Software: Underground structures have significant importance for the economy of a country. The stability of such structure is of extreme importance because the safety of Human lives is directly associated. Excavation of an underground opening always induces some deformation and stresses in the surrounding material. The number of induced deformations and stresses is highly dependent on the nature of surrounding material as well as the depth of the excavation. The transition between the surface and underground structures are tunnel portals, at this junction the conditions can abruptly change causing several issues of instability as well as the stability of associated structures and adjacent slopes are also attached with tunnel portals. Furthermore, tunnel portal excavation becomes much more challenging when the encountered material is the soft ground of low shear strength such as alluvial deposits. Such material offers great resistance to any excavation as their properties are much closer to those of soil.

To enhance the stability of underground structure during construction and post-construction, always there exist two approaches either to increase tunnel support or to change tunnel excavation sequence. The later one is always given preference because of cost constraints and many other projects factors. Normally, the selection of a suitable excavation sequence can enable safe and stable excavation in any material. Among various approaches of excavation, sequential excavation method (SEM) appropriately defines the sequences of excavation by considering the nature of surrounding material and size of structure opening. But the final selection of excavation sequence is highly dependent on the cost, safety, project conditions and project scheduling. In addition to all these, technical factors such as, surrounding material properties, size and shape of the opening, regional geology, and many to name more have proven themselves as a handful tools for the selection of an optimum excavation sequence.

Finally, the tunnel portal was constructed with the selection of an appropriate excavation design. Major contributions of this study are:

- 2D FEM modelling of tunnel excavation in alluvial deposit of non- uniform nature.
- Comparison of heading and benching, and sequential excavation sequence methods of tunnel excavation.
- Selection of an appropriate excavation sequence to ensure maximum safety within the project constraints and pre-defined tunnel supports.

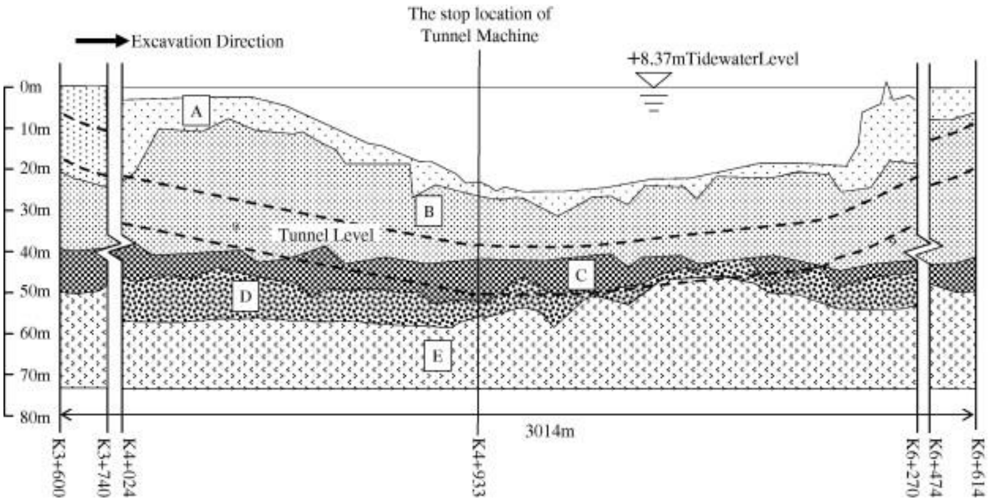

Fig: 5 Tunnel Boaring Cross Section.

4.2 Data Analysis and Calculations: Excavation and Analysis of Tunnel Design step by step: After installing the Rocscience Phase 2 V8 software follow the step below.

4.2.1 Maximum Shear Strain at various stage with Display Stage Trajectories, Display Deformed Boundries, Display Deformation Vectors:

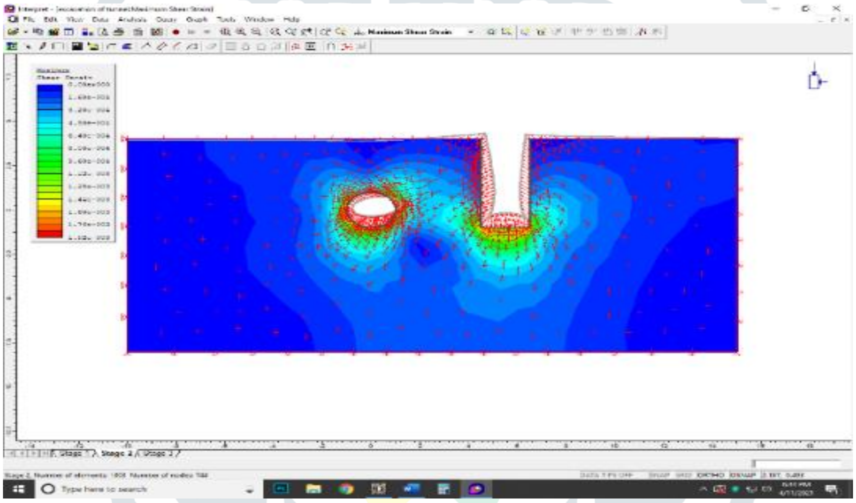

Fig: 7 Maximum Shear Strain (Stage 2)

4.4 Result and Discussion:

Phase2 Analysis Information

Document Name

Excavation of Tunnel

Project Settings

Project Name: Earth Work
Number of Stages: 3
Analysis Type: Plane Strain
Maximum Number of Iterations: 500
Tolerance: 0.001
Number of Load Steps: Automatic
Solver Type: Gaussian Elimination

Groundwater

Method: Piezometric Lines
Pore Fluid Unit Weight: 0.00981

Field Stress

Field stress: gravity
Ground surface elevation: 4 m
Unit weight of overburden: 0.02 MN/m^3
Stress ratio (horizontal:vertical in-plane): 0.5
Stress ratio (horizontal:vertical out-of-plane): 0.5
Locked-in horizontal stress (in-plane): 0
Locked-in horizontal stress (out-of-plane): 0

Mesh

Mesh type: graded.
Element type: 3 noded triangles
Number of elements on stage 1: 1513
Number of nodes on stage 1: 824
Number of elements on stage 2: 1303
Number of nodes on stage 2: 744
Number of elements on stage 3: 1303
Number of nodes on stage 3: 744

Mesh Quality

3 of 1747 Elements (0.2 % of elements) are poor quality elements
0 of 1747 Elements (0.0 % of elements) are poor quality elements because of the side length ratio
0 of 1747 Elements (0.0 % of elements) are poor quality elements because of the minimum interior angle
3 of 1747 Elements (0.2 % of elements) are poor quality elements because of the maximum interior angle
(elements can be of poor quality for more than one reason)

Mesh Quality Statistics

The worst element has (ratio = 2.78), (min angle = 21.02) (max angle = 126.11)
10.0% of elements have: (ratios > 1.7), (min angles < 34.8) (max angles > 90.6)
20.0% of elements have: (ratios > 1.6), (min angles < 38.7) (max angles > 84.1)
30.0% of elements have: (ratios > 1.5), (min angles < 41.4) (max angles > 80.0)
40.0% of elements have: (ratios > 1.4), (min angles < 43.7) (max angles > 77.2)
50.0% of elements have: (ratios > 1.4), (min angles < 45.7) (max angles > 75.2)
60.0% of elements have: (ratios > 1.3), (min angles < 47.6) (max angles > 73.2)
70.0% of elements have: (ratios > 1.3), (min angles < 49.4) (max angles > 71.0)
80.0% of elements have: (ratios > 1.2), (min angles < 51.1) (max angles > 68.9)
90.0% of elements have: (ratios > 1.2), (min angles < 52.9) (max angles > 66.9)
100.0% of elements have: (ratios > 1.1), (min angles < 55.1) (max angles > 64.9)

Poor quality elements are those with:

(maximum side length) / (minimum side length) > 10.00
Minimum interior angle < 20.0 degrees
Maximum interior angle > 120.0 degrees

Material Properties

Material: soil Excavation
Initial element loading: field stress & body force
Unit weight 0.02
Material type: isotropic
Young's modulus 50 MPa
Poisson's ratio 0.25
Failure criterion: Mohr-Coulomb
Tensile strength 0 MPa
Peak friction angle 38 degrees
Peak cohesion 0.01 MPa
Material type: Elastic

Displacements

Displacement data is not available for stage 1 until total displacement is viewed in a window.
Displacement data is not available for stage 2 until total displacement is viewed in a window.
Displacement data is not available for stage 3 until total displacement is viewed in a window.

Fig: 5 Actual View

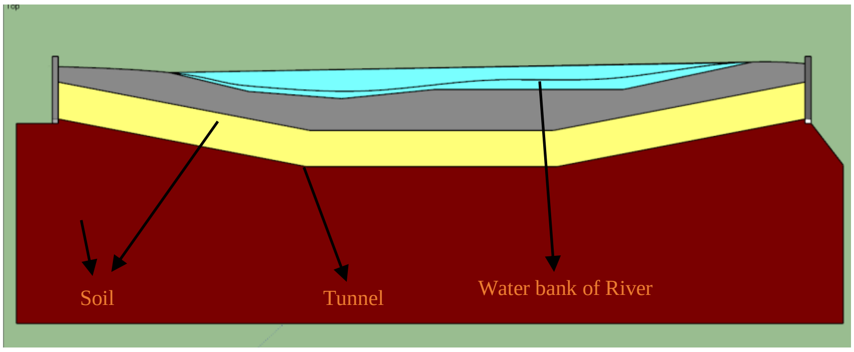

Fig: 6 Cross Section View

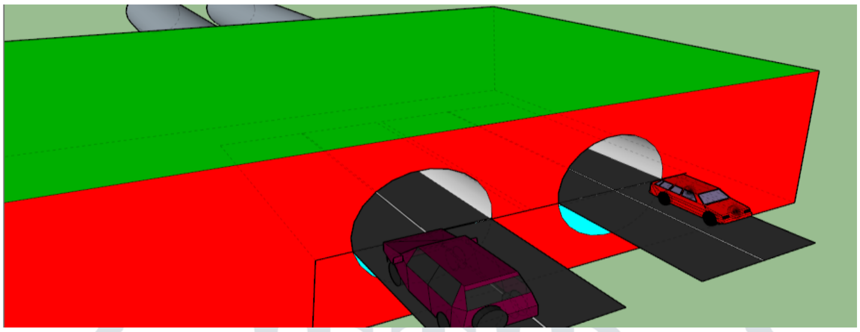

Fig: 7 Front View of tunnel.

5. CONCLUSIONS:

In Our Project, we have Worked on Various Terms following several criteria. Now, we are coming to conclude on High Note that:

- We Have Worked on Rocscience Phase 02 V8i Tunnel Software on Our Project. It is an epoch-making Software in terms of Tunnel Designing. It has brought about immense revolution On Tunnel Excavation Work.
- FEM Tunnel Software can also be used on Our Project Work. It is used to design and analyze the Tunnel like Tunnel lining, Tunnel Designing etc.
- For Structural Drawing of Our Project, we have used AUTO DESK, AutoCAD and Google Sketch Up Software. A good number of Software is available for Structural Drawing like STAAD Pro, Etabs, Revit Architecture etc.
- In Our Project, we have followed several Geological conditions to accomplish Our Task.
- Various Loading Conditions have been followed On Our Data Analysis Work.
- The pressure second control of the huge, submerged tunnel pipe sinking pipe lifting arm is figured it out.
- The programmed change capacity of the position and direction of the sinking pipe lifting in the huge, submerged tunnel is improved.
- The exactness of position and posture following for enormous, submerged tunnel sinking pipe raising cycle is high.
- The security and knowledge of sinking pipe lifting in the submerged tunnel are improved.
- This technique has great application esteem in keen control of tunnel sinking pipe lifting controller.

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