

## 1 General

The aim of the document is to provide information about the required input parameters and the necessary steps for the calculation of a face support pressure. This calculation is carried out under the project name “Sample Project“, at the location “Section 2 - Under Sea Bed” and calculation section “Station 1+200”. The calculation has following features:

Type of TBM	Slurry TBM
Unit of Calculation	US Feet
Safety Concept in General	Partial safety factor
Safety Concept for Ordinate Check	Addition
Method of Calculation	Anagnostou and Kovári

The selected combination of the type of TBM, method of calculation, safety concept etc. in this project is aimed to illustrate various possibilities available in the program. It should not be interpreted as the combination to be followed always. Users are completely free to decide these parameters as per the suitability of their project.

1.1 Input Data			
Tunnel diameter (Excavation diameter)	D	8.0	[ft]
Depth of tunnel (measured from the highest surface, either ground surface or water surface)	h	40.8	[ft]
Depth of groundwater table	$h_{GWL}$	0.0	[ft]
Unit weight of support medium (Advance)	$\gamma_b$	76.4	[lb/ft <sup>3</sup> ]
Unit weight of support medium (Drawdown)	$\gamma_b$	66.8	[lb/ft <sup>3</sup> ]
Operational tolerance support medium	$\Delta_{pM}$	209.0	[lb/ft <sup>2</sup> ]
Operational tolerance compressed air	$\Delta_{pCAP}$	209.0	[lb/ft <sup>2</sup> ]

1.2 Safety Concept			
Partial safety factor for earth pressure	$\gamma_E$	1.50	[-]
Partial safety factor for water pressure	$\gamma_W$	1.05	[-]
Factor for favorable loads in Blow out check	$\gamma_{G, stb}$	0.90	[-]

1.3 Ordinate Check			
Combined ordinate check, crown: coefficient earth pressure	$\Delta p_{kF, ea}$	209	[lb/ft <sup>2</sup> ]
Combined ordinate check, crown: coefficient water pressure	$\Delta p_{kF, W}$	209	[lb/ft <sup>2</sup> ]
Ordinate check bottom edge compressed air, coefficient water pressure	$\Delta p_{CAP, W}$	209	[lb/ft <sup>2</sup> ]
Ordinate check invert, coefficient water pressure	$\Delta p_{, W}$	209	[lb/ft <sup>2</sup> ]

1.4 Surface Loads [as total load or [thickness x unit weight]	Thickness [m]	Unit weight [lb/ft <sup>3</sup> ]	Pressure [lb/ft <sup>2</sup> ]
Temporary surface load			0
Permanent surface load			0

1.5 Soil Layers	Thickness	Unit weight [ $\gamma$ ]	Submerged unit weight	Angle of friction	Cohesion	Lateral pressure Coefficient
	$d_i$ [ft]	[lb/ft <sup>3</sup> ]	[lb/ft <sup>3</sup> ]	$\phi_i'$ [-]	$c_i'$ [lb/ft <sup>2</sup> ]	$\lambda$ [-]
1. Water	20.5					
2. Organic soil	5.0	98	35	30	0	0
3. Sand	31.0	115	64	32	0	0.4

Coefficient of lateral earth pressure at the soil wedge  $\lambda = 0.4$

## 2 Basic Information

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### Project: Sample Project

Location: Section 2 - Under Sea Bed

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**TBM Details**  
The following form contains necessary TBM details.

**TBM Type**  Slurry  EPB

**System of Units**  Metric  US Feet

**Support Medium Unit Weight (Advance)**  lb/ft<sup>3</sup>

**Support Medium Unit Weight (Drawdown)**  lb/ft<sup>3</sup>

**Tunnel Diameter**  ft

**Tunnel Depth**  ft

**Relates to**  Crown  Axis  Invert of the tunnel

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**Drawdown**  
Face support pressure for 1/1, 1/2, and 1/3 Drawdowns will be included in the calculation. If you need extra Drawdown please enter the depth of Drawdown here.

**Additional Drawdown**  ft

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**Miscellaneous Information**  
The miscellaneous information refers to the calculation and will be included in the report.

**Miscellaneous Information**

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In order to save the given data and proceed to the succession of strata please click here.

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Save and proceed to Succession of strata

- 1.1 Before starting calculation, select your language “English” and start from the page “Basic Information”.
- 1.2 **TBM Type: Slurry.** In this type of TBM, face of tunnel is supported by pressurized slurry, which in most of the cases is bentonite suspension.
- 1.3 **System of Units: US Feet.** In this system of units, length will be given in Feet [ft], force in pound [lb] and support pressure will be returned in pounds per square inches [psi].
- 1.4 **Support Medium Unit Weight (Advance): 76.4 [lb/ft<sup>3</sup>],** is the unit weight of the support medium during the excavation.
- 1.5 **Support Medium Unit Weight (Drawdown): 66.8 [lb/ft<sup>3</sup>],** is the unit weight of support medium during the drawdown condition (hyperbaric intervention) for the area which is still filled.
- 1.6 **Tunnel Diameter: 8 [ft],** is the excavation diameter of the tunnel.
- 1.7 **Depth of Tunnel: 40.8 [ft],** as the water surface is above the ground surface, it is taken from the water surface to tunnel reference level.
- 1.8 **Relates to: Crown,** is the reference level for tunnel depth.
- 1.9 **Additional Drawdown: 6.6 [ft].** Calculation can be carried out for an extra drawdown in addition to the standard one third, half and full drawdowns.
- 1.10 **Miscellaneous Information: Tunnel under sea bed.** This field is allocated for additional information about the calculation. It will be presented in the report together with the input information.
- 1.11 **Save and Proceed to Succession of Strata:** to save the provided data and proceed to the next page.

### 3 Succession of Strata

The screenshot shows the 'Succession of Strata' configuration page. It includes a navigation menu with 'Home', 'What is facesupport?', 'Demos', 'Price', 'Imprint', and 'Logout'. The project name is 'Sample Project' and the location is 'Section 2 - Under Sea Bed'. There are tabs for 'Basic Information', 'Succession of Strata', 'Calculation Method', 'Safety Concept', and 'Project Verification'. The 'Succession of Strata' tab is active, showing a 'Groundwater' section with a 'Depth of Groundwater Table' input set to 0 ft. Below this is a 'Surfaceloads' section with input fields for 'Permanent Surface Load' and 'Temporary Surface Load', each with 'Thickness' and 'Unit Weight' fields. A 'Geology' section contains an 'Add Layer' button and a table with columns for 'Water Layer', 'Type of Soil', 't', 'Admixture', 't', 'Layer Thickness', 'Unit Weight', 'Submerged Unit Weight', 'Cohesion', and 'Angle of Friction'. The table has three rows: 'Water' (t=20.5, Unit Weight=63.658), 'Organic soil' (t=5, Unit Weight=98), and 'Sand' (t=31, Unit Weight=115). To the right of the table is a vertical cross-section diagram showing a blue layer (Water) from 0 to 20.5 ft, a pink layer (Organic soil) from 20.5 to 25.5 ft, and an orange layer (Sand) from 25.5 to 56.5 ft. A tunnel is shown at the bottom of the sand layer.

- 2.1 **Depth of Groundwater Table:** 0 [ft]
- 2.2 **Permanent Surface Load:** 0 [lb/ft<sup>2</sup>]
- 2.3 **Temporary Surface Load:** 0 [lb/ft<sup>2</sup>]
- 2.4 **Water layer:** Select the box to assign the first layer as water. For this layer just provide the **Layer Thickness** = 20.5 [ft].
- 2.5  : To add a new layer underneath the selected layer.
- 2.6 For example for the soil layer: silty Sand  
**Type of Soil:** *Sand* (name of the soil layer, major division)  
**Sub Group:** *silty* (name of the soil layer, minor division)  
**t:** S for Sand and *m* for silty, are the symbols for soil layer.  
**Layer Thickness:** h = 31 [ft]  
**Unit Weight of Soil:** γ = 115 [lb/ft<sup>3</sup>]  
**Submerged Unit Weight of Soil:** γ' = 64 [lb/ft<sup>3</sup>]  
**Cohesion:** c' = 0 [lb/ft<sup>2</sup>]  
**Angle of Friction:** φ' = 32 [°]  
 The total thickness of soil and water layers must not be smaller than the depth of tunnel invert.
- 2.7  : to change the color of the soil layer.
- 2.8  : to delete respective soil or water layer.
- 2.9 **Proceed to Calculation Method:** Save the provided data and proceed to next page for the calculation method.

## 4 Calculation Method

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**Calculation Method**  
 You can select one or more calculation methods here.

Anagnostou & Kovári  DIN 4085

**Coefficient of Lateral Pressure (Anagnostou & Kovári) [ $\lambda$ ]**  
 Here you can adjust standard values. Adjustments are accounted in the Calculations.

Bodenart	$\lambda_{\text{default}}$	$\lambda_{\text{new}}$
Water	0	0
Organic soil	0.417	0
Sand	0.389	0.4

$\lambda$  in Sliding Wedge

To navigate back to succession of strata or proceed to safety concept, navigation options are available to you.

### 3.1 Calculation Method: Anagnostou & Kovári

### 3.2 Coefficient of Lateral Pressure [ $\lambda$ ]:

Coefficient of lateral pressure of the individual soil layers can be provided in the calculation. The soil layer will be automatically taken from the geological profile given under “Succession of Strata”.

#### For the Water layer:

When the check box in page “succession of strata” is selected then silo effect will not be considered. So the value of  $\lambda$  is irrelevant for water layer. The coefficient of lateral pressure  $\lambda_{\text{new}}$  is taken as zero.

#### For the Organic soil:

It is taken as the soil layer with poor bearing capacity, so the silo effect of the layer is not considered in the calculation selecting coefficient of lateral pressure 0.  $\lambda_{\text{new}} = 0$ .

#### For the Sand layer:

$\lambda_{\text{default}}$ : 0.389. It is the default value of coefficient of lateral pressure, calculated by the program.

$\lambda_{\text{new}}$ : 0.40. It is the coefficient of lateral pressure for the calculation. Initially this field also contains the same value as in  $\lambda_{\text{default}}$ . This value can be modified by the user if required. Care should be taken that the program only takes the values in these fields.

3.3  **$\lambda$  in Sliding wedge:** Coefficient of lateral pressure for the soil just in front of the TBM. It is 0.4 by default.

3.4 **Save and proceed to Safety Concept:** to save the provided data for the method of calculation and proceed to next page “Safety Concept”.

## 5 Safety Concept

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**Choose a Safety Concept**  
The face support pressure calculation will performed with the selected safety concept.

**Safety Concept**

- ▼ Predefined Safety Concept
  - ▶ ZTWING Slurry
- ▼ User Defined Safety Concept
  - ▶ Slurry Addition
  - ▶ Slurry Zuschlag

**Create new own Safety Concept**  
If you want to create your own safety concept, provide the following values. Later on you will find it in safety concept tree at upper left corner of the page.

Name

TBM Type  Slurry  EPB

Operational Tolerance, Support Medium [lb/ft<sup>2</sup>]

Operational Tolerance, Compressed Air [lb/ft<sup>2</sup>]

Partial Safety Factor, Earth Pressure

Partial Safety Factor, Water Pressure

Factor for Favorable Loads in Blowout Check

Combined Ordinate Check, Crown (Earth Pressure)  Addition [lb/ft<sup>2</sup>]  Factor [-]

Combined Ordinate Check, Crown (Water Pressure)  Addition [lb/ft<sup>2</sup>]  Factor [-]

Ordinate Check, Bottom Edge Compressed Air  Addition [lb/ft<sup>2</sup>]  Factor [-]

Ordinate Check Invert  Addition [lb/ft<sup>2</sup>]  Factor [-]

Safety Concept

Change

You can save the supplied data and navigate to back or next page.

4.1 This sample project presents the way of assigning a new safety concept in the face support calculation. It facilitates user to execute calculation according to the safety concept relevant in the project region. In the following a new safety concept is created with following data:

<b>Name:</b>	<i>Slurry Addition</i>
<b>Operational Tolerance, Support Medium</b>	209 [lb/ft <sup>2</sup> ]
<b>Operational Tolerance, Compressed Air</b>	209 [lb/ft <sup>2</sup> ]
<b>Partial Safety Factor, Earth Pressure</b>	1.5
<b>Partial Safety Factor, Water Pressure</b>	1.05
<b>Factor for favorable loads in blow out check</b>	0.9
<b>Combined Ordinate Check, Crown</b>	<i>Addition</i>
<b>Addition for Earth Pressure</b>	209 [lb/ft <sup>2</sup> ]
<b>Addition for Water Pressure</b>	209 [lb/ft <sup>2</sup> ]
<b>Ordinate Check Bottom Edge</b>	
<b>Compressed Air</b>	<i>Addition</i>
<b>Addition for Water Pressure</b>	209 [lb/ft <sup>2</sup> ]
<b>Ordinate Check Tunnel Invert</b>	<i>Addition</i>
<b>Addition for Water Pressure</b>	209 [lb/ft <sup>2</sup> ]

4.2 **Create new safety concept:** The new safety concept will be saved. Please select it from the safety concept tree, at left side of the page to assign it in the calculation. To calculate with “Predefined Safety concept” and “factor”, instead of “Addition”, refer next sample project.

4.3 **Apply Modification:** to change the parameters of the safety concept.

4.4 **Next to Overview and Calculation:** to navigate to the next page “Project Verification”.

## 6 Project Verification

The screenshot shows the 'Project Verification' page for a 'Sample Project'. The page is divided into several sections:

- 1. Selected Calculation Method:** Indicates that the 'Anagnostou & Kovari' method has been selected.
- 2. Basic Information:** A table showing TBM Type (Slurry) and various parameters:
 

TBM Type	Slurry
Tunnel Diameter $D$	= 8 ft
Tunnel Depth $d$	= 40.8 ft
Depth of the Groundwater Table (In case ground surface lies belowwater table it is 0)	GWL = 0 ft
Support Medium Unit Weight (Advance)	$\gamma$ = 76.4 lb/ft <sup>3</sup>
Support Medium Unit Weight (Drainage)	$\gamma$ = 66.8 lb/ft <sup>3</sup>
Slipwedge	$k$ = 0.4
- 3. Surface Loads and Geology:** A table showing surface loads and geological data:
 

Permanent Surface Load	= 0 lb/ft <sup>2</sup>
Temporary Surface Load	= 0 lb/ft <sup>2</sup>

Water Layer	Type of Soil	L. Admittance	L. Layer Thickness	Unit Weight	Submerged Unit Weight	Angle of Friction	Cohesion
CL	CL	0	5	120	75	30	0.0
Sand	S. silty	0	31	135	64	32	0.0
- 4. Safety Factors:** A list of safety factors and their values:
 

Name	Slurry Addition
Operational Tolerance, Support Medium	= 209 lb/ft <sup>2</sup>
Operational Tolerance, Compressed Air	= 209 lb/ft <sup>2</sup>
Partial Safety Factor, Earth Pressure	= 1.5
Partial Safety Factor, Water Pressure	= 1.05
Factor for favorable loads in Blomout check	= 0.9
Combined Ordinate Check, (Crown addition for earth pressure)	= 209 lb/ft <sup>2</sup>
Combined Ordinate Check, (Crown addition for water pressure)	= 209 lb/ft <sup>2</sup>
Ordinate Check, Bottom Edge compressed air	= 209 lb/ft <sup>2</sup>
Ordinate Check Invert	= 209 lb/ft <sup>2</sup>
- 5. Payment and Face Support Pressure Calculation:** Includes a 'Terms and Conditions' box and two checkboxes:
  - I have read and accepted the terms and condition.
  - I have checked the complete input.

At the bottom, there is a 'clickandbuy' logo and a 'Calculate now' button.

This page presents the summary of the given data, selected calculation method and safety concepts. Please review these parameters before making the calculation. Navigate back to the respective pages if any corrections as well as modification are required.

Before executing the calculation, read the terms and conditions and accept check boxes.

### Calculate now:

You will be directed to “clickandbuy” for the purpose of payments for the calculation. You have to create an account. The cost of the calculation will be booked from this account. After completion of the payment process, reports of your calculation will be available as a PDF documents in the project administration page under your project (see next page).

## 7 Results of Calculation

The screenshot shows the 'Project Administration' interface on the facesupport.org website. The page title is 'Project Administration' with the subtitle 'Administrate Your Projects.'. Navigation links include 'Home', 'What is facesupport?', 'Price', 'Imprint', and 'Logout'. A language selector shows 'English | Deutsch'. Below the navigation, there are links for 'Create Project', 'Add a new Location', 'Add a new Calculation', and 'Enter Calculation Parameters'. A sidebar on the left lists project categories: 'Beispielprojekt', 'Sample Project', 'Section 1 - Mixed Face', 'Section 2 - Under Sea Bed', 'Station 1+200', 'Anagnostou & Kovári', and 'Slurry Addition'. The main content area displays 'Your face support pressure calculation' with a status message: 'The calculation was completed successfully. The reports are now available as pdf. The invoice is available in English and German as well.'. Below this, there are two rows of report links for 'Deutsch' and 'English'. The 'Deutsch' row includes 'Description of Face Support Model', 'Calculation Results', and 'Rechnung'. The 'English' row includes 'Description of Face Support Model', 'Calculation Results', and 'Invoice'.

Reports will be available in two languages, German and English separately. The first report describes the model of calculation in general and the second report presents the results of your calculation.

For further inquiries, comments and suggestions please use [feedback@facesupport.org](mailto:feedback@facesupport.org).