

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 1 - Mixed Face” and calculation section “Station 21+000”. The calculation has following features:

Type of TBM	EPB TBM
Unit of Calculation	Metric
Safety Concept in General	Partial safety factor
Method of Calculation	DIN 4085
Safety Concept for Ordinate Check	Factor

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	12.00	[m]
Depth of tunnel (measured from the highest surface, either ground surface or water surface)	h	21.30	[m]
Depth of groundwater table	h_{GWL}	7.70	[m]
Unit weight of support medium (Advance)	γ_b	14	[kN/m ³]
Unit weight of support medium (Drawdown)	γ_b	14	[kN/m ³]
Operational tolerance support medium	Δ_{pM}	30	[kN/m ²]
Operational tolerance compressed air	Δ_{pCAP}	10	[kN/m ²]

1.2 Safety Concept			
Partial safety factor for earth pressure	γ_E	1.50	[-]
Partial safety factor for water pressure	γ_W	1.05	[-]
Factor for favorable loads in blow out check	$\gamma_{G,stab}$	0.90	[-]

1.3 Ordinate Check			
Combined ordinate check, crown: coefficient earth pressure	$\gamma_{kF,ea}$	1.30	[-]
Combined ordinate check, crown: coefficient water pressure	$\gamma_{kF,W}$	1.05	[-]
Ordinate check bottom edge compressed air, coefficient water pressure	$\gamma_{DL,W}$	1,05	[-]
Ordinate check invert, coefficient water pressure	γ_W	1.05	[-]

1.4 Surface Loads [as total load or [thickness x unit weight]	Thickness [m]	Unit weight [kN/m ³]	Pressure [kN/m ²]
Temporary surface load	-	-	10
Permanent surface load	1.0	18	18

1.5 Soil Layers	Thickness	Unit weight [γ]	Submerged unit weight	Angle of friction	Cohesion	Earth pressure coefficients	
	d_i [m]	γ_i [kN/m ³]	γ'_i [kN/m ³]	ϕ_i [-]	c'_i [kN/m ²]	K_{agh} [-]	K_{ach} [-]
1. Clay, silty	3.3	18.0	8.0	27	30	0.30	1.2
2. Fine gravel, clayey	1.7	21.0	12.0	40	0	0.20	0.9
3. Silt, sandy	22.8	19.0	10.0	30	0	0.30	1.1
4. Fine gravel, clayey	1.2	21.0	12.0	40	0	0.20	0.9
5. Medium sand	6.0	20.2	11.5	33	0	0.30	1.0

K_{agh} and K_{ach} are the coefficient of active earth pressure for the self weight of soil and cohesion respectively.

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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) kN/m³

Support Medium Unit Weight (Drawdown) kN/m³

Tunnel Diameter m

Tunnel Depth m

Relates to Crown Axis Invert of the tunnel

Groundsurface or Watersurface

Tunnel Depth [m]

Tunnel Diameter [m]

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 m

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

Miscellaneous Information

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

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Save
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: EPB.** In Earth Pressure Balance TBM, tunnel face is supported with earth paste formed by excavated soil and conditioning agents.
- 1.3 **System of Unit: Metric.** In this unit system, length is given in meter, force in kilonewton and the support pressure will be returned in bar.
- 1.4 **Support Medium Unit Weight (Advance): 14 [kN/m³].** It is the unit weight of support medium during excavation.
- 1.5 **Support Medium Unit Weight (Drawdown): 14 [kN/m³].** It is the unit weight of support medium during drawdown condition for the area which is still filled.
- 1.6 **Tunnel Diameter: 12 [m].** It is the excavation diameter of the tunnel.
- 1.7 **Tunnel Depth: 21.3 [m],** from the ground surface to tunnel reference level (in this case, tunnel crown is taken as the reference level.)
- 1.8 **Relates to: Crown,** is the reference level for tunnel depth.
- 1.9 **Additional Drawdown: 2 [m].** Calculation can be carried out for an extra drawdown in addition to the standard one third, half and full drawdowns.
- 1.10 **Miscellaneous Information:** “Three soil layers in tunnel face“. This field is allocated for the 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

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Groundwater
Depth of Groundwater Table: 7.7 m

Surfaceloads

Surface Load	Thickness	Unit Weight	Pressure
Permanent Surface Load	1 m	18 kN/m ³	18 kN/m ²
Temporary Surface Load			10 kN/m ²

Geology

Water Layer	Type of Soil	t	Admixture	t	Layer Thickness	Unit Weight	Submerged Unit Weight	Cohesion	Angle of Friction
Clay	C	silty	m	3.3	18	8	30	27	
Fine gravel	fG	clayey	c	1.7	21	12	0	40	
Silt	M	sandy	s	22.8	19	10	0	30	
Fine gravel	fG	clayey	c	1.2	21	12	0	40	
Medium sand	mS			6	20.2	11.5	0	33	

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- 2.1 **Depth of Groundwater Table:** 7.7 [m]
- 2.2 **Permanent Surface Load:** $1.0 \times 18 = 18$ [kN/m²]
- 2.3 **Temporary Surface Load:** 10 [kN/m²]
- 2.4 For the soil layer silty Clay
Water Layer: Do not select the check box, (select only for water layers like in the case of tunnel below river, lake or sea.)
Type of Soil: *Clay* (Name of the soil layer, major division)
Sub Group: *silty* (Name of the soil layer, minor division)
t: C for clay and m for silty, are the symbols for soil layer.
Layer Thickness: $h = 3.3$ [m]
Unit Weight: $\gamma_i = 18.0$ [kN/m³]
Submerged Unit Weight: $\gamma_i' = 8.0$ [kN/m³]
Cohesion: $c' = 30$ [kN/m²]
Angle of Friction: $\phi' = 27$ [°]
- 2.5 **+**: To add another soil layer underneath the selected layer. Insert the rest soil layers similarly. The total depth of the layers must not be smaller than the depth of tunnel invert.
- 2.6 **Color icon**: In order to change the color of the soil strata.
- 2.7 **-**: To delete the respective soil layer.
- 2.8 **Proceed to Calculation Method:** Save the provided data and proceed to next page for the selection of calculation method.

4 Calculation Method

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

Anagnostou & Kovári DIN 4085

Earth Pressure Coefficients (DIN 4085)
The entries have been successfully adopted.

Type of Soil	K _{ach, default}	K _{ach, new}	K _{agh, default}	K _{agh, new}
Clay	1.226	1.2	0.376	0.3
Fine gravel	0.933	0.9	0.217	0.2
Silt	1.155	1.1	0.333	0.3
Fine gravel	0.933	0.9	0.217	0.2
Medium sand	1.086	1	0.295	0.3

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

3.1 Calculation Method: DIN 4085

3.2 Earth Pressure Coefficients: It provides the opportunity to supply the coefficients of earth pressure for the calculation. The soil layer will be automatically taken from geological profile from page “Succession of Strata”.

As example for the first soil Layer:

K_{ach, default}: 1.226. Coefficient of active earth pressure for cohesion for respective soil layer. It is the default value calculated by the program.

K_{ach, new}: 1.2. Coefficient of active earth pressure for cohesion for the calculation. Initially this field also contains the same value as in K_{ach, default}. This value can be modified by the user if required. Care should be taken that the program only takes the values supplied in these field.

K_{agh, default}: 0.376. Coefficient of active earth pressure for self weight for respective soil layer. It is the default value suggested by the program.

K_{agh, new}: 0.3. Coefficient of active earth pressure for cohesion for calculation. Initially this field also contains the same value as in K_{agh, default}. This value can be modified by the user if required. Care should be taken that the program only takes the values supplied in these field.

3.3 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

Choose safety concept for the face support pressure calculation. Alternatively, you can also create your own safety concept filling the form present in this page.

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.

Safety Concept

- ▼ Predefined Safety Concept
 - ▶ **ZTVING EPB**
 - User Defined Safety Concept

Name	<input type="text" value="ZTVING EPB"/>
TBM Type	<input type="radio"/> Slurry <input checked="" type="radio"/> EPB
Operational Tolerance, Support Medium [kN/m ²]	<input type="text" value="30"/>
Operational Tolerance, Compressed Air [kN/m ²]	<input type="text" value="10"/>
Partial Safety Factor, Earth Pressure	<input type="text" value="1.5"/>
Partial Safety Factor, Water Pressure	<input type="text" value="1.05"/>
Factor for Favorable Loads in Blowout Check	<input type="text" value="0.9"/>
Combined Ordinate Check, Crown (Earth Pressure)	<input type="radio"/> Addition [kN/m ²] <input checked="" type="radio"/> Factor [-] <input type="text" value="1.3"/>
Combined Ordinate Check, Crown (Water Pressure)	<input type="radio"/> Addition [kN/m ²] <input checked="" type="radio"/> Factor [-] <input type="text" value="1.05"/>
Ordinate Check, Bottom Edge Compressed Air	<input type="radio"/> Addition [kN/m ²] <input checked="" type="radio"/> Factor [-] <input type="text" value="1.05"/>
Ordinate Check Invert	<input type="radio"/> Addition [kN/m ²] <input checked="" type="radio"/> Factor [-] <input type="text" value="1.05"/>

Safety Concept

Change

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

4.1 Under “Predefined Safety Concept”, select the “ZTVING EPB” to carry out the calculation with this safety concept. This safety concept is according to the German technical regulation „ZTV-ING“ (Additional Technical Specifications and Guidelines for Civil Engineering Constructions). It will automatically select following parameters:

Operational Tolerance, Support Medium	30 [kN/m ²]
Operational Tolerance, Compressed Air	10 [kN/m ²]
Partial Safety Factor, Earth Pressure	1.5
Partial Safety Factor, Water Pressure	1.05
Factor for Favorable Loads in Blow Out Check	0.9
Combined Ordinate Check, Crown	<i>Factor</i>
(Factor for earth pressure)	1.3
(Factor for water pressure)	1.05
Ordinate Check, Bottom Edge Compressed Air	<i>Factor</i>
(Factor for Water Pressure)	1.05
Ordinate Check Invert	<i>Factor</i>
(Factor for Water Pressure)	1.05

4.2 User can also define his own safety concept. Please refer to the next sample project. For selecting “Addition” instead of “Factor” in ordinate check is shown in the same project.

In ordinate check with factor, the earth and water pressure will be multiplied with the respective factors while in addition, the pressure will be added to earth and water pressure respectively.

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

6 Project Verification

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Project: Sample Project

Location: Section 3 - Head Frame

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1. Selected Calculation Method

You can use your selected calculation for the calculation. Alternatively, you can select another calculation method.

You have selected the calculation method **DIN 4085**.

2. Basic Information

You can use an overview of your default information for the calculation here.

TBM Type = EPB
 Tunnel Diameter $D = 12$ m
 Tunnel Depth $d = 21.3$ m
 Depth of the Groundwater Table (In case ground surface lies below water then it is 0). GWL = 2.7 m
 Support Medium Unit Weight (Advance) $\gamma = 14$ kN/m³
 Support Medium Unit Weight (Drawdown) $\gamma = 14$ kN/m³

3. Surface loads and Geology

You can use an overview of the geology for the calculation here.

Permanent Surface Load = 10 kN/m²
 Temporary Surface Load = 10 kN/m²

Water Layer	Type of Soil	t. Admixture	Layer Thickness	Unit Weight	Submerged Unit Weight	Angle of Friction	Cohesion
0	Water	0	0.0	9.8	0.0	0.0	0.0
1	Fine gravel	FG	0.7	21	12	40	0.0
2	Silt	M	22.8	18	18	30	0.0
3	Fine gravel	FG	1.2	21	12	40	0.0
4	Medium sand	MS	6	20.2	11.5	35	0.0

4. Safety Factors

You can use an overview of the safety concept for the calculation here.

Name: ZIVING EPB

Operational Tolerance, Support Medium = 30 kN/m²
 Operational Tolerance, Compressed Air = 10 kN/m²
 Partial Safety Factor, Earth Pressure = 1.5
 Partial Safety Factor, Water Pressure = 1.05
 Factor for favorable loads in Blowsout check = 0.9
 Combined Ordinate Check, (Crown addition for earth pressure) = 1.3
 Combined Ordinate Check, (Crown addition for water pressure) = 1.05
 Ordinate Check, bottom edge compressed air = 1.05
 Ordinate Check Invert = 1.05

5. Payment and Face Support Pressure Calculation

Terms and Conditions

The user himself/herself is solely responsible for his/her input parameters and the accuracy. Subcontracted Engineers (Unter) ensure the correctness of the mathematical operations used in the calculation method. The successful operation at the construction site is the responsibility of the user. The subsequent change of the calculation results, even partially, is prohibited by copyright.

I have read and accepted the terms and condition.
 I have checked the complete input.

clickandbuy Calculate now.

This page presents the summary of the given data, selected calculation method and safety concepts. Please review these parameters before calculating. Navigate back to the respective pages if any corrections or 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 of 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 'facesupport.org' website interface. At the top, there is a navigation bar with links for 'Home', 'What is facesupport?', 'Price', 'Imprint', and 'Logout'. Below this is the 'Project Administration' section with the tagline 'Administrate Your Projects.' and links for 'Create Project', 'Add a new Location', 'Add a new Calculation', and 'Enter Calculation Parameters'. The main content area displays a tree view of projects: 'Beispielprojekt', 'Sample Project', 'Section 1 - Mixed Face', 'Station 21+000', 'DIN 4085', and 'ZTVING EPB'. The 'ZTVING EPB' item is selected and highlighted. To the right of this selection, the text reads: 'Your face support pressure calculation. The calculation was completed successfully. The reports are now available as pdf. The invoice is available in English and German as well.' Below this text, there are two rows of links for downloading reports. The first row is for 'Deutsch' and includes links for 'Description of Face Support Model', 'Calculation Results', and 'Rechnung'. The second row is for 'English' and includes links for 'Description of Face Support Model', 'Calculation Results', and 'Invoice'. Each link is accompanied by a small PDF icon.

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.