

Verification of a gravity wall

Program: Gravity wall

File: Demo_manual_03.gtz

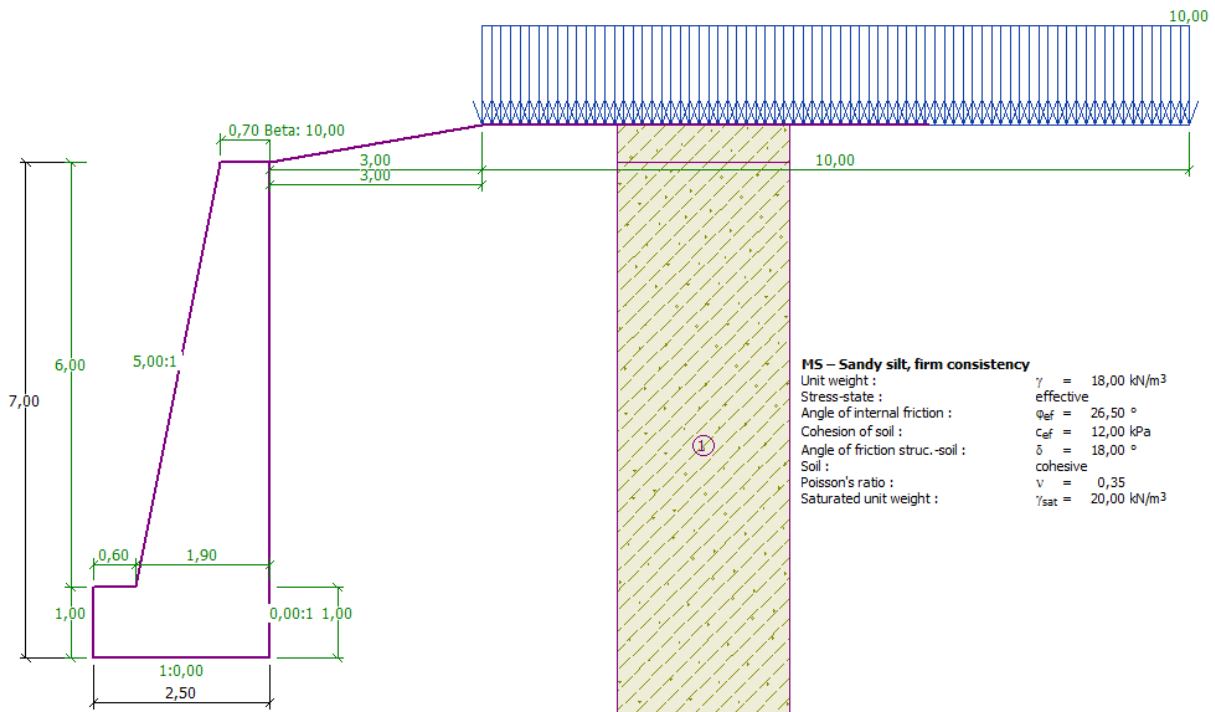
In this chapter an analysis of an existing gravity wall for permanent and accidental design situations is performed. Construction stages are also explained.

Assignment

Using the EN 1997-1 (EC 7-1, DA2) standard, analyze an existing gravity wall for stability, overturning, and slip.

Road traffic acts on the wall with a magnitude of 10 kPa. Check if it is possible to install a barrier on the top of the wall. An accidental load from a car crash is considered to be 50 kN/m and it acts horizontally at 1,0 m above the wall. The dimensions and the shape of the concrete wall can be seen in the picture below. The inclination of the terrain behind the construction is $\beta = 10^\circ$, the foundation soil consists of silty sand. The friction angle between the soil and the wall is $\delta = 18^\circ$.

Determination of bearing capacity and dimensioning the wall is not a part of this task. In this analysis, consider effective parameters of soil.



Scheme of the gravity wall – assignment

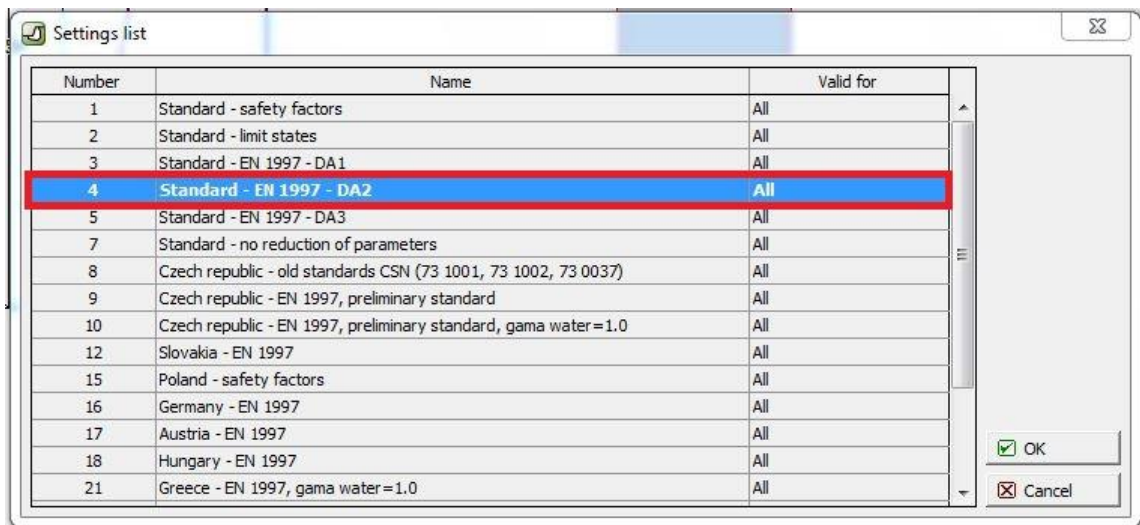
Solution:

To analyze this task, use the GEO5 “Gravity wall” program. In this text, we will describe analyzing this example step by step in two construction stages.

- 1st construction stage – analyzing the existing wall for road traffic.
- 2nd construction stage – analyzing the impact of a vehicle on the barrier on the top of the wall.

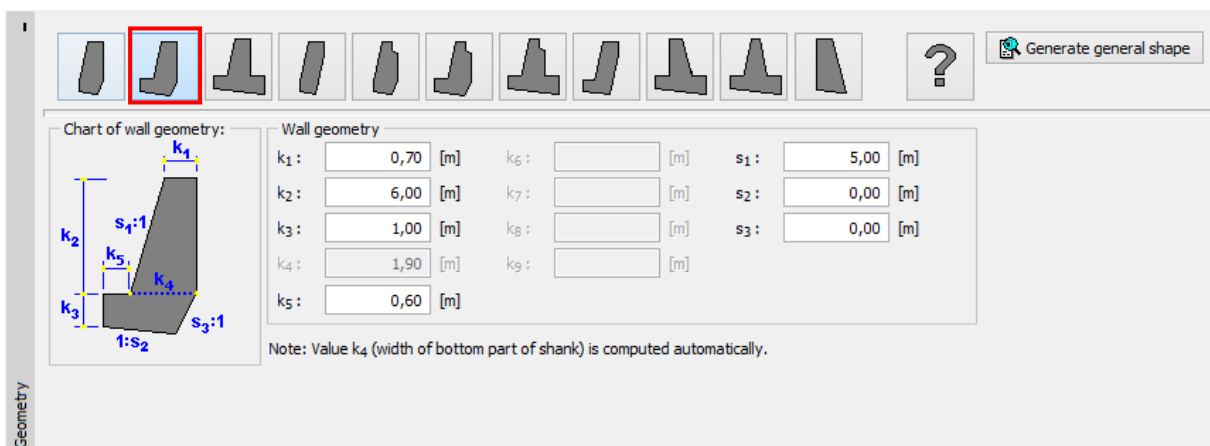
Stage 1

In the frame “Settings” click on “Select” and choose No. 4 – “Standard – EN 1997 – DA2”.



Dialog window “Settings list”

Then, in the frame “Geometry”, select the shape of the gravity wall and define its parameters.



Frame “Geometry”

In the next step, input the material of the wall and the geological profile. The unit weight of the wall is $\gamma = 24 \text{ kN/m}^3$. The wall is made from concrete C 12/15 and steel B500. Then define the parameters of the soil and assign them to the profile.

Table with the soil parameters

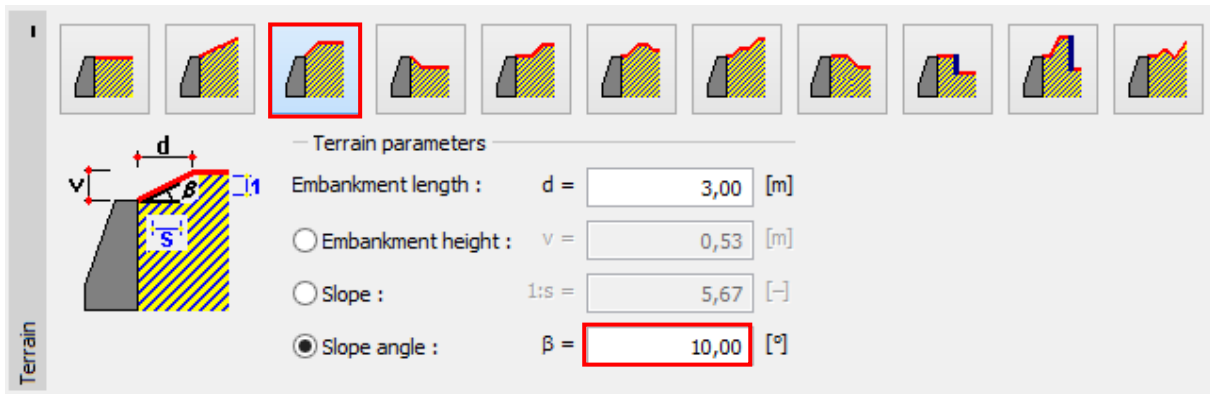
Soil (Soil classification)	Unit weight $\gamma \text{ [kN/m}^3\text{]}$	Angle of internal friction $\varphi_{ef} \text{ [}^\circ\text{]}$	Cohesion of soil $c_{ef} \text{ [kPa]}$	Angle of friction structure – soil $\delta = \text{[}^\circ\text{]}$
MS – Sandy silt, firm consistency	18,0	26,5	12,0	18,0

Dialog window “Add new soils”

Note: The magnitude of the active pressure also depends on the friction between the structure and the soil in an angle $\delta \approx \left(\frac{1}{3} \div \frac{2}{3}\right) \cdot \varphi_{ef}$. In this case we consider the influence of friction between

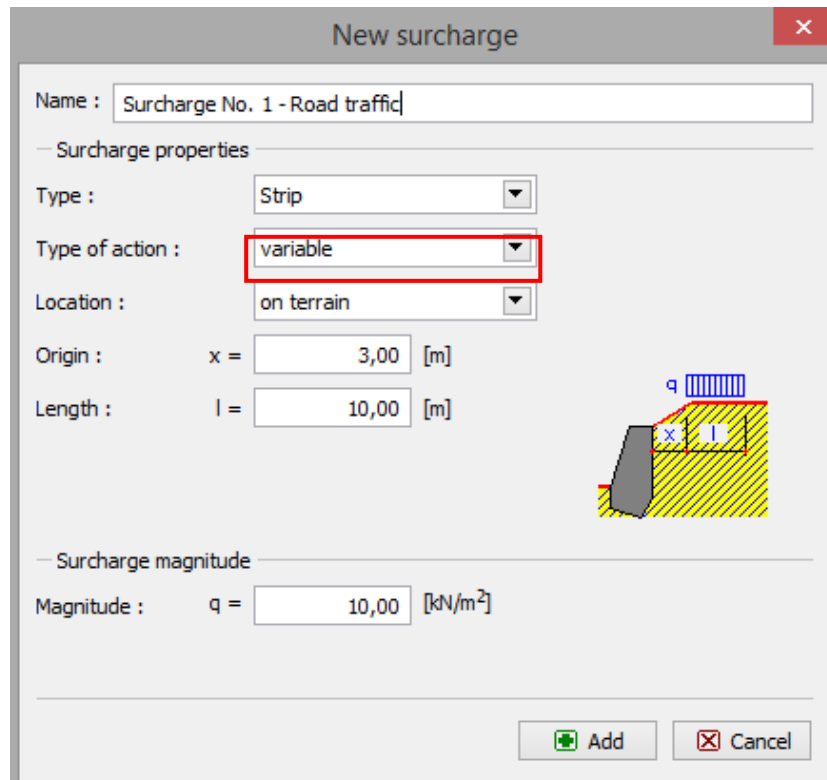
the structure and the soil to have a value of $\frac{2}{3} \cdot \varphi_{ef}$ ($\delta=18^\circ$), when analyzing earth pressure. (More info in HELP – F1).

In the frame “Terrain” select the shape of the terrain behind the wall. Define its parameters, in terms of embankment length and slope angle as shown below.



Frame “Terrain”

In the next frame, define the “Surcharge”. Input the surcharge from the road traffic as a strip, with its location on the terrain, and as a type of action select “Variable”.

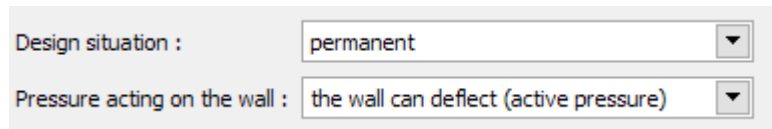


Dialog window “Edit surcharge”

We skip the frame “FF resistance”, the shape of the terrain in front of the wall is horizontal.

Note: In this case, we do not consider the resistance on the front face, so the results will be conservative. The FF resistance depends on the quality of soil and the allowable displacement of the structure. We can consider the pressure at rest for the original soil or well compacted soil. It is possible to consider the passive pressure only if the displacement of a structure is allowed. (More info in HELP – F1).

In the frame “Stage settings” select the type of the design situation. In the first construction stage, consider the “permanent” design situation.



Frame “Stage settings”

Now open up the frame “Verification”, where we analyze the gravity wall for overturning and slip.

No. of force	Force	F_x [kN/m]	F_z [kN/m]	Application point		Minor load
				x [m]	z [m]	
1	Weight - wall	0,00	247,20	1,67	-2,80	
2	Active pressure	-84,17	27,35	2,50	-1,73	
> 3	Surcharge No. 1 - Road traffic	-16,36	6,05	2,50	-2,72	

Verification		
OVERTURNING :	SATISFACTORY	(70,0%)
SLIP :	SATISFACTORY	(90,6%)

Frame “Verification – stage 1”

Note: The “In detail” button in the right section of the screen opens a dialog window with detailed information about the results of the analysis.

Forces acting on construction							
Name	F _{hor} [kN/m]	App.Pt. z [m]	F _{vert} [kN/m]	App.Pt. x [m]	Coeff. overturn.	Coeff. sliding	Coeff. stress
Weight - wall	0,00	-2,80	247,20	1,67	1,000	1,000	1,350
Active pressure	84,17	-1,73	27,35	2,50	1,350	1,350	1,000
Surcharge No. 1 - Road traffic	16,36	-2,72	6,05	2,50	1,500	1,500	1,500

Verification of complete wall

Check for overturning stability
 Resisting moment $M_{res} = 376,91$ kNm/m
 Overturning moment $M_{ovr} = 263,73$ kNm/m
 Wall for overturning is **SATISFACTORY**

Check for slip
 Resisting horizontal force $H_{res} = 152,53$ kN/m
 Active horizontal force $H_{act} = 138,17$ kN/m
 Wall for slip is **SATISFACTORY**

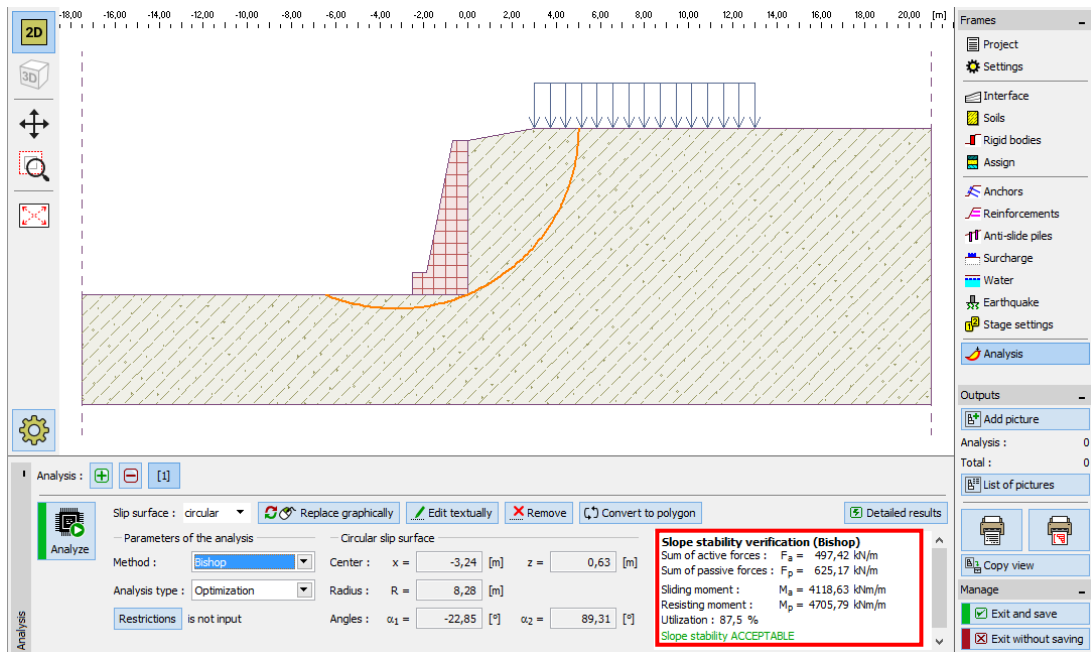
Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 162,84 kPa

Dialog window "Verification (in detail)"

Note: For analyses based on EN-1997, the program determines if the force acts favorably or unfavorably. Then each force is multiplied by the corresponding partial factor which is then shown in the report.

Next, open up the frame "Stability" and analyze the overall stability of the wall. In our case, we will use the "Bishop" method. Perform an analysis with **optimization of circular slip surface** and then validate everything by clicking "OK". Results or pictures will be shown in the analysis report in the "Gravity wall" program.



Program "Slope stability" – stage 1

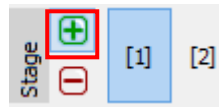
Analysis results: Stage 1

When analyzing bearing capacity, we are looking for values of overturning and slip of the wall on the footing bottom. Then we need to know its overall stability. In our case, the utilization of the wall is:

- Overturning: 70,0 % $M_{res} = 376,91 > M_{ovr} = 263,73$ [kNm/m] SATISFACTORY
- Slip: 90,6 % $H_{res} = 152,53 > H_{act} = 138,17$ [kN/m] SATISFACTORY
- Overall stability: 87,5 % Method – Bishop (optimization) SATISFACTORY

Stage 2

Now, add construction stage 2 using the tool bar in the upper left corner of the screen.

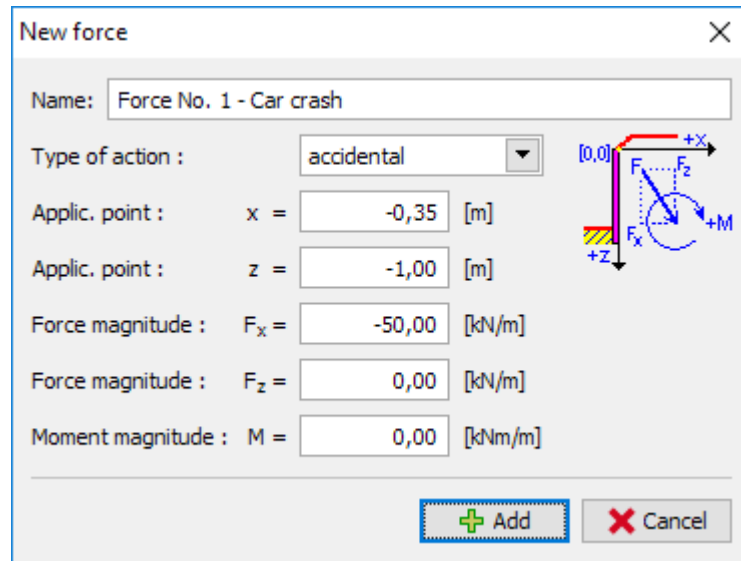


“Construction stage” toolbar

In this stage, define the load from the impact of the vehicle on the barrier, using the frame “Input forces”. The load is accidental.

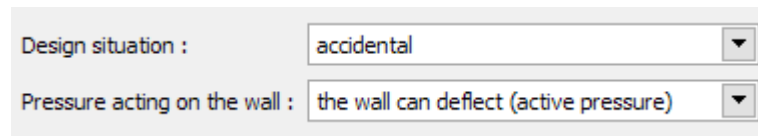
No.	Force new edit	Name	Action	F _x [kN/m]	F _z [kN/m]	M [kNm/m]	Applic. point x [m] z [m]	

Frame “Applied forces” – adding a new force



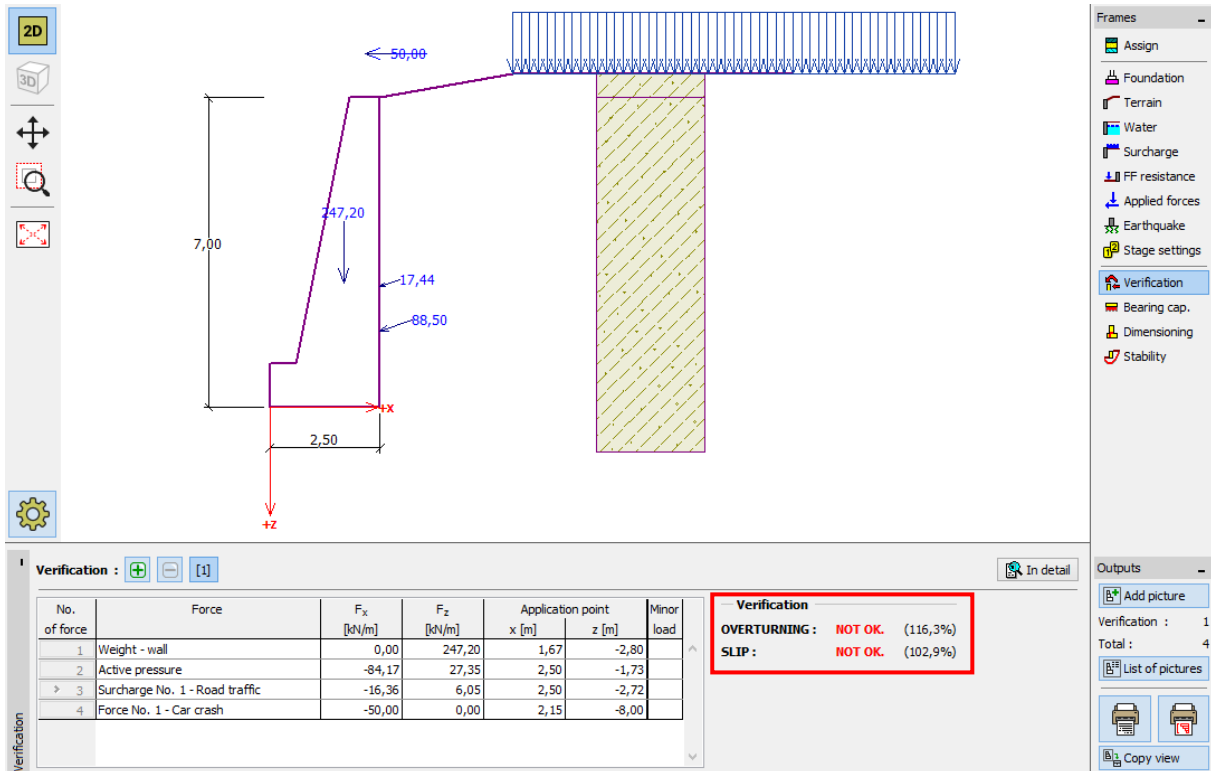
Dialog window "Edit force" – construction stage 2 (accidental design situation)

Then in the frame "Stage settings" change the design situation to "accidental". The program will use partial factors for an accidental situation.



Frame "Stage settings"

The data in the other frames that we entered in stage 1 has not changed, so we don't have to open these frames again. Select the frame "Verification" to perform a verification of overturning and slip again.



Frame "Verification – stage 2"

Analysis results: Stage 2

From the results we see that the existing wall is not satisfactory in case an accidental car crash impacts the barrier. In this case, the utilization of the wall is:

- Overturning: 116,3 % $M_{res} = 488,62 < M_{ovr} = 568,13$ [kNm/m] **NOT OK.**
- Slip: 102,9 % $H_{res} = 138,39 < H_{act} = 142,35$ [kN/m] **NOT OK.**

Conclusion

The analysis of the existing gravity wall shows that the bearing capacity is only satisfactory in the first construction stage, where just the road traffic acts. In the second construction stage, which simulates an accidental impact of a crashing vehicle on the barrier on the top of the wall, the wall is not satisfactory.

As a solution to increase the bearing capacity for overturning and slip, it is possible to introduce soil anchors. Alternatively, it is also possible to place a barrier on the edge of the road, so that the wall is not impacted by the force of a crashing car.