European Commission

The Bulgarian experience in preparing the National Annexes to Eurocode EN 1997

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Development of Bulgarian Technical Codes in Geotechnics – An Overview

- Development of Bulgarian norms and standards in Geotechnics began after the end of the II-nd World War.
- Standards for determining physical properties of building soils have been published in the 50s, while their mechanical properties have been released in the 60s.
- Foundations’ design norms have been prepared and published in several stages from 1962 to 1973.

Development of Bulgarian Technical Codes in Geotechnics

Norms for Flat, raft and pile foundations, foundation in loess collapsed soils, as well as *machine foundations* became effective in the same period.

First design codes *for seismic* regions in Bulgaria were available back in 1964.

- *Chronicle of the I period*

Time period	Documents	Edition
First period – The beginning		
50s years	Standards for the physical properties	First
60s years	Standards for the mechanical properties	First
1962 - 1973	Foundations' design norms	First
	Incl. raft foundations, pile foundations, foundation in loess collapsed soils, machine foundations etc.	First
1964 (After the Skopie's Earthquake)	First design codes for seismic regions in Bulgaria	First

Development of Bulgarian Technical Codes in Geotechnics – An Overview

- Second period of the Bulgarian Codes development.

- Codes and standards created in the 60s were improved and utilized between 1974 to 1996.

Development of Bulgarian Technical Codes in Geotechnics

All codes for building structures and foundations created after 1962 are based on the *Limit States Method (LSM).*

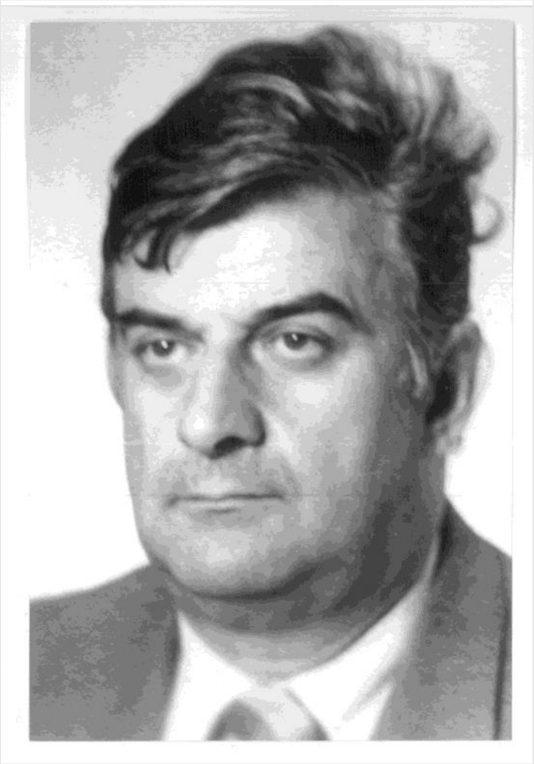
Meanwhile, a lot more standards for *roads, railways and bridges* design came in use, thus covering extensive sections in Geotechnical Engineering.

- *Chronicle of the II period*

Time period	Documents	Edition
Second period - improving		
1974 - 1996	Foundations' design norms	Second
	Incl. raft foundations, pile foundations, foundation in loess collapsed soils, machine foundations etc.	
	Standards for the physical and mechanical properties	Second
1988	Norms for retaining walls	First
	Recommendations for use of geo-textile	First
1974 - 1996	A lot more standards for roads, railways and bridges design came in use, thus covering extensive sections in Geotechnical Engineering.	

Bulgaria's participation in EC7 preparation

- Bulgaria have participated in preparation of EC7 back in the years between 1990 and 2000, when the correspondence between EC Technical Comity and *Prof. Emil Toshkov*, the Head of Geotechnical Engineering Department of Sofia Construction Research Institute was initiated.



Bulgaria's participation in EC7 preparation

- *Prof. E. Toshkov* was Head and Founder of the majority of our Foundation codes – for:
- flat and pile foundations,
- machine foundations,
- foundations for landslides
- and others.

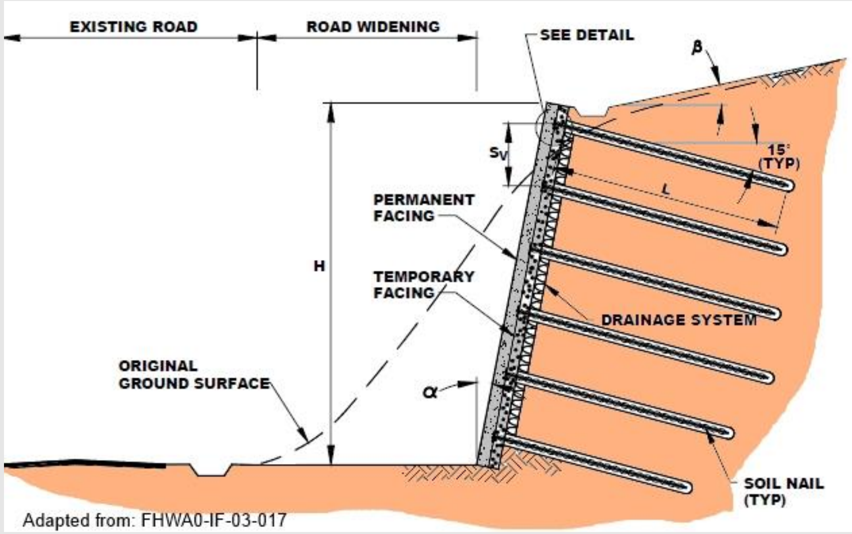
Existing Bulgarian codes

Machine foundations

Foundations in leoss

Developments during the period

Soil nails



Reinforced embankments

Bulgaria's participation in EC7 preparation

- Prof. Toshkov's statements about EC7 advocated the thesis for considering the national experiences and values of achieved technical parameters.
- Particular attention was paid to foundations in loess, to the seismic effect from earthquakes and the impact of machine foundations.
- However, these statements also embraced the new inventions of the other European countries such as the novelties in geo-synthetics, soil nails, "in situ" methods of study and more other.

Bulgaria's participation in EC7 preparation

- Comments on partial coefficients' values showed principle agreement with EC7, but there were differences about the cohesion values.
- There were still no prerequisites for reliable cohesion values, which is why their particular ratio was 1.8, and in the past it was even 2.0.

Development of Bulgarian Technical Codes in Geotechnics

In the spirit of our agreement with the European trend for reliable cohesion value, there were *the Norms for landslides protection in 2001* coming out.

The partial cohesion factor in this document was **1.6** and *the internal friction angle* was **1.2**.

- *Chronicle of the III period*

Time period	Documents	Edition
Third period – transitional to Eurocode		
1996 - 2009	Correspondence between European specialists and institutions, incl. Bulgarian.	
	Conferences and meetings	
	Researches and publications	First
2001	Norms for landslides protection	First
2010	Formal Introdution of Eurocode	First

Bulgaria's participation in EC7 preparation

- The final edition of EC7 and its translation in Bulgarian language, as well as the preparation of our National Annex were supervised ***by Prof. Trifon Germanov*** from the 56-Technical Committee at the Bulgarian Standardization Institute.

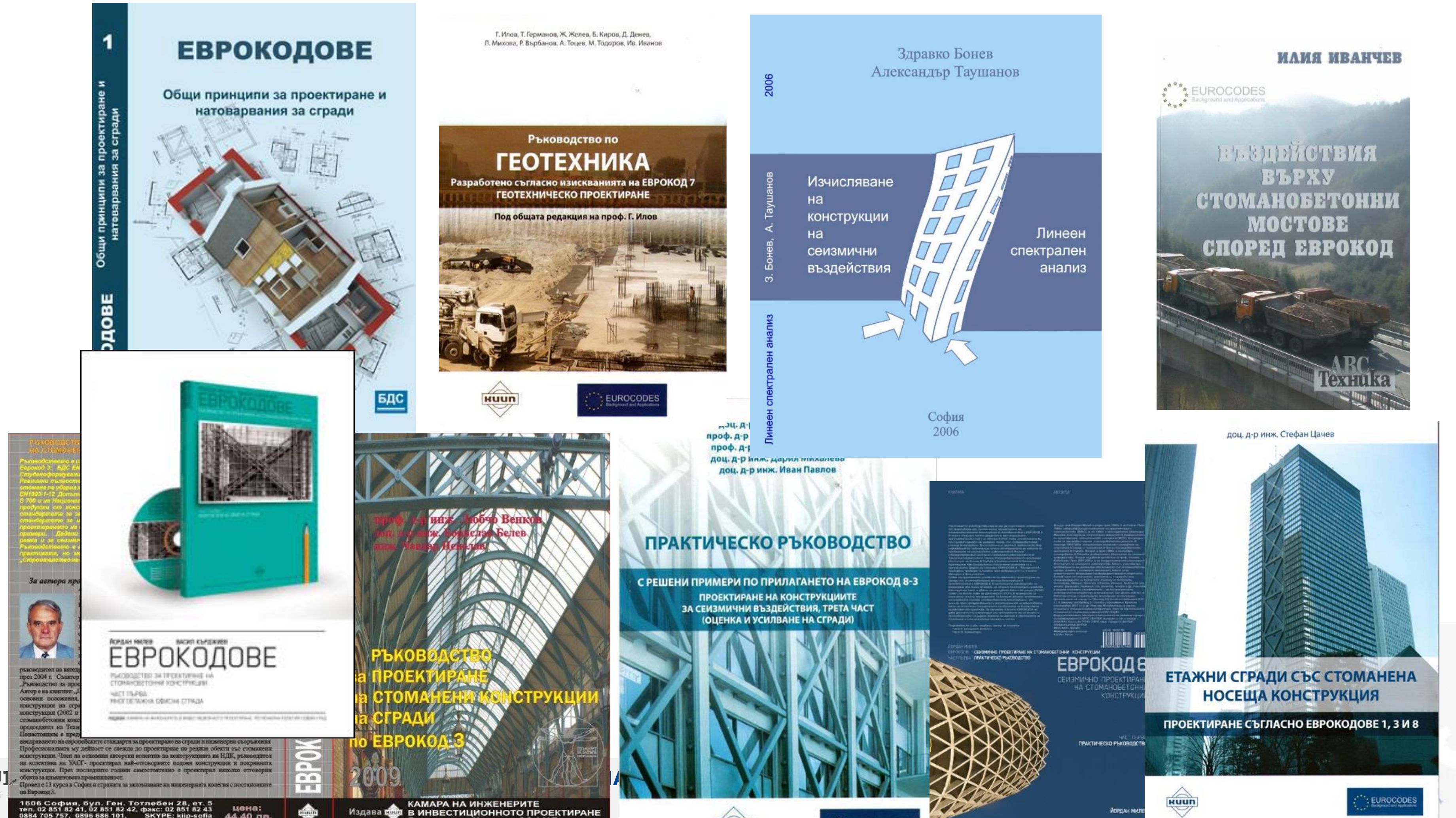
Bulgaria's participation in EC7 preparation

- Thanks to the extremely well organized work in the Bulgarian Standardization Institute by ***Mrs. Eng. Iren Dabizheva,*** Bulgaria was ready on time with the translations of EC7 and its National Annex.
- A bunch of our specialists have attended JRC seminars about the EC7 introduction into our construction practice.

Bulgaria's steps in bringing the Eurocodes and national applications in action

- Invention and adoption of our National Annex to EC7 were preceded by several years of promotion and interpretation.
- A few scientific conferences and short qualification courses took place in this period.
- Books and publications with solved examples came out of print.
- Most of the above were devoted to EC1, EC2, EC3, EC4 and EC8.

Manuals and books on the Eurocode



Bulgaria's steps in bringing the Eurocodes and national applications in action

- National Annex to EC7 was compiled under the impact of the following prerequisites:
  - Former Bulgarian Code used as a base the *Limit States Method (LSM)* and there was a 40 years of local practice already accumulated;
  - Technological upgrading and modernization in Geotechnics have just started in the year of 2000;
  - The introduction period was insufficient for objective assessment of the latest technologies;
  - Norms for landslides protection from 2001 happened to be transitional for the adoption of European Standardization.

Selection of Design Approach

- A quick comparison with our norms shows that the closest to their nature is the second design approach (DA2).
- There are identical values of coefficients even for the pile foundations.

- CEN statistics shows that DA2 is selected by 55% of Member - States for geotechnical design (without resistance for slope stability design), DA1 - 30% and DA3 - 10%.

- 65% of Member - States have selected DA3 for the slope stability design, followed by only 25% for DA1 design; while only Spain preferred to work with DA2.

Selection of Design Approach

- So far our standards have been very close to the Russian ones (SNIP), but historically we can find their roots in German and partly in the French such.
- Germany and France are using project approaches that are also chosen by many member states, and these are DA2 and DA3 for general slope stability.
- Britain and Italy are operating with design approaches adopted by a smaller number of countries, and this is DA1 for general cases and for slope stability.
- British and Italian Geotechnical Standard are not popular in Bulgaria, respectively it is difficult to find coincidences with our rules.

Selection of Design Approach

- Eurocode was drawn mainly from highly qualified German, French, British professionals.

- Their different design approaches are an evidence for the bright Geotechnical tradition in these countries.

Analysis of EC 7 Bulgarian National Application

- There is information about all of the 29 articles of EC 7 available in the national annex, and there are **only 5** of them where we meet some differentiation.
- Bulgarian national annex to EC7 accepts very big part of norms and values, recommended by the general document.
  - For instance, suggested values of particular coefficients γ_F, used for determination of the computing design values of geotechnical impact F_d are the same as the ones available in table A.1 from Appendix 1 to EC7.
  - According to article 2.4.7.3.2 about particular impact coefficients or their effect, we need to accept the suggested values from tables A.3, A.4 of EC7 and so on.

Peculiarities in Bulgarian National Annex

There are differences among the values of partial coefficients for soil characteristics.

They are written in table NA.1 to article 2.4.6.2.

Values of cohesion and friction angle differ from the suggested ones;

they remain the same as the ones in our previous codes

- Table NA.1 to article 2.4.6.2:

Soil parameter	Symbol	Value
Friction angle	γ_{φ}	**1.20**
Effective cohesion	γ_{c}	**1.60**
Undrained shear strength	γ_{cu}	**1.4**
Axial pressure	γ_{qu}	**1.4**
Volume weight	γ_{γ}	**1.0**

DA2/DA3

- Bulgaria has adopted the second Design approach **DA2** to calculate geotechnical structures. This is written in article 2.4.7.3.4.1.

- There is one exception to the rule. Tasks **for slope stability** are solved by the help of **DA3**, the third project approach. This is how is recorded in article 11.5.1 of the national annex.
- Adoption of DA2 was grounded by Bulgarian traditions, as reflected in current foundation standards.
- The argument for choosing DA3 in tasks solving slope stability issues is the same as the one that has Germany and several other European countries.
- DA2 is not suitable for automated determination of such problems.

Values of Limit Distortions

- The 3rd important peculiarity of Bulgarian National Annex to EC7 are tables NA.2 and NA.3 at article 2.4.9, which cover the values of limit distortions like settlement and rotation of flat foundations for different types of structures.
- These tables are carried over from previous flat foundation standards.
- This paragraph is according to the *Informative application **H*** to EC7.

Tables NA.2: Limit settlement [cm]

№	Type of structures and foundations	Displacement type	Limit settlement, *cm*
1	Едропанелни безскелетни сгради: a) на ивични фундаменти b) на обща плоча	Средно слягане	5 10
2	Сгради с носещи бетонни (стоманобетонни) стени по системата "Едроразмерен кофраж" на обща плоча	Средно слягане	12
3	Сгради по системата "Пакетно повдигани плочи": a) на единични фундаменти b) на обща плоча	Средно слягане	5 10
4	Скелетни стоманобетонни сгради на единични фундаменти	Максимално абсолютно слягане	6
5	Сгради с носещи тухлени или едроблокови неармирани стени на ивични фундаменти	Средно слягане	6
6	Сгради с тухлени или едроблокови стени, армирани със стоманобетонни пояси по всички етажи и по цялата дължина на сградата	Средно слягане	5
7	Корави сгради или съоръжения на обща плоча (силози, кули и други) с височина до 100 m включително и сгради със закоравени конструкции на подземните етажи	Средно слягане	15
8	Едноетажни промишлени сгради на единични фундаменти, а също така и други сгради с подобна конструкция при осово разстояние на колоните: a) $l = 6$ m b) $l = 12$ m	Абсолютно слягане	6 8
9	Свободно стоящи комини на обща плоча	Абсолютно слягане	15
10	Сгради и съоръжения, в чиито конструкции не възникват допълнителни усилия от неравномерни слягания	Максимално абсолютно слягане	12

Tables NA.3: Limit rotation [rad]

Type of structures and foundations		Displacement type	Limit rotation, *rad*
1	Едропанелни безскелетни сгради на ивични фундаменти или на обща плоча	Относително огъване на стените	0,0007
		Накланяне в напречна посока	0,004
2	Сгради с носещи бетонни (стоманобетонни) стени по системата "Едроразмерен кофраж"	Накланяне в напречна посока	0,01B/H , но не повече от 0,004
3	Сгради по системата "Пакетно повдигани плочи": a) на единични фундаменти b) на обща плоча	Относително слягане Накланяне в напречна посока	0,002 0,004
4	Скелетни стоманобетонни сгради на единични фундаменти	Относително слягане	0,002
5	Сгради с носещи тухлени или едроблокови неармирани стени на ивични фундаменти	Относително огъване на стените	0,001
6	Сгради с тухлени или едроблокови стени, армирани със стоманобетонни пояси по всички етажи и по цялата дължина	Относително огъване на стените	0,0013
7	Свободно стоящи комини на общи плочи	Накланяне	1/2H, но не повече от 0,004
8	Корави съоръжения на обща плоча (силози, кули и други) с височина до 100 m	Накланяне в напречна посока	0,01B/H, но не повече от 0,004
9	Сгради и съоръжения на единични фундаменти, в чиито конструкции не възникват допълнителни усилия от неравномерни слягания	Относително слягане	0,005
10	Мостови кранове на промишлени сгради	Накланяне на крановия път Накланяне на моста на крана	0,004 0,003

Pile Foundations

- The last important feature of Bulgarian National Annex to EC7 refers to pile foundations.
- Tables of base resistance pressure values and shaft resistance of driven piles were carried over from the current provisions of the national administration.
- These are tables NA.4 and NA.5 to article 7.6.2.3.
- The partial coefficients for the base resistance γ_b and shaft resistance γ_s according to driving technology and soil type are given in the table NA.6.
- They are suitable for preparation of preliminary project feasibility study or technical design.

Tables NA.4 to article 7.6.2.3 – Base resistance pressure [kPa]

Embedded depth of pile's peak	**Average dense sands**						
	Shingle	Coarse	-	Medium	Fine	Dusty	-
	Clayey soils with consistency index I_c						
		0.9	0.8	0.7	0.6	0.5	0.4
	Characteristic value of base resistance pressure in *kPa*						
3	7500		3000			1100	600
4	8300		3800			1250	700
5	8800		4000			1300	800
7	9700		4300			1400	850
10	10500		5000			1500	900
15	11700		5600		2900	1650	1000
20	12600	8500	6200		3200	1800	1100
25	13400	9000	6800	5200	3500	1950	1200
30	14200	9500	7400	5600	3800	2100	1300
35	15000	10000	8000	6000	4100	2250	1400

Tables NA.5 to article 7.6.2.3 – Shaft resistance for driven piles [kPa]

Average depth of soil layer	**Average dense sands**								
	Coarse and medium	Fine	Dusty	-	-	-	-	-	-
	Clayey soils with consistency index I_c								
		0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
	Characteristic value of shaft friction in kPa								
1	35	23	15	12	8	4	4	3	2
2	42	30	21	17	12	7	5	4	4
3	48	35	25	20	14	8	7	6	5
4	53	38	27	22	16	9	8	7	5
5	56	40	29	24	17	10	8	7	6
6	58	42	31	25	18	10	8	7	6
8	62	44	33	26	19	10	8	7	6
10	65	46	34	27	19	10	8	7	6
15	72	51	38	28	20	11	8	7	6
20	79	56	41	30	20	12	8	7	6
25	86	61	44	32	20	12	8	7	6
30	93	66	47	34	21	12	9	8	7
35	100	70	50	36	22	13	9	8	7

Tables NA.6 to article 7.6.2.3 – Partial coefficients γ_b and γ_s for driven piles

	Method of driving piles and type of soil	Partial coefficients γ_b	Partial coefficients γ_s
1	Забиване на плътни пилоти и кухи пилоти със затворен връх чрез свободно падащи паровъздушни и дизелови чукове	1,0	1,00
2	Забиване в предварително изработени водещи сондажи при навлизане на пилота поне 1 m под забоя на сондажа с диаметър:	1,0	1,0
	равен на страната на квадратен пилот	1,0	0,5
	5 cm по-малък	1,0	0,6
	15 cm по-малък от страната на квадратен пилот или от диаметъра на кръгъл пилот	1,0	1,0
3	Забиване с воден подмив в пясъчни почви при навлизане на пилотите в последния метър без прилагане на воден подмив	1,0	0,9
4	Забиване чрез вибриране в среднoплътни песъчливи почви:		
	едрозърнести и среднозърнести пясъци	1,2	1,0
	дребнозърнести пясъци	1,1	1,0
	прахови пясъци	1,0	1,0
	Глинести почви с показателна консистенция $I_c = 0,5$:		
	глинести пясъци	0,9	0,9
	песъчливи глини	0,8	0,9
	глини	0,7	0,9
	Глинести почви с показател на консистенция $I_c \geq 1$	1,0	1,0
5	Забиване с всякакъв вид чукове на кухи цилиндрични пилоти с отворен връх:		
	при диаметър на кухината d ≤ 40 cm	1,0	1,0
	при диаметър на кухината > 40 cm	0,7	1,0

Informative applications to EC7

- All the computing procedures, presented in the Informative applications to EC7 are in compliance with our ongoing practice:

- Earth pressure;
- Bearing capacity;
- Settlement;
- Foundations in rock;
- Supervising.

Practice, comments and domestic use of EC7 after its regulation

- Bulgarian National Annex to Eurocode 7 has undergone two revisions so far.
- No project approach has been selected after the initial publication.
- When Eurocode came into power in 2010, six member EU states only have not declared their design approach preference.
- These were: **Bulgaria**, Estonia, Latvia, Hungary, Czech Republic and Sweden. Ireland has stated that all 3 design approaches can be applied in the country.
- Several months later, Bulgaria overcame the gap and made its design approach selection.
- Since the beginning of 2011, Eurocode is used in parallel with existing national construction norms, and as of 2014 it is a mandatory standard for all large projects.

Discussions

- One of the most debated issue that worried experts was the issue which norm to comply with at loess foundation.
- The norm was defined by the Minister of Investment Planning as follows:

"For design requirements, including geotechnical design of buildings that are not defined in the Eurocodes, the requirements of the national legislation are to comply with."

- So *foundation in loess* and issues with *machine foundations* remain to be settled according to Bulgarian national legislation.

Discussions

Theses

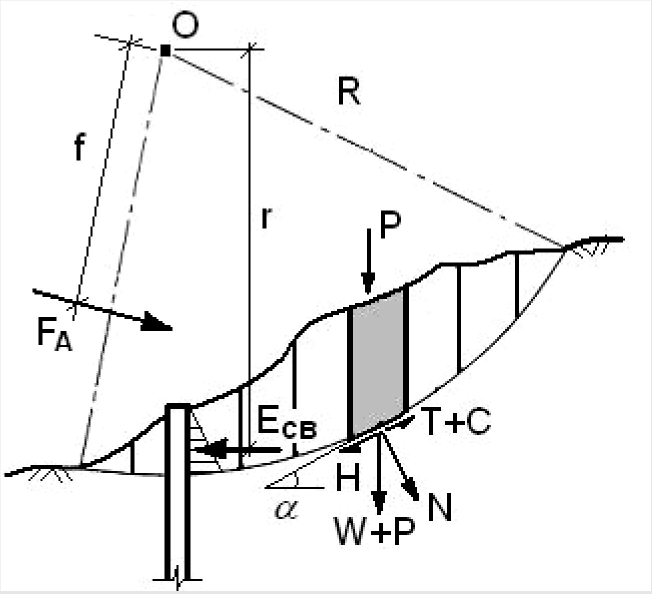
- Ongoing discussions among experts argue about the benefits of Eurocode:
- from adoption of limit state method as a ground base principle in Europe
- to acceptance of reliability theory, which replaces the "expert" approach;

Antitheses

- Antitheses defended were:
- EC7 is very difficult to understand and adopt;
- it requires a lot of time to study;
- How older colleagues will do?
- fear of not holding the competition.

Slopes Stability problem

- Practical implementation of Eurocode 7 and National annex raised inquiries about slope stability computing results under static and seismic load.



Slopes Stability problem

- Comparisons of partial factor values for soil characteristics in different European countries were made to better the Bulgarian situation:
  - A total of 17 countries (61%) have adopted DA3 to calculate slopes stability problem, including Netherlands, Norway, Sweden, Denmark which solve all their geotechnical issues by DA3.
  - 12 (43%) out of the above member states have also adopted the recommended by EC7 coefficients while using DA3 and namely:
  - $\gamma_{\varphi} = 1.25$; $\gamma_{c} = 1.25$.

Exceptions of the Rule

- Exceptions of the rule are allowed only in:
  - Hungary - $\gamma_{\varphi} = 1,25$; $\gamma_{c} = 1,25$; $\gamma_{q} = 1,5$;
  - Denmark - $\gamma_{\varphi} = 1,2$; $\gamma_{c} = 1,2$; $\gamma_{q} = 1,8$;
  - Nederland - $\gamma_{\varphi} = 1,15$; $\gamma_{c} = 1,6$; $\gamma_{q} = 1,35$;
  - ***Bulgaria - $\gamma_{\varphi} = 1,2$; $\gamma_{c} = 1,6$; $\gamma_{q} = 1,4$ (highly seismic area)***
  - Portugal and Italy`(high coefficients - $\gamma_{\varphi} = 1,5$; $\gamma_{c} = 1,5$; $\gamma_{q} = 1,5$, but accepted DA1).

Comparison on the Balkans:

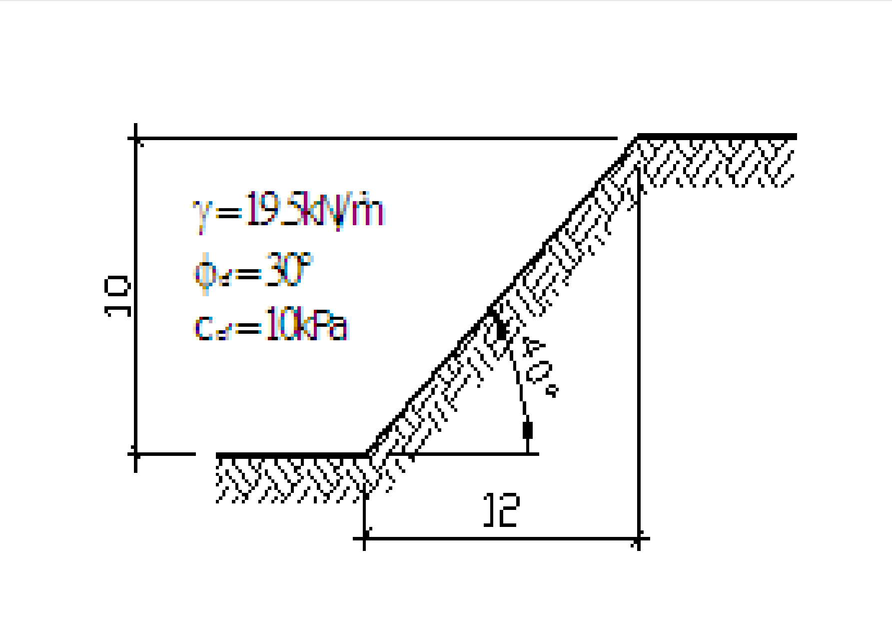
- Bulgaria - $\gamma_{\varphi} = 1,2$; $\gamma_{c} = 1,6$; $\gamma_{q} = 1,4$ – DA2/DA3
- Rumania - $\gamma_{\varphi} = 1,25$; $\gamma_{c} = 1,25$; $\gamma_{q} = 1,4$ – DA1/DA3

Note: **There is a high difference in particular coefficients between Rumania and Bulgaria, although they are so close geographically and economically!**

Resolved Case

Cross section

- Slope Stability Issue



Solution:

- *Solution has been performed by software.*

Solution Results

Parameter	Bulgaria	EC7 – DA3	Denmark	Hungary
Active forces E_d, kN/m	352.87	388.92	439.75	380.78
Passive forces R_d, kN/m	363.66	422.07	464.01	382.59
Utility ratio E_d/R_d	**0.97**	**0.921**	**0.948**	**0.995**

time/geo	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Средно за периода	Коефициент на използване от Пример 1
EU (27 countries)	100	100	100	100	100	100	100	100	100	100	100	100	100,00	
Austria	126	127	128	128	125	126	124	125	126	127	129	130	126,75	0,921
Bulgaria	30	32	34	35	37	38	40	44	44	44	47	47	39,33	0,970
Cyprus	90	89	89	91	93	93	94	100	100	97	94	92	93,50	
Czech Republic	73	74	77	78	79	80	83	81	83	81	81	81	79,25	
Denmark	128	129	124	126	124	124	123	125	124	128	126	126	125,58	0,948
Finland	115	115	113	116	114	114	118	119	115	114	116	115	115,33	0,921
France	116	116	112	110	110	108	108	107	109	109	109	109	110,25	0,921
Germany	116	115	116	116	116	116	116	116	115	120	123	123	117,33	0,921
Greece	87	90	93	94	91	92	90	93	94	88	80	75	88,92	0,921
Hungary	58	61	63	63	63	63	62	64	65	66	67	67	63,50	0,995
Italy	119	113	111	107	105	105	104	104	104	103	102	101	106,50	
Latvia	39	41	44	47	50	53	57	59	54	55	60	64	51,92	0,921
Netherlands	134	134	130	129	131	131	132	134	132	130	129	128	131,17	
Poland	48	48	49	51	51	52	55	56	61	63	65	67	55,50	0,921
Portugal	81	80	80	77	80	79	79	78	80	80	77	76	78,92	
Romania	28	29	31	34	35	38	42	47	47	48	48	50	39,75	0,921
Slovakia	53	54	56	57	60	63	68	73	73	74	75	76	65,17	0,921
Slovenia	80	83	84	87	87	88	89	91	86	84	84	84	85,58	0,921
United Kingdom	121	122	123	125	124	122	118	114	112	108	105	106	116,67	

Results Assessment

Results of utilization rates were assessed according to Gross domestic product (GDP) per capita for the period of 2001 to 2012.

Results Assessment

- The most developed European countries such as Germany and France have the lowest utilization rate - **0.921**, i.e. they have adopted the most economical factors for soil characteristics.
- On the contrary, Bulgaria with a lowest GDP has adopted the highest utilization rate - **0.970**, i.e. the country spent most unnecessary to achieve facilities' high stability.

EU (27 countries	100,00	
Austria	126,75	0,921
Bulgaria	39,33	0,970
Cyprus	93,50	
Czech Republic	79,25	
Denmark	125,58	0,948
Finland	115,33	0,921
France	110,25	0,921
Germany	117,33	0,921
Greece	88,92	0,921
Hungary	63,50	0,995
Italy	106,50	
Latvia	51,92	0,921
Netherlands	131,17	
Poland	55,50	0,921
Portugal	78,92	
Romania	39,75	0,921
Slovakia	65,17	0,921
Slovenia	85,58	0,921
United Kingdom	116,67	

Recommended amendments in the National Application Annex

- 1. Values of the partial factors γ_{φ} and γ_{c} to become **1.25** in Bulgaria

Why?

- We believe that such a decision will motivate all project parties involved - contractors, designers, investigators for higher professionalism, thorough work and quality improvement.

Bulgarian institute for standardization accepted on the proposal *and already published it for public consultation, together with the revised national annexes to Eurocode 0, 1, 2, 5 and 8.5.*

The deadline for consideration is up to 20.11.2014.

Recommended amendments in the National Application Annex

- **2.** To add rules for slope stability and foundations in loess to EC7 national annex.

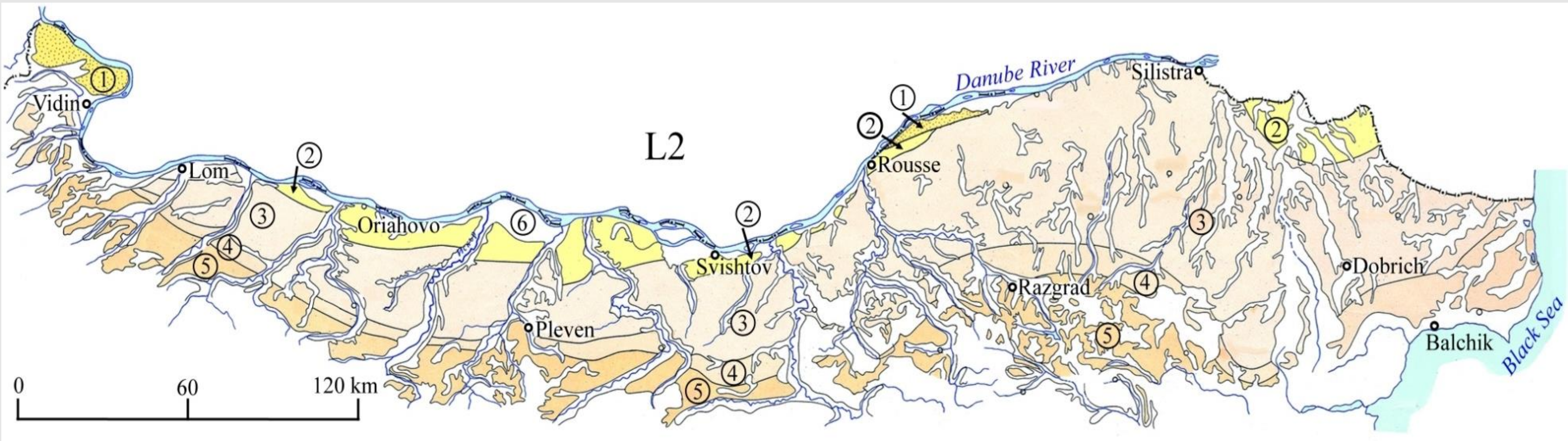
Recommended amendments in the National Application Annex

Why?

It is widely observed in loess areas, that there are the so-called loess walls whose height reaches 30 meters and more.

Slope landslides in loess is not happening around circular slipping surfaces but over sub-vertical shear planes.

This relationship remains under strong seismic influences.
The reason lays in the high degree of loess anisotropy.



Map of the spread of loess in Northern Bulgaria

Recommended amendments in the National Annex

- **3.** We intend to update the tables with limit states distortions, which to include requirements for notably high-rise buildings (over 100 m)

- and for modern bridges.

- The results of practice will be a base for statistics and future analyses.

Conclusions

- Eurocode is a product of united efforts of all member states to improve and develop.
- Its application requires its constant workout due to new knowledge and values precision in a result of accumulated information and practice.
- Bulgarian National Annex to EC7 is a great example of such a progress. It brings together our national experiences and European practice.
- Still, it is constantly updated and collated with practice as from its establishment and on.

Conclusions

- Bulgarian Society for Soil Mechanics and Geotechnical Engineering, Bulgarian Chamber of Engineers for Investment Projects as well as Bulgarian Standardization Institute and Ministry for Investment Planning are highly contributing to distribution and implementation of EC7.
- Interest in Eurocodes and its National Annex among engineers in Bulgaria is constantly growing.

THANK YOU

FOR YOUR ATTENTION!