European Commission

# CURRENT STATUS OF ELABORATION OF MAPS FOR CLIMATIC AND SEISMIC ACTION:
# Country report of MONTENEGRO

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- seismic zones and reference pga
- question on low and very low seismicity
- seismic response spectra

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# ISME/TK 002: Eurocodes – main activities so far

- IPA twinning project on Eurocodes (2012-2013);
- Action plan for Eurocodes adoption and implementation (adopted by Government of Montenegro in January 2014) ;
- New law on spatial planning and building is finished in draft form.

## EUROCODES ADOPTION

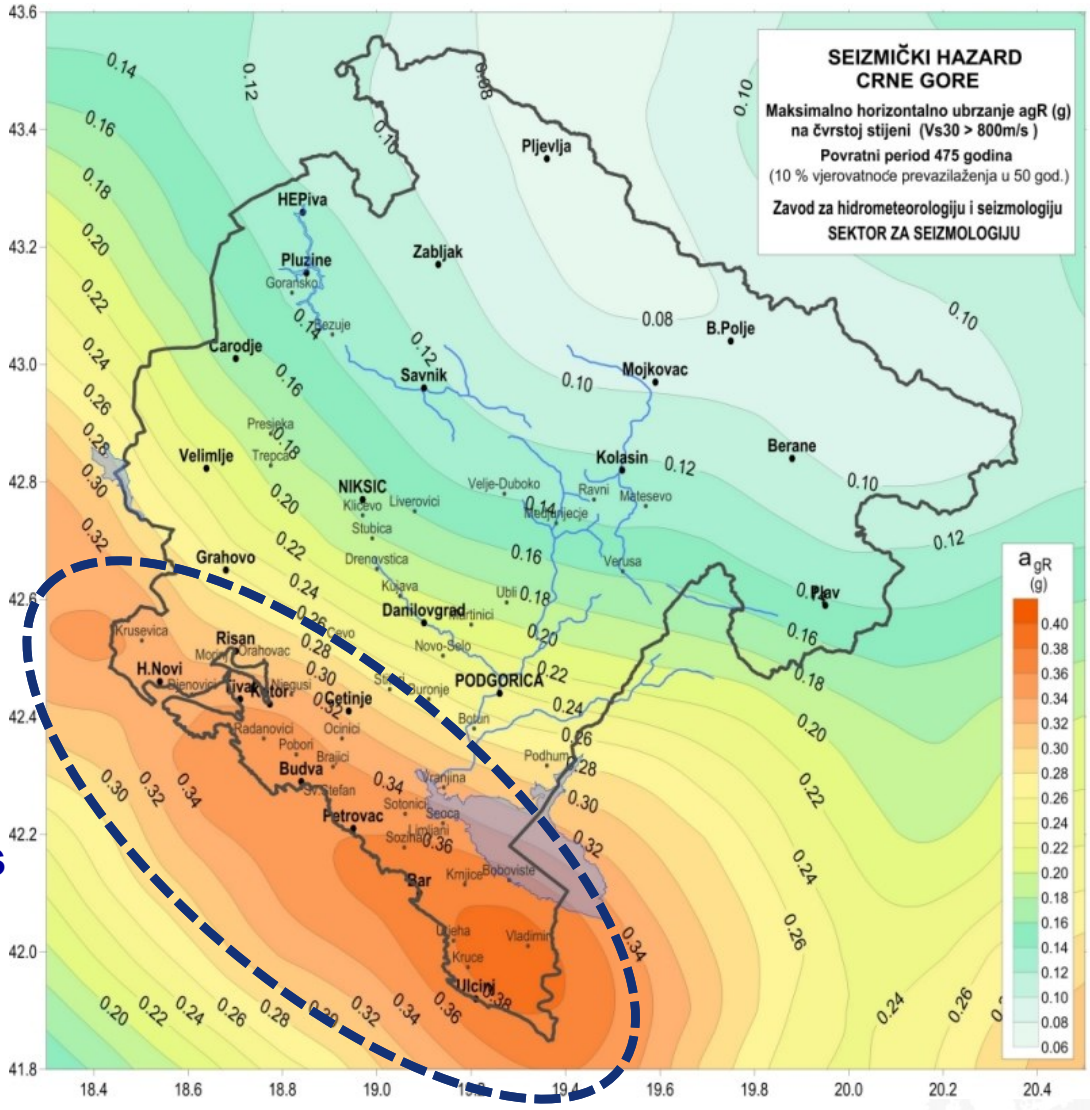
- EN 1990 - published as MEST EN 1990: 2013 in Montenegrin
- MEST EN 1990:2013/NA:2013 published in Montenegrin
- Eurocodes parts EN 1991-1, EN 1991-3 and EN 1991-5, as well as its National Annexes, were prepared by EC WG1 and provided to ISME to realize technical text editing.
- Eurocodes part EN 1998-1 with National Annex was prepared, adopted and published at the end of 2014.

# SEISMIC ACTION

## SEISMIC HAZARD - REFERENCE PGA:

$a_{gR}$
475 years return period (10% in 50y), soil type A

Spatially smoothed seismicity method combined with fault source method in a logic tree approach was used for final seismic hazard maps elaboration



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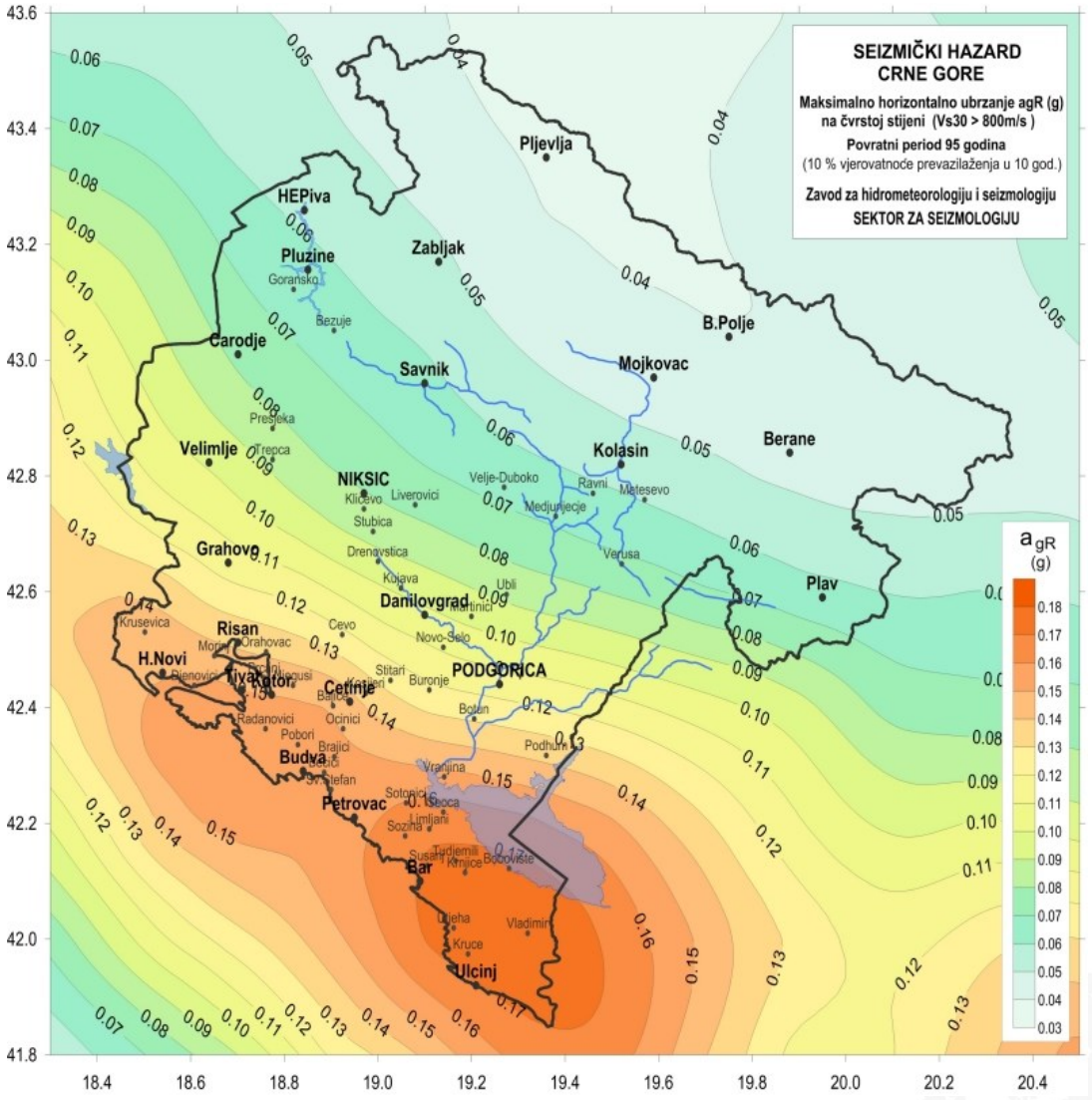
# SEISMIC HAZARD - REFERENCE PGA:

## $a_{gR}$
## 95 years return period (10% in 10y), soil type A

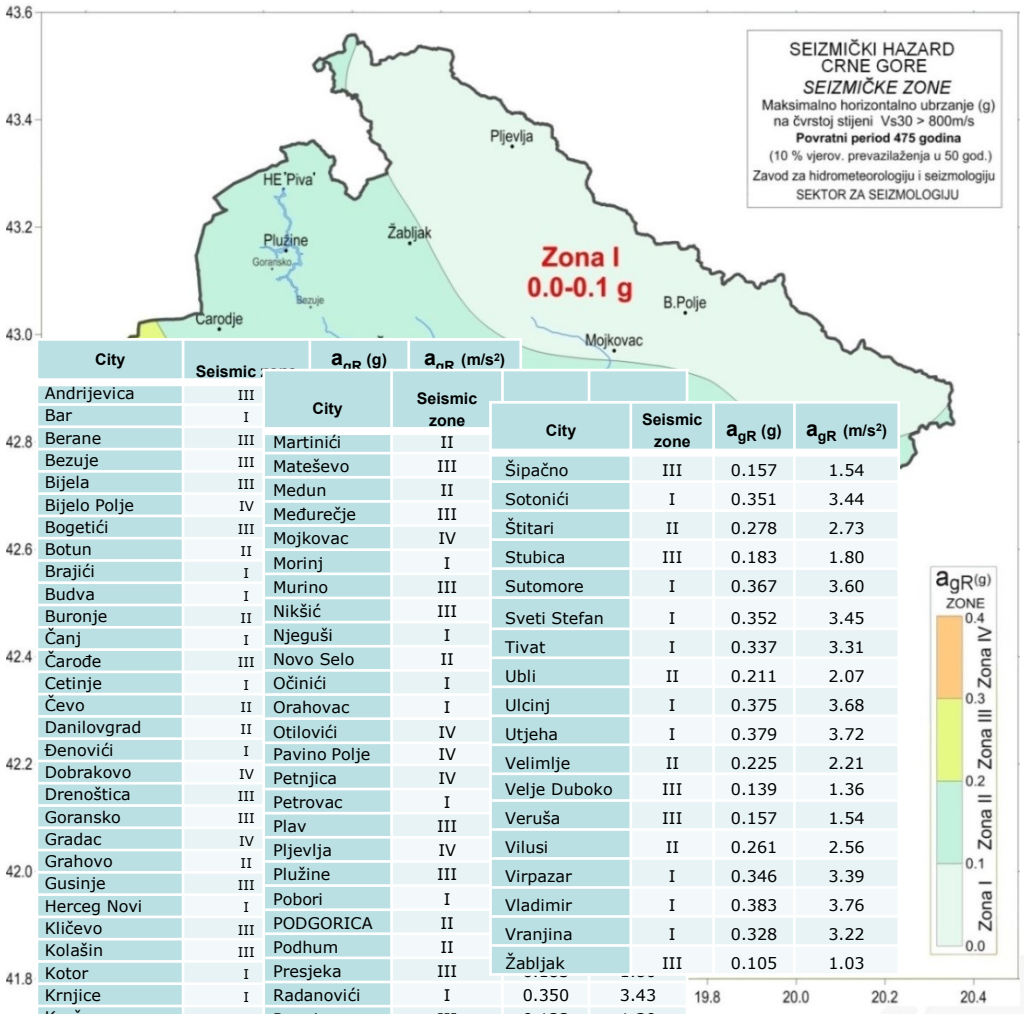


# SEISMIC ZONES

| Seizmic zone | Acceleration (parts of g)* |
|---|---|
| Zone I | ≤ 0.10 |
| Zone II | 0.11 - 0.20 |
| Zone III | 0.21 - 0.30 |
| Zone IV | 0.31 - 0.40 |

* g = 9.81 m/s²

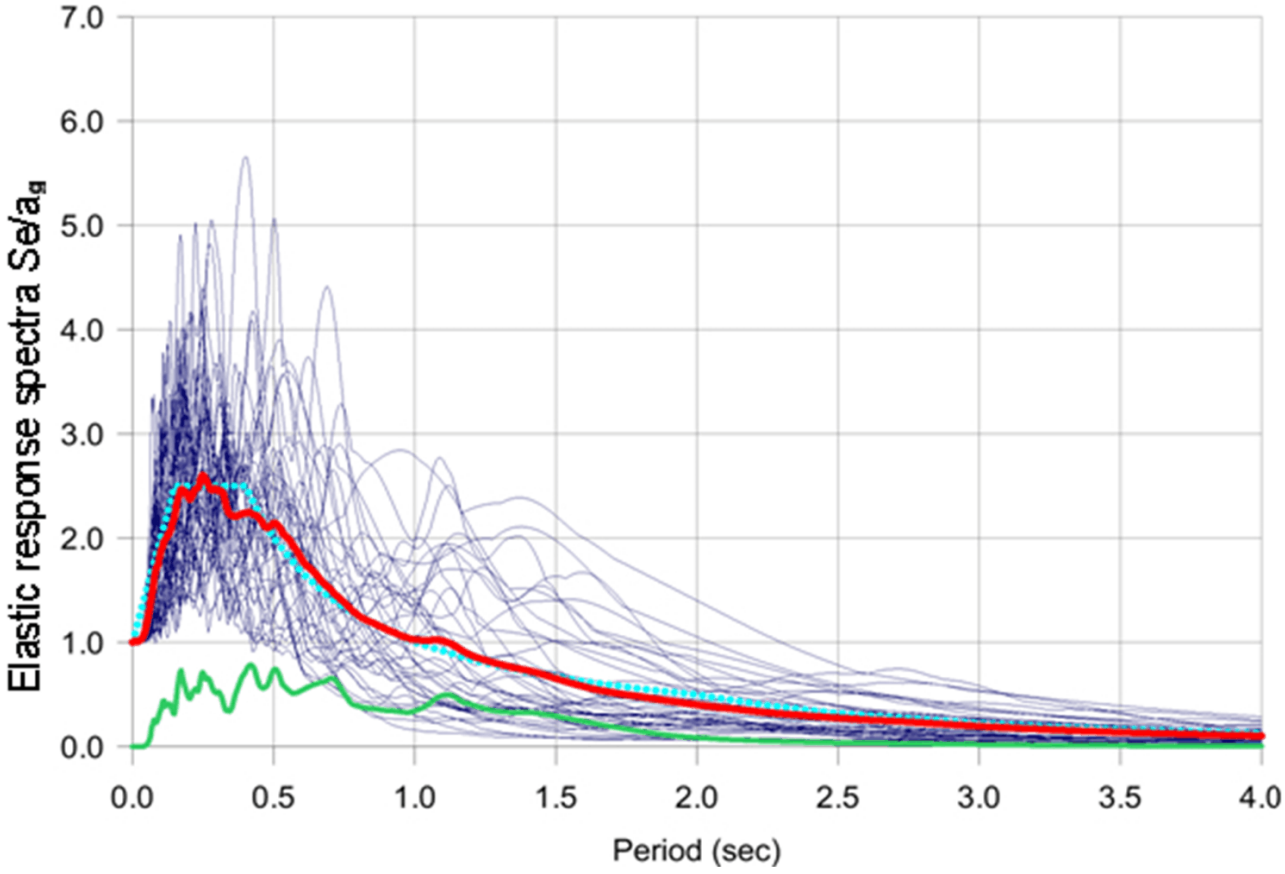
**For every city specific <u>reference PGA</u> $a_{gr}$ has been determined for the return period T=475 years in case of soil type A**




| City | Seismic zone | $a_{gR}$ (g) | $a_{gR}$ (m/s²) |
|---|---|---|---|
| Andrijevica | III | | |
| Bar | I | | |
| Berane | III | | |
| Bezuje | III | | |
| Bijela | III | | |
| Bijelo Polje | IV | | |
| Bogetići | III | | |
| Botun | II | | |
| Brajići | I | | |
| Budva | I | | |
| Buronje | II | | |
| Čanj | I | | |
| Čarođe | III | | |
| Cetinje | I | | |
| Čevo | II | | |
| Danilovgrad | II | | |
| Đenovići | I | | |
| Dobrakovo | IV | | |
| Drenoštica | III | | |
| Goransko | III | | |
| Gradac | IV | | |
| Grahovo | II | | |
| Gusinje | III | | |
| Herceg Novi | I | | |
| Kličevo | III | | |
| Kolašin | III | | |
| Kotor | I | | |
| Krnjice | I | | |
| Kruče | I | | |
| Kržanja | III | | |
| Kujava | II | | |
| Limljani | I | | |
| Liverovići | III | | |
| Martinići | II | | |
| Mateševo | III | | |
| Medun | II | | |
| Međurečje | III | | |
| Mojkovac | IV | | |
| Morinj | I | | |
| Murino | III | | |
| Nikšić | III | | |
| Njeguši | I | | |
| Novo Selo | II | | |
| Očinići | I | | |
| Orahovac | I | | |
| Otilovići | IV | | |
| Pavino Polje | IV | | |
| Petnjica | IV | | |
| Petrovac | I | | |
| Plav | III | | |
| Pljevlja | IV | | |
| Plužine | III | | |
| Pobori | I | | |
| PODGORICA | II | | |
| Podhum | II | | |
| Presjeka | III | | |
| Radanovići | I | 0.350 | 3.43 |
| Ravni | III | 0.133 | 1.30 |
| Rijeka Crnojevića | IV | 0.316 | 3.10 |
| Risan | I | 0.309 | 3.03 |
| Rožaje | IV | 0.096 | 0.94 |
| Šavnik | III | 0.126 | 1.24 |
| Šipačno | III | 0.157 | 1.54 |
| Sotonići | I | 0.351 | 3.44 |
| Štitari | II | 0.278 | 2.73 |
| Stubica | III | 0.183 | 1.80 |
| Sutomore | I | 0.367 | 3.60 |
| Sveti Stefan | I | 0.352 | 3.45 |
| Tivat | I | 0.337 | 3.31 |
| Ubli | II | 0.211 | 2.07 |
| Ulcinj | I | 0.375 | 3.68 |
| Utjeha | I | 0.379 | 3.72 |
| Velimlje | II | 0.225 | 2.21 |
| Velje Duboko | III | 0.139 | 1.36 |
| Veruša | III | 0.157 | 1.54 |
| Vilusi | II | 0.261 | 2.56 |
| Virpazar | I | 0.346 | 3.39 |
| Vladimir | I | 0.383 | 3.76 |
| Vranjina | I | 0.328 | 3.22 |
| Žabljak | III | 0.105 | 1.03 |

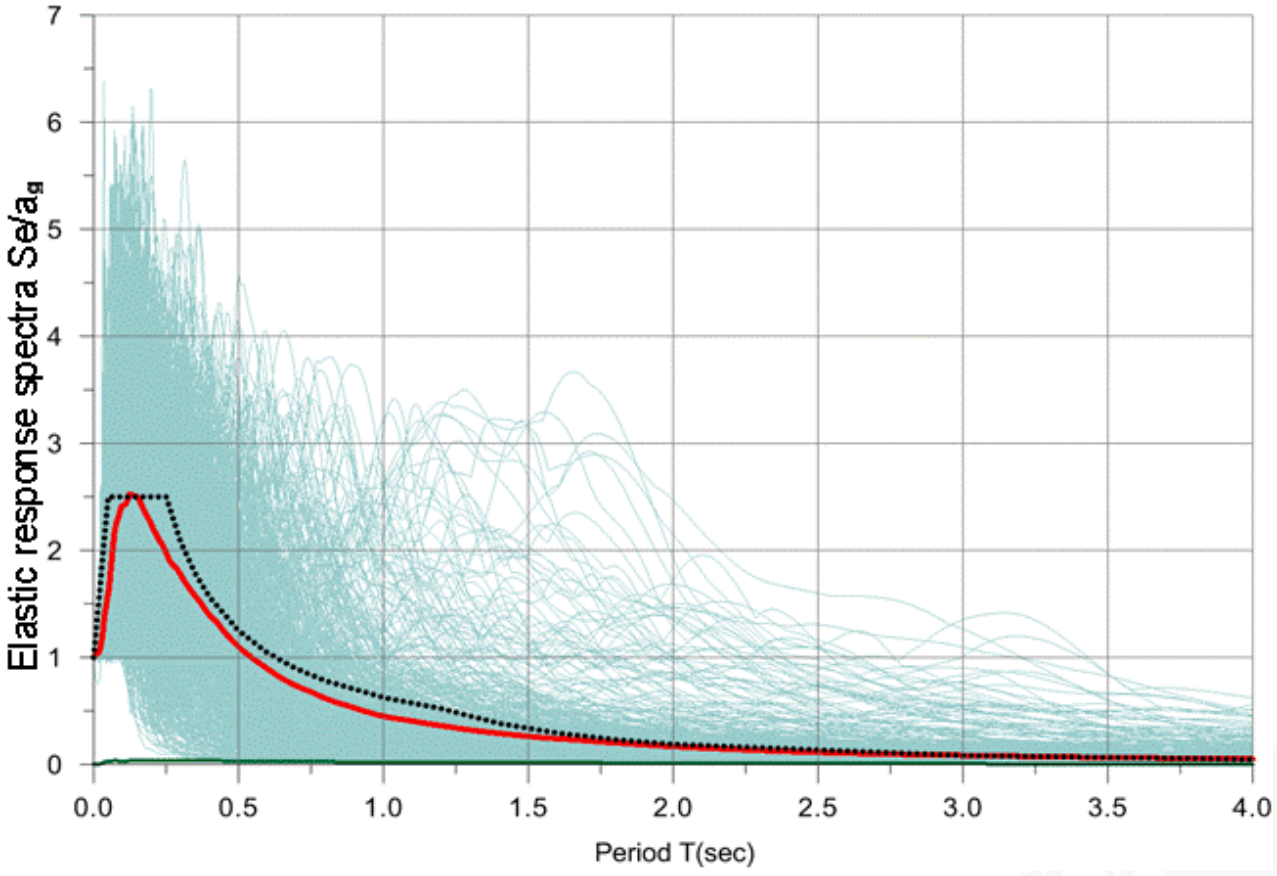
## Horizontal elastic spectral response for:

- Earthquakes of **Type 1** (Ms ≥ 5.5, or ML ≥ 5.8),
- **40 strong motion histories** in case of stronger earthquakes in Montenegro,
- Records on **soil type A**.



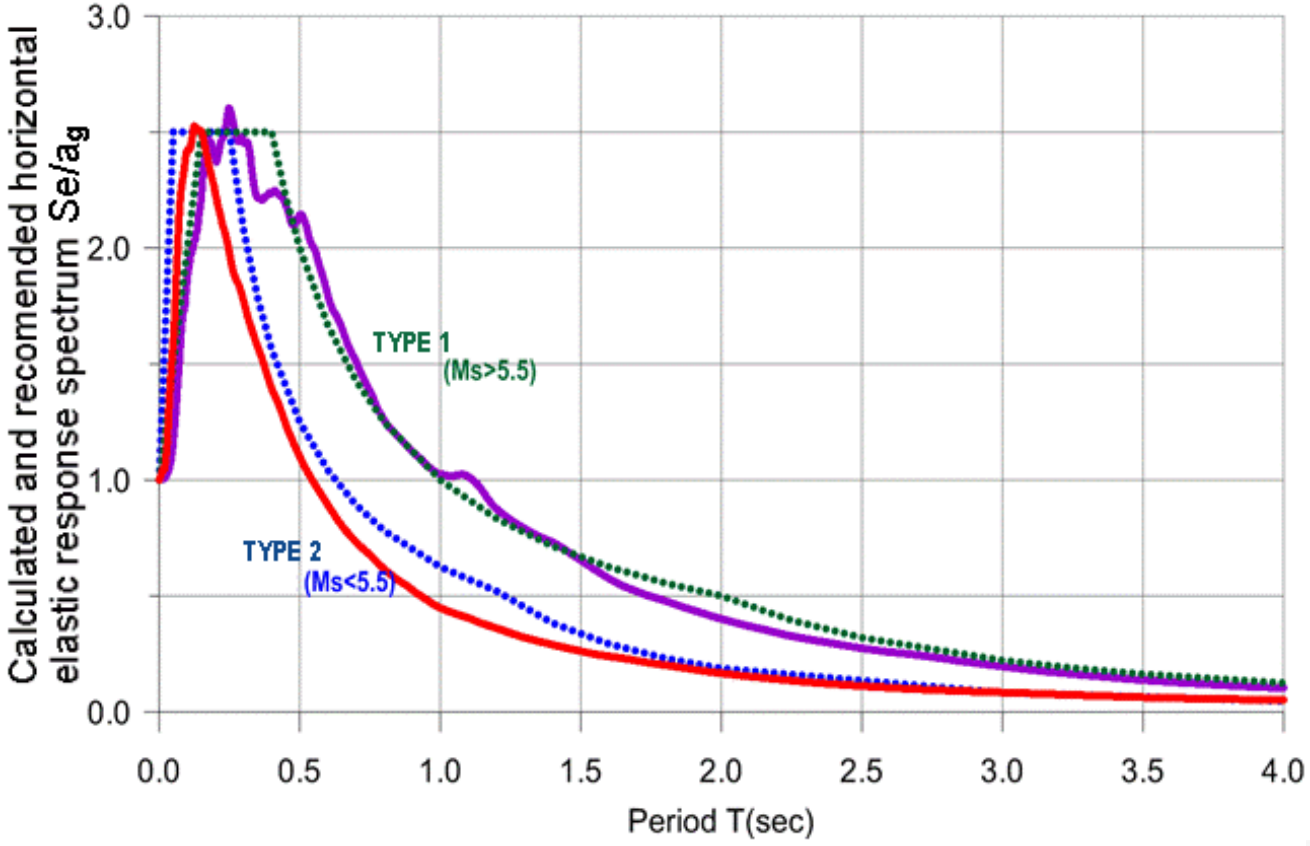
## Horizontal elastic spectral response for:

- Earthquakes of **Type 2** (Ms < 5.5, or ML < 5.8),
- **732 strong motion histories** in case of weaker earthquakes in Montenegro,
- Recorded on **soil type A**.




90 % of records in case of earthquakes with **ML < 4.5**

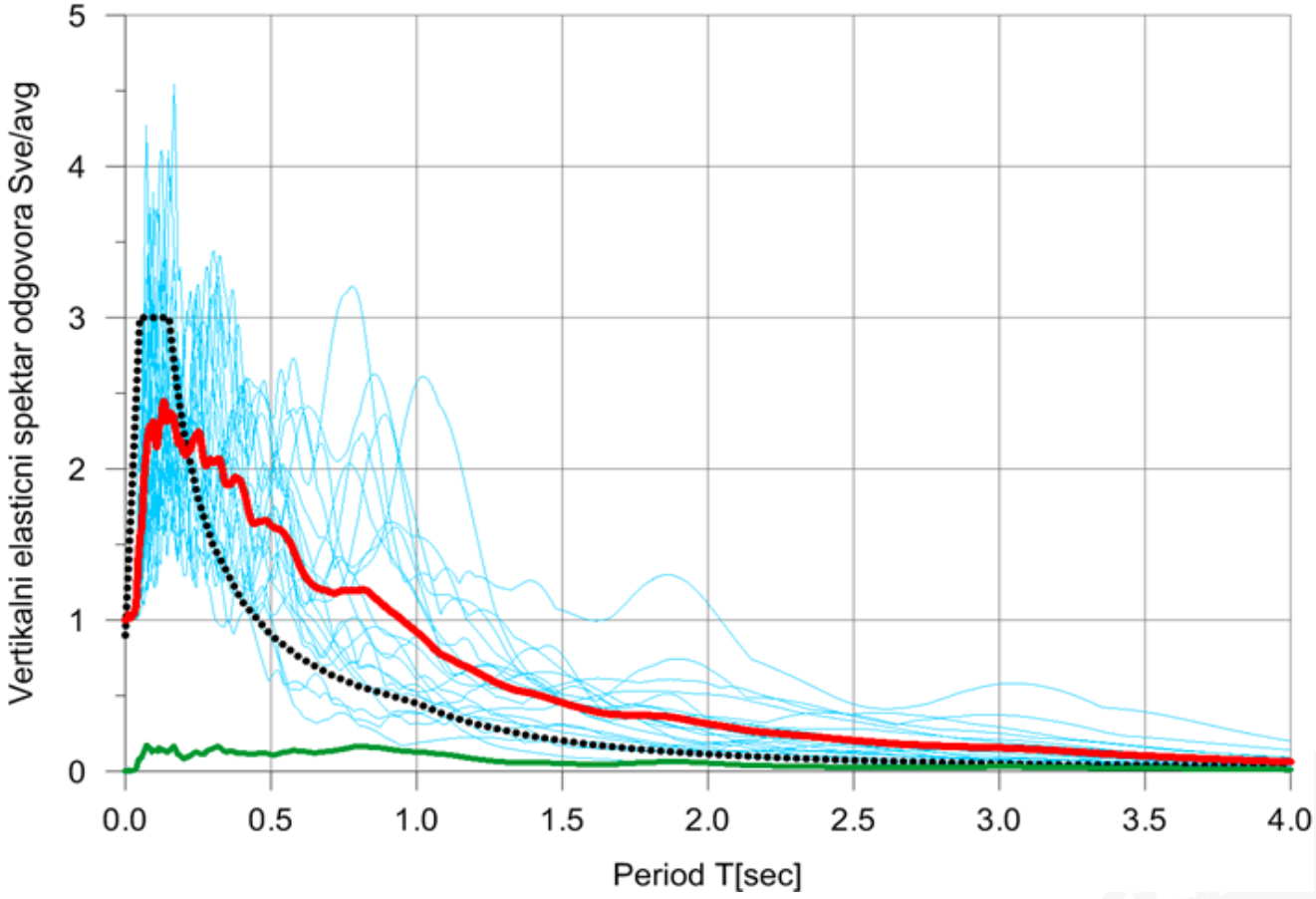
## Comparisons of horizontal elastic spectral response shapes: recommended vs. calculated shapes




**As the data base of strong motion records is still relatively small, for now we decided to keep recommended shapes.**

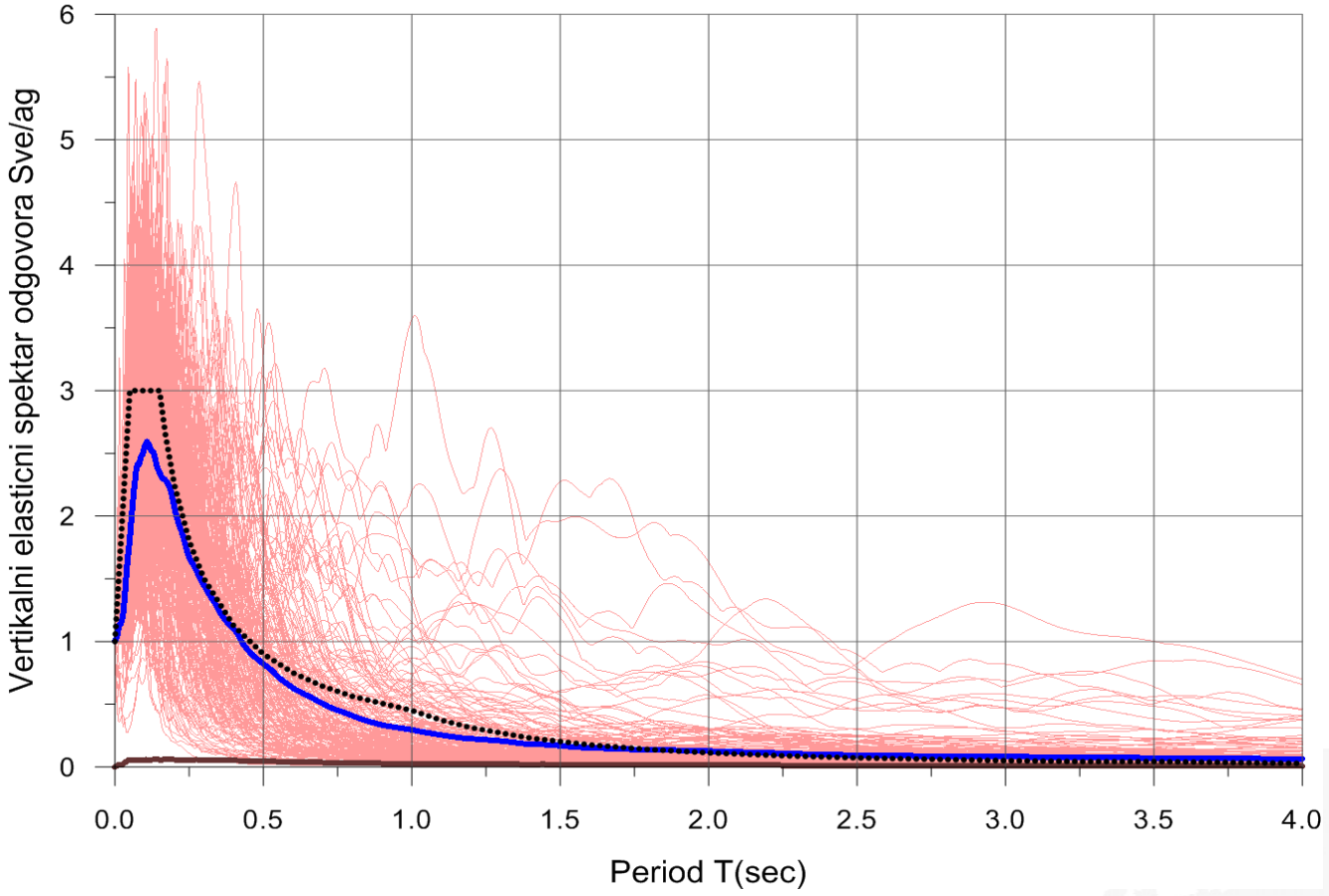
## Vertical elastic response spectra for:

- Earthquakes of **Type 1** (Ms ≥ 5.5, or ML ≥ 5.8),
- **20 strong motion records**,
- Records on **soil type A**.



## Vertical elastic response spectra for:

- Earthquakes of **Type 2** (Ms < 5.5, or ML < 5.8),
- **221 strong motion records**,
- Records on **soil type A**.




Again – small number of records with **ML > 4.5**

## SOIL CLASIFICATION:

**General classification was accepted, but detailed explanation of soil type was determined - appropriate to the regional geological characteristics of the territory of Montenegro**

**Tabela 1:** Klasifikacija tla

| tip tla | opis geološkog profila | parametri | | |
|---|---|---|---|---|
| | | Vs,30 (m/s) | NSPT (udarci/30cm) | Cu (kPa) |
| A | Stijena ili slična geološka formacija, uključujući i najviše 5 metara slabijeg materijala na površini kao što su: krečnjaci i dolomiti slojevito masivne i bankovite teksture, velike otpornosti na mehanička i erozivna dejstva, rožnaci, pješčari, škriljci, kvarciti i slične stijene | > 800 | - | - |
| B | Depoziti veoma zbijenog pijeska, šljunka ili veoma čvrste gline, najmanje nekoliko desetina metara debljine, koje karakteriše postepeno povećanje mehaničkih karakteristika sa dubinom: glacijalni, glacio-fluvijalni, jezerski šljunkovi, pjeskovi i gline, aluvijalno-proluvijalni meterijali šljunkovito-glinovito i glinovito-drobinskog sastava i slični sedimenti | 360-800 | > 50 | > 250 |
| C | Duboki depoziti zbijenog ili srednje zbijenog pijeska, šljunka ili tvrde gline sa debljinom od nekoliko desetina metara do više stotina metara: aluvijalni i aluvijalno-proluvijalni šljunkovi, pjeskovi i gline i slično tlo | 180 - 360 | 15 - 50 | 70 – 250 |
| D | Depoziti slabo do srednje zbijenih nekohezionih tla (sa ili bez mekih kohezionih proslojaka) ili dominantno mekih do čvstih kohezionih tla kao što su: pjeskovi sitnozrnog sastava, neravnomjerno konsolidovani, nepostojane stabilnosti i slično tlo | < 180 | < 15 | < 70 |
| E | Profil tla koji se sastoji od površinskog aluvijalnog sloja sa vrijednostima Vs,30 tipa C ili D i debljine između 5 i 20 metara, ispod kojeg se nalazi čvršći materijal sa Vs,30 > 800 m/s | | | |
| S1 | Depoziti koji se sastoje ili sadrže najmanje 10 metara debeo sloj mekih glina/ mulja sa visokim vrijednostima indeksa plastičnosti (PI > 40) i visokim sadržajem vode | < 100 (indikativno) | - | 10 –20 |
| S2 | Depoziti tečnih tla osjetljivih glina, ili bilo koji drugi profil tla | | | |

## *Question on low and very low seismicity* *{EN98-1: 3.2.1(4) and 3.2.1(5)}*

**There are no areas characterized as very low or low seismicity in Montenegro**

***3.2.2.5(4)P***

***Design spectra for the case of horizontal component of seismic action, is defined as:***

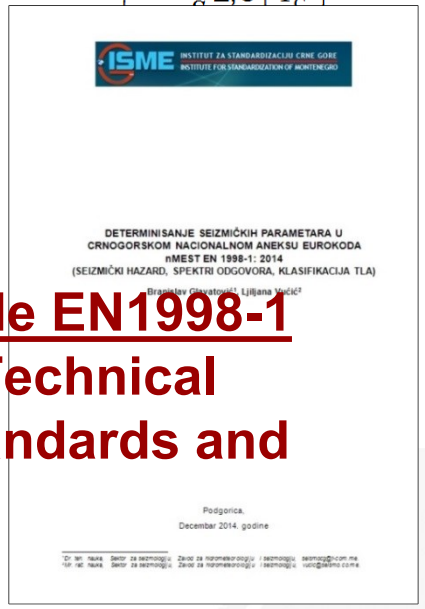
$$0 \le T \le T_B: \quad S_d(T) = a_g S\left[\frac{2}{3} + \frac{T}{T_B}\left(\frac{2,5}{q} - \frac{2}{3}\right)\right]$$

$$T_B \le T \le T_C: \quad S_d(T) = a_g S \frac{2,5}{q}$$

$$T_C \le T \le T_D:$$

$$T_D \le T:$$

**Value of 0.2 was adopted as lower factor β for design spectra - as recommended in EN98-1**




**At the end of 2014 National Annex for Eurocode EN1998-1 (nMEST EN 1998-1 2014) was adopted by the Technical Committee of the Montenegrin Institute for Standards and now is available for the implementation.**

# EDUCATION

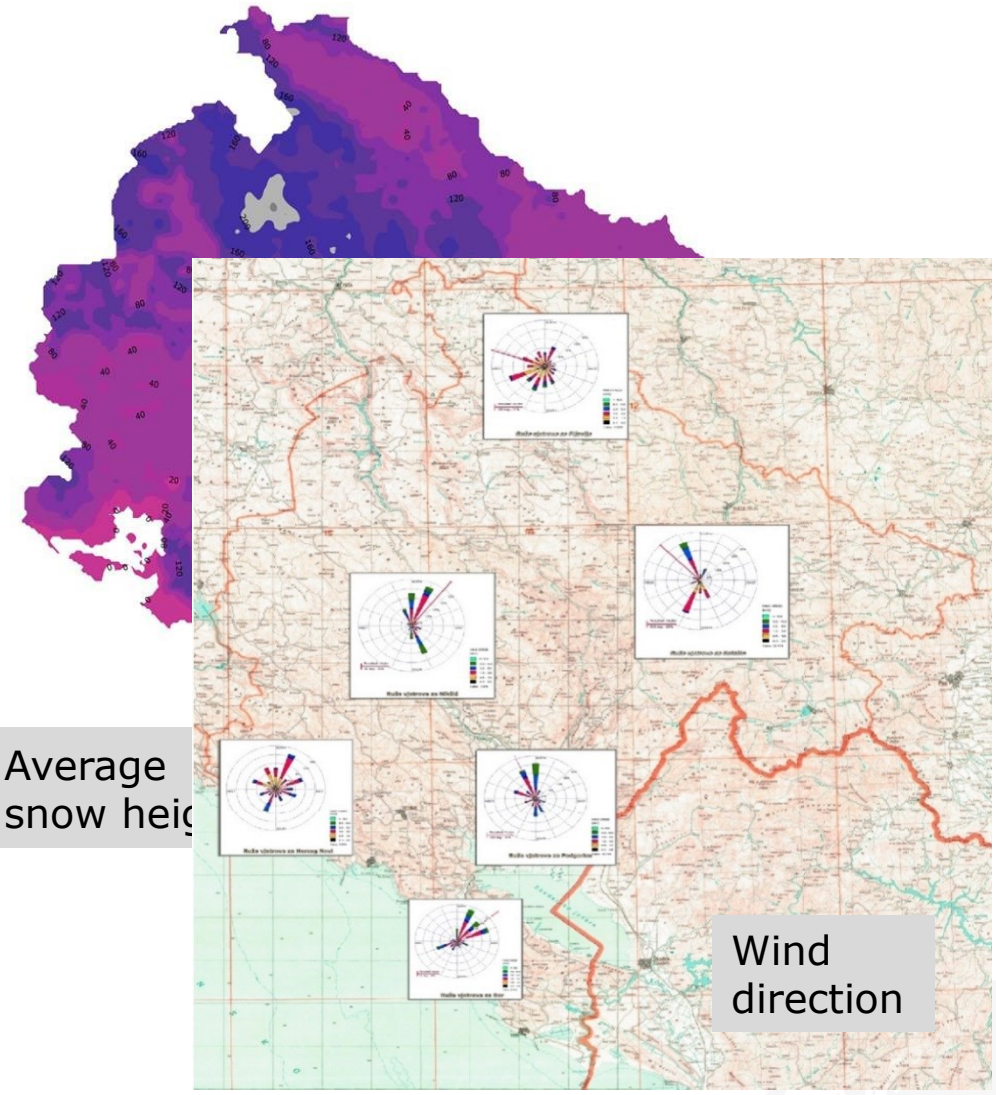
**For Montenegrin Chamber of engineers the education of members is one of the most important tasks. Since 2006, the Chamber organized and financially supported numerous activities related to the implementation of Eurocodes: through seminars, round tables, conferences, lecturing, publishing related educational materials, etc.**

**According to the Action Plan of the Montenegrin Government on implementation of Eurocodes, Chamber of Engineers was appointed as the institution responsible for education of engineers in Eurocodes implementation. We will continue with organizing educational seminars in next two years.**

# CLIMATIC MAPS

**Climatic data were processed and climatic maps prepared, but still in raw form.**

**It is expected that National Annex for EN 1991 will be finalized and prepared for adoption until the end of this year**



Average snow heig

Wind direction