Twenty-Third Annual Undergraduate Seismic Design Competition (SDC)

GROUND MOTION SELECTION GUIDE

Organized and Run by:

EERI Student Leadership Council (SLC)

Competition Website:

2026 Seismic Design Competition – Student Leadership Council

EERI and the SLC are deeply grateful to our 2026 SDC sponsors!

ANCHOR SPONSOR

Table of Contents

1. Disclaimer

This Ground Motion Selection Guide has been prepared by the SLC to assist students in understanding the step-by-step process of ground motion selection. While every effort has been made to ensure the accuracy and reliability of the information provided, the SLC does not make any warranties regarding the completeness, accuracy, suitability, or reliability of the content contained within this guide.

The information in this guide is intended for educational purposes only and should not be considered as professional advice. Ground motion selection for seismic design is a complex task that involves various factors, and it is recommended that students consult with qualified professionals or experts in the field for specific and detailed guidance tailored to their projects, while adhering to role expectations for advisors outlined in Section 3.2 of the *Official Rules*.

The SLC shall not be held responsible for any loss, damage, or injury that may arise from the use of this guide or its content in other contexts beyond the SDC.

Additionally, please be aware that the second ground motion used during the shaking day is a simulated version derived from ground motion records available on different databases. It is not an exact replication of any single record. For your analysis, you can use this guide to estimate the intensity of the second ground motion, but we will not disclose the specific details of the record used until Shake Day.

2. Target Response Spectrum

A response spectrum is a graphical representation used in structural engineering and seismology to depict the peak structural response of all possible linear single-degree-of-freedom systems to a particular component of ground motion [1]. It illustrates the maximum response of a building (acceleration, velocity, or displacement) plotted against corresponding structural periods (or frequencies). Engineers rely on these spectra to design and evaluate the performance of a structure during an earthquake.

Building codes, such as ASCE 7-22 [2], typically establish a target spectrum for design purposes. This spectrum aligns with a designated hazard or risk level, aiming to achieve a specific level of structural performance. For instance, the structure might be designed to achieve Collapse Prevention during an earthquake event with a return period of 2,500 years. For the 2026 SDC, the client wants to ensure that their structure does not collapse when subject to an earthquake event representative of the Risk-Targeted Maximum Considered Earthquake (MCE_R) as defined in ASCE 7-22. To assess the performance of the proposed design, a structural balsa wood model will be built and tested at the UCIST shake table using two scaled ground motions.

The second ground motion, **GM#2**, will be selected and scaled by the SLC to approximately match the intensity of the MCE_R, subject to the limitations of the shake table. Unlike previous SDC editions, acceleration data for **GM#2** will not be disclosed to the participating teams. Instead, teams are expected to select a ground-motion set from a database of recorded ground motions from different seismograph stations. Students will use the MCE_R spectrum from ASCE 7-22 as a target and assess how closely the recorded ground-motion spectra resemble this target in their selection process. The selected ground motions will serve as an estimate of **GM#2**'s potential characteristics.

The MCE_R, as defined in ASCE 7-22, is determined based on the location, site class, and risk category. To ensure consistency across teams, the SLC will provide a CSV file that estimates the DE and MCE_R target response spectra. While geotechnical considerations are still part of the score, they will not be necessary for selecting a suite of ground motions this year.

3. Ground Motion Selection

Using the provided CSV file, it is possible to use the PEER NGA-West2 database [4] to begin the ground motion selection.

To access this database, please click on the following link:

https://ngawest2.berkeley.edu/.

> **Note:** Alternatively, teams have the option to utilize the NHR3 NGA-Subduction Web Portal [5] for ground motion selection:
>
> http://ec2-35-167-122-9.us-west-2.compute.amazonaws.com/ngasubductions/new
>
> This web application features a comparable interface to NGA-West2 but includes subduction ground motions, offering a broader range of ground motions for consideration.

Upon clicking, a window similar to the one shown in Figure 1 will appear.

To access the NGA-West2 center depicted on the right side of Figure 1, simply click on it. Upon doing so, the system will prompt you to sign in. If you do not have an existing account, you will need to register on the website. During the registration process, provide your email address (preferably your university email) and set a password. Once your account is created, you can sign in and start using the application.

> Similarly, the NHR3 NGA-Subduction website will also require users to sign up.

After signing in, the application will guide you to upload a user-defined target spectrum, allowing you to proceed with the ground motion selection process; see Figure 2. Following the website instructions, we have uploaded a CSV file containing the MCE_R spectrum. Click on 'Submit', and you should receive a plotted spectrum, visible in Figure 3, confirming the successful completion of this step.

> On the NHR3 application, rather than uploading a CSV file, users just copy and paste the values of the spectrum into the website.

Next, click on the 'Search Records' at the bottom of the page (Figure 3), and a new window, as shown in Figure 4, will appear.

To configure the selection criteria, as demonstrated with an example in Figure 4, follow these steps:

- Input a range of (5.50, 9.5) in the magnitude box. This range signifies the minimum and maximum magnitudes of the records to be searched. This selection is an estimate to US codes.

- For the distance parameter to rupture, enter (30,100), representing 55±25.

- Regarding V_{s30} (m/s), input (150, 550).

- Set the maximum number of records to search at 30, ensuring a comprehensive exploration across the databases to match the target spectrum.

- For the scaling factor, use (0.5, 5.0), representing the minimum and maximum values for scaling the ground motions. Note that a maximum scale factor of 5.0 is typically considered very high in practice but will be considered acceptable for our case study.

Upon configuring these settings, clicking on 'Search Records' at the bottom of the page will display 30 ground motions that best match the target spectrum (MCE_R). An example of the result page is detailed in Figure 5. *The values provided may be adjusted for the site-specific location, if desired.*

The figure displays various parameters corresponding to each ground motion, including Record Number, MSE (mean square error of scaled records), Scale Factor, Duration, Arias Intensity, Event Name, Year of Occurrence, Station Name, Magnitude, Fault Type (Mechanism), Distance, and V_{S30} (m/s). For detailed analysis, you can download all the time series records, including metadata, spectra, and traces, by clicking on 'Download Time Series Records' at the bottom of the page.

> Similarly, on the NHR3 website, you can download all the time series records and their metadata by clicking on 'Download Unscaled Time Series & Metadata' at the bottom of the webpage.

It is important to note that each record has a specific scaling factor. If you intend to use any of the 30 ground motion records for your response history analysis, you will need to multiply your time series by the corresponding scale factor of the selected record. Also, note that these records usually have two horizontal components of acceleration (e.g., N-S and E-W, H1 and H2, or 00 and 90 deg.). You can ignore the vertical component of these ground motions for your analyses since we will not be shaking your structural models vertically.

Additionally, please be aware that the acceleration records from PEER NGA-West2 and NHR3 NGA-Subduction are formatted using the .AT2 format. These files should be read line by line, with each line containing groups of 5 consecutive values recorded using a constant time step.

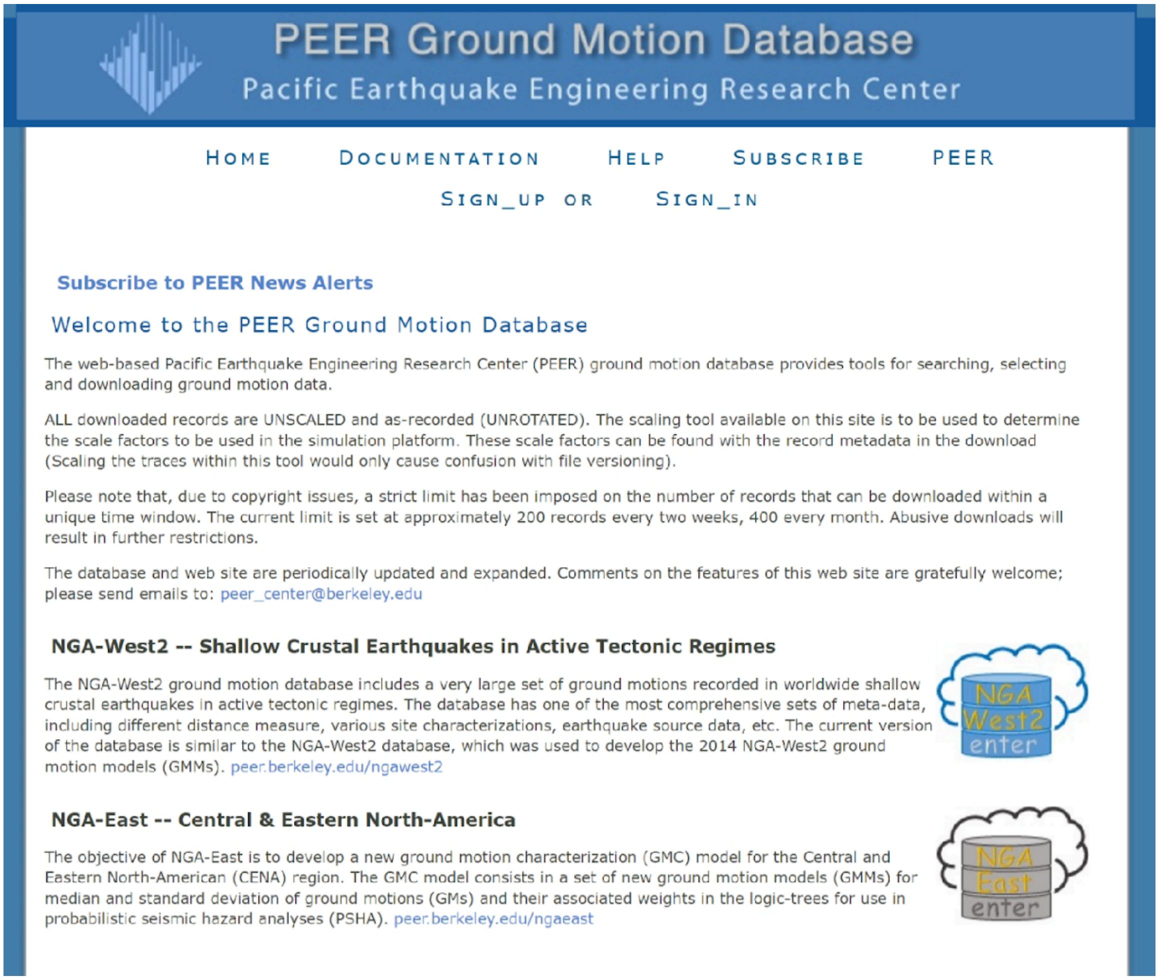

Figure 1 PEER NGA welcome page.

Figure 2 Defining Target Spectrum on the PEER NGA-West2 website.

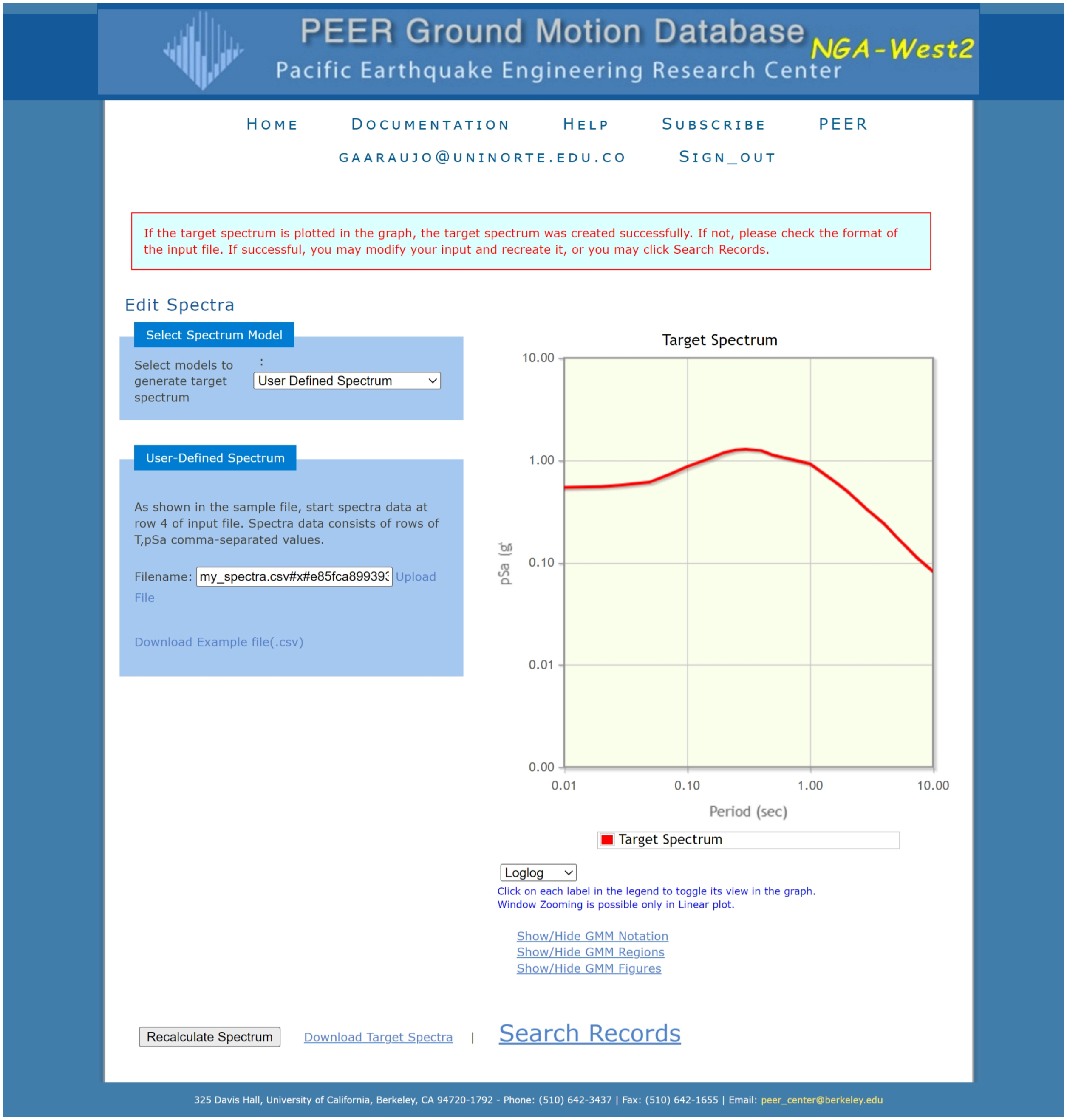

Figure 3 MCE_R spectrum successfully loaded to the PEER NGA-West 2 application.

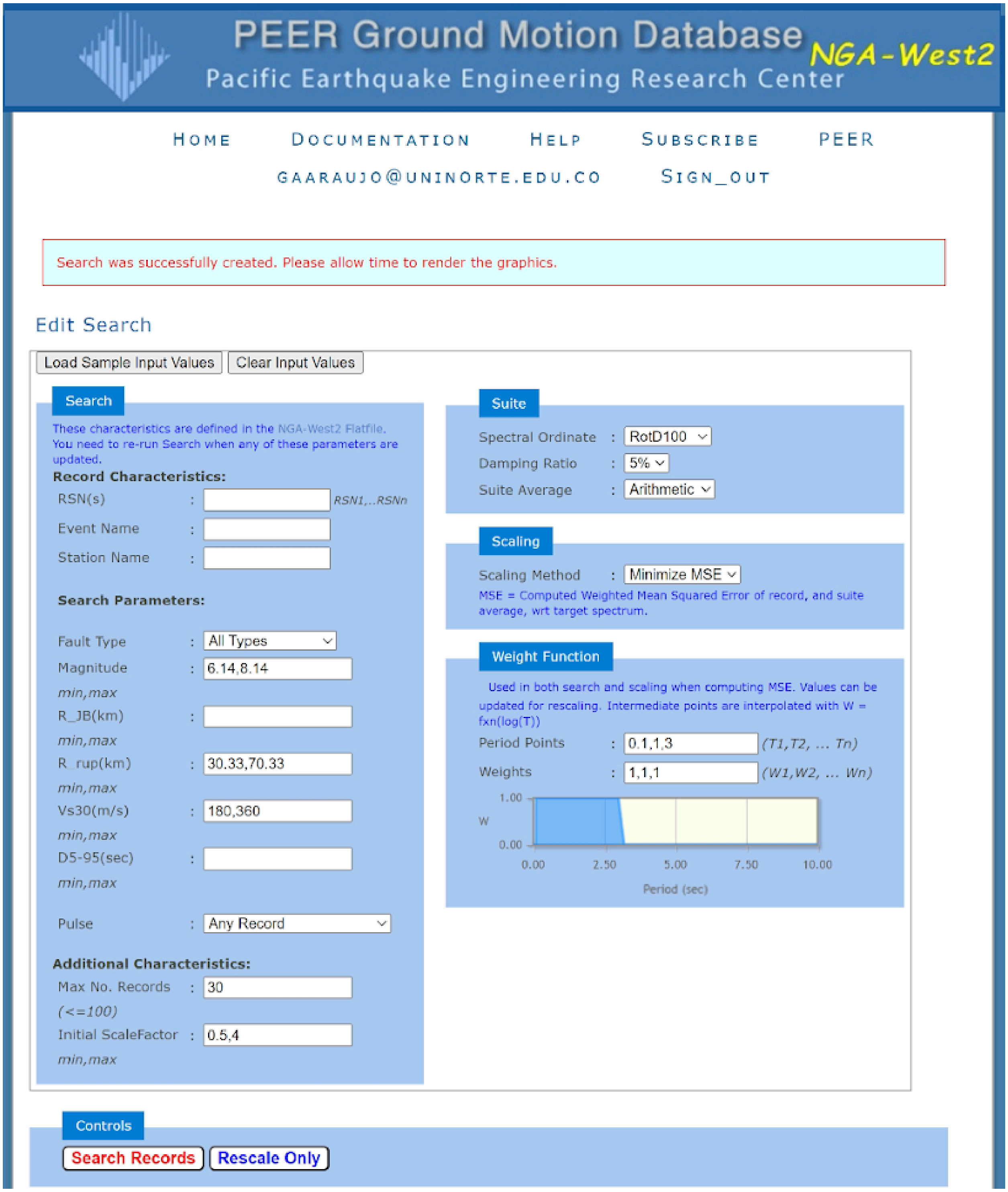
PEER Ground Motion Database
NGA-West2
Pacific Earthquake Engineering Research Center
Home
Documentation
Help
Subscribe
PEER
GAARAUJO@UNINORTE.EDU.CO
Sign_out
Search was successfully created. Please allow time to render the graphics.
Edit Search
Load Sample Input Values
Clear Input Values
Search
These characteristics are defined in the NGA-West2 Flatfile. You need to re-run Search when any of these parameters are updated.
Record Characteristics:
RSN(s) :
RSN1,..RSNn
Event Name :
Station Name :
Search Parameters:
Fault Type : All Types
Magnitude : 6.14,8.14
min,max
R_JB(km) :
min,max
R_rup(km) : 30.33,70.33
min,max
Vs30(m/s) : 180,360
min,max
D5-95(sec) :
min,max
Pulse : Any Record
Additional Characteristics:
Max No. Records : 30
(<=100)
Initial ScaleFactor : 0.5,4
min,max
Suite
Spectral Ordinate : RotD100
Damping Ratio : 5%
Suite Average : Arithmetic
Scaling
Scaling Method : Minimize MSE
MSE = Computed Weighted Mean Squared Error of record, and suite average, wrt target spectrum.
Weight Function
Used in both search and scaling when computing MSE. Values can be updated for rescaling. Intermediate points are interpolated with W = fxn(log(T))
Period Points : 0.1,1,3
(T1,T2, ... Tn)
Weights : 1,1,1
(W1,W2, ... Wn)
1.00
W
0.00
0.00
2.50
5.00
7.50
10.00
Period (sec)
Controls
Search Records
Rescale Only

Figure 4 Parameter setting for ground motion selection using PEER NGA-West2.

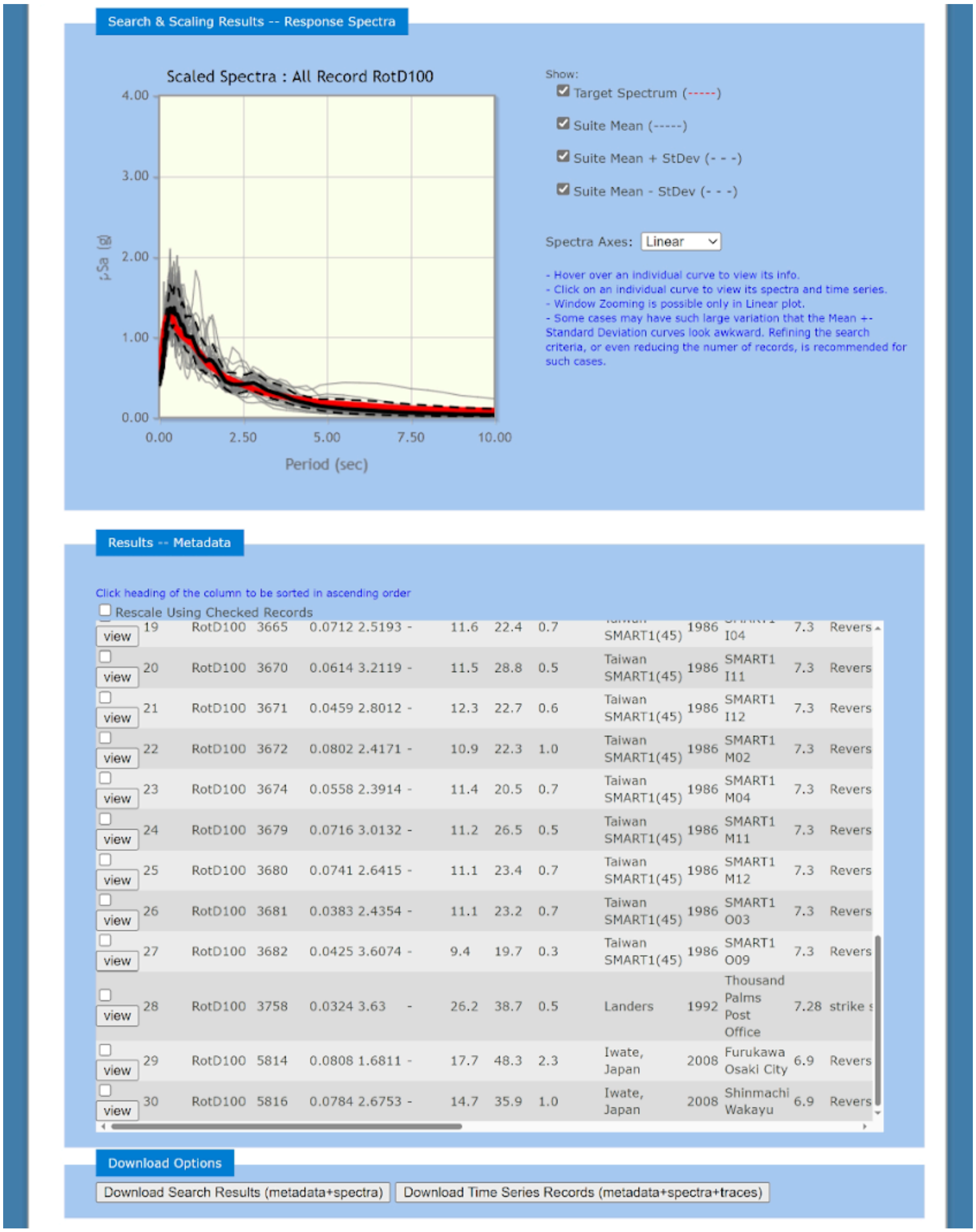

Figure 5 Example of ground motions from PEER NGA-West2 matching the MCE_R.

4. Proposal Requirements

Part of the 2026 SDC ***Proposal Requirements*** is conducting a ground motion selection representative of **GM#2**. For this section, please meet the following requirements:

- Provide a concise overview of the ground motion selection process, focusing on the steps taken by the teams to curate a representative set of at least 11 ground motions corresponding to **GM#2**, as defined in the *Official Rules*. The narrative should emphasize the parameters you considered in selecting the final ground motions, including characteristics that may be similar to those experienced in Portland, Oregon in the past. Highlight the tools and databases utilized, including PEER NGA-West2 or NHR3 NGA-Subduction, and briefly discuss any criteria or constraints applied during the selection process. Important to note, the proposal should address the potential removal of ground motions from the 30 records initially suggested by the NGA websites. Ground motions that individually do not match the target spectrum very well might be considered for removal to improve the selected ground motion set.

- Present a detailed table listing the selected ground motions. Include essential metadata for each motion, such as earthquake details (name, date), station information, year of occurrence, magnitude, and distance from the epicenter. Also, provide the corresponding scale factors applied to each motion.

- Include a figure displaying the RotD100 response spectra of the chosen ground motions. Clearly illustrate these spectra alongside the target spectrum for **GM#2**.

5. References

[1] A. K. Chopra, «Elastic response spectrum: a historical note,» *Earthquake Engineering & Structural Dynamics,* vol. 36, pp. 3-12, 2007.

[2] ASCE 7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, ASCE/SEI 7-22, Reston, Virginia: American Society of Civil Engineers, 2022.

[3] USGS, «USGS Earthquake Hazard Toolbox, Version 1.0.3,» US Geological Survey, 2022. [En línea]. Available: https://earthquake.usgs.gov/nshmp/.

[4] T. D. Ancheta, R. B. Darragh, J. P. Stewart, E. Seyhan, W. J. Silva, B. S.-J. Chiou, K. E. Wooddell, R. W. Graves, A. R. Kottke, D. M. Boore, T. Kishida y J. L. Donahue, «PEER NGA-West2 Database,» Pacific Earthquake Engineering Research Center, Berkeley, CA, United States., 2013.

[5] S. Mazzoni, «NGA-Subduction Portal: Ground-Motion Record Selection and Download,» The B. John Garrick Institute for the Risk Sciences., 2022. [En línea]. Available: https://doi.org/10.34948/N3D59V.