An Online Query Service for Seismic Design Response Spectra Based on the Taiwan Building Code: Sederes

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Abstract

In Taiwan, the latest revision of the Seismic Design Specifications and Commentary for Buildings was officially implemented on October 1, 2022. To facilitate access to the up-to-date design earthquake information on a reliable and public platform, the National Center for Research on Earthquake Engineering launched the "Seismic Design Response Spectra based on Taiwan Building Code" online query service, or called "Sederes" (https://seaport.ncree.org/sederes). Sederes offers several unique features, including the integration of the latest GIS data, such as active fault traces and municipal map, and the provision of four site locating options, i.e., marking on the map, street address, administrative divisions, and latitude-longitude. The service also calculates the maximum design values for near-fault sites and identifies suitable design values for sites within the Taipei Basin or enclaves. Additionally, Sederes provides detailed design parameters and site information. Overall, Sederes provides an intuitive and user-friendly interface for accessing the Taiwan's latest seismic design response spectra. Sederes is a valuable resource for engineering practice, academic research, and general education.

Keywords: Sederes, online query, Taiwan Building Code, seismic design response spectra, GIS

Introduction and Motivation

In Taiwan, the Construction and Planning Agency of the Ministry of the Interior (CPAMI) first issued the national seismic design code for building structures on February 15, 1974. In response to the advancement of knowledge in earthquake engineering and the need for social and economic development, there are seven revisions made in 1982, 1989, 1997, 1999, 2006, 2011, and 2022. These changes lead to a more rational and detailed approach in developing the design earthquake.

Recently, the latest revision of the "Seismic Design Specifications and Commentary for Buildings" by CPAMI was formally implemented on October 1, 2022. However, these numerous changes, such as new parameters, updated coefficients, additional active faults, and adjusted administrative divisions, cause difficulties and inconveniences for code-users in design earthquake calculations and data source management.

In the past, based on the draft editions of revision regulations proposed in 2014 and 2019, the "Design Earthquake Query System" standalone software (Liu *et al*., 2014) and the "Online Inquiry System for Design Response Spectra for Buildings in Taiwan" intranet website (Yen *et al*., 2019) were developed, respectively. Nonetheless, there is still a need for a new and public application tool that can rapidly and correctly provide the site-specific seismic design values for the 2022 revision regulations.

As a result, to assist code users in obtaining the up-to-date design earthquake on a feasible and reliable platform, the National Center for Research on Earthquake Engineering (NCREE) launched "Seismic Design Response Spectra based on Taiwan Building Code" query web (https://seaport.ncree.org/sederes), or "Sederes" The core objectives of Sederes are (1) to construct a widely accessible online platform, (2) to integrate geographic information systems (GIS), and (3) to provide reliable and long-term services for design earthquake of the Taiwan building code (TBC).

Sederes Development

In addition to establishing the design parameters database and design spectrum construction procedures by Chapter 2 of the latest TBC, Sederes collects and integrates the following geographic map data:

1. The 1100928 version of Taiwan's administrative

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divisions, which comes from the Open Government Data platform managed by the Ministry of Digital Affairs (MODA).

2. The 2021 version of the active fault traces, which derives from the Central Geological Survey (CGS) of the Ministry of Economic Affairs (MOEA).
3. The national address locating function, which interconnects with the Taiwan Geospatial One Stop (TGOS) portal developed by the Ministry of the Interior (MOI).
4. The Taiwan electronic map, which obtains from the OpenStreetMap world map.

Sederes Features

As shown in Figure 1, Sederes is inherently a GIS platform. In the layout of the webpage, the left side is for site locating and parameters display/tuning, and the right side exhibits response spectra plot and stored results table. Sederes furnishes users with an excellent experience of pleasing arrangement, intuitive operation, and rapid data acquisition. The following introduces the six distinctive features of Sederes.

Integrated Map Data

All map data used in Sederes are from authoritative sources. Through the integrated map data from the Taiwan street map, administrative divisions, active fault traces, and Taipei Basin boundary, users can directly examine if the site location is correct and clearly overview the nearby geographic environment, relative position, and belonged seismic zone.

Multiple Site Locating Options

Sederes provides four site-positioning options, e.g., longitude-latitude coordinate using TWD97 datum, marking on the map, administrative divisions, and street address. For the last option, Sederes will self-list several possible addresses after keywords input.

Upon completing the site-positioning, a message window appears and displays information on the location, default values, and spectral parameters (see the left of Figure 1). Users can modify the default values of the shortest horizontal site-to-fault distance and site classification, and then the spectral parameters will subsequently update. The abovementioned spectral parameters refer to the site-adjusted spectral response acceleration parameters for short periods (S_{DS}, S_{MS}) and 1.0 second period (S_{D1}, S_{M1}), and the transition periods (T_0) between short and moderate period ranges of the design spectrum. When the inputs and results are confirmed, users can click the “Plot/Save Query Result” button for parameters study and output.

Adaptive Near-Fault Design Spectra

Following the new requirements in Section 2.4 of the latest TBC, Sederes uses the latest CGS 2021 version of fault traces to search for the code-designated active fault(s) within a radius of 14 km of the site as well as determine the shortest horizontal site-to-fault distance(s). Moreover, Sederes can cleverly evaluate the maximum values of the near-fault mapped spectral response acceleration parameters for short periods (S_s^D, S_s^M) and 1.0 second period (S_1^D, S_1^M).

Regarding the site-to-fault distance, users can also adjust by themselves. Considering the uncertainty of fault trace location and the geologically sensitive area of active faults, it is recommended to reduce the default site-to-fault distance by at least 300 m for conservative purposes. It should be noted that the near-fault design parameters in the latest TBC were formulated based on the CGS-2012 active faults, so the additional Chekualin fault in the CGS-2012 Holocene active fault needs to be regulated and announced in the future by the CPAMI. Furthermore, in order to reflect the seismic sequence

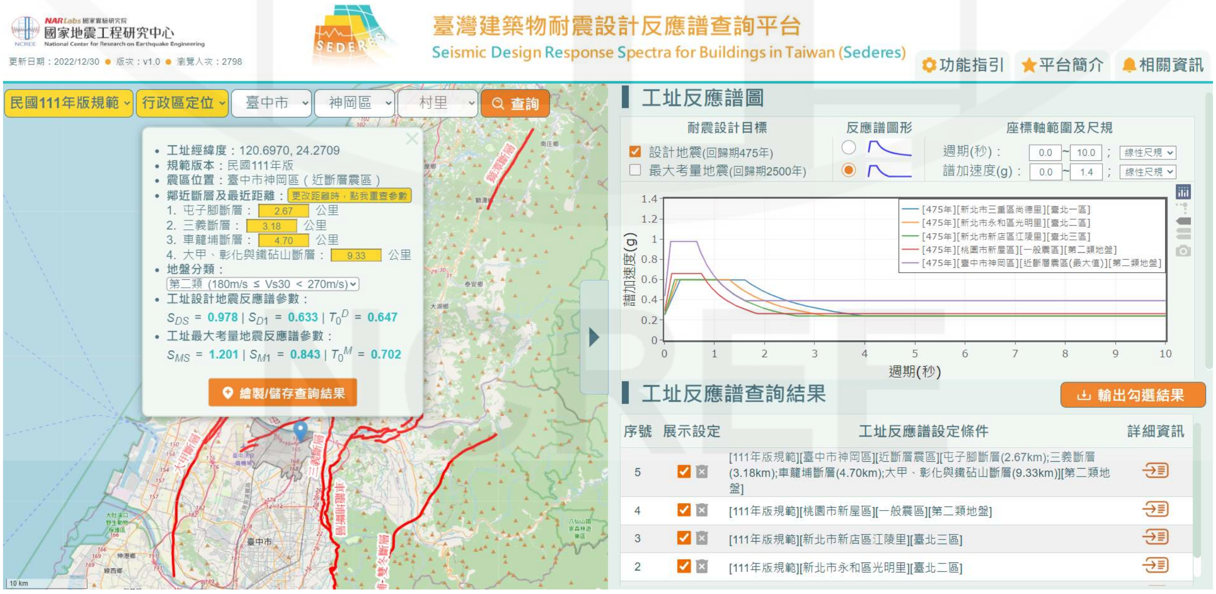

Fig. 1 Sederes webpage.

characteristics of the longitudinal valley faults and the combined rupture model of the Tachia and Changhua faults considered in the TBC, Sederes includes the Lichi and Linding faults of the Late Pleistocene active faults and calculates the site-to-fault distance using the continuous trace of the Tachia-Changhua fault system.

Map-Based Taipei Site Design Spectra

Sederes shows the scope of the Taipei Basin area, which is consistent with the delimitation shown in TBC's Figure 2-1, to facilitate geographic comparisons.

For the site located in the Taipei Metro Area, the corresponding seismic zone are usually obtained from TBC's Table 2-6. The seismic zone can be categorized as the General Zone, Near-Fault Zone, Taipei Zone 1, Taipei Zone 2, and Taipei Zone 3. This table is based on the official map data from earlier years. However, when using the current municipal divisions and Table 2-6 to construct a Taipei seismic zone map, some villages show discrepancies with the Taipei Basin micro-zonation map illustrated in TBC's Figure 2-1. Upon investigation, eleven villages in Xizhi District and one village in Xindian District are categorized as Ordinary Zone in TBC's Table 2-6 but correspond to Taipei Zone 3 in TBC's Figure 2-1.

To address this issue, Sederes also proposes the map-based seismic zone and its design parameters to Taipei sites that exist inconsistency between TBC's Table 2-6 and Figure 2-1. Figure 2 shows an example of a query result with alternatives for a Taipei site in Xizhi District. In addition, For Taipei villages that are not listed in TBC Table 2-6, such as Xiangfeng Village in Xinzhuang District, New Taipei City, Sederes propose suitable seismic zone based on TBC's Figure 2-1 as well.

Fig. 2 The map-based query result for a Taipei site

Map-Based Enclave Site Design Spectra

The meaning of enclave is a distinct territory that is enclosed within one other territory. Several enclaves in Taiwan have discrepancies in design parameters due to different names between street address and seismic zone. For example, Majia Junior High School is located at No. 16, Sanhe Lane, Sanhe Village, Majia Township, Pingtung County; however, this village is actually an enclave contained within Neipu Township, Pingtung County. Therefore, the S_s^D and S_s^M should be 0.6 and 0.8, respectively, corresponding to Neipu Township, rather than 0.7 and 0.9, which are associated with Majia Township. Figure 3 shows this school's query result.

By using GIS-based platform, Sederes can correctly provide the seismic design parameters for enclaves in accordance with the distribution maps of nationally mapped spectral response acceleration parameters illustrated in Figure C2-2 to C2-5 of the latest TBC.

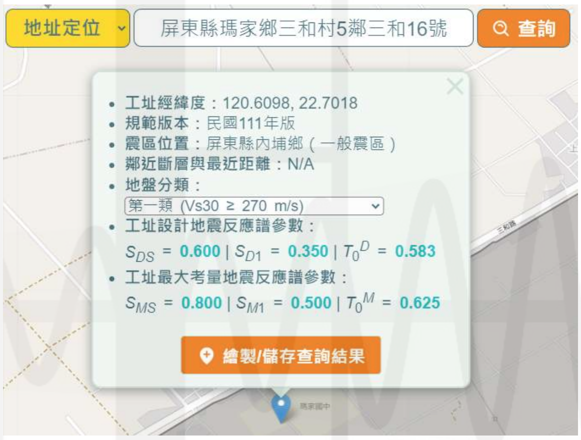

Fig. 3 The map-based query result for an enclave site

Detailed Design Spectra Information

Sederes can display multiple query results in a plot and table, allowing users to conveniently gather design values, compare design spectra, and store outputs.

The handy functions of the query results spectral plot indicate below. (1) The spectral shape at the long-period range can select as either a lower limit value (0.4S_{DS}, 0.4S_{MS}) or a decaying trend following the inverse of the period (T^{-1}). (2) Each spectrum can hide or show when clicking the corresponding legend label. (3) The single ( ) or all ( ) spectral accelerations (S_a) at a period can appear when the cursor puts on the plot. (4) Users can snapshot the plot as a PNG file ( ).

Each stored design earthquake in the query results table can customize to display, hide, or delete. Users can click the "Details" icon ( ) to obtain the complete horizontal design spectra parameters for return periods of 475 years (the Design Basis Earthquake level, DBE) and 2500 years (the Maximum Considered Earthquake level, MCE). The detailed information is as follows: latitude-longitude coordinate, administrative division, seismic zone (General Zone, Near-Fault Zone, Taipei Zone 1, Taipei Zone 2, or Taipei Zone 3), site classification (Class 1 Site, Class 2 Site, or Class 3 Site), mapped spectral response acceleration parameters (S_S^D, S_1^D, S_S^M, S_1^M), near-fault name(s), the shortest horizontal site-to-fault distance(s), near-fault mapped spectral response acceleration parameters, site amplification factors (F_a, F_v), site-adjusted spectral response acceleration parameters (S_{DS}, S_{D1}, S_{MS}, S_{M1}), effective peak acceleration (EPA) coefficients, and transition periods (T_0, $0.2T_0$, $2.5T_0$). Figure 4 shows the tabulated design spectra parameters for a site near active faults.

The above information, along with the design spectral response accelerations (S_{aD}, S_{aM}) for the 101 logarithmically spaced periods, with and without lower constraints ($0.4S_{DS}$, $0.4S_{MS}$) at the long period range, can save as a CSV file by clicking the "Results Export" bottom. If site is near active fault(s), the CSV file also details the response spectrum for each near-fault. In addition, the parameter values are rounded off to the third decimal place, except for site-to-fault distance and latitude-longitude, which are rounded to the second and forth decimal places, respectively; N/A is displayed for parameters that do not need to be considered.

Summary

The online query service of "Seismic Design Response Spectra based on Taiwan Building Code", also known as "Sederes", is wholly designed and developed by NCREE. Sederes provides site-specific design spectra solutions that comply with the latest TBC, and offers an intuitive, convenient, and functional user interface. This GIS-oriented platform can effectively support engineering practice, academic research, and general education.

In practice, it is recommended that users may conservatively reduce the default site-to-fault distance by at least 300 m to account for the uncertainty in the fault trace location. Additionally, by utilizing the site-adjusted spectral response acceleration parameters (S_{DS}, S_{D1}; S_{MS}, S_{M1}) from Sederes, users can quickly set up the target spectrum on the "Input Motion Selection for Taiwan" website, also known as "INMOST," (Liu *et al.*, 2022; https://seaport.ncree.org/inmost) and obtain a set of recorded ground motions with similar spectral shape to the target spectrum for time-history analysis.

Sederes was launched on December 30, 2022, and its URL is available at https://seaport.ncree.org/sederes. All are welcome to use, give feedback, and promote it.

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Fig. 4 The detailed design spectra parameters for a near-fault site.