# PROTECTING AMERICA'S DIPLOMATIC STRUCTURES A SEISMIC PROGRAM PREVIEW

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## *Abstract*

OBO Background

The U.S. Department of State's Bureau of Overseas Buildings Operations' (OBO) mission is to provide safe, secure, functional, and resilient facilities that represent American values. In accomplishing this mission, OBO is charged with a broad range of responsibilities related to its portfolio of over 25,000 properties spread throughout 290 diplomatic missions including acquisition, design, construction, and operations and maintenance. The portfolio includes properties ranging from open market leased residential structures to the design and construction of highly unique embassy campuses. It also includes a significant number of heritage structures which may have local, national, and/or UNESCO World Heritage Site designations.

Problem Statement

Approximately 60% of OBO's portfolio is located in a region of moderately high to very high seismicity. This encompasses approximately 10,700 properties, of which 120 are considered culturally significant, and the majority of which are leased on the local open markets. With such a large and diverse portfolio, managing the seismic risk and providing proper resource allocations is a challenge.

Resolution Statement

The seismic component of OBO's Climate Security & Resilience program has evolved over the years to respond to seismic risk exposure faced by many diplomatic posts. The program has recently renewed its efforts on becoming more data-driven and proactive with efficient resource allocation strategies to gain a better grasp and be more transparent on risk exposure across OBO's extensive portfolio. At present, portfolio risk is defined by OBO as a function of hazard exposure, building vulnerability, and building population.

Hazard exposure is related to the seismicity at a given diplomatic post. It is defined at each diplomatic mission through various means, one of which being through contracted geotechnical and structural engineers who develop site-specific seismicity updates.

Building vulnerability is related herein to specific building characteristics that may make a building susceptible to damage during an earthquake. OBO captures baseline building vulnerability information using rapid visual survey worksheets and related metrics currently being evolved (based on FEMA's P-154, but with OBO-specific modifications) to equate hazard exposure and vulnerability with a level of risk.

Following the collection of hazard exposure and building vulnerability, and subsequent determination of risk, the collected data can be analyzed, communicated with stakeholders, and used as a basis for mitigation planning. Interpretation of the data can lead to many different results, so OBO's Climate Security & Resilience program analyzes the data through a series of programmatic questions typically asked:

- Which office facilities have the highest life-safety risk, and at which post(s)?
- Which representational buildings have the highest seismic risk, and at which post(s)?
- What post warrants building new staff housing given risk in buildings on the local market?
- What heritage structures are at high risk of seismic damage?

To add clarity to OBO's portfolio risk, new methods, utilizing the data visualization software Tableau, have been developed to help quantify, analyze, prioritize, and communicate the seismic risk exposure. The introduction of such new data visualization practices has helped improved transparency and better informed the need for mitigation resources. In addition to seismic risk, there is a delicate balance that OBO must consider when also considering other considerations, such as, but not limited to fire, accessibility, security posture, mission functionality, and market availability.

Portfolio risk analysis and action is challenging for the State Department due to several factors such as portfolio size and diversity encountered. By utilizing the practices discussed herein, along with continual multi-discipline stakeholder engagement, the OBO Climate Security & Resilience program has positioned itself to provide more efficient and reliable data available to inform the larger risk management process.

In combination with the portfolio analysis process, through the further development of its educational and emergency preparedness initiatives, the OBO Climate Security & Resilience program is holistically intervening on multiple levels to best affect portfolio risk management.

*Keywords: Risk Mitigation; Portfolio Management; Data Analytics; Diplomatic Structures; Heritage Structures*

## 1. Introduction

The Bureau of Overseas Buildings Operations (OBO) serves as the asset manager for the U.S. Department of State's properties abroad. OBO's portfolio contains over $70 billion in assets, spread across approximately 290 foreign missions, and encompasses approximately 25,000 properties ranging in function including office structures, residences, support facilities such as shops and warehouses, and other miscellaneous facilities. Some OBO facilities also have significant cultural importance.

OBO's core mission is to provide safe, secure, functional, and resilient facilities that represent the U.S. government to the host nation and to support the Department's U.S. foreign policy objectives. These facilities represent American values and the best in American architecture, design, engineering, technology, sustainability, art, culture, and construction execution. The team of in-house professionals at OBO includes architects, engineers, real estate professionals, facility managers, and construction managers. The OBO team collectively oversees the entire life cycle of its diplomatic facilities from acquisition through design, construction, commissioning, facility management, decommissioning and disposal.

The safety and security of U.S. personnel serving overseas has always been paramount to the OBO mission. Following embassy terrorist attacks in 1983 and 1998, U.S. Congress passed the Secure Embassy Construction and Counterterrorism Act (SECCA) which codified several physical security requirements for diplomatic facilities and required OBO to outline facilities that were vulnerable to attacks and in need of mitigation.

When considering the safety of embassy facilities and personnel, OBO also started to include risks from natural hazards. In 1982, OBO established the Seismic Functional Program to implement modern seismic engineering practices and standards into its building program. In 2005, the program evolved into OBO's Natural Hazards Program whereby its scope expanded to provide educational and supporting technical expertise to OBO's building program on the effects of not just earthquakes, but also tropical cyclones, tsunamis, geohazards, and flooding.

Recently, in 2020, the Natural Hazards Program evolved further into OBO's Climate Security & Resilience (CS&R) Program whereby its scope again evolved to cover additional hazards (water stress, extreme heat) and to focus on proactive risk assessment and mitigation strategies considering the sometimes-compounding effects from a changing climate (e.g., sea level rise). Figure 1 identifies each particular hazard in CS&R's purview organized under two technical functional leads – the Earth Hazards Group Lead, and the Climate Hazards Group Lead. The program considers natural hazards to be a security risk that, as with physical security hazards, OBO must ensure its facilities are secure from and resilient against.




Figure 1: Climate Security & Resiliency Purview

Earthquakes, in particular have and continue to pose a threat to many Department of State's diplomatic missions. For example, in 1986, U.S. Embassy San Salvador suffered severe earthquake damage; in the 2010 Port-au-Prince earthquake, the new embassy largely remained operational, but the mission lost over 50% of its leased residences; in the 2015 Kathmandu earthquake, the mission fared better but had 5% of housing unoccupiable until structural repairs could be made, and approximately 50% of residences had minor damage. Numerous earthquakes have impacted U.S. diplomatic missions since (e.g., Mexico City (2017); Port of Spain (2018)), albeit fortunately limited more so to repairable nonstructural damage. For this reason, the CS&R program continues to utilize the latest developments in earthquake engineering practices and risk mitigation strategies to increase its effectiveness at reducing life safety risks, possible mission disruption, and economic losses from seismic events.

CS&R defines seismic risk as a function of exposure (or sometimes referred to internally as the seismic "threat" to draw parallels with physical security considerations), vulnerability, and population (see Figure 2). Each one of these elements plays a specific role in the development of property risk distribution breakdown, ultimately feeding into mitigation requirements. The three dots adjacent to population are meant to indicate that seismic risk can consider additional variables, which CS&R is currently assessing for applicability into its risk definition. For example, remoteness of a particular mission and lack of acceptable structural engineers local to it (i.e., ability to support post-earthquake) is currently just one additional factor being looked at.


Figure 2: OBO Seismic Risk Function

Figure 3 provides a general overview of the specific functions associated with CS&R's earthquake-focused efforts aimed at facilitating the OBO-wide effort of understanding and mitigating seismic risk throughout its portfolio over the long-term. The sections that follow will further elaborate on each. Specifically, Section 2 (Planning) highlights elements of the data collection, data analysis, and cross-program prioritization processes. Section 3 (Mitigation) highlights technical support CS&R offers in terms of design development, educational outreach, and post-disaster response.




Figure 3: CS&R Earthquake Focused Functions

## 2. Planning

Through planning, CS&R contributes to the broader bureau-wide effort to understand and mitigate seismic risk. Overall planning-focused efforts can be more discretely looked at in terms of data collection, data analysis, and a cross-program prioritization.

Data Collection

There are several data collection elements gathered by the program. Historically (and currently), regional seismicity information and building vulnerability data account for a significant allocation of time and effort. Collection of building-specific population data is also currently being rolled into standard data collection standard operating procedures.

For new OBO capital construction and modernization projects, due to their scale and potentially significant safety and cost implications, it is important to have best-available seismicity data for informing the design. Accordingly, studies to develop site-specific seismic design parameters are conducted ahead of time using U.S.-based consultants. The output of the seismicity study includes spectral acceleration data points at varied return periods allowing for implementation of various U.S.-based codes and standards, such as the International Building Code (IBC) or the Seismic Evaluation and Retrofit of Existing Structures (ASCE 41).

For discussion with non-technical staff, the defined seismicity is also characterized using the former Uniform Building Code (UBC) defined "Zones" {0 (extremely low) – 4 (very high)} nomenclature; it offers a clear and concise means of informing diplomats of the level of seismicity at their particular post for their awareness. Figure 4 provided a sample of the output from the seismicity update studies. To-date, such seismicity studies have been completed for nearly 80% of posts considered to be located in regions of high or very high seismicity. Seismicity data is gathered through a variety of other methods for posts not having site-specific seismicity update studies, such as by reference to other U.S. agency code criteria, locally available building codes, and/or historic codes or earthquake records.

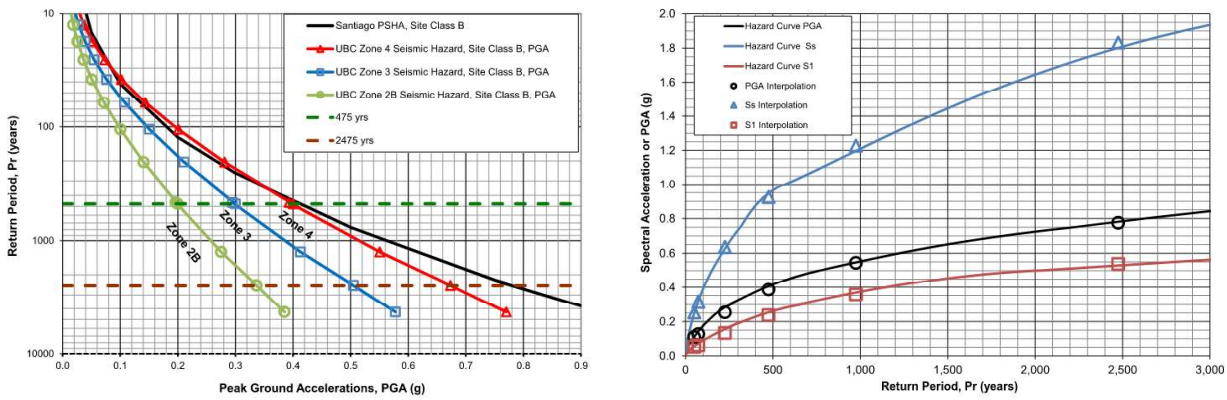



Figure 4: Excerpts of Data from a Limited Seismicity Update Study



Using the collected acceleration data, the CS&R Earth Hazards Group has developed several interactive dashboards, using the visualization software Tableau, to better visualize regional seismicity and group posts by this metric; this was found to help present seismic hazard information and distribution thereof to the non-technical colleagues and management. Figure 5 illustrates a sample visualization.

Note the indication of "USGS Zones" to the top right of the figure. These indications are associated with pre-defined U.S. Geological Survey (USGS) seismicity classification {low to very high} based on ranges of spectral accelerations. These classifications are also used in conjunction with OBO's Rapid Visual Survey program (to be discussed in subsequent sections, herein).

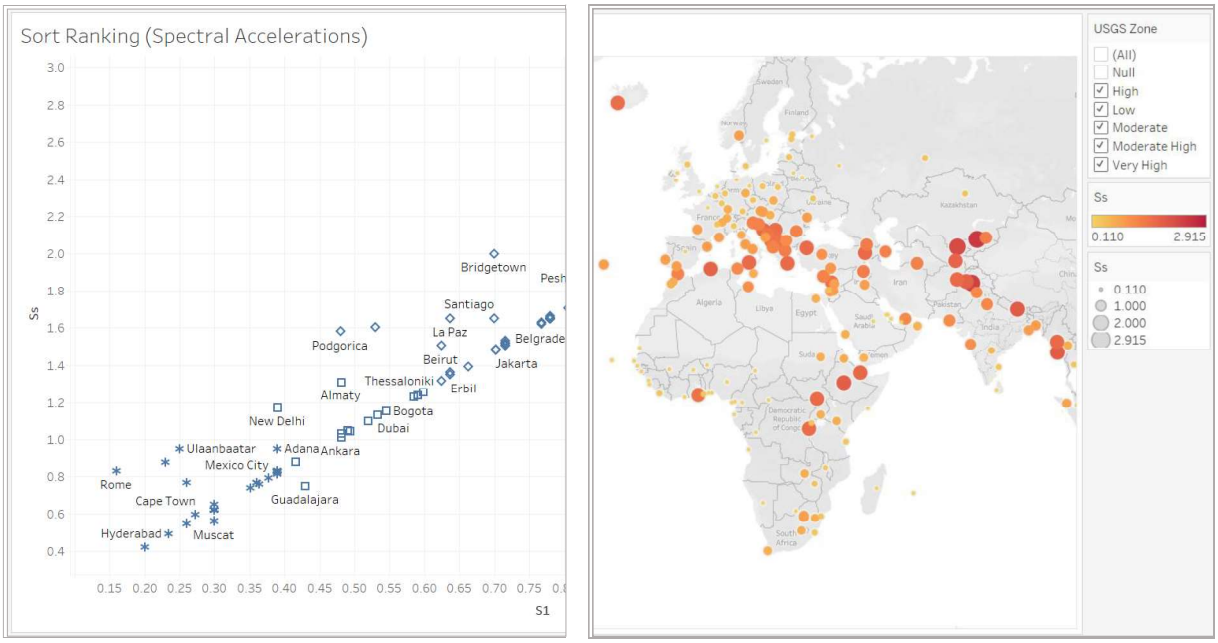



Figure 5: Seismicity (Hazard Exposure) Data Visualizations

A major component of OBO's portfolio-wide seismic risk management is a rapid visual survey program (RVS) for the collection of building-specific structural characteristic (or vulnerability) data across the portfolio, with a focus on posts in regions of moderately high to very high seismicity. More detailed levels of assessment have and can be conducted, particularly for the more valuable or higher occupancy structures, but rapid visual surveys strike a balance between needing to have engineering assessments and the appropriate level of detail to cover a large portfolio over geographically diverse locations with oftentimes limited existing design documentation.

The RVS program is carried out with combined assistance from contracted U.S.-based engineering firms, approved local/regional engineers, and via in-house OBO structural engineers. Where complete and dependable structural drawings sets are available, survey assessments can be done from the office. More typically, however, drawings are either not available or incomplete, so the survey assessments are typically conducted via field visits to buildings. Pandemic-related travel restrictions have resulted in recent exploration of using 360 degree cameras and virtual walk-thru technology to complete surveys remotely (ref: Figure 6); these methods are still being further developed internally.



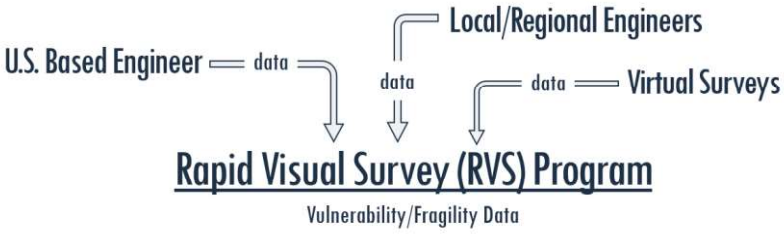
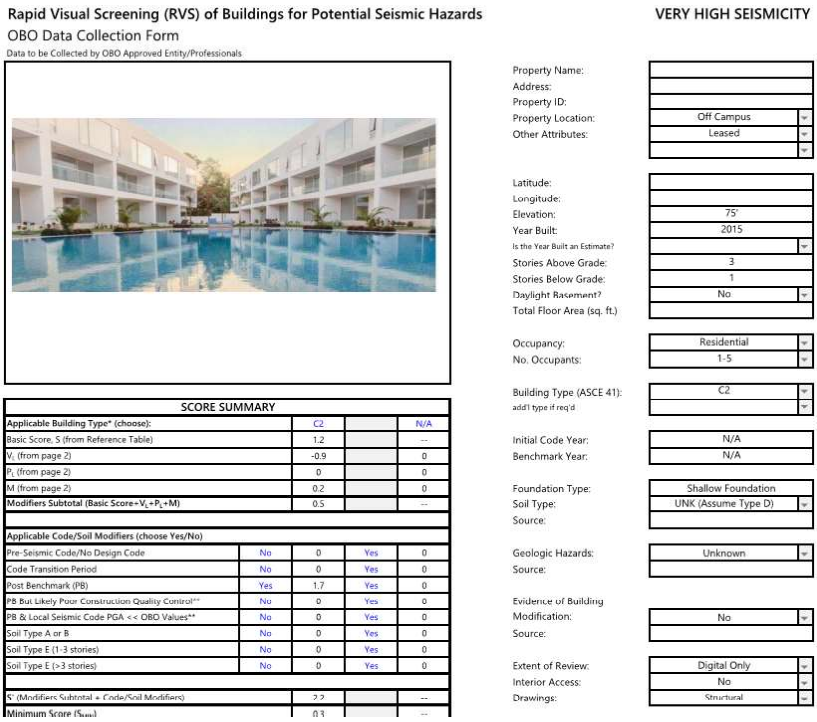



Figure 6: Rapid Visual Survey (RVS) Contributors

Historically, building seismic surveys (primarily of residential, non-critical facilities) were completed using a two-page worksheet to gather building structural characteristic/vulnerability information over the course of a 1 to 1-1/2 hour site visit, which was then used to inform a Seismic Hazard Rating, developed based on an early iteration of University of California school system's seismic risk program metrics. The qualitative and subjective assigned ratings ranged from "Good" (Minor Damage), "Fair" (Moderate Damage), "Poor" (Major Damage), to "Very Poor" (Partial/Total Collapse). The underlying method for that system relied on a combination of quasi-qualitative observations (building geometry, the appearance of material quality, etc.) and engineering judgment.

Recently OBO has initiated the adoption of a new metric for documenting building vulnerability and rapidly assessing seismic risk. The new approach to rapid survey assessments will be based on the framework of the United States Federal Emergency Management Administration's (FEMA) rapid visual survey methodology (ref: FEMA P-154) but modified for OBO use and data collection needs, and with modifications intended to capture structural systems typical outside of the U.S. (ref: Figure 7 for an excerpt of the data collection form developed). In short, the FEMA P-154 system provides a numerical "score" for each building that is loosely tied to a collapse probability. Factors that affect the score range from seismicity, geometric irregularities, the sophistication of local codes for seismic practices, and more. The modified approach is still under development, but the benefits will include an increased reliance on quantitative guiderails to inform a final assessment rating, as opposed to solely a qualitative and subjective ranking.



Rapid Visual Screening (RVS) of Buildings for Potential Seismic Hazards

OBO Data Collection Form

Data to be Collected by OBO Approved Entity/Professionals

VERY HIGH SEISMICITY

| SCORE SUMMARY | | | | |
|---|---|---|---|---|
| Applicable Building Type* (choose): | | C2 | | N/A |
| Basic Score, S (from Reference Table) | | 1.2 | | -- |
| $V_L$ (from page 2) | | -0.9 | | 0 |
| $P_L$ (from page 2) | | 0 | | 0 |
| M (from page 2) | | 0.2 | | 0 |
| Modifiers Subtotal (Basic Score+$V_L$+$P_L$+M) | | 0.5 | | -- |
| | | | | |
| Applicable Code/Soil Modifiers (choose Yes/No) | | | | |
| Pre-Seismic Code/No Design Code | No | 0 | Yes | 0 |
| Code Transition Period | No | 0 | Yes | 0 |
| Post Benchmark (PB) | Yes | 1.7 | Yes | 0 |
| PB But Likely Poor Construction Quality Control** | No | 0 | Yes | 0 |
| PB & Local Seismic Code PGA << OBO Values** | No | 0 | Yes | 0 |
| Soil Type A or B | No | 0 | Yes | 0 |
| Soil Type E (1-3 stories) | No | 0 | Yes | 0 |
| Soil Type E (>3 stories) | No | 0 | Yes | 0 |
| | | | | |
| S' (Modifiers Subtotal + Code/Soil Modifiers) | | 2.2 | | -- |
| Minimum Score ($S_{min}$) | | 0.3 | | -- |

| | |
|---|---|
| Property Name: | |
| Address: | |
| Property ID: | |
| Property Location: | Off Campus |
| Other Attributes: | Leased |
| | |
| Latitude: | |
| Longitude: | |
| Elevation: | 75' |
| Year Built: | 2015 |
| Is the Year Built an Estimate? | |
| Stories Above Grade: | 3 |
| Stories Below Grade: | 1 |
| Daylight Basement? | No |
| Total Floor Area (sq. ft.) | |
| | |
| Occupancy: | Residential |
| No. Occupants: | 1-5 |
| | |
| Building Type (ASCE 41): | C2 |
| add'l type if req'd | |
| | |
| Initial Code Year: | N/A |
| Benchmark Year: | N/A |
| | |
| Foundation Type: | Shallow Foundation |
| Soil Type: | UNK (Assume Type D) |
| Source: | |
| | |
| Geologic Hazards: | Unknown |
| Source: | |
| | |
| Evidence of Building Modification: | No |
| Source: | |
| | |
| Extent of Review: | Digital Only |
| Interior Access: | No |
| Drawings: | Structural |

Figure 7: Rapid Visual Survey Summary Sheet



By predefining the scoring factors and garnering a final numerical "score" for each property, there is an advantage of consistency and differentiation of scores between surveyed properties. This is especially beneficial due to the scale and global nature of OBO's portfolio. Similar to how the hazard exposure (or seismicity) information is presented, visualization software is used to create effective dashboards to easily identify, group, and filter through the collected information and ratings. Figure 8 highlights a sample of survey assessment ratings collected over the years that when compiled allows for quick assessment of trends and where future portfolio risk management focus and resource allocation is required.

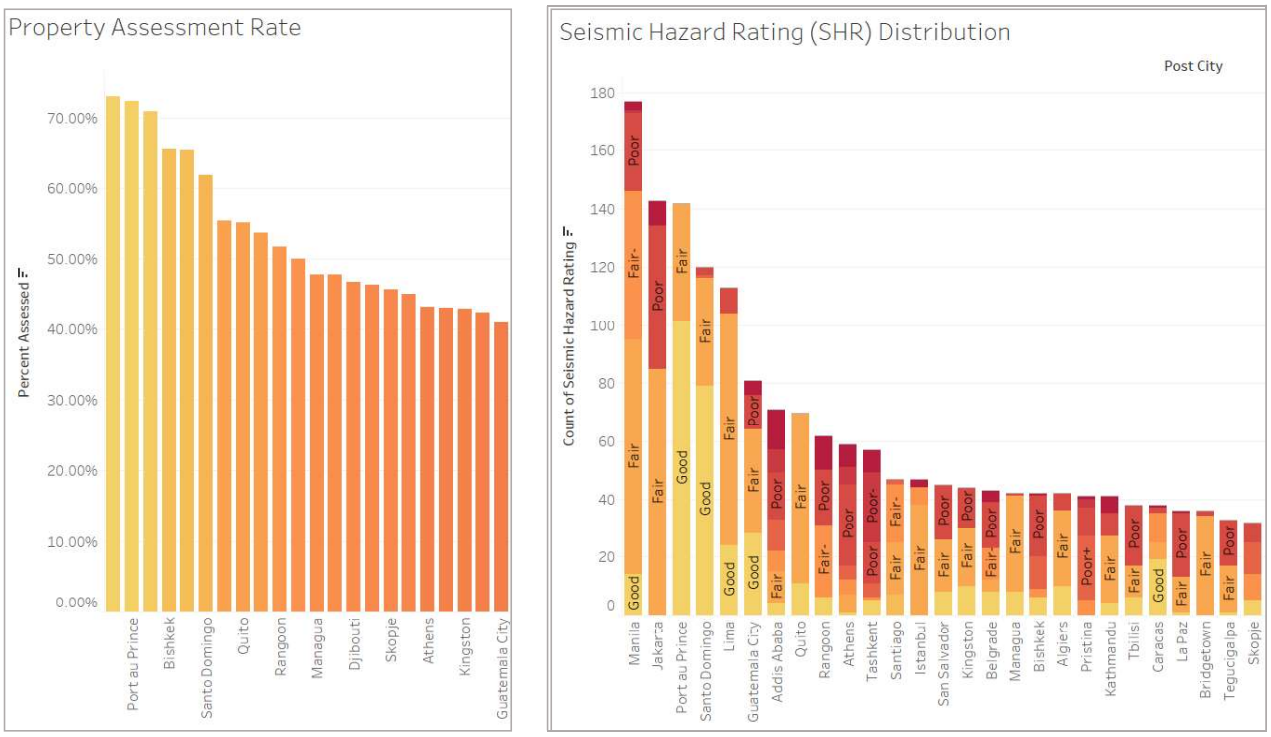



Figure 8: Sample of Rapid Survey Program Data Visualizations

## Data Analysis

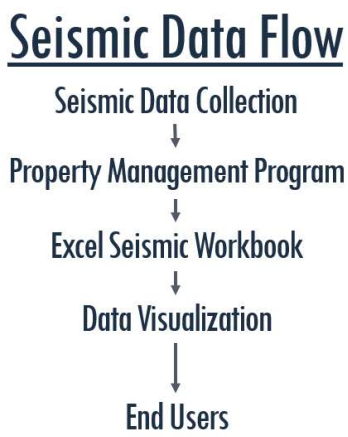
Having large quantities of information related to seismicity, building structural characteristics, and assessed risk ratings based on rapid surveys throughout the portfolio allows for distillation and identification of risk management needs. Having such capabilities on-hand is important for readily being able to respond to any number of questions from any stakeholder group, each of which may be looking at possible mitigation approaches from different perspectives. For example, some of the more typical requests for advisement include the following:

- Which office facilities have the highest life-safety risk, and at which post(s)?
- Which representational buildings have the highest seismic risk, and at which post(s)?
- What post warrants building new staff housing given risk in buildings on the local market?
- What heritage structures are at high risk of seismic damage?

As a specific example, take the question, "What OBO heritage structures are at high risk of seismic damage?" Following the process illustrated in Figure 9, the first step would be to pull all pertinent portfolio data available from the property management database for each of our culturally significant structures, oftentimes in the form of a large spreadsheet (Figure 9), and review the data for anomalies (e.g., do levels of seismicity associated with posts appear correct, are survey ratings assigned to buildings where they should be, etc).






| Post | Criteria - Significance | UBC Zone | USGS Zone | Ss | S1 | Population | Seismic Hazard Rating |
|---|---|---|---|---|---|---|---|
| ADDIS ABABA | Cultural, Historical | 4 | Very High | 1.859 | 0.884 | 100 | Very Poor |
| ADDIS ABABA | Historical | 4 | Very High | 1.859 | 0.884 | 30 | Very Poor |
| ALGIERS | Cultural, Historical | 4 | Very High | 1.771 | 0.845 | 30 | Poor |
| ALGIERS | Architectural, Cultural | 4 | Very High | 1.771 | 0.845 | 10 | Poor |
| AMSTERDAM | Architectural, Cultural | 0 | Low | 0.11 | 0.04 | 100 | 0 |
| ANKARA | Architectural, Historical | 2B | High | 1.012 | 0.481 | 100 | 0 |
| ANKARA | | 2B | High | 1.012 | 0.481 | 30 | 0 |
| ASUNCION | Architectural | 0 | Low | 0.11 | 0.04 | | 0 |
| ATHENS | | 4 | Very High | 1.65 | 0.78 | 100 | 0 |
| ATHENS | Historical | 4 | Very High | 1.65 | 0.78 | 10 | 0 |
| BAKU | | 3 | High | 1.232 | 0.585 | 100 | Poor |
| BANGKOK | | 1 | Moderate | 0.31 | 0.11 | 30 | 0 |
| BANGKOK | | 1 | Moderate | 0.31 | 0.11 | 1 | 0 |
| BANGKOK | Architectural | 1 | Moderate | 0.31 | 0.11 | 5 | 0 |
| BANGKOK | Architectural | 1 | Moderate | 0.31 | 0.11 | 5 | 0 |
| BANGKOK | Architectural | 1 | Moderate | 0.31 | 0.11 | 5 | 0 |
| BANJUL | | 0 | Low | 0.11 | 0.04 | 30 | 0 |
| BARCELONA | | 2B | Moderate High | 0.83 | 0.39 | 100 | 0 |
| BELFAST | | 0 | Low | 0.11 | 0.04 | 30 | 0 |
| BELGRADE | | 3 | Very High | 1.617 | 0.767 | 30 | Very Poor |

Figure 9: An Example of the Data Flow Process and Select Data Items

Once the data has been validated and adjusted for anomalies, it is then imported into the visualization program for processing and discussion. Figure 10 illustrates an example dashboard that is readily populated to tell a story of seismic portfolio risk for Cultural Heritage properties in the portfolio. Note, the dashboards created provide a dynamic and interactive relationship with the data, which is not fully captured by a static image. For the seismic data, the dynamic nature and visual methods of Tableau provide benefits missed using a more tabular system such as Excel.

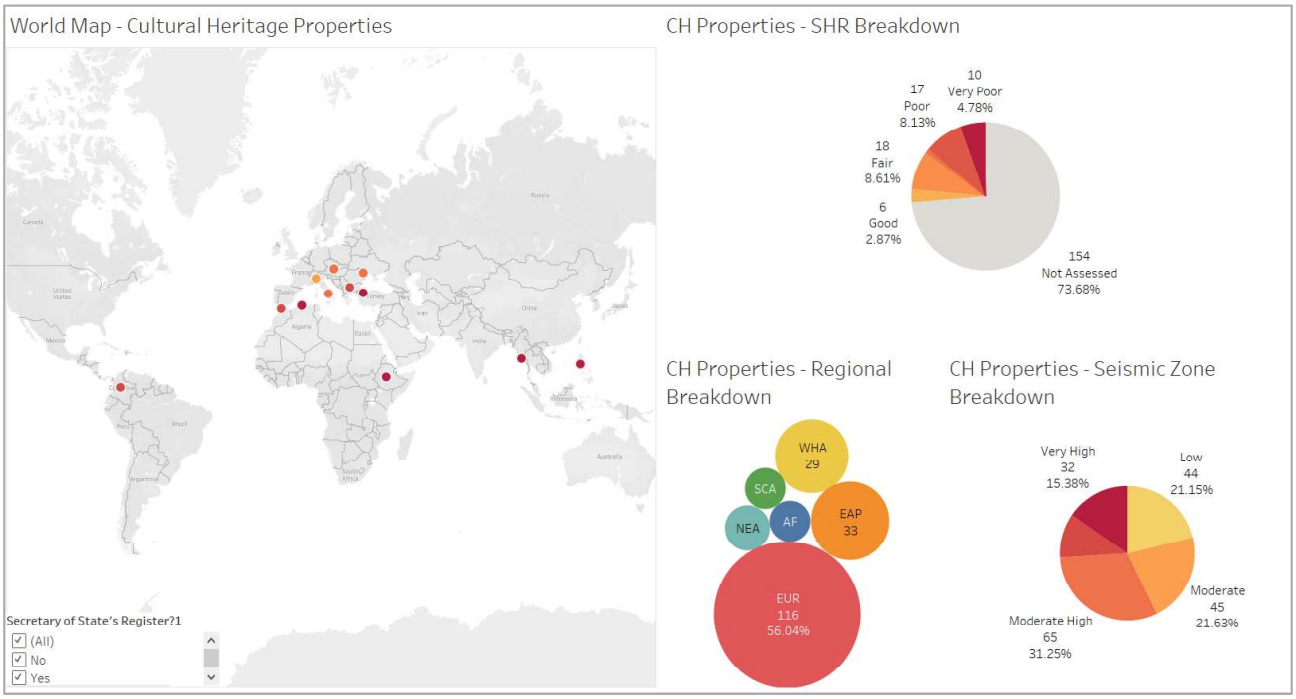



Figure 10: Cultural Heritage Property Dashboard

In recent history, this approach has resulted in intentional elevation in priority of specific buildings in need of either further study or full strengthening projects whereas in the past (without such tools) they may have been overlooked by bias perspectives suggesting needs and resources be focused elsewhere.



This process has also had the added benefit of strengthening ties between various stakeholder offices, such as with OBO strategic planners and master planners responsible for varying levels of portfolio risk management and formulating a project outlook that seeks to ensure U.S. diplomats are in safe, secure, functional, and resilient facilities. This rapid portfolio-level data analysis provides them with information to support their work thereby allowing them to better succeed.

Cross-Program Prioritization

Seismic risk is not the only factor impacting how OBO manages its portfolio. Other factors include those related to political violence, terrorism, crime, overall building condition, quality of life, commute duration, and more (ref: Figure 11). Seismic risk information distilled from the rapid visual survey program must be appropriately combined with the other factors. The result is a prioritized list of projects against which resources are sought and/or prioritized.

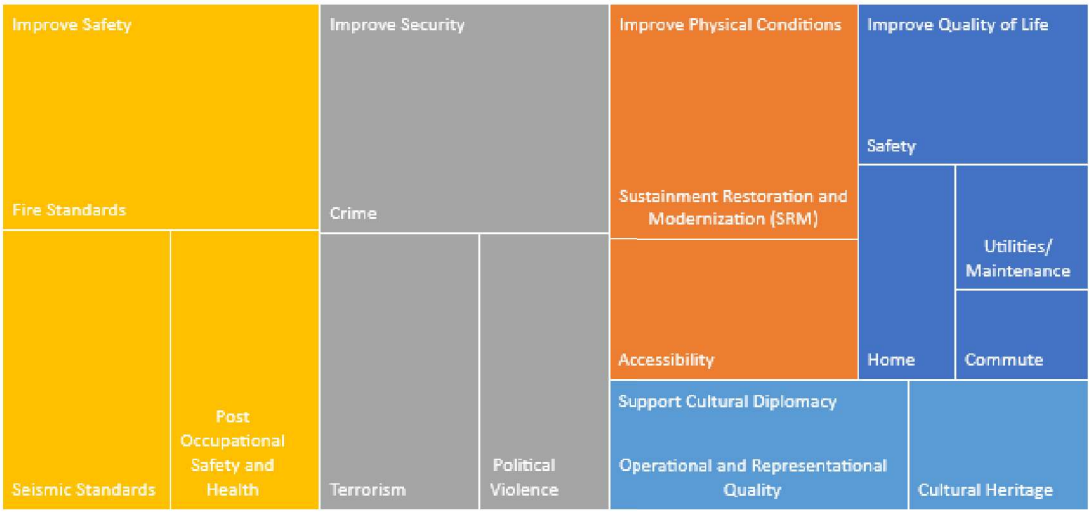



Figure 11: Example of other factors to be considered.

It should be noted that the process of identifying and prioritizing needs considers numerous, and sometimes very dynamic factors, some of which are not represented in Figure 11 (e.g., availability of land, ease of executing projects in some countries, etc.). As data is further developed and risks evolve, the process is refined and adjusted, as needed, further supporting the need for readily available data analytics capability to view data in different ways.

## 3. Mitigation

The CS&R Earth Hazards Group's work relative to earthquakes supports OBO's portfolio management on multiple levels (ref: Figure 12). The large-scale planning efforts through rapid visual building surveys highlighted in preceding sections encompass the high-level processes in-place to drive systematic global prioritization alongside other non-seismic considerations. Support is also provided through seismic design support for new buildings and building modifications, either at a conceptual level or through to complete construction documents.

Mitigation of seismic risk also means interacting with the diplomats occupying the facilities within the portfolio, both before and after earthquakes. This facilitates posts being prepared for what to do should an earthquake occur, and also what do to during and afterwards.




Figure 12: Scaling Diagram of Seismic Program Initiatives

Seismic Building Design Support

The structural engineers within OBO, in conjunction with the CS&R Earth Hazards Group, seek to work closely with internal real estate professionals to avoid addition of properties having poor seismic resilience to the portfolio (purchase or lease) – thereby mitigating risk at the onset. Where risk is unavoidable at the onset, OBO structural engineers provide consulting engineers with direction on seismic code applications, as well as design (documentation and analysis) oversight for projects.

A typical path forward, post-planning phase, for mitigating known seismic risks is to contract a U.S.-based architect/engineer consultant team to survey and develop conceptual strengthening documents, and potentially continue through to construction documents. In Bogota, Colombia, for example, OBO has undertaken a seismic mitigation effort for one of its owned and culturally significant residences, in which the structural engineers produced conceptual designs utilizing ASCE 41-13, considering the basic performance objective for new and existing buildings. Following the document development, a business case analysis was developed in-order to find the most cost and time-effective path forward for mitigation (i.e., whether to conduct the mitigation or to sell the property and relocate). This example followed the general approach outlined in Figure 13. Currently, this project is being prioritized against others for funding allocation.

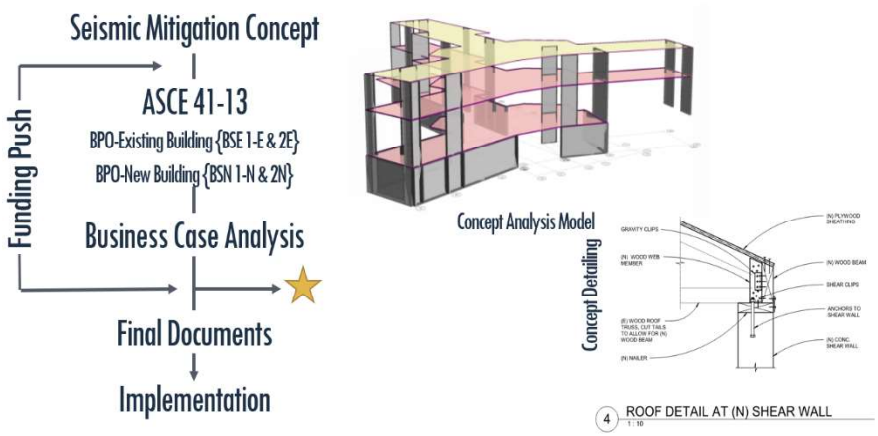



Figure 13:Typical Phasing for OBO Seismic Strengthening Project

Emergency Preparedness & Educational Events

For all the development and analysis of non-emotive seismic data, it is important to remember that seismic events affect people (physically and emotionally) and consequently the functionality of diplomatic missions



abroad. This why it is important for OBO earthquake-focused effort to engage in emergency preparedness and education events at the granular level.

The CS&R program has representatives on the OBO Disaster Response Committee. In the event of an earthquake, OBO structural engineers can fly to the impacted mission (in conjunction with contracted private engineers, if supplemental support is required) and provide post-disaster building surveys, recommendations for emergency repairs and shoring requirements as well as recommendations on the occupancy of structures. Figure 14 shows an example of damage seen in Port-au-Prince following the 2010 earthquake, and Figure 15 is an image of a town hall event conducted by the seismic team following the 2017 Mexico City earthquake.

Figure 14: Damaged Property – 2010 Port-au-Prince

Figure 15: 2017 Mexico City Townhall

Consistently, the CS&R program structural engineers provide educational events, mainly to facility and building oriented staff, giving an overview of how to be prepared before, during, and after an event. In addition, information about how their building stock may respond, and building characteristics they should avoid in acquisitions is provided. In the future, the program intends to host yearly in-person regional seismic conferences to better educate nontechnical diplomats about the regional seismicity, and information on typical local building design/construction practices and what characteristics to avoid in property acquisitions through hands-on events.

## 4. Conclusion

The Overseas Buildings Operations has a very diverse and complicated building portfolio. Variations in location, natural hazards, building type, and cultural significance are some of the important factors under consideration when managing the portfolio. The CS&R program's first and foremost responsibility, is work towards keeping U.S. diplomats safe from natural hazards while they serve abroad. A primary means of achieving this for the earthquake hazard is through the creation and maintenance of an efficient method for identifying, communicating, and working with other offices to prioritize seismic risks. In addition, preparing and educating those on the ground, and driving the criteria for which State Department buildings are seismically designed and modified is essential.

The recent development of its data analysis and visualization methods has not only spurred very positive results on efficiently categorizing its structures but has had strong benefits in interoffice working relationships throughout OBO. The program will continue to further develop its data collection and analytic processes, while further engaging diplomatic missions in furtherance of seismic risk mitigation best practices.

