

## Appendix A

---

# Performance Estimation Tool User Manual

The *Performance Estimation Tool* (PET) is an interactive spreadsheet provided in FEMA P-58, Volume 3, *Supporting Electronic Materials and Background Documentation*. The tool was developed from an application of the FEMA P-58 methodology to 1,755 archetypical buildings conforming to the seismic design requirements of ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*, (ASCE, 2010) for different structure types and different occupancies. The tool was originally developed to view and analyze data from these assessments, and overall results and conclusions from these data are summarized in FEMA P-58, Volume 5.

The *Performance Estimation Tool* can also be used as a design aid to quickly determine the level of strength and story drift necessary to achieve specific performance objectives for the systems and occupancies represented within the database. Once the required shear strength and design story drift are known, designers can proceed in selecting member sizes that result in a structural system with the necessary strength and stiffness.

### A.1 Design Space

The *Performance Estimation Tool* incorporates the concept of a code-conforming design space that bounds the possible archetype designs and represents a reasonable range of lateral strengths and stiffnesses that would be expected in typical modern buildings designed in accordance with ASCE/SEI 7-10 seismic design requirements. The design space is intended to capture the range of structural design choices, from buildings designed to code-specified minimum base shear and maximum allowable story drift to those designed more conservatively in whole or in part.

Figure A-1 shows a typical design space with 13 points used to characterize archetypes with different strength and stiffness combinations. Lateral stiffness, in terms of story drift ratio, is presented on the horizontal axis, and lateral strength, as a multiple of the minimum design base shear strength, is presented on the vertical axis. The four corners of the design space represent the limits of the combinations of lateral strength and stiffness considered in the study. Point 1 represents a structure with a low design story drift ratio

and minimum permitted lateral strength. Point 2 represents theoretical code-minimum design, which is a structure having the maximum practical design story drift ratio and code-minimum lateral strength. Point 3 represents the stiffest, strongest structure considered in the study. Point 4 represents a flexible structure having the maximum practical design story drift ratio and a high level of lateral strength.

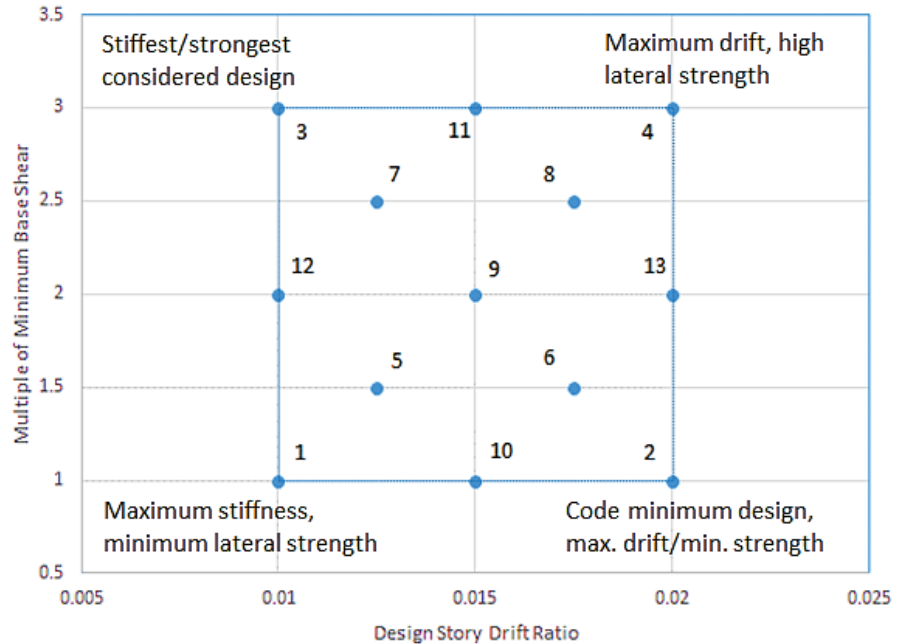


Figure A-1 Typical design space showing 13 points used to characterize the different strength and stiffness combinations of each archetype.

Seismic requirements only specify the minimum strength and maximum allowable drift boundaries of the design space. The design space boundaries vary for each seismic force-resisting system based on the strength and stiffness characteristics of typical buildings utilizing these systems. Design space boundaries and parameters for representative designs are presented in FEMA P-58, Volume 5.

## A.2 Usage Notes

The *Performance Estimation Tool* was created in Microsoft Office 2013 as a macro enabled Excel file (.xlsm). The tool uses Excel macros, and macros must be enabled for the tool to run. It contains several worksheets, accessed as tabs, and labeled as follows:

- **Instructions.** The Instructions tab summarizes important information about the use of the tool.
- **User Interface.** The User Interface tab is used for selecting input parameters and obtaining the results.

- **Detailed Plots.** The Detailed Plots tab presents additional, more detailed information in graphical format for each loss metric shown on the User Interface tab.

In each tab, users access all options through of grey-shaded buttons, drop-down menus, and sliders located on the bottom and right side of the design space. Information should not be typed into any of the cells, especially the selection cells identified with heavy black borders.

### **A.3 User Interface Tab**

Figure A-2 shows the PET User Interface tab. The left side of the tab is the user input interface. The user may select any combination of seismic force-resisting system, occupancy type, Risk Category, building height, and seismic hazard from the available options. Risk Category II office occupancies will allow selection of low-, mid-, and high-rise buildings, but healthcare occupancies and Risk Category IV office occupancies are limited to low- and mid-rise selections. The available gradient in seismic hazard level (i.e., Low SDC D, SDC D and SDC E/F) is representative of the Seismic Design Category D-E transition. The figure shows the tool with the following selections: special steel moment-resisting frame (“Steel SMRF”), “office” occupancy, Risk Category “II”, “mid-rise” building height, and “SDC D” hazard level.

Figure A-3 shows the stiffness and strength input interface, including the design space graphic, which shows the boundaries of the design space for the selected seismic force-resisting system. Each point within the design space is characterized by a design story drift ratio and design strength expressed as a multiple of minimum base shear. The green dot indicates the location of the representative design within the design space. The red dot reflects the current selection of stiffness and strength within the design space. The red dot can be moved using the sliders located along the bottom and right side of the design space, or through selections from dropdown menus associated with the buttons for multiple of minimum base shear and design story drift. In the figure, input fields indicate the selection of a design story drift ratio of 0.015 and base shear ratio of 2.5.

Once data have been entered, the User Interface tab provides graphs showing estimates of building performance in terms of median, mean, and 90<sup>th</sup> percentile repair costs and repair times; probability of collapse; probability of reparability; and probability of unrepairable permanent drifts for different intensities of ground motion expressed as a percentage of the MCE shaking intensity at the building site. A change in any of the input parameters automatically updates all of the graphs.

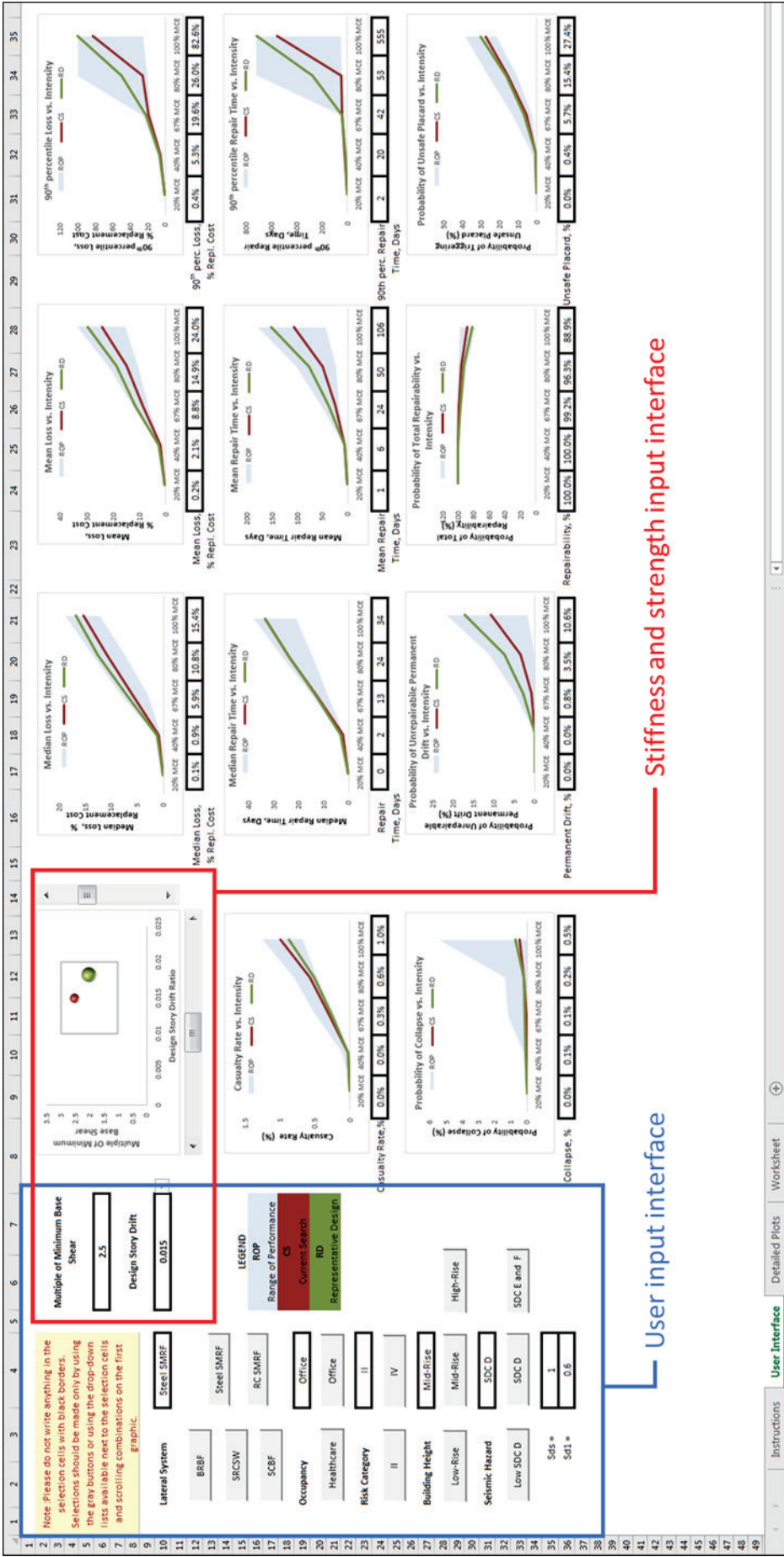


Figure A-2 PET User Interface tab.

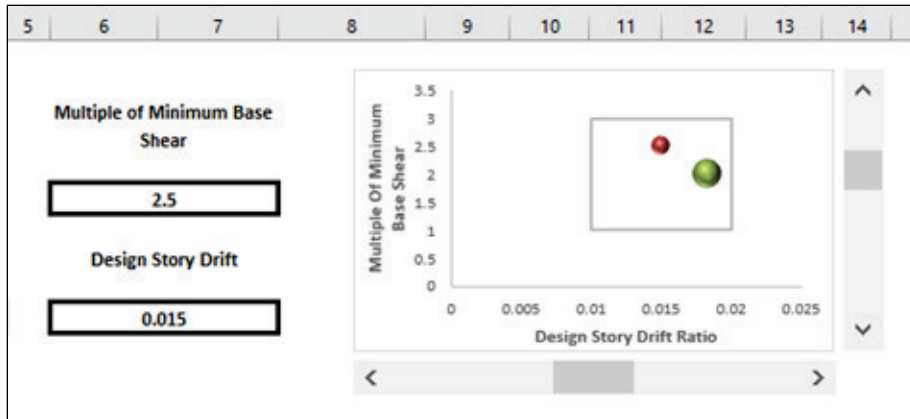


Figure A-3 Stiffness and strength input interface and design space graphic on the User Interface tab.

Figure A-4 provides an example of one graph showing mean repair cost expressed as percentage of replacement cost. In all graphs, a blue shaded area indicates the range of performance (ROP) for all buildings within the design space. A green line indicates the performance of the representative design (RD) for the selected system, and a red line indicates the performance of the current search (CS) parameters including the selected values of story drift ratio and base shear multiple. Performance values for current search (CS) parameters are also tabulated below the graph at each intensity level.

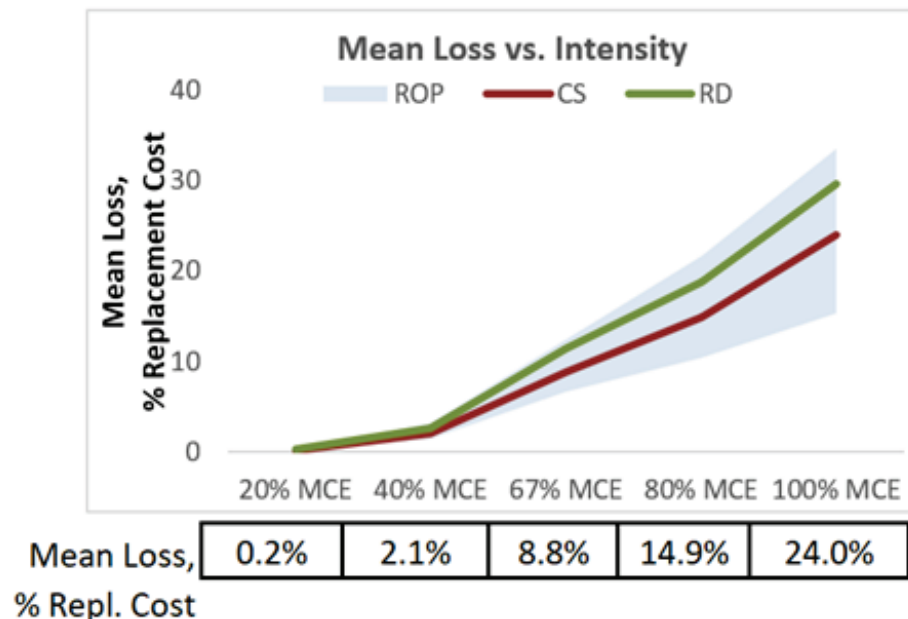


Figure A-4 Graph showing mean repair cost as a percentage of replacement cost on the User Interface tab.

### A.4 Detailed Plots Tab

The Detailed Plots tab provides all data for the parameters currently selected in the User Interface tab in larger scale and with additional detail. The tab displays one detailed plot at a time for the selected performance metric. Results for different performance metrics can be accessed through gray-shaded buttons on the left side of the tab. Figure A-5 provides a detailed plot of mean repair cost versus intensity, which is a more detailed version of the information shown in Figure A-4. Similar to Figure A-4, the red line shows the performance of the current search parameters, and the green line shows the performance of a representative building design for the selected system. The two blue lines indicate an upper and lower bound characterizing the range of performance considering all buildings within the design space. The performance of the current search, representative design, and bounds for the performance range are also tabulated below the plot.

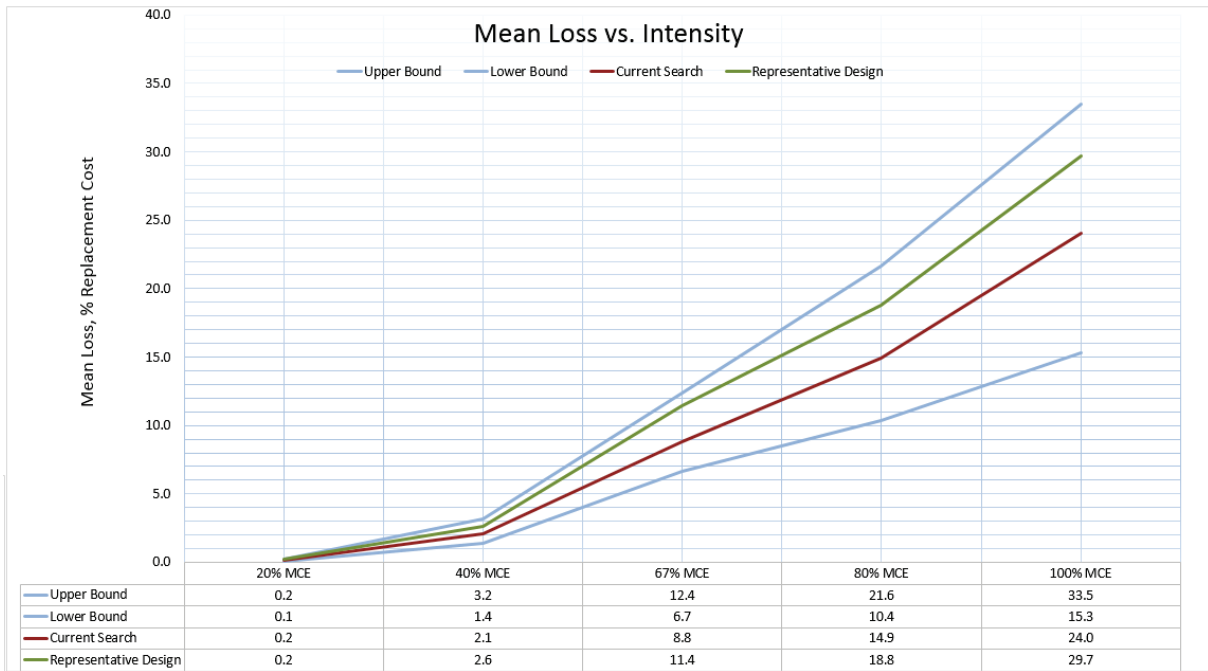


Figure A-5 Detailed plot of mean repair cost versus intensity.