Additional Information on Changes from Version 3 to Version 4 of the FEMA BCA Earthquake Structural Module

Version 4 of the BCA Earthquake Structural Module includes the following changes from Version 3:

1. Incorporates the seismic ground shaking data from the U.S. Geological Survey's (USGS's) 2008 National Seismic Hazard Maps
2. Fully implements FEMA's HAZUS-MH technology developed through the National Institute of Building Sciences (NIBS)
3. Results in improved building vulnerability characterization that leads to more accurate damage prediction
4. Corrects errors found in Version 3

Updated Ground Motion Data

Version 3 included outdated USGS ground motion data for only three return periods (475, 975, and 2,475 years). Version 3 required extrapolation to determine probabilities for ground motion outside of these three data points. Benefit-cost analysis (BCA) results are very sensitive to more frequently occurring ground motions (i.e., return periods of 10 to 475 years), and this extrapolation produced unrealistically high benefit-cost ratios (BCRs) in Version 3. Version 4 includes the 2008 USGS ground motion data for return periods ranging from the 10-year event through the 10,000-year event. The user specifies the site coordinates (latitude and longitude), and Version 4 incorporates the site-specific ground shaking data for the user-entered latitude and longitude. The new ground motions are the result of extensive efforts by the USGS to provide a consistent, nationwide perspective of the earthquake hazard. The user must also specify the site soil conditions (e.g., rock, very firm soil, firm soil, or soft soil) so that the software can modify the ground motion data to represent site-specific conditions.

Full Version of HAZUS-MH Earthquake Model

Version 3 included a simplified version of the HAZUS-MH Earthquake Model, in which ground motion was represented by peak ground acceleration (PGA) only. Version 4 implements the complete HAZUS-MH Earthquake Model, in which ground motions are represented as a spectrum that includes PGA and spectral acceleration (Sa) values. The spectrum accounts for the dynamic characteristics of the building better because it includes the fundamental period of vibration of the building and considers the effect of earthquake magnitude on the spectrum shape.

Adapting HAZUS to the Vulnerability of the Specific Building, Before and After Retrofit

Version 3 was limited in the way it represents the pre- and post-retrofit vulnerability of the building in question. It offered "default" model building types, seismic design levels, and the corresponding fragility curves from the HAZUS damage model. Fragility curves can be modified to represent a particular building based on input and documentation from a civil or structural engineer. However, most practicing engineers experienced with seismic retrofit are not familiar with fragility curves. Consequently, users commonly model vulnerability using a "default" model building type and seismic design code level without modification of fragility curves, which does not accurately represent vulnerability before and after retrofit.

With Version 4, the user must input vulnerability parameters for the particular building before and after retrofit. The vulnerability parameters include the fundamental period of vibration, the design strength, and damping. The user still chooses a seismic design code level most representative of the building that sets initial vulnerability parameters. However, the initial vulnerability parameters only represent a generic HAZUS model building type, not the particular building proposed for retrofit. Therefore, modifying these parameters based on documentation from a civil or structural engineer is important. The user can also modify values related to the onset of the "complete" damage state (e.g., drift ratios and acceleration) for the structural components (e.g., beams, columns, diaphragms), for the architectural drift-sensitive components (e.g., full-height partitions and cladding), and for the acceleration-sensitive components (e.g., suspended ceilings and floor-mounted equipment). The changes to these properties change the structural performance, and reduce the vulnerability of the building. These parameters are familiar to engineers experienced with retrofit and are key to developing a detailed scope of work required for FEMA mitigation grant programs. Failure to modify these parameters from the initial parameters can lead to inaccurate and often lower BCRs.

Corrections to Errors in Version 3

Version 4 corrects errors that were present in Version 3, such as the aforementioned probability calculations for the ground motion data and the benefits associated with reduced casualties. These errors were responsible for some of the unrealistic results obtained using Version 3. The BCRs from Version 4 have been compared to and are in relative agreement with typical retrofits commonly promoted as cost effective.