2 Updated lookup table (Z transformation)

In accordance with the *CHEER-Safe (MATLAB)* documentation, the lookup table is defined as a dictionary that maps structural and hazard parameters to a vector of 50 probabilities corresponding to 50 discrete damage states, ranging from 0% to 140% of the structure's nominal value.

Formally, the lookup table $\mathcal{L}$ is defined as:

$$\mathcal{L} : (M, C, w, f) \mapsto \mathbf{p} = [p_1, p_2, \ldots, p_{50}] \tag{1}$$

where:

- M is the structural archetype (e.g., material, number of stories),
- C is the construction type,
- w is the wind speed (in mph),
- f is the flood depth (in inches),
- $\mathbf{p}$ is a vector of 50 probabilities, where p_i represents the probability of being in damage state i,
- The damage states correspond to loss ratios from 0% to 140% of the structure's nominal value.

Still, given a structure in the building inventory, it is important to note that a building cannot be represented by a single (C, M) pair (please refer to the CHEER-Safe documentation). Instead, each building is associated with a specific M value and a 192-by-1 array of C value probabilities. To accelerate the final loss estimation process—which, in some cases, may take days to complete due to computational complexity—we perform a change of variables by introducing a new variable Z. The variable Z is a function of M and C, with C itself being modeled as a function of the building's year of construction and its distance to the coast (see Tables 3.6 and 3.7 in Jiazhen Peng's dissertation). This leads to a total of 48 distinct Z combinations. By computing the corresponding 48 probability vectors once and building a lookup dictionary of the form:

$$Dict[Z][W, F] \mapsto \mathbf{p}_{damage} \in R^{50} \tag{2}$$

where W is wind speed and F is flood depth, we significantly reduce runtime during hazard simulation. Additionally, we go one step further and pre-compute the expected damage by multiplying the 50-element damage probability vector with the corresponding damage state ratios (ranging from 0% to 140% of the property's value). This further reduces computational time for the ultimate loss estimation.