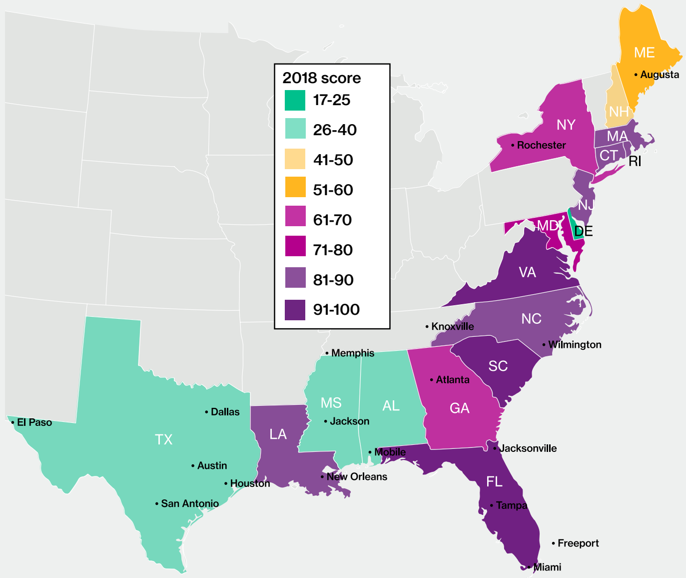
# IBHS state ratings, building codes and their uses in catastrophe modeling

**Major natural disasters often act as validation of the current building code practice, but also act as facilitators for significant code improvement and implementation. Post-event damage surveys of Hurricane Irma, including Willis Re's own report, credited effective building codes and enforcement in limiting property damage in Florida. In general, Hurricane Irma's estimated wind speeds on the ground were significantly below the minimum design level wind speeds for residential buildings. Florida's strong, up-to-date and mandatory statewide code played a critical role in minimizing the wind damage to homes, along with less intense Irma winds on the ground. A good and strong building code is effective if it is adopted by communities and enforced by the administration.**

## IBHS state ratings

Recently, the Insurance Institute for Business & Home Safety (IBHS) released the latest edition of Rating the States, an assessment of residential building code and enforcement systems for life safety and property protection in hurricane prone regions. This report identifies the strengths and weaknesses of the current practice of a building code administration and provides a road map to help improve building strength and community resilience.

Figure 1. **IBHS state ratings**




| State | 2012 score | 2015 score | 2018 score |
|---|---|---|---|
| FL | 95 | 94 | 95 |
| VA | 95 | 95 | 94 |
| SC | 84 | 92 | 92 |
| NJ | 93 | 89 | 90 |
| CT | 81 | 88 | 89 |
| RI | 78 | 87 | 87 |
| NC | 81 | 84 | 83 |
| LA | 73 | 82 | 83 |
| MA | 87 | 79 | 81 |
| MD | 73 | 78 | 78 |
| GA | 66 | 69 | 68 |
| NY | 60 | 56 | 64 |
| ME | 64 | 55 | 54 |
| NH | 49 | 48 | 46 |
| TX | 18 | 36 | 34 |
| MS | 4 | 28 | 28 |
| AL | 18 | 26 | 27 |
| DE | 17 | 17 | 17 |

IBHS uses 47 data points to assess the effectiveness of a state's residential building code and its adaption and enforcement. This assessment covered important factors such as current residential building codes, the processes in effect to ensure universality of code application without weakening amendments, state and local level enforcement, and licensing and education of building officials, contractors and subcontractors who implement building code provisions. This report looks at state-level performance as a whole and provides a relative standing for each state. IBHS constructed a model that assigns 50% weight to the total score allotted to statewide adoption and enforcement of building codes, 25% weight to the state-adopted requirements for code official certification and training, and 25% weight to state regulations for onsite implementation. The possible scores range from zero – 100, with zero being the weakest and 100 the strongest score. The state ratings are shown in *Figure 1* (previous page). Florida and Virginia continue to be the leaders in building code administration as indicated by IBHS score.

Florida building code is based on the 2015 version of the *International Residential Code* (IRC), which edition effective December 31, 2017. *Figure 2* shows which edition of the IRC a state was using at the two different time periods. The scores in 2018 haven't changed significantly compared to 2015 except for New York, which scored much higher compared to 2015. The key factor behind this progress is that the state adopted the 2015 edition of the IRC. However, New York City is exempt from this state requirement since the city took several encouraging steps in updating and strengthening their building codes, especially for wind and wind-driven rain resistance in the aftermath of Hurricane Sandy.

It is surprising that Texas – which has seen 17 major hurricanes make landfall since 1900 and is vulnerable to a wide range of other natural disasters including flooding, wildfires, hail and severe convective storms – does not require mandatory adoption and enforcement of its residential building code. However, post-event surveys revealed that several parts of the state hit by high winds during Hurricane Harvey actually had adopted more recent editions of the IRC (2012 or 2015). In general, it was observed that there was limited wind damage to houses built to newer building codes. Adoption of a mandatory statewide code system throughout the state would help establish uniformity in enforcement and application of the code provisions, and reduce losses in areas that have not adopted building codes.

The IBHS rating is not based on design wind speeds; rather, it is based on the adoption and enforcement practice within the state. When two houses from two different states or regions are subjected to the same intensity of wind speed, the performance of the two houses will be different due to the differences in design wind speeds that were used during the construction. For instance, even though the IBHS ratings for Florida and Virginia are similar due to both of their strict code enforcement practices, the performance of a similar house could be significantly different due to different design wind speeds in the two states.

Figure 2. **IRC edition utilized by state in 2015 and 2018**

| State | 2018 | 2015 |
|---|---|---|
| FL | 2015 IRC | 2009 IRC |
| VA | 2012 IRC | 2012 IRC |
| SC | 2015 IRC | 2012 IRC |
| NJ | 2015 IRC | 2009 IRC |
| CT | 2012 IRC | 2009 IRC |
| RI | 2012 IRC | 2012 IRC |
| NC | 2009 IRC | 2009 IRC |
| LA | 2015 IRC | 2012 IRC |
| MA | 2015 IRC | 2009 IRC |
| MD | 2015 IRC | 2012 IRC |
| GA | 2012 IRC | No mandatory code |
| NY | 2015 IRC | 2006 IRC |
| ME | 2009 IRC | 2009 IRC |
| NH | 2009 IRC | 2009 IRC |
| TX | 2006 IRC (optional) | 2006 IRC (optional) |
| MS | No mandatory code | No mandatory code |
| AL | No mandatory code | No mandatory code |
| DE | No mandatory code | No mandatory code |

## ASCE 7-16 nominal design wind speed

The map in *Figure 3* shows the nominal design three-second gust wind speeds (mph) from ASCE 7-16 for Risk Category II. The majority of structures such as residential, commercial and industrial buildings are included in this risk category. The design wind speed is highly location specific. The Florida Keys have the highest design wind speeds followed by the coastal area of New Orleans. The nominal design wind speeds in Virginia are relatively lower than most parts in Florida. The plot in *Figure 3* shows the chronological change in design wind speeds for Risk Category II at different hurricane-prone cities in the East and the Gulf Coast. ASCE 7-05 design wind speeds are adjusted with load and resistance factor design (LRFD) load factor for wind, so these wind speeds are directly comparable. In general, there was a decrease in design wind speeds while switching from ASCE 7-05 to ASCE 7-10 in most of the places. The changes in ASCE 7-16 are minimal and are mostly concentrated in the Northeast.

## How are catastrophe risk models accounting for building code and its enforcement?

In the catastrophe risk models, the building damage due to wind forces is expressed in terms of vulnerability functions. These vulnerability functions vary by construction types, year built, number of stories, floor areas and occupancy types. The vulnerability functions also vary by state, region and/or distance from the coast. From purely an engineering-based approach, these vulnerability functions would reflect the differences in regional wind hazard levels, building code and its enforcement. Though modeling companies built their vulnerability functions based on engineering principles, the curves are calibrated and validated using claim data from historical events, since the ultimate objective of a catastrophe model is not the estimation of physical damage – it is the estimation of losses that an insurer will actually pay out following a catastrophe event (Bobby et al., 2017).[1] However, insurance companies are often not able to document the losses at a high resolution, particularly in areas with lower hurricane frequencies, which can confidently be used in the calibration of vulnerability curves.

[1] Bobby, S.; Johnson, T.; Kordi, B.; Moghim, F. and Ramanathan, K (2017) "The Impact of Temporal and Spatial Variation in Building Codes on the Hurricane Wind Vulnerability of Residential Single Family Homes," Structures Congress 2017 (183-195).

Figure 3. **Nominal design three-second gust wind speeds (mph) from ASCE 7-16 for Risk Category II (Source: https://hazards.atcouncil.org/). Chronological change in design wind speeds for Risk Category II in different cities.**

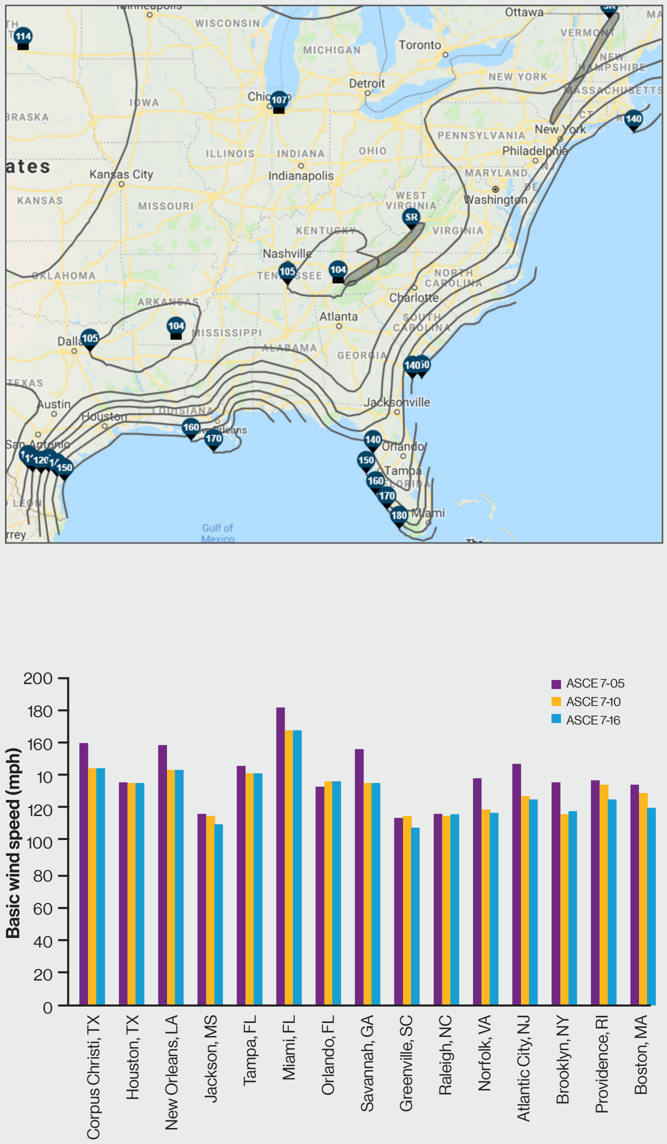


*Figure 4* shows the relative mean damage ratio (MDR) of a single-family dwelling made of wood at a wind speed bin of 115 to 120 mph three-second gust. The 18 coastal states are shown here and normalized by the MDR of Florida from the two commercial catastrophe models. The 2015 IBHS state ratings are also superimposed on the figure. The 2015 rating is used since the year built was assumed to be 2015 and a 2018 rating would not be effective at the time of the construction. It is apparent that both models assume Florida has the lowest vulnerability at this wind speed. The damageability in Model A does not vary much in other states. No model shows a visible correlation with the IBHS state ratings due to the fact that the rating is not based on design wind speeds, but is based on the adoption and enforcement practice within the state. The different design wind speeds in a different region would yield different damage ratios.

*Figure 5* shows the standard deviation of the MDR for each state. This figure is basically displaying the variability of the damageability in each state from the two modeling vendors. The state abbreviations with an asterisk are the states that do not have a mandatory building code enforced. Model B is somewhat able to produce large standard deviations for the states with no mandatory code. This large standard deviation for those states in Model B could be a reflection of a larger variation in building damageability than other states, or could be due to the fact that some part of the state with no mandatory building codes might have adopted newer building codes and some parts may have not.

In summary, the IBHS state ratings are not necessarily the reflection of hazard intensity – rather, they are based on the adoption and enforcement practice within the state. The building vulnerability curves in the commercial models are supposed to be region specific and reflect the local building codes and construction practices as presented in IBHS state ratings. However, the vulnerability curves are often adjusted using the claim data, and this dependency on claims could deviate from the actual reflection of the regional construction practice on damageability.

Figure 4. **The relative MDR of a single-family dwelling made out of wood at a wind speed bin of 115 to 120 mph three-second gust**

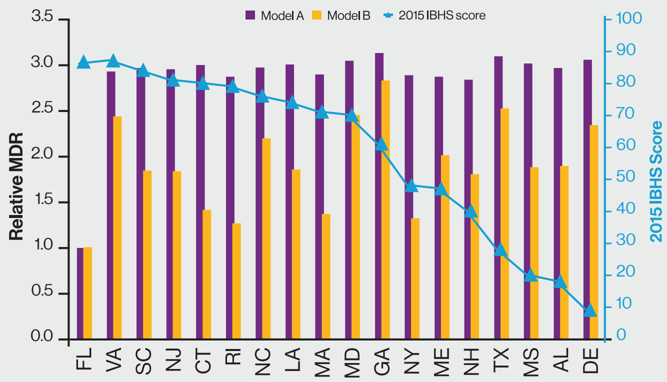
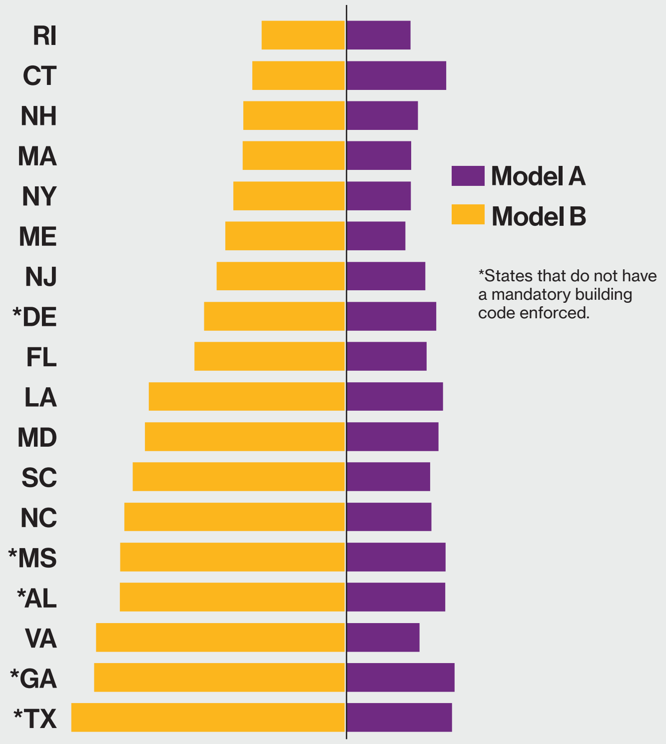



Figure 5. **Standard deviation of the MDR for each state**



## Contacts

**Partha Sarathi, Ph.D.**
Assistant Vice President
+1 212 915 8726
partha.sarathi@willistowerswatson.com

**Prasad Gunturi**
Executive Vice President
+1 952 841 6638
prasad.gunturi@willistowerswatson.com



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