August 27-31, 2023
FLORENCE - ITALY
16th International Conference on Wind Engineering

Dynamic Roof Age Considerations in Catastrophe Modelling

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SUMMARY:
As asphalt shingle roofs age, the shingles become more brittle. When exposed to high winds, these more brittle shingles are more easily damaged by high winds, and when damaged, are more likely to require a full roof replacement. While catastrophe models commonly capture and account for the roof age at the time the location is first used in a catastrophe model, this might not be reflective of the roof age at the time of an event. This paper examines the effect of dynamically considering the age of a roof in a catastrophe model.

Keywords: Catastrophe Modelling, Roof Age, Hurricane Irma, Asphalt Shingles

1. DAMAGE TO OLDER SHINGLE ROOFS

It is well established that as asphalt shingles age, they become more brittle. This can be particularly true in high-UV exposed areas, such as Florida, where hurricanes are more common. Post-event investigations, claims analysis and discussions with loss adjusters have all confirmed that as shingle roofs surpass approximately 5 years of age, the probability of even minor damage leading to a full roof replacement becomes increasingly likely.

When older, more brittle shingles are damaged by high winds, it is more likely to trigger a full roof replacement, even if only very few shingles are damaged, and the 25% roof replacement rule in the Florida Building Code would otherwise not expect to be triggered. In the case of only a few shingles being damaged, the brittle nature of the old shingles makes it more likely that, while attempting to replace the damaged shingle, the surrounding ones are damaged when lifted to insert the replacement one. This effect can quickly cascade into a large area of the roof being damaged and requiring replacement. As well, some types of older shingles may have degraded or changed colour due to prolonged UV exposure. This could trigger a full replacement of the roof to ensure that the colour of the roof remains uniform.

2. HURRICANE IRMA ROOF REPLACEMENTS

Claims data from the 2004-2005 storm season is extensively used in catastrophe model calibration, as well as part of regulatory submissions and model evaluations. In 2017, many models undershot Hurricane Irma losses. Many factors affected this, including litigation and assignment of benefits – as discussed in Stedman et al. (2022, ACWE conference). Another factor which may have affected the overall losses in hurricane Irma was the overall roof age for the affected building stock.

The 2004-2005 hurricane season did extensive damage to much of Florida, and a lot of roofs were replaced after these events. Between 2005 and 2017, there were some minor events, as well as convective storm events, but no major hurricane events. Thus, the overall average roof age increased significantly. Given the more than 10-year gap, many of the roofs which were replaced after the 04-05 season would not have required replacement yet. The large swath of wind generated by Hurricane Irma affected many of these older roofs, causing damage and forcing replacements – further increased in quantity by AOB, the 25% roof replacement rule and other similar factors. This combination of overall older roofs and other factors likely increased the losses and number of roof replacements after Hurricane Irma.

Due to all of the roofs which were replaced after Hurricane Irma, as well as changes to the 25% roof replacement rule as specified in the recent Florida senate bills (Senate Bill 4-D passed in May 2022) reduce the likelihood of such a "mass replacement" event in the near-future. As Hurricane Ian recently had a major impact on Florida, it will be seen if these legislation changes, and theoretically younger overall roof age of the building stock have a tangible difference on losses. Though, it should be notable that many different factors, such as economic inflation, will also play a large role in the losses from Hurricane Ian.

3. SIMULATION OF ROOF AGES

A simulation was developed to estimate the percentage of roofs by age in Florida during any given year. This was built using publicly available roof permit data for several counties. In order to accurately construct a simulation, several different factors had to be derived.

During any given year where there is not a major hurricane, many roofs will still be replaced. Using permit data, crossed with census data on the number of housing units, a base replacement rate was defined, which defines the probability of a random roof getting replaced in a given year. This can be dynamically adjusted to account for macro-scale economic changes, but for most tests in this case was left as constant.

However, not all roofs in a given year will have the same age, and it is more likely that older roofs will be replaced than younger roofs. In the simulation, a factor is assigned to each roof being simulated, which increases or decreases the overall probability that roof is replaced in a given year. This function is based on a defined median roof age (variable), and a functional shape (linear or sinusoidal), as shown in Figure 1. After the factor is applied to all roofs, it is normalized with the base replacement probability to ensure the correct overall number of roofs are replaced every year, while still adhering to the age distribution.

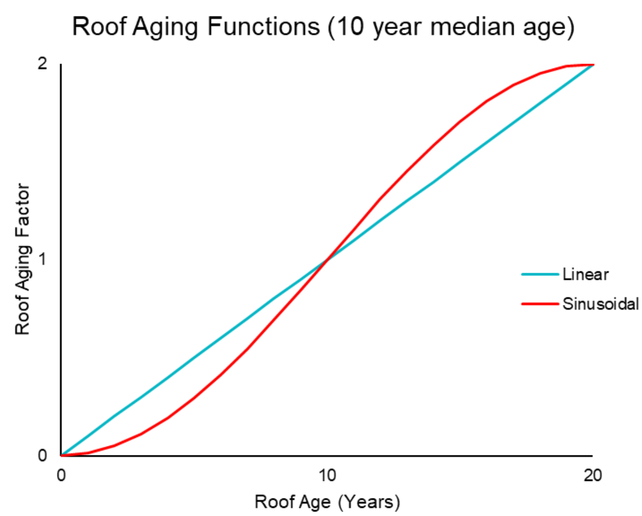

Figure 1 – Roof aging factor for increasing or decreasing probability of replacement

The simulation accounted for years with significant roof-replacement events. In these years: 1992, 2005, 2017 and 2018, an additional percentage of all roofs were considered to be added, based on available permit data and number of housing units present at the time of the event. For example, 10% of all roofs are assumed to have been replaced in 2017 after Hurricane Irma. The overall percentage of roofs replaced at each key event year were based on roof permit data analysis.

While significant uncertainty in the simulated roof ages exists, a validation study was performed to compare the simulated roof age distribution against the available permit data. Due to uncertainty in results, the results were divided into 5-year bins. As Shown in Figure 2, the overall percentage of new roofs simulated lies below Collier County, but slightly higher than other counties with available data. Considering where Irma had the largest impacts and expected overall building quality being better in Monroe, it is reasonable that Collier County has a very high number of recently replaced roofs.

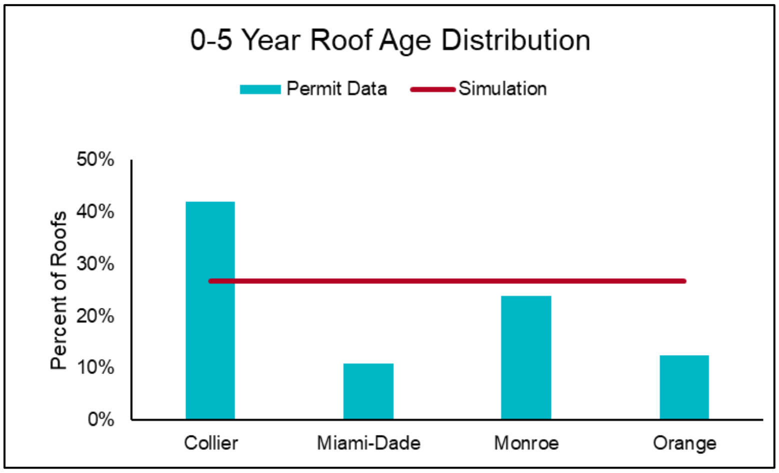

Figure 2 – Simulated percentage of 0-5 year old roofs by county

4. ROOF AGE IN CATASTROPHE MODELS

Catastrophe models generally consider roof age as a parameter affecting losses. However, for a given dataset, that information is often considered static, or "as of" the vintage of the dataset in question. That is, a dataset of homes from 2004 being run through Hurricane Irma for loss calibration would consider the roof ages in the data as of 2004. This would not provide an accurate reflection of the data when running in 2017 for Irma. Figure 3 shows how the percentage of roofs expected to be in each age band given the year is 2004 and then given the year is 2017. This much higher percentage of older roofs in Irma would increase the number of expected roof replacements and loss.

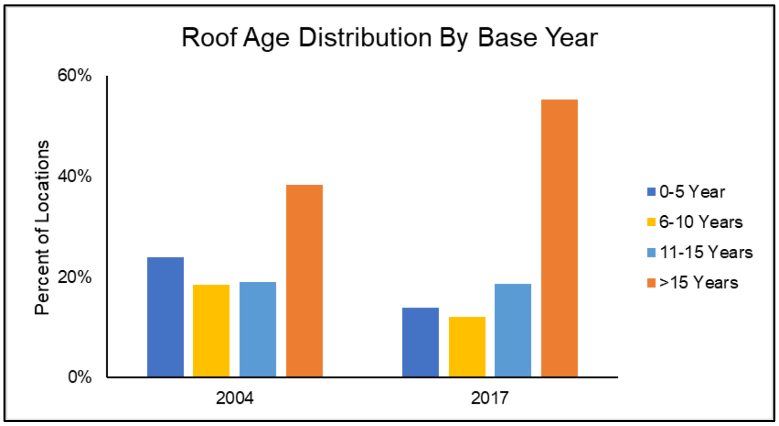

Figure 3 - Simulated Roof age distribution in 2004 and 2017

Instead of considering the roof age as a static value, or as a specific year then using a "banded" approach to calculating the expected roof damage, a catastrophe model should consider the roof age dynamically. When a historical event is being analysed, the model should consider the current age of the roof and adjust the vulnerability of the structure accordingly. This would also provide a better realization of potential losses for the “if Andrew happened today” type scenarios. While, particularly at lower wind speeds, roof damage usually governs hurricane losses, the building code used in construction of the roof and rest of the structure still plays a large role in overall structure damage. Thus, a more appropriate way to dynamically consider roof age and structure vintage in a catastrophe model is to blend the roof age with the structure age/vintage to generate an effective year built for the whole structure.

5. CONCLUSION

Many different factors drove the high losses caused by Hurricane Irma. This paper explored one such aspect, the overall age of roofs in Florida at the time of the event. Due to a somewhat longer drought of major hurricane impacts in the years leading up to Irma, many roofs had aged, increasing the loss from the event. This became especially true when combined with the now amended 25% roof replacement rule in the Florida Building Code. Simulating the distribution of roof ages throughout the state confirmed the overall older vintage of roofs at the time of Hurricane Irma. In the realm of catastrophe modelling, a proposed dynamic roof age methodology was proposed to capture the roof age as well as the building code/overall vintage of the structure.

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