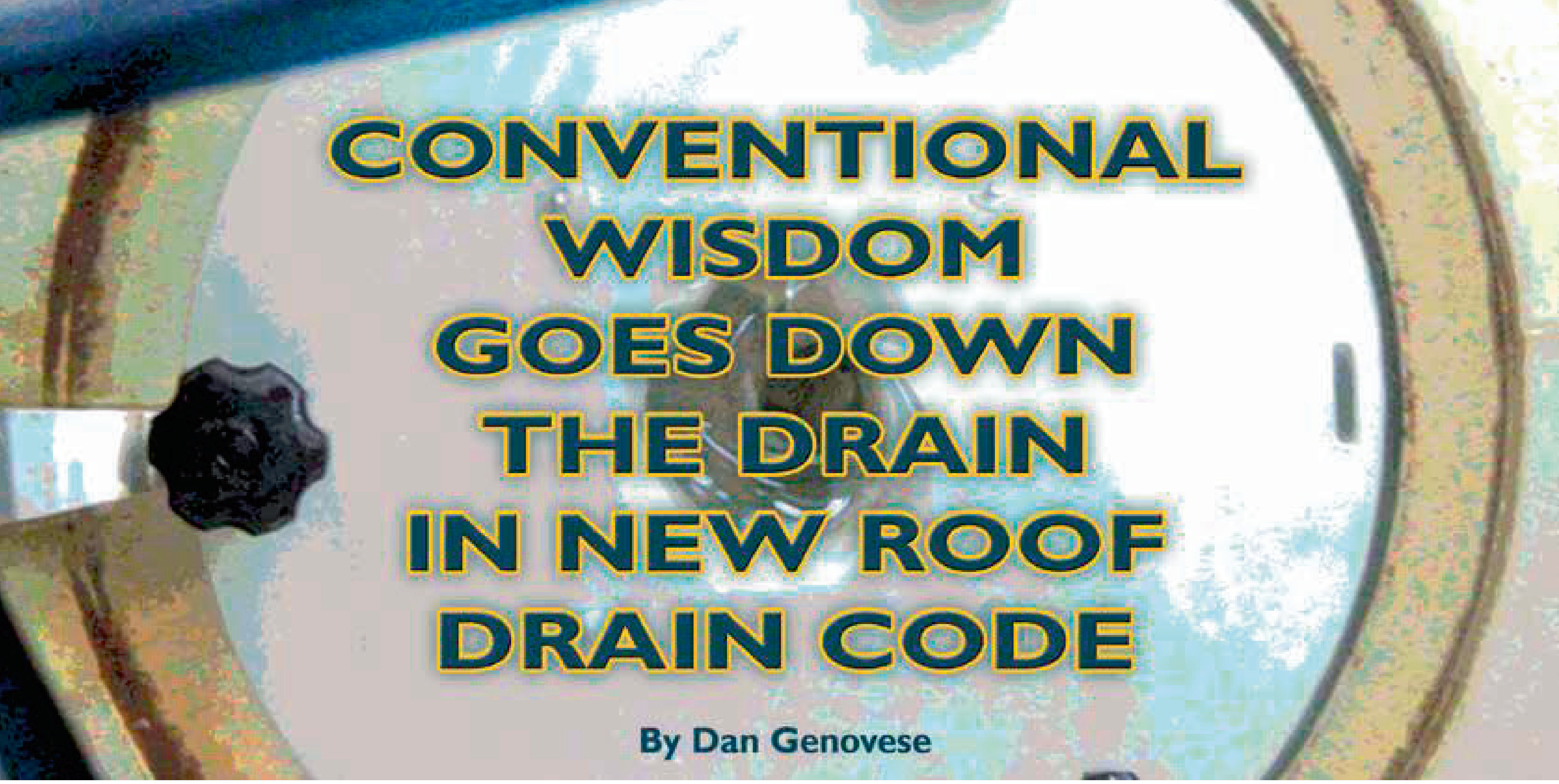

CONVENTIONAL WISDOM GOES DOWN THE DRAIN IN NEW ROOF DRAIN CODE

By Dan Genovese

The frequency of torrential rains in much of the United States has increased dramatically since 1958, according to the U.S. National Climate Assessment's "Climate Change Impacts in the United States." The report, which was published in May 2014, states that the proportion of precipitation that is falling in very heavy rain events has jumped by 71% in the Northeast, 37% in the Midwest, and 27% in the South (*Figure 1*).

The impact of all this heavy rainfall on roofs can be and has been catastrophic, especially when roof drainage systems fail. "We've been seeing more roof drainage failures, some of which have led to piping systems blowing apart or even to total roof collapses," said Julius Ballanco, PE, CPD, FASPE, president of J.B. Engineering & Code Consulting of Munster, Indiana, and a former American Society of Plumbing Engineers (ASPE) president. "In fact, I have recently been involved in investigating 20 roof failures. This is unusual, because in the past, no one was focused on roof drain performance."

Due to the noticeable increase in roof drainage failures, ASPE's Research Foundation decided to perform storm drainage testing. With $160,000 in funding, ASPE conducted a two-year study from 2010 to 2012 (*Figure 2*). Some of the preliminary testing was designed to evaluate drains 10 to 11 inches in diameter, but the committee later decided to focus on drains with 6-in. or smaller diameters since that was the American Society of Mechanical Engineers (ASME) standard and since these sizes represent the majority of the roof drain market. In total, 60 roof drains from 2 to 6 inches in diameter were tested and evaluated.

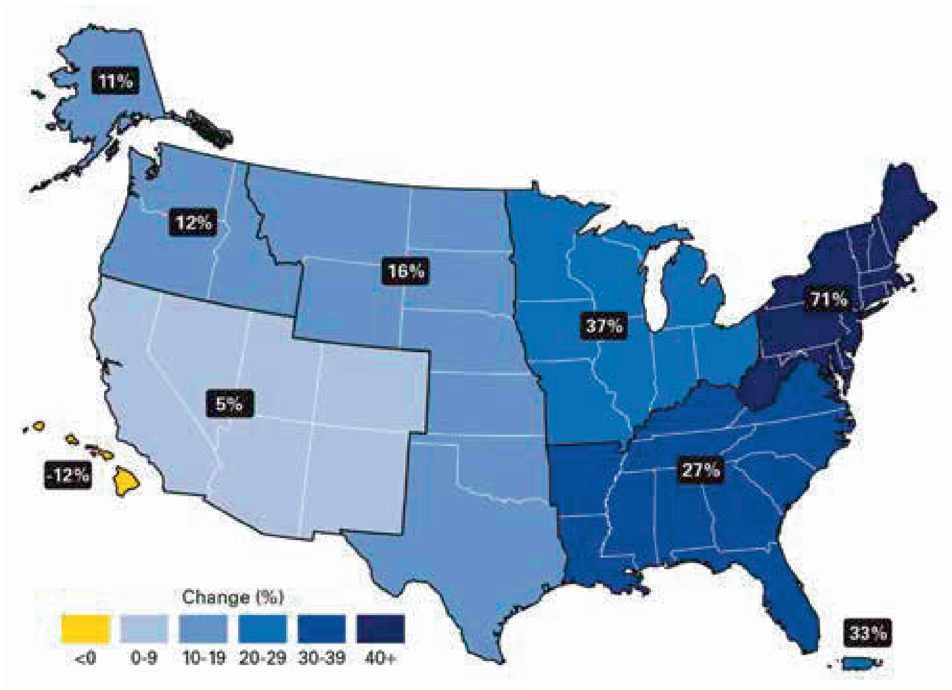

Figure 1 – Map shows percentage increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2012 for each region of the continental U.S., resulting in an increased number of microburst rainstorms with a significant amount of rain in a short period of time. Source: U.S. National Climate Assessment's "Climate Change Impacts in the United States," published in 2014.

ASPE RESULTS EYE-OPENING

The drains were each tested with three different piping configurations:

- As an open hole without any piping – basically just a hole in the test "roof" assembly

- With a straight vertical section of pipe directed into the reservoir
- With offset piping, including both vertical and horizontal pipes that ended with a vertical pipe leading to the reservoir

From the outset, it was expected that the "open-hole" configuration would allow the greatest volume of water flow; but, in fact, the opposite was found to be true. The "open-hole" drain configurations actually had the lowest flow rates, and the drains with straight vertical piping had the highest flow rates. In fact, some of the tested drains with straight vertical piping had flow rates that were up to 4.5 greater than the flow rates of the same drains without any piping.

Another surprising result was how quickly the actual water flow rate exceeded the capacity of the existing plumbing system. One inch of ponding water above a 2- or 3-in. drain easily exceeded the flow capacity of the plumbing system. Two inches of ponding water above a 4-in. drain created the same problem, as did 3 in. of ponding water above a 6-in. drain.

The conclusion that is drawn from this research is that many roof drains on the market today allow too much water into the roof drainage plumbing system too quickly.

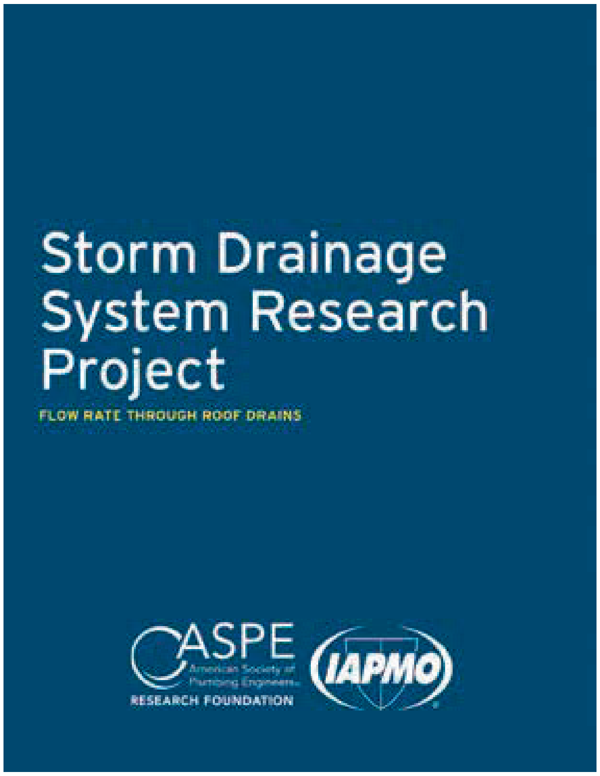

Figure 2 – To view the complete report on the eye-opening testing performed by the American Society of Plumbing Engineers' Research Foundation, go to https://aspe.org/sites/default/files/webfm/pdfs/rf_report_roof_drain.pdf.

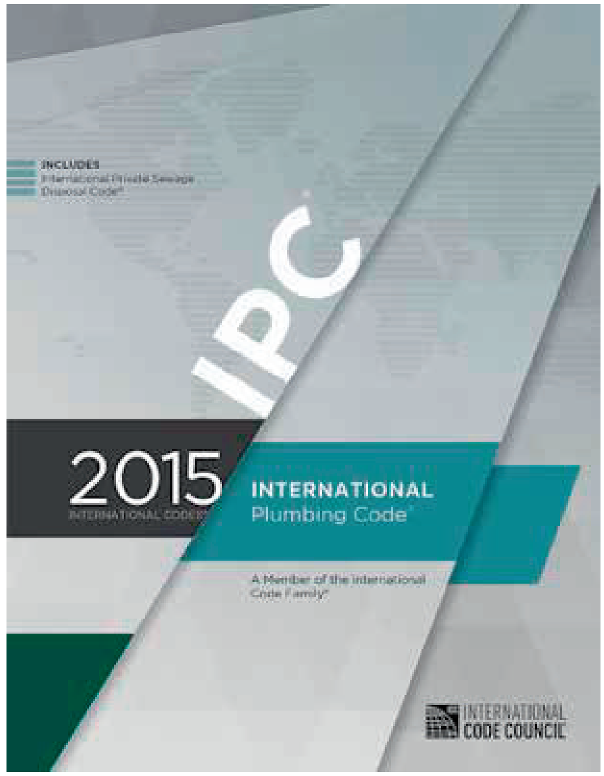

Figure 3 – As referenced in the 2015 International Plumbing Code, Section 1106.2, Size of Storm Drain Piping: Vertical and horizontal storm drain piping shall be sized based on the flow rate through the roof drain. The flow rate in storm drain piping shall not exceed that specified in Table 1106.2.

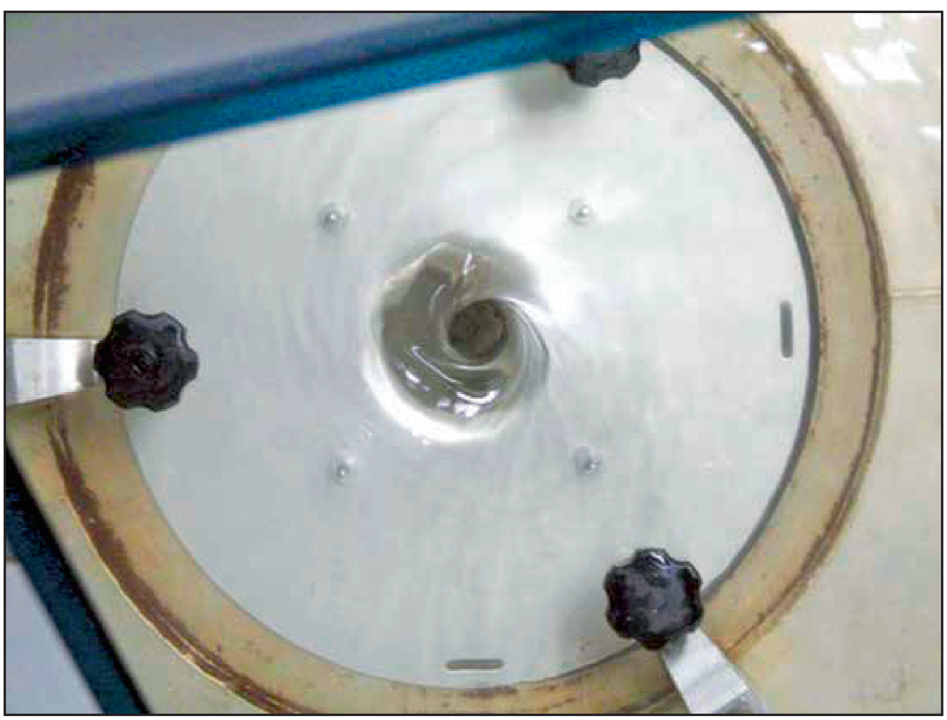

Figure 4 – This image of a roof drain within a drain flow test rig clearly shows the vortex fully formed, which can significantly slow the speed of water flowing through a drain fixture.

Perhaps even more eye-opening is the fact that the flow rate of different drains varied considerably, even among drains of the same size. In some instances, for example, the flow rate for one manufacturer's 4-in. drain provides three or more times the flow rate of another manufacturer's 4-in. drain with the same amount of ponding water. The results of the study highlight the major pitfall of current roof drain standards. Simply stated, these codeapproved standards do not have a requirement for flow rate performance testing and reporting.

The results of the ASPE testing are startling, to say the least. "All the drains were flowing considerably more water than we expected when there were excessive amounts of water on the roof. This can easily lead to situations where you have pressurized flow, plumbing system ruptures, and broken pipes, which was a shock," Ballanco remarked. "The other shocker was that there was no consistency in the actual flow rates of the various roof drains. While they all complied with the existing plumbing standards, the flow rates varied greatly, even though the drains were the same size."

WHAT'S GOING ON?

According to the ASPE Research Foundation's engineering analysis of the study, several of the basic assumptions were proven false. First, the sizing method in the plumbing code relies on consistentwater flow through the roof drains. The assumption is that as water reaches the roof drain, it will proceed down the drainpipe at a consistent rate. What happens, in reality, is that as water proceeds down the drain, it frequently forms a vortex by traveling around the inside of the pipe rather than straight down the pipe. This actually slows the flow rate, allowing water to back up or pond on the roof until the vortex collapses, resulting in a gush of water that completely fills the drainpipe and can pressurize the system.

Another hypothesis of the study was that roof drains will not overload the maximum capacity of the drainpipe. However, it was discovered that unless the water flow rate is controlled, the actual rate is based on the head height of the ponding above the drain. The ponding is determined by the slope of the roof, the position of the roof drain, and the amount of rainfall.

THE IMPORTANCE OF FLOW RATES

As a result of this study, the International Plumbing Code (IPC) in 2015 (*Figure 3*) will require that manufacturers publish flow rates for roof drains.

"I know many drain manufacturers see this as a burden, but I know of one company that has known and been very forthcoming with this information for years, so we know it can be done," Ballanco explained.

Why is flow rate so important? If the flow rate is too low, more water remains on the roof, adding five pounds per square foot per inch to the weight of the roof and potentially overtaxing the building's structural live-load capacity. If the flow rate is too high, then too much water can enter the building's plumbing system, pressurizing the flow, which acts as a massive weight and can result in bursting pipes.

"We now know that some drains actually worked too well, allowing too much water into the plumbing system too fast and overloading the piping system," Ballanco said. "It is clear from the study that the industry needs more control in the roof drain."

One new drain with which Ballanco has been very impressed is one that features a vortex breaker at the top of the drain to control the flow rate. To explain, as water approaches the roof drain, a vortex forms (*Figure 4*), which slows down the flow into the piping system. This causes the head height of water to increase as water is waiting to drain (*Figures 5* and*6*). As the head height reaches a certain level, the centrifugal force of the approaching water overcomes the vortex, causing it to collapse. When the vortex collapses, a short duration of full-bore or pressurized flow happens. This causes the head height to drop and will cycle in this manner until the flow rate to the drain slows down. The three fins on the vortex breaker prevent the water from forming a vortex as it goes down the drain, allowing the water to go straight down with the force of gravity and avoiding a pressurized flow. "It's a very clever design," Ballanco remarked.

In addition to its unique design, one benefit of this drain is the simplicity of installation. "It eliminates the need for a plumber to repipe the system and allows the roofing contractor to simply secure it in place from the rooftop," said Ballanco.

ADDRESSING THE PROBLEM

As a result of its testing, ASPE recommends that a new method be used for sizing storm drainage systems. This method "must be based on the capacity of the roof drain, the maximum amount of ponding under various storm conditions at the roof drain, and the maximum capacity of the piping system," the ASPE report states. (See *Figure 7*.)

Once the engineering and roof ing communities know what the flow rate is for the drains and how to properly size the roof drainage system, the installer has three options for bringing existing drainage systems up to code:

2015 IPC Table 1106.2

Storm Drain Pipe Sizing

Pipe Size (in.)	Capacity (Gallons Per Minute)
	Vertical Drain
2	34
3	87
4	180
5	311
6	538

Figure 7 – The values in this table were taken from the 2015 IPC.

Figure 5 – This image of a roof drain within a drain flow test rig depicts the potential danger of the flow delayed by a vortex when subjected to the maximum flow capacity of the storm drain piping. The head height of water continued to grow, and the test was stopped.

Figure 6 – A patented roof drain featuring a vortex breaker within a drain flow test rig breaks the vortex and flows to the maximum capacity of the storm drain piping while maintaining a consistent head of water. A video of the test can be seen at www.omgroofing.com/roof-drains-and-vents/RedLine-AFR.html.

- **Rework the drains.** The roofer could rework the drain to meet code, which may include cleaning up the drain, replacing broken bolts, and repainting the drain. A flow restrictor may be required, or additional drains may have to be installed to reduce the amount of water through each drain, thus reducing the amount of water through the existing pipelines. A structural engineering analysis may also need to be conducted to confirm that the structure can hold any potential added water weight.
- **Replace the drains.** The existing drains could be replaced with new drains with the desired flow rate, which most likely would involve using a plumber to connect the drains to the existing plumbing. This option tends to be the most costly

and disruptive to the building's occupants, as access to the underside of the roof decking is required.

- **Use drains that meet the code and standard.** Drains with a mechanical watertight seal to help prevent leaks from backflow pressure (meeting ANSI/SPRI RD-1) can simply be inserted into the existing plumbing and hand-tightened in place. A mechanical, watertight seal creates a symmetrical, watertight connection and prevents over-tightening or under-tightening during installation. Typically, these include new clamping rings and strainer domes. Because of the nature of an insert drain, use of a vortex breaker aids in increasing flow performance in order to meet the flow rate code. Such drains can be installed in five or 10 minutes.

RETHINKING ROOF DRAINS

The conventional thinking about roof drains was to remove as much water as quickly as possible from the roof. Recent roof drainage failures and testing by the ASPE have shown that the real goal should be to get the water off as quickly as the existing plumbing system can handle without exceeding the live-load capacity of the roof structure and the maximum allowable flow rate of the piping system. This is going to be increasingly important as microbursts and heavy rainfalls put large amounts of rain on the roof in very short periods of time.

Drains that are easy to install, that can be used with existing drains, and that allow and control maximum allowable flow will be in demand, offering a viable and inexpensive solution to these newly discovered problems.

Dan Genovese

Dan Genovese, a product manager for OMG Roofing Products in Agawam, MA, oversees its OlyFlow® line of roof drains. Genovese has been with OMG for 28 years. He is a member of ASPE and the International Association of Plumbing and Mechanical Officials and worked alongside SPRI's Retrofit Drain Task Force to develop the first national standard for retrofit roof drains (ANSI/SPRI RD-1). He was responsible for launching the OMG Roofing Products Distant Learning and Webinar program, which awards RCI continuing education credits. Genovese also led the development of the OMG RedLine AFR™ Roof Drain.