TECHNICAL Queries+ Quandaries

By Chuck Muehlbauer, MIA Technical Director

Limestone Paving: Freeze/Thaw Resistant?

Q: We are quoting the supply of a limestone for exterior pavement in the Chicago area. The supplier of the material says it has been proven freeze/thaw resistant for 48 cycles. Is there anything that documents that this is sufficient for Chicago?

A: There isn't any table or other selection guide that would make this decision for you. Forty-eight cycles is a fairly common default for testing via the European EN -12371 method, although there are numerous different methodologies used to determine the number of cycles run in that test. From the data that I've seen on accelerated weathering of limestone, if significant degradation occurs, it is more likely to occur later, from about 50 to 125 cycles. It should be clarified that within the United States based ASTM system, we do not yet have a standardized procedure for accelerated weathering testing of dimension stone. The lack of a standardized procedure makes it really difficult to establish any formal guidelines as to how many cycles is significant, since any data we have comes from a variety of nonstandardized procedures.

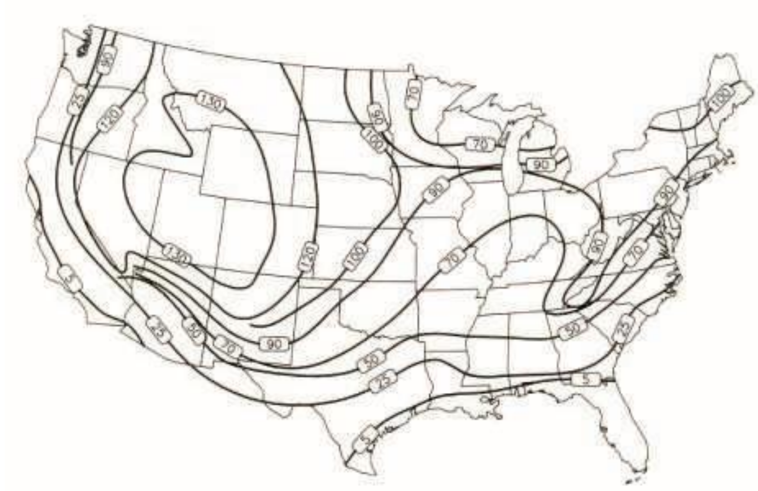
All freeze thaw cycles are, of course, not created equal. The most significant variable is the saturation level of the cycle. Saturated cycles cause far more damage than dryer ones. This is the primary reason that freeze/thaw cycling is a bigger factor in pavements than cladding, because it is far more likely that the pavements will freeze in a saturated state.

A second condition is how rapidly the temperature of the stone crosses the freezing mark. For these reasons, the correlation between accelerated laboratory cycles and Mother Nature's cycles will definitely not be one to one. The laboratory cycles are intended to be more aggressive, hence the term "accelerated." We have to remember that this is a "test," and like ALL laboratory tests, it will not be an exact replication of the in-service experience.

Unfortunately, there isn't really a suitable surrogate to properly measure and evaluate a stone's resistance to freeze/thaw cycling. A study in England some years back showed that as density decreased, so did weathering resistance, until a point where the decreasing density actually improved weathering resistance, because the greater porosity of the stone allowed it to more effectively evacuate the water prior to and during freezing. So even density and porosity, while very influential, are not reliable indicators of freeze/thaw resistance.

The development of a weathering test procedure has been a big political hurdle for several reasons. For one, the testing is expensive. It takes a lot of time, it requires some fairly costly equipment, and it consumes a significant amount of energy. The cost of it drives fear into some of the producers that the mere existence of a standardized test procedure would result in an expensive, time consuming procedure being specified to test stones that don't need it – those stones that already have well documented, exemplary weathering performance. There is also a marketing influence, in that without a test procedure, the only weathering performance measurement we have is to view existing applications. This is actually advantageous to some suppliers.

Suppliers of materials that have been used extensively over history do have the existing applications to cite, while the suppliers of newly opened quarries are disadvantaged because they do not. The third issue is fear that the post-test condition of the specimens may in some cases be unsightly, and this would simply make the materials look bad in front of architects and owners. I believe that all of these issues can and will be addressed some day and a standardized procedure will be published, but I make no predictions as to when that day will occur.



Approximate Annual Freeze Thaw Cycles in the United States

As to identifying the regions that experience high numbers of cycles, reference is made to the graphic below. That sketch shows the approximate number of annual cycles experienced within the United States. It is not exact due to the data smoothing required to draw the freeze/thaw "contour" lines, but it is a rough guide. The map illustrates a few interesting things about the numbers of cycles experienced in various portions of the country. The first thing you will notice is that altitude has as much, maybe more influence than does latitude.

One can clearly see both the Rocky and Appalachian Mountain ranges just by the increase in the number of cycles. The other interesting thing is that while we expect latitude to be an influence, there becomes a point where increased latitude results in a decrease in cycles. In the center portion of the country, we see ±90 annual cycles in the Chicago/Milwaukee region, but as we move further north, we see that Minneapolis only averages somewhere around 70 cycles. This is because Minneapolis has more days where the daytime high never gets above freezing, therefore there is no cycle on that day.

Attempting to relate the required number of test cycles to the climate of the intended application might not be all that relevant. Within the United States, there isn't really a major city that has never experienced a freeze/thaw cycle. Even Miami and Los Angeles have recorded record lows below freezing. But for practical considerations, along most of the southern border the frequency of freeze/thaw cycling is so slight that it can be ignored. But once you're out of this region, the number of annual cycles is only an indication of how many years it takes to reach a given number; so a 30 year old building in Dallas would likely have experienced a similar number of cycles as a 10 year old building in Chicago. It basically comes down to a question of "Do I have freeze/thaw or not?" As most stone applications are designed for extended service lives, the cumulative effect over many years in moderate climates can still be a significant number of cycles.

Certainly the more severe climate requires additional design and selection acumen, but one cannot ignore the effects of freeze/thaw just because the annual average is low in a given region. And the design of the installation method is as important, or even more important, than the stone selection.

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