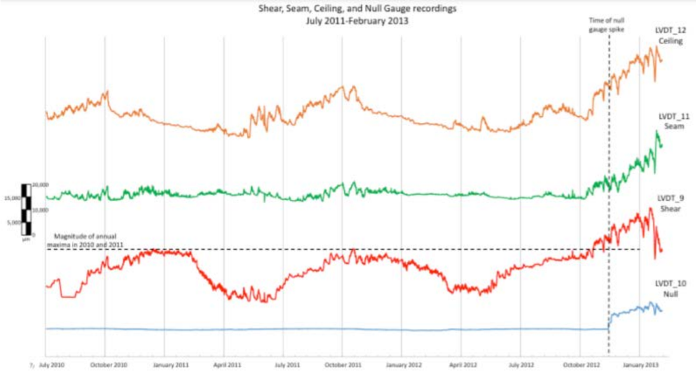
Newsletter #28

Importance of Yearly Cycles of Crack Response and An Extreme Weather or Occupant Induced Event that Caused a Cosmetic Crack



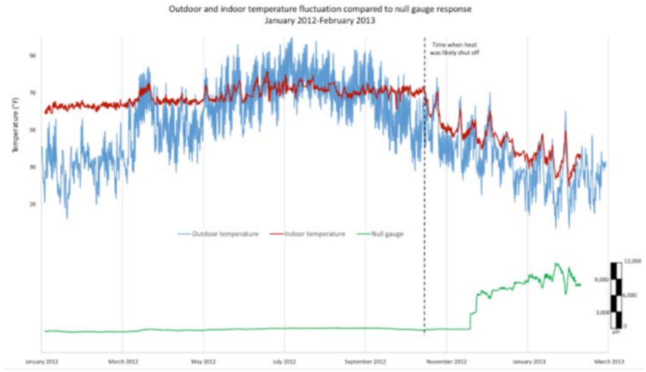


Figure 1 (left): Precise instant of the crack appearance is marked by a vertical dotted line. Previous cyclic maxima from 2010 and 2011 are marked by a horizontal dotted line. Figure 2: (right). Comparison of outdoor and indoor temperature fluctuation and null gauge response. The instant of interior heat deactivation is shown with a dotted line.

This newsletter demonstrates the importance of the single peak during a yearly cycle of crack response and the extremity of the additional change necessary to produce a crack. These two concepts, yearly maximum and extreme events, are key components to the understanding of the importance of long term, naturally occurring events and occupant induced events. It is the second in a series of four on the implications of occupant induced crack response. The summarized study (Dowding, et al, 2015) comprises one of the longest known periods of continuous monitoring of crack response in a test house. As shown in Figure 1, it includes two previous seasonal large crack responses during the fall and winter seasons of 2010 and 2011 as well as 2012 during which the time the owner induced extreme event produced a cosmetic crack.

Crack responses were measured in a two-story wood-framed structure with gypsum drywall interior walls on top of a basement foundation. It was located approximately 300 feet (91 m) south of edge of a limestone quarry. The four micrometer crack displacement sensors, the focus of this summary, are part of a family of more than 15 sensors. Three of the four micrometer displacement sensors were located on the south facing exterior wall of the first floor, while the fourth was placed across a crack in the ceiling of one of the upstairs bedrooms. Of the three sensors on the first floor, one was placed across a crack in the seam between an addition and the original structure, another across a shear crack in the original wall and the fourth across un-cracked drywall to serve as a null gage.

Comparison of interior and exterior temperature data in Figure 2 show that deactivation of the heating system in October of 2012 cooled the interior to the outdoor temperature. The heating system was deactivated to make way for demolition of the house to allow for the quarry's expansion. The resulting dramatic cooling produced the significant increases in crack width (response) shown in Figure 1 and lead to the crack through the null gage gap. Blasting could not have contributed to this cracking, because blasting had ceased two months earlier on 24 September.

Figure 1 compares the response of the null gauge (bottom time history) – where the crack shown in Figure 3 appeared -- with long-term response of shear, seam, and ceiling cracks, respectively (top three time histories). Between July 2010 and January 2013 there are three annual cycles of crack response with a single maximum peak. This cyclic pattern is especially pronounced in the shear crack, which is nearest to the new crack on the instrumented wall. After October of 2012, there is a large aberration from the previous cyclic responses of all three cracks. The null gauge begins to respond when the crack is formed through the null gauge gap. Responses of the shear, seam and ceiling cracks exceed those recorded over the previous two years around the same time that the crack occurred through the null gauge gap. This time can be seen near the intersection of the dotted lines in Figure 1. Exceedance of yearly maximum response of the shear, seam and ceiling cracks was not small as shown by comparison with the past annual peaks (indicated by the horizontal line). The crack did not appear until the shear crack response was more than 20 to 40% greater than the maxim yearly response. Blast induced peak particle velocities of 0.2 to 0.7 ips at this house produced shear crack responses of 190 to 700 µin compared to 13,000 µin. for a peak yearly response or 1.5 to 5.4% of the daily crack response (Abeel, 2012)

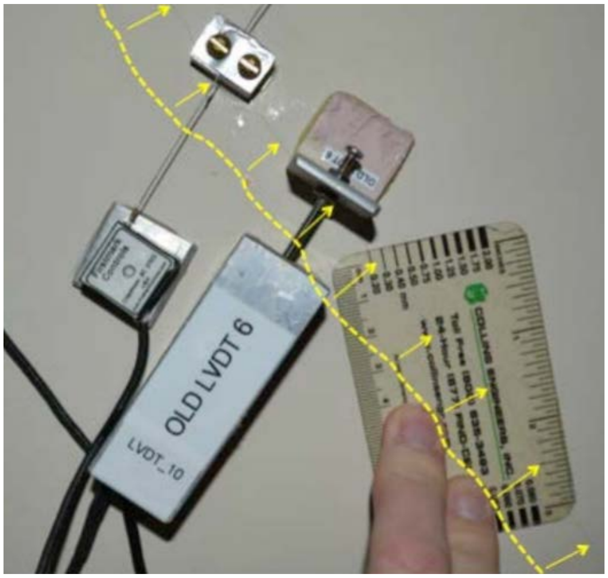


Figure 3: Null gauge with arrows pointing to the visible crack and an offset dotted line indicating the crack contour. The crack gauge shows an approximate crack width of 0.20 mm.

This case history shows that for an external dynamic event to cause a cosmetic crack, the wall or a crack would have to be precariously on the brink of cracking or extension at the same instant this dynamic event occurs. For this brink to occur, the wall/crack would have to be subjected simultaneously to the same sign peaks of the 1) largest daily temperature response, 2) largest weather front response, 3) largest yearly, seasonal response, and finally 4) historical extreme event. Even then a 5) sufficiently intense (high) dynamic event would be required to produce a crack or an extension.

As shown in Figure 1 conditions 1, 2, 3 necessary to produce the condition of maximum precariousness only exist once a year for any wall or crack. By implication conditions 1, 2, 3, and 4 would exist only rarely on the order of once in several decades. In this summarized case it was the deactivation of home heating system that produced the addition of condition 4. As will be shown in Newsletter # 29, the time history of the single peak of the maximum, yearly, long term crack response is a critical component of the process of comparing the importance of occupant induced dynamic events.

References

Abeel, P. (2012) Building and Crack Response to Blasting, Construction Vibrations and Weather Effects. M.S.Thesis, Department of Civil and Environmental Engineering, Northwestern University, Evanston, IL. Also available at http://www.civil.northwestern.edu/people/dowding/acm/publications/dowding/Abeel-thesis2012.pdf. as of Jan. 2022.

Dowding, C.H., Lueker, J., and Abeel, P. (2015) Instrumental Detection of a Climatologically-Induced Cosmetic Crack in Wall Covering, Proceedings of 41st Conference on Explosives and Blasting Technique, International Society of Explosives Engineers, Cleveland, OH, February.