Response

The Hazard From Earthquakes in the Boston Area by P.J. Barosh, Vol. 4, No. 1, Spring 1989, pp. 65-78

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The discussion by William Weiler (on pages 82-84 in this issue) centers on the differences between "The Hazard From Earthquakes in the Boston Area" with reports prepared for the Massachusetts Civil Defense Agency (MCDA). First, the original article is a short summary of the latest information on the earthquake hazard in Boston. It represents an abbreviated version of a much longer work entitled, "Geology of the City of Boston, Massachusetts," that is currently in press with the *Bulletin of the Association of Engineering Geologists*. The articles on pages 33-117 of the Spring 1989 issue of *Civil Engineering Practice* were selected from and were based on this larger work as is noted in the acknowledgements on page 118 of that issue. In the editing process, several of the points about the MCDA reports and additional references were omitted. Second, the MCDA reports that Weiler cites as differing from the published article are 'quick and dirty' compilations that were prepared solely for the in-house use of a government agency; they are not for publication and have not been reviewed. These MCDA reports are not the product of a rigorous scientific investigation, 'significant' or otherwise.

The MCDA reports had very limited goals that they successfully met. The Federal Emergency Management Administration (FEMA) and the MCDA wanted to know whether or not eastern Massachusetts had a significant earthquake hazard and, if so, what would be the kind of damage that could be expected. In Phase 1 of this study the review panel evaluated the general hazard.[1] This 'significant study' consisted of an unfunded brief review conducted over the course of two or three meet-

ings. The review panel, of which I was a member, concluded that there is a hazard for earthquakes in eastern Massachusetts. The attendant report included errors; however, these errors did not affect the report's conclusion. Phase 2 of the study was to evaluate the geology of eastern Massachusetts in order to determine what kind of intensities that could be expected across the region from an intensity VIII earthquake centered off of Cape Ann, the effects of which decreased at a given attenuation rate.[2] Simplified data on the surficial geology was compiled and assigned to standard 'soil' columns in the document.[3] These columns have different values in causing the intensity to increase and these values were used to arrive at variations in the expected local intensity. This study was successful in that it met the requirements of the sponsoring agencies, FEMA and MCDA. However, given the scope of the coverage, limited time and funds, and the uncertainty in assigning the ATC 3-06 values, the results are necessarily 'quick and dirty.' Indeed, the maps are imprinted with the caveat '— for emergency planning purposes only.' The compilation also contains an error in methodology that is discussed below. Phase 3 of the study consisted of an estimate of the building damage based on the conclusions drawn from Phases 1 and 2. Since the previous parts of the study were limited, the results yielded can only represent a general 'ballpark' figure. Nevertheless, its results should satisfy the needs of the FEMA and MCDA. The MCDA reports had very limited goals that they fulfilled, and the participants can feel proud of their accomplishment, but the reports are in-house working papers that should not be published in their current form, nor should they be given too much consideration.

The significant investigations into the earthquake hazard of the region consist of those studies undertaken for nuclear power plant sites by consultants for the utility companies, for dam sites by the Army Corps of Engineers, and for the entire region by the New England Seismotectonic Study. The New England Seismotectonic Study was a ten-year investigation sponsored by the U.S. Nuclear Regulatory Commission and the Army Corps of Engineers. It involved about 30 researchers a year from 20 universities and a few state geological surveys. This pool of data was the primary source of information for my paper.

Weiler questions that the relatively more seismically active areas in the Northeast United States are well defined. For nearly 400 years earthquakes have been occurring in relatively local areas as shown by both historical and instrumental data.[4] This recognition of the 'permanence' of these areas is implicit in the MCDA reports and is the most important element in them. Without accepting this, none of the MCDA reports would have any value. Both the New Brunswick and Quebec earthquakes cited by Weiler are associated with known active areas and his statement is puzzling. The Quebec earthquake is interesting in that it is unusually large for one on the fringe of the La Malbaie seismic area. The activity within individual areas varies from time to time, but the locations of this activity have not.

Earthquake-prone areas along the East Coast are geographically related to subsidence. They are apparently related to fault movement that causes both the earthquakes and the subsidence.[5] Weiler questions this relation by citing the earthquakes in central Quebec and in central New Brunswick. But these areas are obviously not along the coast. These inland earthquakes are controlled by other vertical movements that are not germane to a discussion of the geology of Boston.

Weiler also questions the use of a magnitude of other than 6.25 for the maximum credible earthquake. The maximum credible earthquake of an active area can be estimated by the past large earthquakes, the rate of historic activity and its tectonic setting. When this evaluation is performed and the values are reconciled, the area can be compared with other active areas in the region for a further check. These results are generally consistent. Such studies give the Cape Ann area an epicentral intensity of IX;[6,7] an intensity of VIII is clearly too low. The magnitude for older earthquakes must be estimated from the intensity. The magnitude-to-intensity relationship is very poorly known for the northeastern United States, but a magnitude of 6.25 for the Cape Ann Earthquake is too low. The earthquakes cited by

Weiler are a case in point, especially that of central New Brunswick. The 5.8 magnitude earthquake mentioned did not even knock small bottles off a shelf in a cabin near the epicenter and had very minor effects in nearby towns. The maximum intensity known in the epicentral region is V.[8] If this earthquake were used as a standard, then Cape Ann would need to be assigned a magnitude around 7.5.

Weiler misses the point about my comment on the intensity increases due to local geology in the MCDA report. The attenuation rate given for this study is the average intensity decrease with distance (incidentally, the rate is only approximate since energy does not radiate out uniformly from an epicenter, but has an azimuthal variation that is controlled by the geologic structure). When dealing with an average rate, bad ground conditions cause an increase in intensity; whereas good ground conditions cause a decrease in intensity.[9] In the MCDA report Weiler uses a system that only makes increases. Thus, bedrock (which is usually considered one intensity unit less than the average) is shown as the average. In such a case, an attenuation rate based on the minimum intensity values should be used, not the average intensity values.

Weiler's comments point out a major problem in earthquake engineering whereby the basic earthquake parameters can be casually arrived at, or, in the case of some probabilistic studies, even assumed and then sanctified into 'facts' that cannot be tampered with. This process is too common in drawing up building codes. The public, then, may suffer from either unsafe buildings or needlessly expensive ones. The MCDA reports are fine for what they were meant to do, but should not be forced to mean more than they do.

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