# Impact Analysis of Seismic Source Area Extent on Hazard Estimate for Chennai City

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## ABSTRACT

*The present work is intended to study the effect of variation of seismic area source zone on hazard value for Chennai, India. In the conventional Cornell-McGuire approach to probabilistic seismic hazard analysis, the seismic activity rate for an area source is most often determined using the Gutenberg-Richter (G-R) recurrence law. The seismic area is delineated using geology, geography and/or seismotectonic characteristics of the region. However if the area lies in a distributed seismicity region, the delineation into different area zones introduces subjectivity. The impact of the areal extent of seismic area zone on the final hazard value is studied using two approaches - the conventional Cornell-McGuire and zone-free approaches. It is observed that in the conventional Cornell-McGuire approach, the peak ground acceleration decreases when the area source zone is increased while maintaining all other seismicity parameters same. In the kernel method, the PGA remained unchanged though the seismic source area is increased. This is due to the fact that in the kernel method, the seismic activity rate is a spatially varying parameter unlike the seismic activity rate determined from the G-R recurrence law, which assumes a homogeneous distribution of the activity rate for each of the area source zones. The uniform hazard spectra are obtained for various return periods by both the approaches. It is observed that in the Cornell-McGuire approach, the variation in the extent of seismic source area has little effect on longer return periods as compared to the smaller return periods.*

*Keywords:* *G-R Recurrence Law, Hazard Value, Seismic Area, Seismotectonic, Source Zone*

## 1. INTRODUCTION

Mathematical expressions and experimental results have always come to aid in removing human subjectivity that creep into any system to make it more objective. One such example is the subjectivity involved in delineating the seismic area source zone in seismic hazard analysis (SHA). Identification and characterization of the seismic source is the very first step in SHA no matter whether the methodology adopted is deterministic or probabilistic. Such seismic sources are in the form of point, line or area. In case of area source zoning, the knowledge of the geography, geology and/or seismotectonic characteristics are considered

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in forming the zones (Reiter, 1991; Kramer, 1996). However, it would be tedious if the area falls in the region of intraplate and/or distributed seismic regions. This is due to the fact that the intraplate seismicity is very complex unlike the interplate seismicity and the correlation between earthquakes and the geological features is absent. An ideal seismic area source zone needs to satisfy the condition that the seismicity defined by the Gutenberg-Richter (G-R) recurrence law is uniform. This condition is rarely satisfied in the case of regions having distributed seismicity. A few other problems related to seismic area zoning are compiled by many researchers (Allen et al., 1965; Bender, 1986; Woo, 1996; Beauval & Scotti, 2003; Beauval et al., 2006a; Li et al., 2009). It is a common practice to use a logic tree to reduce the effect of subjectivity while retaining the conventional Cornell-McGuire approach to hazard estimation (e.g., Lai et al., 2009). In this method, all possible area source zoning options/patterns are considered by giving appropriate weight to each of them and the usual seismic hazard steps are carried out for the combination of the models with each terminal branch. Finally, the results of each analysis are weighted by the relative likelihood of its combination of branches, with the final result taken as the sum of the weighted individual results. However, this does not address the fundamental validity of the zonation procedure itself (Woo, 1996). The other alternative to this approach is to do away with the area source zone itself. Many such methods can be found in the works of Frankel (1995), Woo (1996), Stock and Smith (2002), Lapajne et al. (2003), Zolfaghari (2009) and Li et al. (2009) to name a few.

The impact of variation of delineating the area source zone on hazard estimates may be attributed to two reasons - the choice of the zonation pattern and/or the areal extent. The G-R recurrence law is affected by the zonation pattern followed for delineation whereas it remains unaffected by the areal extent, however both affect the final hazard value. Such variation is very common for large areas as well as for small areas. Figures 1 and 2 show the seismic zonation adopted by the earlier studies (Gupta, 2006; Seeber et al., 1999; Jaiswal & Sinha, 2007) for Peninsular India (PI). It can be observed that though the PI is a vast region, due to its distributed seismicity characteristics (in most areas), except for Narmada seismicity regions (Zone 66 in Figure 1 and Zone 3 in Figure 2), the zonation in terms of pattern and areal extent for other parts of PI do not match. Figure 3 and Figure 4 show the zonation patterns and the areal extent adopted to carry out area specific hazard estimate for Kanchipuram region located 76 km south of Chennai city. A variation in the uniform hazard spectral (UHS) values was observed among the two zonation patterns followed, but has been suppressed by using logic tree. The percentage difference observed in peak spectral values is 0.2 to 20% between the zonation pattern depicted in Figure 3 and Figure 4 for Raghu Kanth and Iyengar (2007) attenuation relationship considering the Visual Cumulative (Tinti & Mulargia, 1985) method and the statistical method suggested by Stepp (1973) for completeness analyses. Further Figure 5 shows the area zones adopted for arriving at the seismic hazard map for Tamil Nadu by Menon et al. (2010) where zones 8, 9, 10 and 11 (offshore zones) are spread over large area encompassing regions where no seismicity is observed.

In the present study, the impact on the hazard value such as the peak ground acceleration (PGA) and UHS by varying the areal extent of the seismic area source zone is studied for Chennai. The city lies in a region of low to moderate seismicity in the southern part of Peninsular India (PI) known for its distributed seismicity. The seismicity in the influence area of 300 km radius considered for the study around Chennai is not uniform. Hence, this study is an ideal case for impact analysis by considering variation in the seismic area source zone on the hazard estimates. The impact analysis is attempted using two approaches of probabilistic seismic hazard analysis (PSHA), one is the conventional Cornell-McGuire approach and the other is the fixed kernel technique of zone-free methodol-

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