THE NEEDS OF THE NUCLEAR REGULATORY COMMISSION IN THE FIELD OF STRONG MOTION SEISMOLOGY

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The Nuclear Regulatory Commission (NRC) looks to the seismological and engineering community to help develop methods that provide reliable estimates of earthquake induced ground motion at different levels of risk for various sites throughout the country. These estimates should be in a form permitting effective use by geotechnical and structural engineers in the evaluation of sites and the design of structures for nuclear related facilities. Our needs generally parallel earthquake engineering needs of non-nuclear facilities except that most nuclear facilities must be designed to achieve very low levels of acceptable risk. Much recent research in strong motion seismology has been related directly or indirectly to nuclear power plant design so that our needs and problems have had an impact upon the trends within the science as a whole.

The problems we see today and the questions that we believe need answering can be divided into areas related to the earthquake source, seismic wave type and propagation, site effects and engineering input.

1) Earthquake Source

The most difficult problem we face today is estimating strong motion in the vicinity of the earthquake source, i.e. the near field. No nuclear power plant is intentionally placed near a known earthquake source or "capable" fault but subsequent investigations have revealed new faults and resulted in reassessment of some old faults. In order to determine whether facilities at these sites are sufficiently safe as designed, need to be upgraded or need to be abandoned requires an assessment of motion from near earthquake sources where we have few measurements, most of which are from small earthquakes. One approach has been to extrapolate inward from records taken at longer epicentral distances. An assessment of the validity at this approach is needed since the particular physical and geometric configuration of the source which is dominant in controlling the near field motion is of secondary importance in the far field. Are the more elegant theoretical models and numerical procedures for calculating the motion from these models are in a stage where their results can be considered reliable?

Other aspects of the earthquake source problem relate to the eastern U. S. It has been postulated that intraplate earthquakes have higher stress drops than interplate earthquakes. Is this correct and if so, does it result in increased amplitudes at the high frequencies? While earthquakes in the east cannot be associated with surface faulting and the larger events appear to be occurring at hypocentral depths of at least 10 kilometers, there are several occurrences of small near surface events that have resulted in very small felt areas of relatively high intensity. The magnitude 3.8, Intensity VII, event of August 14, 1965 in Cairo, Illinois is one such example. It is believed to have had a focal depth of approximately one kilometer. These events have not been associated with structure. What magnitude may these events reach and what characterizes their ground motion?

2) Wave Type and Propagation

Most present techniques,such as those used to estimate soil response, utilize models of ground motion which assume a predominance of vertically propagating horizontally polarized shear waves. Studies of records such as those from the San Fernando earthquake, show the importance of other types of waves, particularly surface waves. We need better quantitative estimates of the different wave types involved in strong ground motion and their effect on structural behavior. To what extend does the existence of horizontally propagating waves result in the reduced effective motion transmitted into structures with large foundations? To what extend does the existence of these waves also result in rocking or torsional motions which need to be considered for earthquake design.

A regional propagation difference is apparent between eastern and western U. S. The much larger felt areas for similar sized earthquake in the east necessitates consideration of the effect of distant (greater than 100 kilometers) large events such as New Madrid. In what ways is damaging ground motion from these earthquakes different than that from sources less than 100 kilometers away?

3) Site Dependence

The most frequent problem we face is that of how to incorporate differences in site geology into estimates of free field ground motions. Several investigators have classified sites in three or four broad categories and have shown differences in ground motion parameters such as peak acceleration and spectral shape associated with each category. The variation within each category however is rather large and it is not clear how significant the differences are. Investigations NRC has funded indicate that the surficial classification of accelerometer site conditions often is not confirmed by borings made in field investigations. All the comparative studies show relatively higher acceleration at rock for periods less than 0.5 seconds. Since most safety related structures at nuclear power plants have periods equal to or less than 0.5 seconds, does this mean it is less safe to build on rock than on soft sites? Observations of earthquake damage do not support this conclusion. Given the existing data base and state of our knowledge with respect to strong motion recording sites, how detailed a categorization is possible?

Along with differences in site properties, the effects of depth upon ground motion is also of great importance. Present methods account for these effects through the deconvolution of surface ground motion records. Some individuals utilizing these methods complain of irrational results which they attribute to computational techniques. What are the limiting conditions to which deconvolution may be presently applied? When it is applied a consensus view is needed as to the types of input ground motion records utilized and where this input is assumed. Ground motion at depth is not only a problem with respect to foundations several tens of feet below the surface but is also of importance in the design of waste repositories at depths of hundreds or even thousands of feet.

4) Engineering Input

Most present methods utilize standard response spectral shapes whose absolute level is determined by peak acceleration. The relatively high peak accelerations associated with some undamaging earthquakes raises serious questions as to the validity of this approximation. Should we use other peak parameters such as velocity and displacement? Should we as some of have suggested use a lower "effective" acceleration? If so how may this parameter be reliably estimated? Should we abandon reference values completely and go directly to each spectral ordinate given source and site characteristics? All the above questions assume that the response spectrum and related time history are seismological inputs that adequately describe ground motion for engineering purposes. Long durations are believed to be a critical factor in determining damage from large earthquakes. However, long duration events may not always be adequately reflected in the response spectra required by NRC. How may duration of strong motion best be incorporated into seismological input? Can this problem be separated from the present use of elastic analysis? If inelastic analysis is called for, what are the changes in required seismological input? Does it require a change in instrumentation so as to make a more faithful recovery of ground displacement?

Finally, any designed structures, including those related to nuclear facilities, entail the acceptance of some risk. Very often the most minimal of risks have to be weighed against other societal factors. Estimating these risks is a difficult and complex problem. The ability to place expected earthquake ground motion into a quantitative probabilistic framework would be an important contribution to arriving at both reasonable and reliable estimates of this risk.