CODES AND ENGINEERING PRACTICES AS RELATED TO CURRENT RESEARCH DEVELOPMENTS

BY

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By relating building codes and current earthquake engineering practices to an equivalent static force concept, many engineers and research workers are misled into thinking that earthquake engineering is similar to engineering for other more commonly occurring forces.

In most engineering practice and design, the forces to be resisted are known and the appropriate strengths can be provided with adequate factors of safety. In earthquake resistant design, the magnitude of the forces and motions are actually unknown although assumptions have been made estimating the ground motion. With what we do know about the forces and motions, however, it is certain that the actual forces are much greater than any code specified forces and consequently the engineering design problem must be concerned not only with the strength of the structure but even more importantly with the post-elastic strength or ductility, the stability of the structure at large deformations, and the manner and consequences of member failure.(1)

There are major elements that are different when comparing research assumptions and procedures and the design practices and requirements in earthquake engineering. It is necessary that these differences be recognized by both groups so that the needs and the limitations can be understood by all.

While research must necessarily precede practice by a considerable amount and consequently must rely on certain assumptions that have not been tested, the design engineer must furnish a structure <u>now,</u> and that structure must be safe. When he uses the results of research, he must be aware of the assumptions involved, their possible effects on the results, and the consequences of using different analytical techniques as used in research compared to those used in the design office.

Some of the elements that differentiate between research and practice can be grouped broadly into three categories although individual items may fall into more than one category.

The first group of elements relate to basic structural analysis.

1. Most design analysis in practice is done on an elastic basis, while most current earthquake research analysis is on an elasto-plastic basis. There are basic differences in performance as predicted by these methods that can only be roughly approximated. In addition, most current

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(1) Refers to bibliography reference.

of each material, but has not related the properties of one material to others under dynamic plastic loadings to determine adequate design factors.

2. Most major materials have problems at the connections and in the panel zone that have not been recognized either in research or in practice.(3)(6) Design practices and details used nationally in most countries are not suitable in areas of major seismic activity and require additional research and major changes in practice and code requirements.(7)(8) Research is needed and design practices must be revised in the use of heavy steels and weldments(9) and in the bond and anchorage requirements of concrete reinforcing under cyclic loadings. The high strain, low cycle of fatigue failure modes of concrete need major investigative work.(8)

3. The performance of shear wall elements, piers and spandrels has been investigated only minimally and usual design practices incorporate concepts that are not valid.(10)

4. Various definitions of ductility and their incorporation into analysis and the assumed relationship between elastic and elasto-plastic design methods are most confusing to engineers and to many research workers.(1) There are major differences in definition that can affect design results or the interpretation of analysis by several hundred percent.

There are other items that will greatly affect the performance of a structure in an earthquake which must be considered in the design of the structure, but which at present have been too complicated for adequate codification, have had little research, or have often been overlooked. There are too many to make a reasonably complete listing, but certain examples can be cited.

1. While much research has been done on foundations and soil response, the subject is so complicated or unrecognized by engineers that few national codes even attempt to allow for this major factor in a realistic manner. Some method must be found to present this very complex factor in a design method that can be used by the engineer.

2. That most important element of aseismic design - tieing together to make the structure act as a unit - is not mentioned or recognized in codes and no research attempts have been made to quantify it.

3. Earthquake ground motion consists of waves which travel with a finite velocity so that the motion at one point in a foundation will not be in phase with the motion at another point. Little has been done to research this difference in motions which causes the "accordion" effect so important in pavements, railroad tracks, utilities, bridges, and large buildings.(11)

4. Little has been done on the effects of earthquake motion on underground structures except on retaining walls and basement walls.

5. Little or nothing has been done to study the results of member failure - the transfer of function to other members - or the consequences of failure, comparing total collapse and "pancake" with other types of gross failure that may cause much fewer casualties.

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