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An Overview on Seismic Analysis and Its Methods

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About the Study

Seismic analysis is a branch of structural analysis that involves calculating a building's (or nonbuilding's) earthquake reaction. In earthquake-prone areas, it is an element of the structural design, earthquake engineering, or structural evaluation and retrofit (also structural engineering).

During an earthquake, a structure has the ability to 'wave' back and forth (or even a severe wind storm). The fundamental mode is the lowest frequency of building response and is referred to as the 'basic mode.' Most structures, on the other hand, have greater modes of reaction that are only engaged during earthquakes. The image only depicts the second phase; higher 'shimmy' (abnormal vibration) modes exist. However, in most circumstances, the first and second modes do the greatest harm.

The obligation to design for a lateral force equivalent to a proportion of the building weight was one of the first seismic rules (applied at each floor level). The appendix of the 1927 Uniform Building Code (UBC), which was utilized on the west coast of the United States, followed this technique. It was eventually discovered that the structure's dynamic qualities influenced the loads created during an earthquake. A provision to alter the load dependent on the number of floor levels was incorporated in the Los Angeles County Building Code of 1943.

Since the early days, earthquake engineering has progressed significantly, and some of the most complicated designs now incorporate unique earthquake protection components, either in the foundation (base isolation) or throughout the structure. Analyzing these structures necessitates specialized explicit finite element computer code that splits time into extremely small slices and represents the underlying physics, similar to the "physics engines" seen in many video games. This method may be used to simulate very big and complicated structures (such as the Osaka International Convention Centre).

The following five types of structural analysis approaches can be classified. They are as follows:

Equivalent static analysis

This method specifies a set of forces operating on a structure to simulate the influence of earthquake ground motion, which is normally specified by a seismic design response spectrum. It is assumed that the structure reacts in its basic manner. The building must be low-rise and not twist considerably as the earth changes for this to be true. Given the natural frequency of the structure, the response is read from a design response spectrum (either calculated or defined by the building code). Many building standards enhance the usefulness of this concept by adding components to account for higher buildings with certain higher modes, as well as modest degrees of twisting.

Response spectrum analysis

This method allows for the consideration of a building's many forms of reaction (in the frequency domain). With the exception of very basic or highly complicated structures, many construction rules mandate this. A structure's reaction may be characterized as a collection of many different particular forms (modes) that correspond to the "harmonics" in a vibrating string. These modes for a structure can be determined through computer analysis.

Linear dynamic analysis

When higher mode effects are not considerable, static techniques are appropriate. This is usually the case with short, regular structures. As a result, a dynamic approach is necessary for tall buildings, buildings with torsional anomalies, or non-orthogonal systems. The building is treated as a Multi-Degree-Of-Freedom (MDOF) system with a linear elastic stiffness matrix and an equivalent viscous damping matrix in the linear dynamic process. The seismic input is modeled using either modal spectrum analysis or time history analysis, but in both situations, linear elastic analysis is used to estimate the appropriate internal forces and displacements. Higher modes may be considered, which a benefit of these linear dynamic methods is over linear static procedures.

Nonlinear static analysis

Linear techniques are utilized when the structure is expected to remain nearly elastic for the amount of ground motion or when the design results in a nearly equal distribution of nonlinear response across the structure. The uncertainty with linear methods rises as the structure's performance target implies increasing inelastic demands, requiring a high level of conservatism in demand assumptions and acceptance criteria to avoid unexpected performance. As a result, processes that include inelastic analysis can help to minimise uncertainty and conservatism.

Nonlinear dynamic analysis

Although nonlinear dynamic analysis combines ground motion recordings with a thorough structural model, it is possible to produce results with a low level of uncertainty. The comprehensive structural model exposed to a ground-motion record gives estimates of component deformations for each degree of freedom in the model, and the modal responses are merged using techniques like the square-root-sum-of-squares in nonlinear dynamic studies.