Basic Seismological Characterization for Platte County, Wyoming

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BACKGROUND

Seismological characterizations of an area can range from an analysis of historic seismicity to a long-term probabilistic seismic hazard assessment. A complete characterization usually includes a summary of historic seismicity, an analysis of the Seismic Zone Map of the Uniform Building Code, deterministic analyses on active faults, "floating earthquake" analyses, and short- or long-term probabilistic seismic hazard analyses.

Presented below, for Platte County, Wyoming, are an analysis of historic seismicity, an analysis of the Uniform Building Code, deterministic analyses of nearby active faults, an analysis of the maximum credible "floating earthquake", and current short- and long-term probabilistic seismic hazard analyses.

Historic Seismicity

The enclosed map of "Earthquake Epicenters and Suspected Active Faults with Surficial Expression in Wyoming" (Case and others, 1997) shows the historic distribution of earthquakes in Wyoming. Only one earthquake has been recorded in Platte County. That earthquake and many from neighboring counties are discussed.

Guernsey Area

Only one earthquake has been recorded in Platte County. On October 3, 1954, an intensity IV earthquake was reported near Guernsey. Although the event was felt from Douglas to Wheatland, no damage was reported. Train traffic between Douglas and Wheatland was temporarily halted until it was determined that the tracks were not damaged (Laramie Republican-Boomerang, October 4, 1954).

Northern Laramie Range Area

Seismic activity in the northern Laramie Range has an influence on the seismic hazard for Platte County. There have been a series of earthquakes recorded in the Esterbrook and northern Albany County areas. Although the earthquakes did not occur in Platte County, many have been felt there. As a result, all significant earthquakes are discussed. Many of the earthquakes that have been felt in the area originated near Esterbrook, in the Laramie Range south of Douglas. On August 21,1952, an intensity IV earthquake was reported northeast of Esterbrook near the Platte County line. It was felt by several people in the area, and was reportedly felt 40 miles to the southwest of Esterbrook (Murphy and Cloud, 1954). Three additional earthquakes have occurred in the same location as the August 21, 1952 event. The first, a small magnitude event with no associated magnitude or intensity, occurred on September 2, 1952. The second, an intensity III event, occurred on January 5, 1957. The most recent, an intensity IV event, occurred on March 31, 1964. No damage was reported for any of the events. On January 15, 1978, a magnitude 3.0, intensity III earthquake occurred near Esterbrook. No damage was reported.

In the 1980's, there were a series of relatively significant earthquakes in northern Albany County that were felt over a wide area. On February 13, 1983, a magnitude 4.0, intensity IV event occurred approximately 40 miles southwest of Douglas. That non-damaging earthquake was felt in Laramie, Casper, Wheatland, and Medicine Bow (Laramie Daily Boomerang, February 15, 1983). The most significant earthquake to occur in the area, a magnitude 5.5, intensity VI event, occurred on October 18, 1984. That earthquake, with an epicenter located approximately 21 miles south of Esterbrook, was felt in Wyoming, South Dakota, Nebraska, Colorado, Utah, Montana, and Kansas. Stover (1985) reports that cracks were found in the exterior brick walls of the Douglas City Hall and a public school in Medicine Bow. Chimneys were cracked at Casper, Douglas, Guernsey, Lusk, and Rock River. A wall in a Laramie-area school was slightly cracked by the earthquake. The earthquake was one of the largest felt in eastern Wyoming. There were a number of aftershocks to the main event, with the most significant being a magnitude 4.5, intensity IV event, and a magnitude 3.8 event occurring on October 18, 1984; a magnitude 3.5 event on October 20, 1984; magnitude 3.3 events on October 19, November 6, and December 17, 1984; a magnitude 3.1 event on October 22, 1984; a magnitude 3.2 event on October 24, 1984; and a magnitude 2.9 event on December 5, 1984. On June 12, 1986, a magnitude 3.0 earthquake occurred in the same general area.

In 1993, there were a series of earthquakes recorded in the Esterbrook area, in the general vicinity of the October 18, 1984 event, near Esterbrook. On July 23, 1993, a magnitude 3.7, intensity IV earthquake occurred 26 miles southwest of Douglas. This event was felt as far away as Laramie. On October 9, 1993, a magnitude 3.7, intensity IV earthquake occurred approximately 34 miles southwest of Douglas. The earthquake was felt in Garrett. On December 13, 1993, another earthquake occurred approximately 33 miles south of Douglas. This non-damaging event had a magnitude of 3.5.

Uniform Building Code

The Uniform Building Code (UBC) is a document prepared by the International Conference of Building Officials. Its stated intent is to "provide minimum standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of all buildings and structures within this jurisdiction and certain equipment specifically regulated herein."

The UBC contains information and guidance on designing buildings and structures to withstand seismic events. With safety in mind, the UBC provides Seismic Zone Maps to help identify which design factors are critical to specific areas of the country. In addition, depending upon the type of building, there is also an "importance factor". The "importance factor" can, in effect, raise the standards that are applied to a building.

The current UBC Seismic Zone Map (1997) has five seismic zones, ranging from Zone 0 to Zone 4, as can be seen on the enclosed map. The seismic zones are in part defined by the probability of having a certain level of ground shaking (horizontal acceleration) in 50 years. The criteria used for defining boundaries on the Seismic Zone Map were established by the Seismology Committee of the Structural Engineers Association of California (Building Standards, September-October, 1986). The criteria they developed are as follows:

Zone	Effective Peak Acceleration, % gravity (g)
4	30% and greater
3	20% to less than 30%
2	10% to less than 20%
1	5% to less than 10%
0	less than 5%

The committee assumed that there was a 90% probability that the above values would not be exceeded in 50 years, or a 100% probability that the values would be exceeded in 475 to 500 years.

Platte County is in Seismic Zone 1 of the UBC. Since effective peak accelerations (90% chance of non-exceedance in 50 years) can range from 5%-10%g in Zone 1, and there has been little historic seismicity in the County, it may be reasonable to assume that an average peak acceleration of 5.0%g could be applied to the design of a non-critical facility located in the County if only the UBC were used. Such an acceleration, however, is significantly less than would be suggested through newer building codes.

Recently, the UBC has been replaced by the International Building Code (IBC). The IBC is based upon probabilistic analyses, which are described in a following section. Platte County still uses the UBC, however, as do most Wyoming Counties as of July, 2002.

Deterministic Analysis Of Regional Active Faults With A Surficial Expression

There are no known exposed active faults with a surficial expression in Platte County. McGrew (1961) stated that the Wheatland-Whalen fault system, located in southern Platte County and northern Goshen County, was active until the late Quaternary. This would have classified the fault as active. More recent investigations did not support that conclusion, and the fault is not now considered to be active. As a result, no deterministic analysis can be generated for Platte County.

Maximum Tectonic Province Earthquake - "Floating Earthquake"/Seismogenic Source

Many federal regulations require an analysis of the earthquake potential in areas where active faults are not exposed, and where earthquakes are tied to buried faults with no surface expression. Regions with a uniform potential for the occurrence of such earthquakes are called tectonic provinces. Within a tectonic province, earthquakes associated with buried faults are assumed to occur randomly, and as a result can theoretically occur anywhere within that area of uniform earthquake potential. In reality, that random distribution may not be the case, as all earthquakes are associated with specific faults. If all buried faults have not been identified, however, the distribution has to be considered random. "Floating earthquakes" or seismogenic sources are earthquakes that are considered to occur randomly in a tectonic province.

It is difficult to accurately define tectonic provinces when there is a limited historic earthquake record. When there are no nearby seismic stations that can detect small-magnitude earthquakes, which occur more frequently than larger events, the problem is compounded. Under these conditions, it is common to delineate larger, rather than smaller, tectonic provinces.

The U.S. Geological Survey identified tectonic provinces in a report titled "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States" (Algermissen and others, 1982). In that report, Platte County was roughly classified as being in the "Faulted Laramide-Age Mountain Uplift" tectonic province. That province was assigned a "floating earthquake" with a maximum magnitude of 6.1. Geomatrix (1988b) suggested using a more extensive regional tectonic province, called the "Wyoming Foreland Structural Province", which is approximately defined by the Idaho-Wyoming Thrust Belt on the west, 104° West longitude on the east, 40° North latitude on the south, and 45° North latitude on the north. Geomatrix (1988b) estimated that the largest "floating" earthquake in the "Wyoming Foreland Structural Province" would have a magnitude in the 6.0 – 6.5 range, with an average value of magnitude 6.25.

Federal or state regulations usually specify if a "floating earthquake", seismogenic source, or tectonic province analysis is required for a facility. Usually, those regulations also specify at what distance a floating earthquake is to be placed from a facility. For example, for uranium mill tailings sites, the Nuclear Regulatory Commission requires that a floating earthquake be placed 15 kilometers from the site. That earthquake is then used to determine what horizontal accelerations may occur at the site. A magnitude 6.25 "floating" earthquake, placed 15 kilometers from any structure in Platte County, would generate horizontal accelerations of approximately 15%g at the

site. That acceleration would be adequate for designing a uranium mill tailings site, but may be too large for less critical sites, such as a landfill. Critical facilities, such as dams, usually require a more detailed probabilistic analysis of random earthquakes. Based upon probabilistic analyses of random earthquakes in an area distant from exposed active faults (Geomatrix, 1988b), however, placing a magnitude 6.25 earthquake at 15 kilometers from a site will provide a fairly conservative estimate of design ground accelerations.

Probabilistic Seismic Hazard Analyses

The U.S. Geological Survey (USGS) publishes probabilistic acceleration maps for 500-, 1000-, and 2,500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a 10% probability that an acceleration may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years.

The USGS has recently generated new probabilistic acceleration maps for Wyoming (Case, 2000). Copies of the 500-year (10% probability of exceedance in 50 years), 1000-year (5% probability of exceedance in 50 years), and 2,500-year (2% probability of exceedance in 50 years) maps are attached. Until recently, the 500-year map was often used for planning purposes for average structures, and was the basis of the most current Uniform Building Code. The new International Building Code, however, uses a 2,500-year map as the basis for building design. The attached maps reflect current perceptions on seismicity in Wyoming. In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased due to local soil conditions. For example, if fairly soft, saturated sediments are present at the surface, and seismic waves are passed through them, surface ground accelerations will usually be greater than would be experienced if only bedrock was present. In this case, the ground accelerations shown on the USGS maps would underestimate the local hazard, as they are based upon accelerations that would be expected if firm soil or rock were present at the surface..

Based upon the 500-year map (10% probability of exceedance in 50 years), the estimated peak horizontal acceleration in Platte County ranges from 3%g in the southeastern corner of the County to 6%g in the northwestern corner of the County. Wheatland would be subjected to an acceleration of approximately 5%g. Those accelerations are roughly comparable to intensity IV earthquakes (3%g) to intensity V earthquakes (5%g-6%g). These accelerations are comparable to the low end of accelerations to be expected in Seismic Zone 1 of the Uniform Building Code. Intensity IV earthquakes cause little damage. Intensity V earthquakes may result in cracked plaster and broken dishes.

Based upon the 1000-year map (5% probability of exceedance in 50 years), the estimated peak horizontal acceleration in Platte County ranges from 6%g in the southeastern corner of the County to nearly 12%g in the northwestern corner of the County. Wheatland would be subjected to an acceleration of approximately 8%g. Those accelerations are roughly comparable to intensity V earthquakes (6%g-8%g) to intensity VI earthquakes (12%g). Intensity V earthquakes can result in cracked plaster and broken dishes. Intensity VI earthquakes can result in fallen plaster and damaged chimneys.

Based upon the 2500-year map (2% probability of exceedance in 50 years), the estimated peak horizontal acceleration in Platte County ranges from 10%g in the southeastern corner of the County to over 20%g in the northwestern corner of the County. Wheatland would be subjected to an acceleration of approximately 16%g. Those accelerations are roughly comparable to intensity VI earthquakes (10%g) to intensity VII earthquakes (16%g-20%g). Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures. Chimneys may be broken.

As the historic record is limited, it is nearly impossible to determine when a 2,500-year event last occurred in the County. Because of the uncertainty involved, and based upon the fact that the new International Building Code utilizes 2,500-year events for building design, it is suggested that the 2,500-year probabilistic maps be used for Platte County analyses. This conservative approach is in the interest of public safety.

Summary

There has been only one historic earthquake recorded in Platte County, although earthquakes in nearby Counties have caused minor damage. Because of the lack of recent earthquakes, it is possible to underestimate the seismic hazard in Platte County if historic earthquakes are used as the sole basis for analysis. Earthquake and ground motion probability maps give a more reasonable estimate of damage potential in areas without exposed active faults at the surface, such as Platte County.

Current earthquake probability maps that are used in the newest building codes suggest a scenario that would result in moderate damage to buildings and their contents, with damage increasing from the southeast to the northwest. More specifically, the probability-based worst-case scenario could result in the following damage at points throughout the County:

<u>Intensity VI Earthquake Areas</u>

Meadowdale area
Guernsey/Hartville area
Chugwater

In intensity VI earthquakes, some heavy furniture can be moved. There may be some instances of fallen plaster and damaged chimneys.

<u>Intensity VI-VII EarthquakeAreas</u>

Wheatland/Ferguson Corner area

In intensity VI-VII earthquakes, damage is slight-to moderate in well-built ordinary structures, moderate to considerable in some poorly built or badly designed structures. Some chimneys will be broken. Unreinforced masonry buildings are generally considered to be poorly built.

Intensity VII Earthquake Areas

Glendo area

In intensity VII earthquakes, damage is negligible in buildings of good design and construction, slight-to-moderate in well-built ordinary structures, considerable in poorly built or badly designed structures. Some chimneys will be broken. Unreinforced masonry buildings are generally considered to be poorly built.

damage seismic hazard/ground acceleration maps are used as a basis for analysis, maximum ground accelerations in the County could result in moderate damage to buildings and contents. The Uniform Building Code, which is adopted in Platte County, utilizes a Seismic Zone Map that underestimates the ground-shaking hazard compared to probabilistic ground acceleration maps that are the basis of the new International Building Code.

HAZUS Analysis

A recent HAZUS analysis, run using default data, indicates that there may be $13, 900,000 in direct and indirect damage in Platte County if a worst case probabilistic earthquake occurs. The analysis is based upon incomplete data, and as such should not be referenced publicly.

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