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論文内容の要旨

A comprehensive seismic hazard analysis and its application to Engineering design for the Philippines have been performed. The technique has been also applied to the central Japan where the seismic activity is considerably high. Overall work is summarized as follows:

In Chapter 1, the previous works concerning the seismic hazards of the Philippines are reviewed. It is found out that the Philippines lacks comprehensive seismic hazard studies. For this reason, the seismic design code in the country assumed a uniform seismicity coefficient for the entire country. The assumption adapted the highest coefficient based on the US Uniform Building Code's zone 4. Other seismic ground motion parameters that has not studied in the past were pointed out. Outline and scope of the study were discussed.

In Chapter 2, attenuation relationships for peak ground motion intensities were discussed. Attenuation formula derived using the 118 components of modified strong motion records from Japanese accelerograms. Multiple regression analysis was performed to formulate the peak ground acceleration, peak ground velocity and effective ground acceleration attenuation formula. Methodologies for the simulation of strong ground motion time histories were discussed. Micozonation techniques for seismic hazards were presented. For this present study, microzonation was done using the correlation of surface geology and Standard Penetration Test (SPT) blowcount profiles. For each surface geology type, the representative ground motion amplification corrections were calculated. These corrections were multiplied to the rock-surface level ground motion intensities to get the equivalent intensities on soil surface.

In Chapter 3, the theoretical derivation of seismic hazard analysis was presented. Both the time independent (stationary) and time dependent (non-stationary) hazard were discussed. The hazard analysis model using Poisson process for hazards from seismogenic zones and fault sources are discussed. The concept of non-stationary seismic hazard was introduced. Distribution models of failure times for nonstationary seismic hazard applied was the Lognormal Distribution and Brownian Passage Time models. The memoryless model Exponential Distribution was also discussed. The unique property for each model was discussed.

Chapter 4 dealt with the data used for the seismic hazard analysis of the Philippines. In this chapter, the historical earthquakes in the Philippines were presented. The historical earthquake records in the country were found to be incomplete for lower magnitudes. Correction factors for different magnitude ranges were determined and these factors were applied to the earthquake frequencies to get the adjusted number of occurrences. Based on the historical earthquakes, seismic source zoning to be used for the hazard analysis was done. A total of 27 seismogenic zones were designated. Active faults in the country were compiled. Three rupture scenarios were assumed for each fault and for each scenario, the expected earthquake magnitudes determined.

In Chapter 5, seismic hazard analysis for the land area of the Philippines was performed. Seismic hazard intensities for peak ground acceleration, velocity and effective accelerations were presented. The hazards were for annual exceedance levels of $p_0=0.01$ and $p_0=0.002$. Central Luzon island and the eastern Mindanao Island was found to have the highest seismic hazards. High seismicity in Central Luzon is due to the presence of Philippine Fault whereas the high seismicity in Eastern Mindanao Island is due to both the Philippine Fault and Philippine Trench. Hazards for the acceleration response spectra were also presented for periods T=0.20 sec. and T=1.0 sec. Review of the present seismic design provisions in the Philippines was done. It was found out that seismicity coefficient, Z, used in the current design code of the Philippines do not accurately represent the variability of the seismicity for its various regions. The current design code assumes a uniform seismicity for all areas in the country, which is inconsistent with the results from this work.

In Chapter 6, a comprehensive seismic hazard study for the three major cities in the Philippines was done. The cities are Manila, Cebu, and Davao. This was done because of the high vulnerability to seismic damage in these three highly urbanized cities. For each city, the peak ground motion intensities were analyzed. Results showed that the capital city Manila has the highest seismic hazard followed in order by Davao and Cebu. Hazard deaggration study for various sources (i.e., seismogenic zones and fault sources) was presented. Result conclusively pointed out that their respective seismogenic zone location has the highest hazard contribution except at $p_0=0.001$ in Manila where the Marikina fault is the highest. Hazard-consistent magnitudes and hypocentral distances for each city were determined. Based on these parameters, ground motion time histories were simulated.

In Chapter 7, nonstationary hazard model was applied to determine the seismic hazards for Central Japan region. Lognormal distribution and Brownian Passage Time models were applied to calculate the hazards corresponding to 10¥% and 20¥% exceedance in 50 years. The hazard contributions from historical earthquakes and active faults were considered. The active faults were divided into two categories, the inland faults and offshore faults. Stationary hazard model (i.e., Exponential Distribution) was also used to calculate the seismic hazards and the results were compared to the values obtained from nonstationary models. It was concluded that nonstationary models gave higher values. Shizuoka Prefecture and eastern Aichi Prefecture have the highest seismic hazard in the region. High seismic hazards in these areas are due to the presence of Tokai and Tonankai faults.

論文審査結果の要旨

環太平洋造山帯に含まれる我が国のような地震国において、人々の住家や種々の社会基盤施設の耐震化をはかることは基本的な課題である。このためには、地域における地震危険度を正確に把握し、それに見合った合理的な耐震設計を実施する必要がある。本論文は、耐震・地震工学分野における基本的研究テーマのひとつである地震危険度解析ならびに地震動マイクロゾーニング技術に関して、これまでに提案されてきている手法に新たなアイディア、知見を加えたうえで、フィリピン国全域ならびに中部日本地域に適用したものである。以下に、本研究の成果をまとめる。

(1) 活断層データと地震発生データを組み合わせたフィリピン全域における地震危険度解析を行った。ここでは、地震発生状況に基づいて全国を 27 のゾーンに区分し、各ゾーンの危険度への寄与率を考慮するとともに、活断層については発生地震規模に関して３種のシナリオを与え、危険度への影響について考察した。また、３つの主要都市を対象として各危険度レベルに対応する地震規模と震源距離の組み合わせを算出し、工学的基盤での時刻歴加速度波形を求めて比較検討した。
(2) さらに、地盤資料が十分にない地域における地震動推定の一手法として、地質区分マップとボーリングデータを利用した地震動マイクロゾーニング法を示し、地震危険度解析結果と組み合わせてフィリピン全土に適用した。これらの結果は、地域地震危険度を考慮した耐震設計コードが適用されていないフィリピン国に、大変有用な情報を提供するものである。
(3) 我が国の南海トラフ沿いにおいては過去の巨大地震の発生履歴が得られている。地震の発生に比較的規則性がある場合には、当該断層による地震危険度は時間に依存したものとして扱うことができる。このように過去の巨大地震発生履歴が知られている中部日本地域における地震危険度解析について検討し、危険度が時間に依存するモデルを提示した。

以上が本研究の主な成果である。本研究で提示された一連の解析手法は、とくにフィリピンをはじめとするアジア地域の地震多発国における耐震設計に資することがおおいに期待され、工学的意義が大きい。したがって、本研究は学位論文として認定するに値

するものと判定した。

最 終 試 験 結 果 の 要 旨

杉戸真太、能島暢呂、八嶋　厚、および本城勇介で構成する審査委員会は、本論文および論文別刷りなどを慎重に検討した。本論文は学位論文として十分に完成された内容を有していること、提出された査読付き論文は申請者によって書かれていることを確認した。また、最終試験（公聴会）を平成 14 年2月 20 日に開催し、審査した。審査委員会での審議の結果、合格と判定した。