SEISMIC ZONNING MAPS OF VIETNAM FOR THE BUILDING CODE

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The seismic zoning maps of Vietnam were included in the Vietnamese Building Code TCXDVN 375-2006: Seismic Design Standards in 2006 for the first time. The maps were characterized with the Peak Ground Acceleration (PGA) with a return period of 500 years on ground type A. In 2012, the Association of Structure and Construction Techniques of Vietnam required to implement seismic design in seismic regions for ground type B to meet the current requirements of the design and construction of structures for seismic safety in Vietnam. To meet the above requirements, another version of seismic zoning map for the territory of Vietnam under the MSK-64 scale has been built by using and updating the 2006's seismic zoning map for Vietnam, with an exceedance probability of 10%, 5%, 1% and 0.5% in 50 years, respectively (corresponding to a return period of 250, 500, 1000, 5000, and 10000 years, respectively). These results are based on the catalogue of earthquakes and the map of the seismogenic zone map for Vietnamese territory then calculated with the CRISSIS99 program based on probabilistic analysis methods, by using the vibration attenuation relationship proposed by Nguyen Dinh Xuyen and Tran Thi My Thanh.

Tectonic Faults in Viet Nam

Under the tectonic stress field of N-S compression, the northwest of Vietnam has developed a NW-SE trending fault system, a N-S trending fault system and a NE-SW trending fault system (Nguyen Dinh Xuyen et al. 2004). Among these systems, the NW-SE trending fault system is the most significant, including the Red River (Song Hong), Chay River (Song Chay), Ma River (Song Ma) and Son La faults. Most of the large and moderate earthquakes in the northwest region of Vietnam have occurred in this fault system. The N-S trending fault system is also an important system. The main fault of the system is the Dien Bien – Lai Chau fault, the fault shown in Figure 1 at the western termination of the Song Hong, Son La and Song Ma Faults. On the other hand, the NE-SW trending fault system is rather inactive.

The NW-SE trending system includes major faults that could produce large magnitude earthquakes. In particular, the Red River Fault zone, represented in Viet Nam by the Song Hong and Song Chay Faults, at over 900 km length rivals New Zealand's Alpine Fault in length, and could potentially produce similar magnitude earthquakes. It is a major tectonic feature, separating the Indochina and South China blocks.

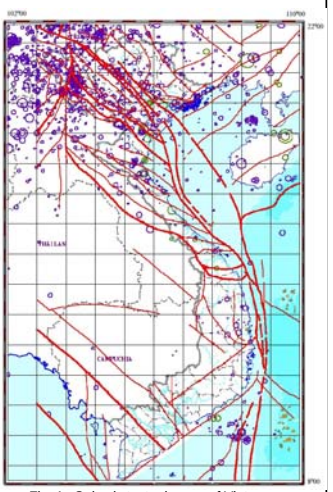

Fig. 1. Seismic tectonic map of Vietnam

Ground Motion Attenuation Relationships

In the past, earthquakes with intensity of 8 and larger in the MSK-64 scale (estimated magnitude M_S = 6-7) occurred in Hanoi (1278, 1285), in lower section of the Ma river (1635) and at the Ca river (1821). More recently, in 1935 and 1983, earthquakes of magnitude M_S 6.7 - 6.8 occurred in the north west of Vietnam, namely the Dien Bien Phu earthquake (November 1935) and the Tuangiao earthquake (June 24, 1983). Both destroyed and heavily damaged many houses, buildings and agricultural lands in an area covering about 13,000 km^2. Many people died or were injured by the collapse of houses. These were the largest earthquakes recorded in Viet Nam since 1900. In addition to the above earthquakes, several moderate earthquakes that were known by many people have occurred in recent years. These include the Ta Khoa earthquake with magnitude of M = 4.9 in 1991, the Lai chau earthquake with magnitude of M = 4.9 in 1993, the Muong Luan earthquake with magnitude of M = 4.8 in 1996, the Lai Chau earthquake with magnitude of M = 4.8 earthquake in 2001 and the Dien Bien earthquake with magnitude of M = 5.3 in 2001. The earthquake catalogue up to 2010 including the data sources: Historical up to 1900, the Seismological network of VietNam and others (ISC, NEIC, NOAA, …). The epicenter's distribution map in Vietnam and adjacent area is shown in Fig 1.

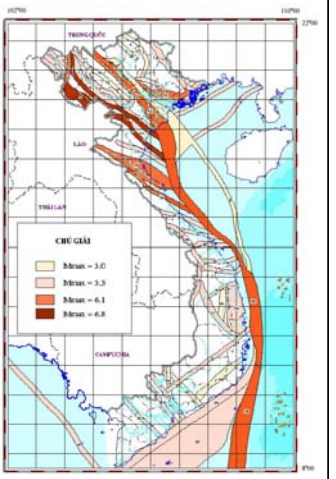

Fig. 2: The seismic source zones in Vietnam

Local Magnitude Scale

The laws of seismicity manifestation serve the basis for delineation of seismogenic (source) zones and estimation of their seismic characterestics (Mmax, depth h, earthquake occurrence frequency). The following laws of seismicity manifestation in Vietnam were identified in results of study on earthquake distribution, focal characterestics...

Relation between earthquake focus and tectonic structure: The focus of the earthquakes Ms≥4.5 are closely connected with the deep faults seperating the main tectonic units.

Distribution of earthquakes in depth: Although the faults may reach to the depth of 40-50 km the earthquake focus depth don't exceed 30 km and varie from zone to zone.Maximum focus depth h=25-30 km are observed in Sonla,Ma River fault zones and in northeast border of Hanoi depression,in the Red River fault zone the focus depth is h≤25 km,in the other fault zones h≤15-20 km.

Magnitude-frequency relation Gurenberg-Richter formula

Potential source zones

Seismogenic faults are considered potential seismic source zones (Fig.2).The width of the zones is taken equal to one of the destruction zone related to the faults; for a single fault it is about 10 km.

Magnitude of maximum possible earthquake in the zones is estimated by

-Geological extrapolation method: the maximum earthquake which occurred in any part of fault may arise in remain parts of this fault and also in the other faults with similar tectonic condition.

-Gumbel's asymtotic distribution of extrems G3

-Correlation between upper limit magnitude and dimension of fault segment established for Vietnam

$M_{max} \leq 2\log L + 1.77$

$M_{max} \leq 4\log H + 0.48$

L,H- fault segment length and active layer thickness in km.

Attenuation law

2006: Applied the Campbell 97 attenuation law (Campbell, 1997).
2013: The Vietnam attennuation law (Nguyen Dinh Xuyen and Tran Thi My Thanh, 1999).

Seismic hazard maps

The PGA map of 500, 5000 and 10000 years return period on ground type A have been calculated and compiled in scale 1:1.000.000 (Fig 3, 4, 5, 6).

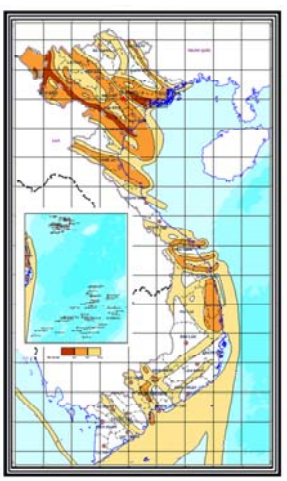

Fig. 3. The PGA map, 500 years - Campbell W. Kenneth, 1997

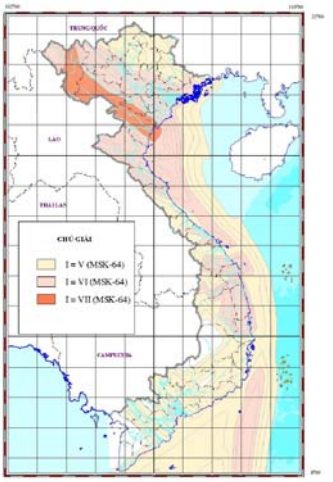

Fig. 4. The PGA map, 500 years

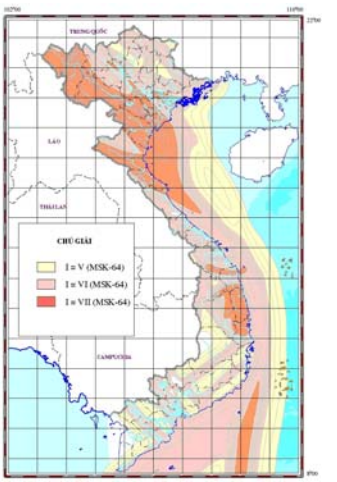

Fig. 5. The PGA map, 5000 years

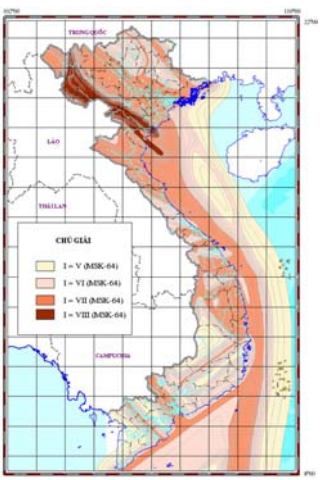

Fig. 6. The PGA map, 10000 years

References

Nguyen Dinh Xuyen, Tran Thi My Thanh, 1999, Defining a peak ground motion attenuation relationship for Vietnam. Journal of Earth Sciences,Vol.21, 3, 207-213

Campbell W. Kenneth, 1997, Empirical near-source attenuation relations for horizontal and vertical components of peak ground acceleration, peak ground velocity, and Pseudo-absolute acceleration response spectra, Seismological research letters, 68(1), pp. 154-179