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Fault Specific Seismic Hazard Maps as Input to Loss Reserves Calculation for Attica Buildings

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Greece is prone to various natural disasters, such as wildfires, floods, landslides and earthquakes, due to the special environmental and geological conditions dominating in tectonic plate boundaries. Seismic is the predominant risk, in terms of damages and casualties in the Greek territory. The historical record of earthquakes in Greece has been published from various researchers, providing useful data in seismic hazard assessment of Greece. However, the completeness of the historical record in Greece, despite being one of the longest worldwide, reaches only 500 years for M $\geq$ 7.3 and less than 200 years for M $\geq$ 6.5. Considering that active faults in the area have recurrence intervals of a few hundred to several thousands of years, it is clear that many active faults have not been activated during the completeness period covered by the historical records. New Seismic Hazard Assessment methodologies tend to follow fault specific approaches where seismic sources are geologically constrained active faults, in order to address problems related to the historical records incompleteness, obtain higher spatial resolution and calculate realistic source locality distances, since seismic sources are very accurately located. Fault specific approaches provide quantitative assessments as they measure fault slip rates from geological data, providing a more reliable estimate of seismic hazard.

We used a fault specific seismic hazard assessment approach for the region of Attica. The method of seismic hazard mapping from geological fault throw-rate data combined three major factors:

1. Empirical data which combine fault rupture lengths, earthquake magnitudes and coseismic slip relationships.
2. The radiuses of VI, VII, VIII and IX isoseismals on the Modified Mercalli (MM) intensity scale.
3. Attenuation - amplification functions for seismic shaking on bedrock compared to basin filling sediments.

We explicitly modeled 22 active faults that could affect the region of Attica, including Athens, using detailed data derived from published papers, neotectonic maps and fieldwork observations. Moreover, we incorporated background seismicity models from the historic record and also the subduction zone earthquakes distribution, for the integration of strong deep earthquakes that could also affect Attica region.

We created 4 high spatial resolution seismic hazard maps for the region of Attica, one for each of the intensities VII – X (MM). These maps offer a locality specific shaking recurrence record, which represents the long-term shaking record in a more complete way, since they incorporate several seismic cycles of the active faults that could affect Attica. Each one of these high resolution seismic hazard maps displays both the spatial distribution and the recurrence, over a specific time period, of the relevant intensity.

Time – independent probabilities were extracted based on these average recurrence intervals, using the stationary Poisson model $P = 1 - e^{-\lambda t}$. The "λ" value was provided by the intensities recurrence, as displayed in the seismic hazard maps. However, the insurance contracts usually lack of detailed spatial information and they refer to Postal Codes level, akin to CRESTA zones. To this end, a time-independent probability of shaking at intensities VII - X was calculated for every Postal Code, for a given time period, using the Poisson model.

The reserves calculation on buildings portfolio combines the probability of events of specific intensities within the Postal Codes, with the buildings characteristics, such as the building construction type and the insured value. We propose a standard approach for the reserves calculation $K(t)$ for a specific time period:

$$K(t) = \frac{x_2}{x_1} \cdot [x_1 \cdot y_1 \cdot P_{1(t)} + x_1 \cdot y_2 \cdot P_{2(t)} + x_1 \cdot y_3 \cdot P_{3(t)} + x_1 \cdot y_4 \cdot P_{4(t)}]$$

which is a function of the probabilities of occurrence for the seismic intensities VII – X $(P_{1(t)} - P_{4(t)})$ for the same period, the value of the building x_1, the insured value x_2 and the characteristics of the building, such as the construction type, age, height and use of property $(y_1 - y_4)$.

Furthermore a stochastic approach is also adopted in order to obtain the relevant reserve value $K(t)$ for the specific time period. This calculation considers a set of simulations from the Poisson random variable and then taking the respective expectations.