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Quantifying subsidence exposure – decision-making tools for risk-management in the insurance industry

M. Chirouze and Dr. R. Cheetham

Guy Carpenter & Co. S.A.S., Tour Ariane, 5 place de la Pyramide, 92088 Paris La Défense Cedex
(manuel.chirouze@guycarp.com, rebecca.cheetham@guycarp.com)

Geotechnical subsidence is exhibited by soils that are rich in clay minerals. Subsidence is downward ground movement due to soil shrinkage occurring during periods of drought. Subsidence on clay-rich soils can be followed by the opposite process of heave, which is upward soil movement that occurs due to soil swelling, following more humid conditions.

Subsidence and heave can cause movement in building foundations that may result in damage, most typically manifested as crack formation within building walls or openings (doors/ window frames). Eventual damage severity can depend on additional factors, such as construction design and the proximity of deep-rooted vegetation.

In France over the period 1989 to 2003, ground movement due to subsidence and heave has cost on average over €250 million per year to the French insurance industry.

The significant exposure of a number of French insurance companies to this peril and the lack of tools available for its quantification, motivated the risk and reinsurance specialist Guy Carpenter to develop a probabilistic model which is now available for use.

Guy Carpenter's probabilistic subsidence model incorporates detailed information of the subsidence hazard across France, combined with a sophisticated event set, a model of France's built environment and its vulnerability to damage from expansive clay soils. The model enables the elucidation of the subsidence hazard that exists in different areas of the country and quantification of the potential damage caused to vulnerable buildings by a range of subsidence events of varying intensity.

The model was built in partnership with the French geological institution, the Bureau de Recherches Géologiques et Minières (BRGM) and uses a modular approach to quantify the various components of subsidence risk and subsequent damage, namely:

• Soil characteristics: Soils with a clay mineral content of greater than 5 percent by weight will exhibit expansive properties and certain clay minerals, such as the smectite clay montmorillonite, give soils the most profound shrink/swell properties. The BRGM has developed a series of soil hazard maps that quantify the shrink/swell potential of soil types across France and Corsica.

• Climate: If an expansive soil is exposed to periods of drought interspersed with more humid conditions, cycles of soil shrinkage and swelling can occur, causing soil movements that can place a building foundation and superstructure under stress. Volumetric soil water content estimates for the period 1957 – 2008 from the European Centre for Medium-Range Weather Forecasting (ECMWF) were used to derive a stochastic event-set representative of 500 cycles of soil drought and re-humidification across the French territory.

• Land cover: The presence of deep-rooted vegetation in the vicinity of buildings can increase local water deficits, thus exacerbating soil shrinkage and differential movements within building foundations.

• Built Environment: Detailed structural information is required to assess the potential damage and monetary loss to a given building. Such information is not usually collected by insurance companies. Guy Carpenter developed a logic tree approach, which, combined with building inventory data, allows for the calculation of the probability that a given building will have certain structural characteristics.

• Vulnerabilities and insurance conditions: A database with over 100,000 claims was created and vulnerability functions were derived for a variety of soil types, climatic events and building structure categories.

A probabilistic modelling framework was built, integrating the above-mentioned datasets. Via a desktop application, an analyst can import a portfolio of insured risks, run the model and obtain a probability distribution function of loss amounts in addition to a map of the portfolio's exposure to subsidence at various return periods.