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the flow of good and services due to direct physical damages to stocks or lifelines. It has been observed that the recover time is significantly contributed in the indirect losses. Existing models for estimation of recovery time of facilities has been mostly developed by expert opinion. In this paper, an analytical model for estimation of earthquake induced indirect economic impacts of industrial facilities based on system dynamic approaches is introduced.

In the proposed model, system dynamic approach is employed for estimation of recovery time of factory after a probable earthquake by estimation of reconstruction time and recovery time after reconstruction. In this method, first a conceptual recovery framework for recovery of industry after earthquake has been developed by considering contributing factors on recovery level like availability of financial resource for reconstruction, lifeline, households, availability of source for production and demands. Then a simulation technique is employed for developing the numerical platform of the model and the method is applied to a hypothetical refinery and the results are presented in addition to some parametric studies. The numerical results have shown that the degree of indirect losses is significantly higher than direct one in the numerical example.

MODELLING SEISMIC RISK IN SWITZERLAND – ID 1202

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Earthquake hazard in Switzerland is low relative to regions of Southern Europe and the Mediterranean. Yet the region has experienced damaging earthquakes, such as the 1356 Basel and 1855 Visp earthquakes. In this, the 650th anniversary year of the 1356 Basel earthquake, government and private researchers are reassessing seismic risk in Switzerland in light of both the low probability threat and the less seismic resistant building inventory. As part of this effort, the authors have developed a probabilistic earthquake loss-estimation model for Switzerland to facilitate the management of catastrophe risk by the (re)insurance industry. The model includes ground motion estimation and building vulnerability modules, as well as an industry-wide building inventory database that categorizes structures by wall material and building height. This paper presents technical details on the ground motion hazard and building vulnerability. Ground motions are calculated based on Bay et al. (2003) and Ambraseys et al. (1996) attenuation relations, which is then adjusted through the NEHRP (National Earthquake Hazard Reduction Program) soil-amplification procedure according to surface geology. Building vulnerability is measured as a function of Roof Drift Ratio (RDR), which is estimated through the Capacity Spectrum Method (CSM). For masonry construction which is a dominant type in Switzerland, the capacity curve is developed based on experimental and/or analytical studies of buildings specific to the Swiss practice. The model is used to estimate loss distributions of selected historical events, were these events to recur today. The loss distributions reflect the uncertainty in the source parameters of these events as estimated from pre-instrumental era. The selected events include the 1356 Basel and the 1855 Visp earthquakes.

EARTHQUAKE DAMAGE AND LOSS ESTIMATION ON A REGIONAL SCALE – ID 1422

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The main goal of earthquake damage and loss estimation studies is to provide information and support for the decision-making process to guide cost-effective risk management policy in earthquake-prone regions taking into account their specific needs and existing circumstances. The necessary information should include, on the one hand, spatial distribution of existing risk in the area under study and, on the other hand, the level of damage and losses from probable future earthquakes. The paper presents a methodology of damage and loss analysis, which is developed in the frame of an interdisciplinary project "Risk Map Germany" conducted by the Center for Disaster Management and Risk Reduction Technology – CEDIM. The conceptual framework of the GIS-based methodology follows the traditional pattern and includes analysis of probable seismic influence, structural vulnerability of the built environment and exposed assets in communities of the country. For analyses of damage and losses both hazard-based and scenario-based approaches are used in the study. The former provides the possibility of comparative analysis of risk distribution in the whole country for identification of most endangered communities. The latter offers the possibility of estimation of the level of probable damage and losses from potential single seismic events. The results obtained with the use of the hazard-based approach are presented as maps of the probable seismic damage and seismic risk distributions. In parallel, the scenario-approach is applied for a few selected earthquake-prone communities of the country. The results are calibrated with the observations from several damaging earthquakes in Germany and the nearby area in the past 30 years.

RISKSCAPE (NZ) - A MULTIHAZARD RISK ASSESSMENT PROGRAMME – ID 1501

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New Zealand has long been recognized as having a high exposure to earthquake related hazards. In fact New Zealand has the dubious privilege of being exposed to nearly all natural hazards and in many cases this exposure is recognized as being "high" to "severe" by international standards. While considerable advances have been made over the past few decades in understanding the mechanics that underpin these phenomena, only recently has sufficient knowledge been acquired to enable some rational probabilistic models to be developed to quantify the intensity/recurrence relationships of these hazards. By establishing fragility functions for all items of community inventory to the actions resulting from each of these natural phenomena, community risk and thence probable losses can now be ascertained, albeit with varying degrees of reliability.

This paper discusses the development of RiskScape New Zealand, a national multi-hazard impact model that will be able to ascertain relative risks and community exposure to a range of natural hazards. The prototype currently under development and will include earthquake, tsunami and volcanic exposure together with flood and storm impact. Three representative New Zealand communities will be used in the pilot with the default inventory database including buildings, infrastructure, public utility and transportation networks.

The challenge of presenting date derived using either the probabilistic or scenario approach proposed to an essentially non-technical user group and getting their uptake remains before us but will be discussed in the paper along with progress to date.

CONSEQUENCE ASSESSMENT OF EARTHQUAKES: BAM CASE STUDY – ID 1597

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The present paper reports on the methodical developments in regard to the modelling and assessment of consequences due to earthquakes within a multidisciplinary research project presently performed at the Swiss Federal Institute of Technology. The research project aims to develop a generic decision theoretical framework for the consistent quantitative and rational management of earthquake risks in three situations, namely before, during and after an earthquake. First the general framework for the earthquake risk management project is outlined. Thereafter the specific issues relating to the modelling of consequences of earthquakes are addressed including a review of existing methodologies and results of research projects reported in the literature. Finally an example of a Bayesian Probabilistic Net model considered in the project for consequence analysis is presented and it is explained how the net may be utilized for assessing the consequences of relevance prior, during and after an earthquake.