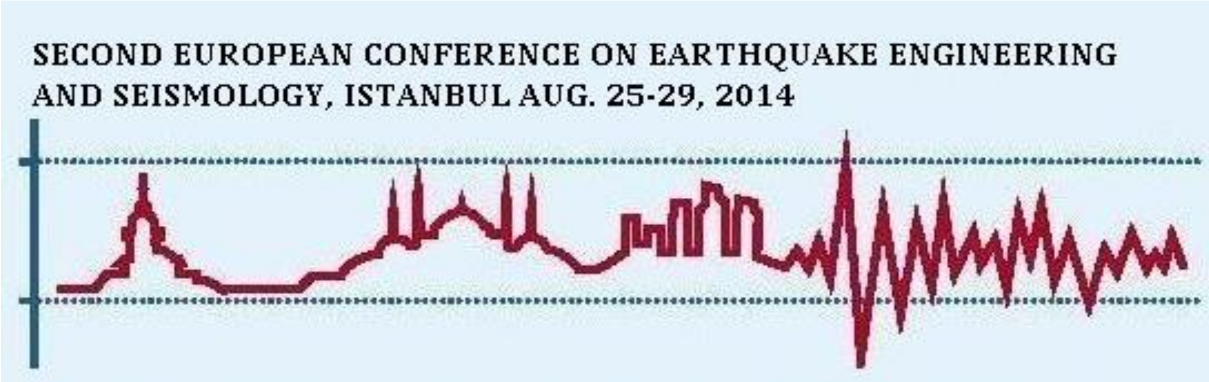

SEISMIC RISK ANALYSIS OF L'AQUILA GAS DISTRIBUTION NETWORK

Simona Esposito[1] and Iunio Iervolino[2]

A gas distribution system comprises two main categories of components: (i) a number of point-like critical facilities (reduction stations and groups); and (ii) pipelines constituting the distribution network. The causes of earthquake damage to components of gas systems include permanent ground deformation (PGD) hazard produced by fault displacements, landslides, liquefaction of sandy soils, as well as transient ground deformation (TGD) hazard associated with travelling seismic waves. Because this kind of systems is extended in space, a key difference with respect to seismic risk analysis of point-like facilities is that the seismic hazard has to be evaluated jointly for all the locations of the system's components. Moreover, the performance evaluation of lifelines, related to the level of service, reflects their spatially distributed and functionally interconnected nature, which needs specific perfomance indicators.

This study aimed at evaluating the seismic risk of the medium pressure portion of L'Aquila (central Italy) gas distribution system (Figure 1), according to the SYNER-G framework (Pitilakis et al., 2014) that includes the probabilistic characterization of seismic input, the definition of vulnerability of the network's components, the analysis of the system's seismic performance measures, and finally the probabilistic simulation for risk assessment. The case study is characterized by three metering/pressure reduction stations (M/R stations) connecting the network to the high-pressure nationwide network, more than two hundred km of pipelines either made of steel or high-density polyethylene pipes, and about two hundred reduction groups (RGs). Detailed information about the system was available for this network, including performance in the 2009 M_w 6.3 earthquake (Esposito et al., 2013) due to a partnership with its operator (Enel Rete Gas s.p.a.).

A simulation-based connectivity analysis was the objective of the study; i.e., the network performance was assessed evaluating the availability of the RGs after an earthquake. Analyses were carried out with a purpose-made object-oriented model of interconnected infrastructural systems (Franchin and Cavalieri, 2013), within which the authors have specifically developed a prototype software for the seismic risk assessment of gas systems. Both TGD and PGD hazards were evaluated. In particular, for each simulation run, earthquakes were generated considering a single fault, the Paganica fault, and characteristic earthquakes of moment magnitude 6.3. TGD intensity measures (peak ground acceleration and velocity) were evaluated though a European ground motion prediction equation (GMPE) and a European spatial correlation model, in a probabilistically consistent manner (Esposito, 2011) via the conditional hazard approach (Iervolino et al., 2010). To account for local site conditions GMPE-based amplification factors were considered. Regarding PGD hazard, the landslide potential of L'Aquila region was evaluated according to a low-input-data procedure and, in each simulated event, the resulting displacement for each site was calculated. Pipelines and M/R stations were considered the vulnerable elements within the network. To estimate earthquake-induced damage, for buried pipelines, repair rate functions of TGD and PGD were selected for each pipe typology and diameter while for the M/R stations, a lognormal fragility curve for un-anchored compressor stations

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was adopted. The connectivity analysis was then performed considering two connectivity-based performance indicators; i.e., the *Serviceability Ratio* (SR) and the *Connectivity Loss* (CL).

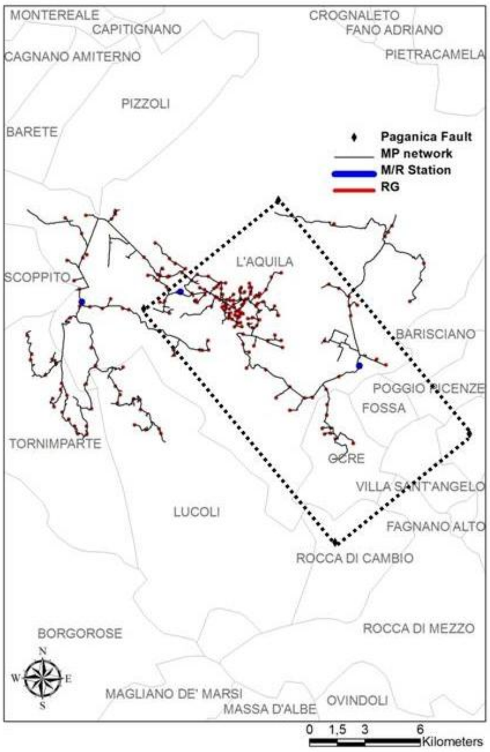

Figure 1. Application network (L'Aquila, central Italy)

Results of the analyses indicate that the expected values of CL and SR for the considered system, given the occurrence of an earthquake on the considered fault, are 0.66 and 0.68, respectively. Figure 2 shows the complementary cumulative distribution functions of the two indicators. It may be observed that the CL curve is characterized by a multimodal distribution yet not exhibited by the corresponding SR curve. This different behavior is due to the different definition of the two performance indicators and the network's configuration (see Esposito et al., 2014, for more details). Analyses also include the disaggregation of network performance, which indicated a clear influence, on the earthquake loss, of the damage state of the M/R stations.

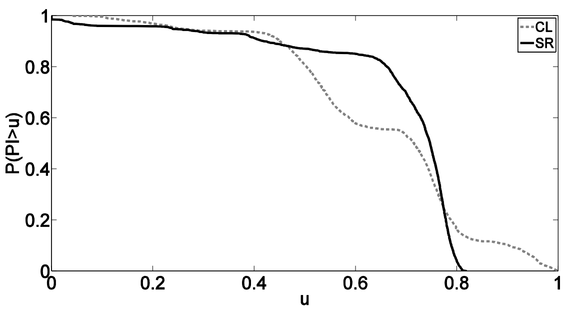

Figure 2. Complementary cumulative distribution of CL and SR

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