SECOND EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING
AND SEISMOLOGY, ISTANBUL AUG. 25-29, 2014

REDUCTION OF SEISMIC IMPACT AT AN INDUSTRIAL COMPLEX

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The Industrial Complex of Sines (Portugal) with more than 13 km^2, is one of the largest in Europe, housing a significant number of critical infrastructures. Located next to the Atlantic Coast, at about 180 km from various major seismogenic sources (the Gorringe Bank, the Marquês de Pombal, Pereira de Sousa and Sao Vicente Faults) able to generate a 8.5 to 9 magnitude earthquakes, leading to Peak Ground Accelerations of about 0.3 g to 0.50 g in stiff rock soils, with the possibility of 0.4 g to 0.65 g in soft soils. In this area, several major industries and services are present, many of them critical infrastructures, interacting in a complex physical and functional dependency so, prone to trigger chain reactions amplifying and propagating disastrous effects. Within a 10 km distance, a population of about 35.000 persons is present, with schools, hospitals, and many other urban facilities.

Already identified as a risk and critical facilities, during the establishment of the National and European Critical Infrastructures Protection projects, the Sines Industrial Complex is an optimum feasibility case study in the field of Seismic Early-Warning Systems (EWS), not only for the elastic waves but also for the tsunami waves. It is no coincidence that several national and international major stakeholders show their interest in this subject, and are participating enthusiastically in this project.

The main advantage of such a system is that the operators of the different infrastructures are able to make better decisions. Furthermore, interdependencies between industrial infrastructures are illustrated in order to estimate the consequences in a territory of a threat to one or several infrastructures.

In first place, this work concentrates in identifying the various stakeholders with heavy industrial civil engineering structures and determines the seismic vulnerabilities of these structures. Secondly, defines in a broader sense, the most important interdependencies existing among the various functions and stakeholders productions. The following "flaws" were identified:

- Elements may suffer faults or failures which may be propagated to other elements.
- The capability of each element to provide the required outputs may depend on its operational condition, which is based on the availability of the input resources it requires in service conditions and on the severity of the failures that affect it.

Main systems interdependencies could be explained through the analysis of four main systems: (i) the Port; (ii) the Water System; (iii) the Energy System and (iv) the Gas System.

In Figure 1 we illustrate the flow of services within the Port, showing the functional intra-dependencies. For the other three cases the situation is similar.

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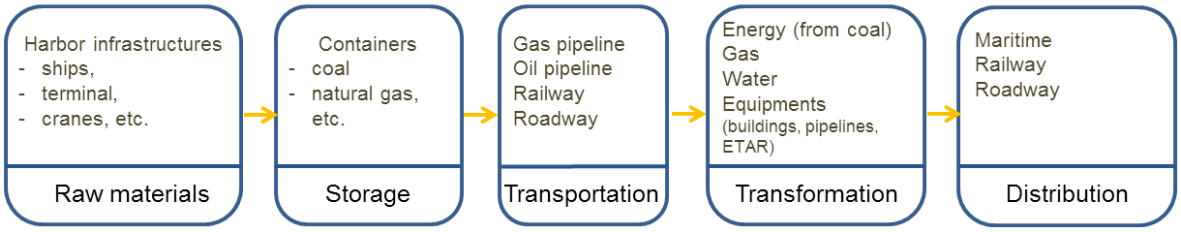

Figure 1. Flow of services within the Port

As a final purpose, the work summarized in this paper looks at the reduction of earthquake impacts in the industrial complex of Sines by using Early Warning Systems as a mean to anticipate the arrival of stronger seismic waves. In fact, EWS may have a tremendous importance in these industrial complexes if it is possible to provide certain amount of seconds of lead time, which would be critical for complete shutdown or initiate shutdown of certain operations and equipments. In the present case if an EW detection system is mounted south of Continental Portugal for earthquakes with epicentres SW of the territory, a 12 to 25 sec lead time can be gained in Sines for seismic waves (Carranza et al, 2013) and tens of minutes for tsunami wave arrivals, depending on the precise location of the epicentre. The value of 12 sec corresponds to the early warning made with 10 stations, while 25 sec with 5 stations.

As far as seismic waves are concern, the importance of launching of an alert is quite different depending on the type of system we are analysing. For instance, if the shutdown of a facility/equipment may cause several days to put it back to normal working conditions, as it is the case of an electric power plant, a false alarm can cause a great economic negative impact with few advantages. However, for other installations such as gas piping, a shutdown has almost no negative impact, and allows turning down the valves which may strongly reduced damage (leakage). But in either of the cases referred, the EWS informing on the early arrival of the waves is very important, as it allows the personnel to be prepared.

In the present paper discussion on details of these problems and information on the minimum amount of lead time required for several infrastructures existing in the Industrial Complex of Sines, south of Lisbon, will be presented.

The tsunami impact is outside the scope of the present paper, but any EW system in coastal zones should also include preparation to act assuming the possibility of occurrence of tsunamis.

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