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VULNERABILITY OF SEISMIC EQUIPMENT

A.D.ANCAS[1] D.TOMA[2] M.PROFIRE[1]

Abstract: *In this article we present a classification of equipment essentials in case of an earthquake, making reference mainly to nonstructural elements, according to Eurocode 8 indicating a method of analyzing networks of underground pipes if a seismic event.*

Key words: *critical facility, earthquake, structural element.*

1. Introduction

A classification of equipment essentials (critical facility) in case of an earthquake can be done taking into account the membership of this category both structural elements and those not structural.

The structural elements are critical in case of earthquake: hospitals, police, fire whose post earthquake intervention is crucial to saving lives and limiting damage in the event of a disaster.

Structural elements can be classified into four categories: electro-mechanical equipment (pump stations, valves and closing control, compressors, fans, air handling units, chillers, etc.), tanks (both water tanks and fuel tanks of various), utility networks (pipes for water, gas, heating, sewage) and technological networks (pipes for various technological agents used particularly in industry) [1].

In urban background can be identified certain critical locations namely those locations whose failure, in case of an earthquake can lead to other disasters affecting man and / or environment [2].

For many existing critical locations, the danger arises that they are designed and built according to seismic design criteria of the equipment. Even some of the current design codes and rehabilitation contain provisions inadequate to protect equipment in case of earthquake. Thus it is possible that certain structures in certain critical locations to withstand earthquakes severe without serious damage while existing equipment - "contents" structure to be damaged or totally destroyed (eg tanks under pressure boilers, vessels expansion, existing mechanical equipment in a substation).

The existing urban background can be identified a number of major critical locations (this depends on the size of the area studied) whose running must be maintained both during and after the earthquake, the system must be kept operability.

The experience gained from this study various effects of earthquakes on cities it can be concluded that the loss of system

[1] *Technical University "Gheorghe Asachi"of Iasi , Faculty of Civil Engineering and Building Services, Department of Building Services.*
[2] *Technical University "Gheorghe Asachi"of Iasi , Faculty of Hydrotechnical Engineering Geodesy and Environmental Engineering.*

operability, going out of operation occurs due to seismic five types of interaction:

● the potential impact of the equipment with adjacent structures due to their relative motion during an earthquake;

● downtime structural and demolition of various structural elements across different systems or components of the equipment;

● lack of flexibility in piping systems and the cables attached;

● flooding the system and thus removing it from service because of damage to ponds, tanks and pipelines;

● explosions occurred due to fuel tank damage, ex. gas stations, explosions in turn can damage other locations.

Thus, in a study of vulnerability to earthquakes made in a specific urban area, eg jud. Iaşi, very important is identifying these critical locations as seen may be of structural or nonstructural.

Infrastructure for Spatial Information is a solution used in our country in various situations. Thus, it is useful if Sesma monitoring equipment and utility networks existing in crowded urban areas.

The methodology that will result from the research will allow interested parties access to the establishment of geographical information system and viewing the results estimated damage caused by a possible earthquake.

A component of the National Infrastructure of Spatial information is proper that a sizeable settlements: digital map is the digital cadastre municipality in which they are located all those locations considered critical.

Identification and positioning on maps GIS structural system: hospitals, police etc. Is very important because in case of a seismic event and a disaster in a certain place, it can occur in a relatively short time to save lives human damage and reducing environmental impact.

In this paper we will refer to non-structural elements contained in an urban area, which are highly diversified, comprising utility networks, storage tanks of various types and with different destinations substations.

According to Eurocode 8 these elements can differ greatly between them in terms of features like.

● the nature and quantity of the substances stored and associated risk

● operational requirements during and after the seismic event;

● environment conditions.

To be consistent with the general framework of Eurocodes in this prestandards two limit states are defined as follows:

Serviceability limit state [1] wich depends on the characteristics and importance of the elements considered being necessary to be fulfilled one the conditions of this state: total integrity or maximum operating level.

The condition of "total integrity" implies that the system under consideration (ie. A thermal point - referring strictly to the equipment and existing pipes in it, does not refer to structure) remain sustainable in its entirety and resistant in a seismic event that It has an annual probability of exceeding the prescribed values and whose value will be determined based on the consequences of the loss of system operability.

Requirements "minimum operation" implies that the system under consideration is subject to a certain extent a certain total damage to some of its components, total being calculated loss control, and system capacity can be brought, and system capacity can be brought up to that level predefined operating.

Seismic event for this state limit must not be exceeded to have a value based on losses related to the reduced capacity of the system and final repairs.

Limit state final [1]

According to the same Eurocode final limit state is defined as the corresponding loss of operational capacity of a partial recovery, subject to the amount of repairs that can be accepted.

Of course, there may be some particular system through damage involve risks and maximum possibility is that damage to items listed do not involce risks important,

In the first case, keeping final limit it will be given by the fault, while in the second case will be given by the state of total collapse.

Reference seismic event which should not be exceend state final limit will be set taking into account the direct and indirect losses caused by damaging the system under consideration.

2. Specifications for Pipe Systems

According to Eurocode 8 – section 4 specifications given by the piping systems can be used as a basis for evaluating resistance or increase redundancy required for piping systems.

A pipeline system runs through a broad geographic and subject to various seismic hazards in different soil conditions. In addition, a large number of subsystems may be positioned along the piping system, which can each be associated facilities: tanks, sumps valves, sumps pumps, electro-mechanical equipment.

It is therefore very important to consider the performance of these critical components if a major earthquake that through their downtime
during or post-earthquake does not cause damage.

Given these requirements for differentiation is essential to the rehabilitation of pipeline systems classifications (Eurocode 8).

Class I: performance critical systems whose operation must be uninterrupted. They are essential for the safe operation of certain critical subsystems in case of an earthquake, not to cause major loss of life, to not have a destructive impact on the environment. (Fire fighting facilities, emergency systems communication etc.).

Class II: Systems that must remain operational after the earthquake, but their operation is not necessary during the event. The installations are vital, but interrupting their operation can be done minor repairs which is not supported component installations that would cause great loss of life.

Class III: Installation systems and equipment out of service which may be accepted even for a longer duration to repairs, this does not involve major damage, loss of life.

For all these classes are defined γ_1 important factors for the most common installation systems [1].

Denomination of the table Table 1

Systems installations	***Class***		
	1	***2***	***3***
Systems that circulate cold water, and other agents nontoxic, nonflammable	***1,2***	***1,0***	***0,8***
Fire extinguishing systems, non-volatile and toxic agents petro-chemical processing various agents with low flammability	***1,4***	***1,2***	***1,0***
Technological systems that circulate different volatile chemical agents, explosive liquids and liquids with high flammability	***1,6***	***1,4***	***1,2***

Requirements in normal operation – piping systems must remain functional even under a high-intensity earthquake induces considerable local damage.

Safety requirements - setting the level of protection starts from seismic hazard and seismic risk assessment. A direct hazard associated with rupture of a pipeline under a seismic event is the explosion and fire. Distance apparently subject to location and population impact of such a rupture should be considered in determining the level of protection.

3. Behavior Analysis Pipeline Seismic Event in Case of an Underground

Pipeline networks are very large and complex and should be treated as a whole, it is possible by identifying networks into one global.

Identification can be made from the separation of part of wider (eg.the separation of urban networks) or by separating the networks through the functions performed within the same system (eg. In a network of water there is a greater number of different networks because the functions performed: water network for fire fighting, drinking water network).

This separation allows different treatment to rehabilitate the two systems even if this physical networks each having common elements.

3.1. Seismic actions on underground pipes [1]

Movement of the earth in the event of an earthquake is made of a mixture from which this location depending on the depth of the furnace and its distance from the location studied. Apart from the fact that the waves are different, they have different speeds of propagation. Geophysical studies may provide clues on this, but they are generally not suitable for building a real model, so there were some assumptions on this issue:

(1) considering a simple model of a wave that is the worst for some effec on pipes;
(2) a number of numerical simulations indicate that the inertial forces resulting from soil-pipe interaction are much lower in comparison with the forces induced deformation of the ground: this allows reducing soil-pipe interaction problem to a static problem (ex.-deformation pipeline it is a result of the passage of wave travel without being taken into account the dynamic aspect of the problem);
(3) the forces acting on the pipeline can be obtained in an analysis of "time-history" along which a certain period of time;
(4) a simpler method, accuracy is proven, is that the pipe is supposed flexible enough to track without sliding or soil deformation interaction;

Such ground motion isrepresented by a singlesine wave [1]:

$$u(x,t) = d \sin \omega \left(t - \frac{x}{c} \right) \quad (1)$$

where d – the total amplitude;
c – wave propagation speed.

Under this method the movement of particles is assumed to be along the propagation direction (where compression) and perpendicular to it (where shear) and for simplicity and to consider the worst case, the pipe axis and direction propagation coincide- efforts to produce longitudinal movement in soil particles and the pipe given by the expression:

$$\varepsilon = \frac{\partial u}{\partial x} = -\frac{\omega d}{c} \cos \omega \left(t - \frac{x}{c} \right) \quad (2)$$

where V=ωd it is the maximum ground speed.

- transverse movement of the particles produce a bend in the pipe given by the expression:

$$\chi \frac{\partial^2 u}{\partial x^2} = -\frac{\omega^2 d}{c^2} \sin \omega \left(t - \frac{x}{c} \right) \quad (3)$$

maximum value of wich is:

$$\chi_{\max} = \frac{a}{c^2} \quad (4)$$

with a = ωd – peak ground acceleration.

If the pipe **axis and the direction of wave propagation is not the same** in both cases where efforts are made longitudinal type and angle of curvature due υ format of two directions.

În acest caz eforturile longitudinale sunt:

$$\varepsilon(\upsilon) = \frac{v}{c} f_1(\upsilon) + \frac{a}{c^2} f_2(\upsilon) R \quad (5)$$

Since the second term of the relationship is much lower compared to the first, the maximum amount is:

$$\varepsilon(\upsilon) = \frac{v}{c} \quad (6)$$

Because the connection between the pipe and the soil to be fully satisfied, the friction force available per unit length must balance the variation of the longitudinal force, which leads to:

$$\tau_{av} = sE \frac{a}{c^2} \quad (7)$$

where:

E – modulud of elasticity;

s – pipe thickness;

τ_{av} -the average shear between the ground voltage and the line which depends on the coefficient of friction between the latter and the depth of friction.

A general criterion for minimizing a movement imposed is to introduce the system under maximum flexibility of movement.This can be achieved by:

- decrease depth to reduce constraints burial ground;
- making wide trenches for pipes to be filled with soft material;
- flexible and expandable input elements.

4. Conclusions

In each Member State of the European Community there are a number of critical infrastructures the disruption or destruction would significantly affect the maintenance of vital societal functions, health, safety, security, social welfare and economic persons, would have a significant impact at local, regional and national, as a result of the failure to maintain those functions, and also having similar cross-border effects.These could include cross-sector effects resulting from interdependencies between interconnected infrastructures (ex: out of service a portion of the water supply network would make it impossible to fire disaster intervention, etc.). Reabiliatare implementation of a methodology for the pipeline network to seismic risk by introducing flexible elements is of paramount importance and constitutes the main research direction of the authors.

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