BULETINUL INSTITUTULUI POLITEHNIC DIN IAȘI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iași
Volumul 63 (67), Numărul 1, 2017
Secția
CONSTRUCȚII. ARHITECTURĂ

DYNAMIC ANALYSIS TO THE SEISMIC ACTION OF A BURIED WATER CONVEYANCE STRUCTURES

BY

MIHAI PROFIRE[*] and DANIEL TOMA

“Gheorghe Asachi” Technical University of Iași,
Faculty of Civil Engineering and Building Services

Received: February 28, 2017
Accepted for publication: March 27, 2017

Abstract. Increased operating performance and operability of networks and behavior study assumes vital urban structures buried water conveyance to natural disasters such as earthquakes. In the literature they are formulated various models and calculation methods for determining the response of this kind of structure, dynamics based on continuous media and interaction structure - solid ground. The most common method of analysis offering potential dynamic enough to consideration of cooperation between the massive structure and the surrounding land is finite element method. This paper aims to present a methodology for calculating dynamic seismic action to determine the response of a buried structure, encompassing all computing elements that must be taken into account in its design.

Keywords: critical infrastructures; buried structure; seismic event; pipe.

1. Introduction

At the level of an urban settlement of any kind there are a number of critical infrastructures the disruption or destruction would significantly affect the maintenance of vital social functions and safety (Ancaş & Toma, 2016).

[*]Corresponding author: *e-mail:* profiremihai@yahoo.com

Over the years, emphasis was placed on calculating seismic especially for civil structures. Seismic events around the globe have shown that equally important is the study on the earthquake behavior of buried structures related to a water transport system.

Seismic interaction can be 5 types (Ancaş & Toma, 2016) of which we mention in this article structural inoperative due to total or partial destruction of a structure buried.

These structures along with other related infrastructure facilities were classified as critical to an urban structures in case of a seismic event (Ancaş & Atanasiu, 2011).

Exiting the operation of such structures, which can be considered a critical urban system leads to weak functioning horizontally other vital systems needed to save lives and reduce damage to property in case of an earthquake (Ancaş & Doniga, 2006).

Any condition leading cause mechanical strain in a structure constitutes an action. An action is classified as exceptional actions seismic action. STAS 10101/0A shares outstanding occur very rarely or never at considerable intensity in the life of a building.

Effort and strain states are considered on the basis of calculation of the intensity of the shares.

Seismic action coefficient (normal load multiplier coefficients) recommended by Romanian prescriptions is 1.00.

Seismic action fits into a special group actions in dynamical and analyzed taking into account:

a) earth action: depending on the intensity seismic pressures will define the vertical and horizontal;

b) water action: hydrodynamic pressures will define where free level structures, pressure pipes under pressure, the effect of seismic wave propagation along the structure.

A more exact intensity actions is still difficult due to numerous parameters evaluated incompletely entering the modeling phenomenon.

The questions posed and still could not fully answer are (Furis, 2012):

1º What is the law of distribution of the action on the surface structure of the earth?

2º How are transmitted loads acting on the structure of the land?

3º What would be a suitable model describing the interaction structure-earth?

Currently calculation relations used are based on experimental results obtained in the laboratory and findings of the practical application.

2. Evaluation of Seismic Action on a Buried Water Conveyance Structures

The answer seismic action on such a structure is a direct result of massive earth-structure interaction. The dynamic analysis is made on the cross section of the pipe in the horizontal and vertical seismic waves and seismic action on the asynchronous longitudinal direction along the axis of the structure.

A methodology for calculating dynamic enough to provide opportunities to consider as correct cooperation structure-solid earth is finite element method (MEF).

If a structure of water high flow (Q > 1 m^3/s) calculation model applies applies cross-section (Fig. 1) and implies inclusion in the structure meshing part enough of the massive land incorporating structure so that its boundary conditions do not influence the efforts of state structure.

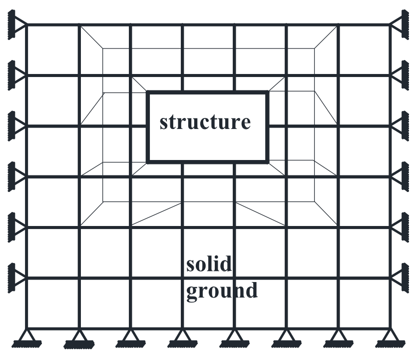

Fig. 1 – Model analysis using MEF.

The equation of motion has the form:

$$[M]\{\ddot{\delta}\}+[C]\{\dot{\delta}\}+[K]\{\delta\}=-[M]\{r\}i, \qquad (1)$$

where: $[M]$ is the equivalent matrix arrays; $\{\ddot{\delta}\}$– vector accelerations; $[C]$ – damping matrix; $\{\dot{\delta}\}$ – vector velocity; $[K]$ – stiffness matrix; $\{\delta\}$ – vector travel; $\{r\}$ – versor earthquake directions projections degrees of freedom; i – earthquake accelelogram.

Eq. (1) is written as a system of second order differential equations with respect to time, relatively easy to solve. Approximate results obtained into practice, have shown that their accuracy depends on:

a) How to mesh and its step;

b) Surface Meshing;

c) Boundary conditions;

d) How deep seismic action;

e) The correctness of matrix rigidity and damping.

The system solution is unique because the frequencies and their corresponding forms massive earth-unitary system structure, they vary depending on the model size.

3. Determination of Earth Pressure Data in Dynamic Conditions

3.1. The Rigid Structure

Vertical load value is calculated using the formula:

$$p = p^n (1 \pm 1.5K), \qquad (2)$$

where: p is the vertical earth pressure in dynamic conditions; p^n – vertical earth pressure, in static conditions; K – seismic coefficient according P100-92.

3.2. Due to Displacement Walls of the Structure Develops Horizontal Seismic Earth Pressures

Horizontal loading is symmetrical because after a certain time an active wall will withstand increased pressure and other massive reaction.

To determine active and reactive pressures caused by seismic movement there following concepts:

a) internal friction angle of the earth changes the value θ = arctg K;

b) depth during growth, internal friction angle increases to a certain value and then remains constant.

3.3. Determine the Effects of Seismic Motion in the Horizontal Direction

In this case it is considered as the medium of propagation of seismic waves both land and water transport structure for water.

Propagation velocities of seismic waves can be considered as Table 1 (Furis, 2012).

Table 1
Propagation Velocities of Seismic Waves

Propagation environment	Velocity of propagation(m/s)
Water	1,500
Weak soil (sandy clays, sands)	200,...,500
Soils medium strength	500,...,1,000
Soils with high resistance	1,000,...,3,500
Hard rocks	3,500,...,5,000

Seismic displacement function $u(x, t)$ is a harmonic function and calling the Euler equations can determine:

1º Overpressure seismic motion uniformly applied on the inner contour:

$$p_{\max} = \frac{K}{2\pi}\gamma_a v T, \tag{3}$$

where: K is the seismic coefficient according P100-92; γ_a – the specific gravity of wateri; v – propagation velocity of seismic waves; T – vibration period, 0.2,...,0.3 s.

2º Longitudinal tensile stresses (tensile/compression):

$$\tau_{\max} = \pm\frac{g}{2\pi}K\frac{E}{v}T, \tag{4}$$

where: E is the modulus of elasticity for the pipe material; g – acceleration due to gravity.

Structures operating pressure when assessed values overpressure during a seismic event can conclude that they grow with the modulus of elasticity and under an earthquake of medium intensity, high resistances capable of materials can be overcome and failures occur, so the corresponding longitudinal reinforcement is required

4. Conclusions

Shares exceptional type earthquake may occur during the lifetime of a structure once, several times or not at all. Finite Element Method is a method that leads to satisfactory results in the dynamic analysis of a structure buried water conveyance provided that the calculation model takes into account the structure due to the massive pressures on land and the effects of seismic motion in the horizontal direction.

REFERENCES

Ancaş A.D., Toma D., Profire M, *Vulnerability of Seismic Equipment*, Proc. of the Internat. Scientific Conf., CIBV 2016, Braşov, Romania, 241-247.

Ancaş A.D., Atanasiu M.G., *Seismic Risk Management Considering the Urban Lifeline Existing System*, Proc. of the 6 th Internat. Conf. on Business Excellence, ICBE 2011, Braşov, Romania, 20-23.

Ancaş A.D., Doniga C.,Atanasiu G.M., *Current State of the Art for Existing Critical Systems in Urban Seismic Area*, Bul. Inst. Polit. Iaşi, **LII**(**LVI**), *1-2*, s. Construct., Aritect., 39-48 (2006).

Furis D., Teodorescu M.E., Sorohan Lucian., *Calculul structurilor pentru transportul apei*, Ed. Conspress, Bucureşti, 58, 2012.

ANALIZA DINAMICĂ LA ACȚIUNE SEISMICĂ A UNEI STRUCTURI ÎNGROPATE PENTRU TRANSPORTUL APEI

(Rezumat)

Creşterea performanțelor de funcționare şi operabilitate a rețelelor urbane vitale presupune şi studiul comportării structurilor îngropate pentru transportul apei, la dezastre naturale de tipul cutremurelor de pământ.

În literatura de specialitate sunt formulate diverse modele şi metode de calcul pentru determinarea răspunsului acestui gen de structuri, bazate pe dinamica mediilor continue şi a interacțiunii structură – masiv de pământ. Cea mai utilizată metodă dinamică de analiză care oferă posibilități destul de mari pentru luarea în considerare a conlucrării între structură şi masivul de pământ înconjurător, este metoda elementelor finite.

Lucrarea de față doreşte să prezinte o metodologie de calcul dinamic la acțiune seismică, pentru determinarea răspunsului la astfel de acțiuni a unei structuri îngropate, care să cuprindă toate elementele de calcul de care trebuie să se țină cont în proiectarea acesteia.