FREQUENCY L_2 ANALYSIS OF THE NATIONAL NEURAL NETWORK FOR PROTECTION OF BUILDINGS AND FACILITIES FROM SEISMIC AND WIND LOADINGS

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ЧЕСТОТЕН АНАЛИЗ В L_2 НА НАЦИОНАЛНАТА НЕВРОНА МРЕЖА ЗА ЗАЩИТА НА СГРАДИ И СЪОРЪЖЕНИЯ СРЕЩУ СЕИЗМИЧНИ И ВЕТРОВИ НАТОВРВАНИЯ

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Резюме. *Разработката комбинира системи за активен и пасивен контрол на динамичния отговор на сгради и инженерни конструкции. В АКТИВНАТА ВЕРСИЯ на изследването, сеизмично уязвими (от 3 до 16 етажа) и ветрови (над 16 етажа) сгради с функциониращи асансьори са обединени в невронна мрежа. Основните обекти – СЕНЗОРИ и ИНЕРИЦИАЛНИ ДВИГАТЕЛИ на активните системи за управление, са разположени в асансьорните шахти на сградата (поне четири копланарни двигателя в горната част на ВСЯКА асансьорна шахта на предложената невронна мрежа, съгласно Фигура 5). Съответно на предварително изготвен инженерен проект за асансьори за ВСЯКА СГРАДА, 3D акселерометри са поставени във основите на асансьорните шахти и в горната част на асансьорните шахти. Инерционните двигатели са поставени в горната част на асансьорната шахта и на допълнителни места върху покривната конструкция (ако е необходимо по изчисления). Акселерометрите и двигателите са елементи на невронната мрежа и за всяка асансьорна шахта те образуват ВЪЗЕЛ на мрежата (съгласно предварителните условия на Теорема 8 от изследването).*

Introduction

The development combines systems for active and passive control of the dynamic response of buildings and engineering structures. In the **ACTIVE VERSION** of the study, seismically vulnerable (from 3 to 16 floors) and wind-vulnerable (over 16 floors) buildings with functioning elevators are combined into a **Neural Network**. The main objects – **SENSORS** and **INERTIAL ENGINES** of the active control systems are situated in the building elevator shafts (at least four coplanar motors at the top of the **EACH** elevator shaft of the prosed Neural Network in accordance to Figure 5.) Respectively to a previously prepared elevator engineering project for **EACH BUILDING**, 3D accelerometers are placed in the foundation of the elevator shafts and at the top of elevator shafts. The Inertial motors are placed at the top of the elevator shaft and at additional locations on the roof structure (if it is necessary by calculations). The accelerometers and motors are elements of the Neural Network, and for each elevator shaft they forms a **NODE** of the network (according the Prerequisites conditions of Theorem 8 of the study).

Unfavorable conditions. Under certain unfavorable conditions (according to the classical theory of probabilities and catastrophes at least three in number):

Unfavorable Condition 1) Earthquake with a magnitude above 6 on the Richter scale,

Unfavorable Condition 2) Coincidence and resonance between the frequency parameters of the facilities and external dynamic loads,

Unfavorable Condition 3) Duration of damage (dynamic loads exceeding certain critical values - see Figure 10 - line number 600 of the study). The damping matrix [C_{yy}] in equation (2) plays an important role in automatic control theory**.**

The Neural Network produces control effects with the same characteristics as the external harmful dynamic effects, but with an **INVERTED SIGN**. This guarantees the **INDESTRUCTIBILITY of ALL NODES** of the neural network, which can be **TRIGGERED** by early warning system or systems. A theorem on the **INDESTRUCTIBILITY** of the nodes of the Neural Network has been proven. This ensures that there will be no casualties in the buildings covered by the Neural Network for any earthquake, any frequency composition of the signals, and any duration of the seismic or wind signals. It is obvious that, in the massive buildings of the construction infrastructure in modern urban agglomerations, there are buildings of the most different origin and quality. The neural network guarantees the absence of victims from harmful dynamic effects regardless of the qualities of the building infrastructure. The main goal of the research is to build such a neural network that does not allow the destruction of nodes under arbitrary earthquake loads (arbitrary magnitude, arbitrary frequency composition of the signals, arbitrary duration). The indestructibility of neural network nodes is guaranteed by the following theorems. The Theorem 8 is the focus of the study.

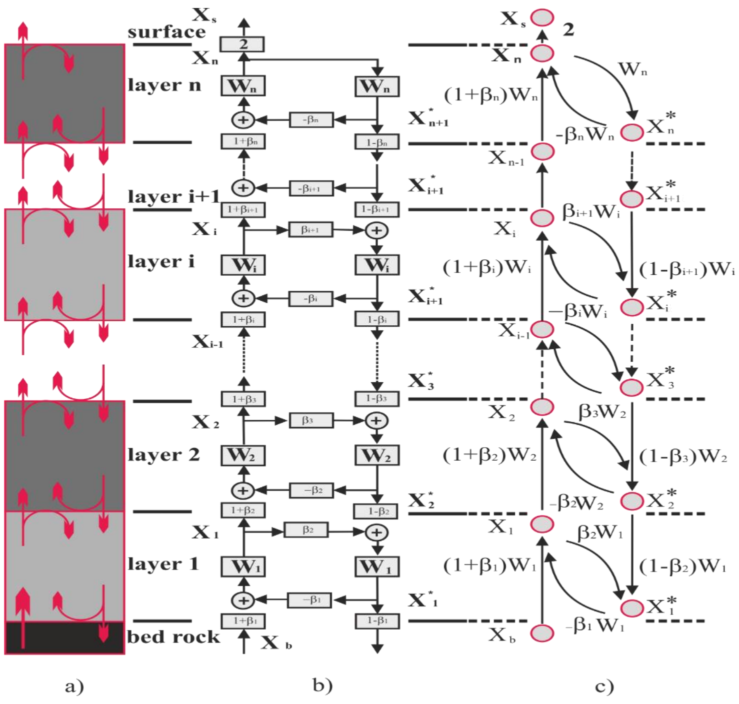

Fig. 1. Structural model of a multilayer media.
a) Reflection - Refraction process for the SH wave; b) Block diagram; c) Signal - flowchart graph

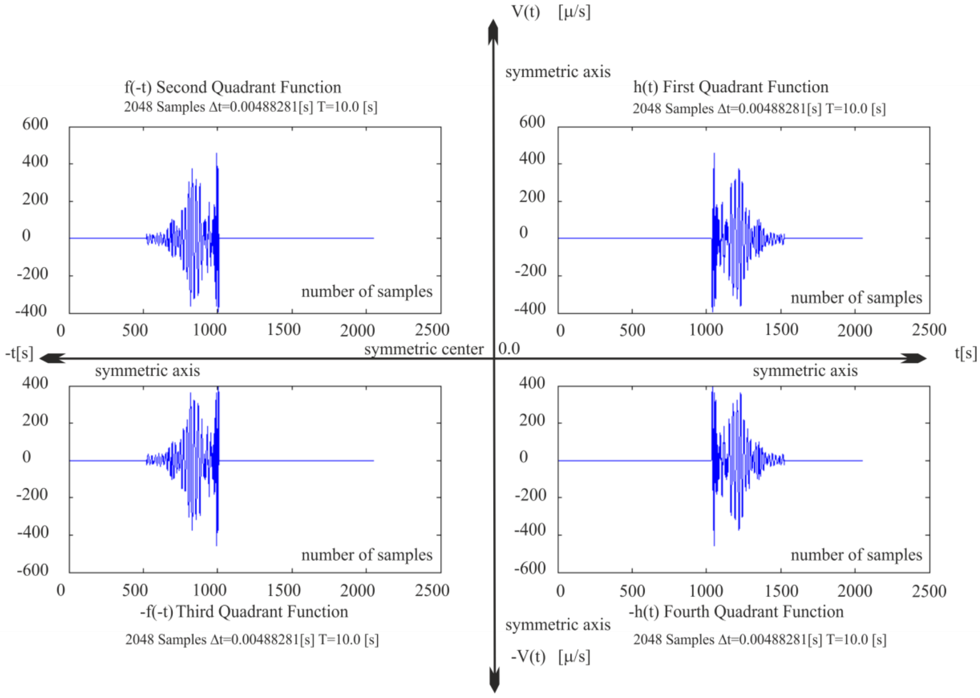

Fig. 2. Quadruple symmetric real functions – for example velocity of particles of the medium V(t) [μ/s] from Fig. 1

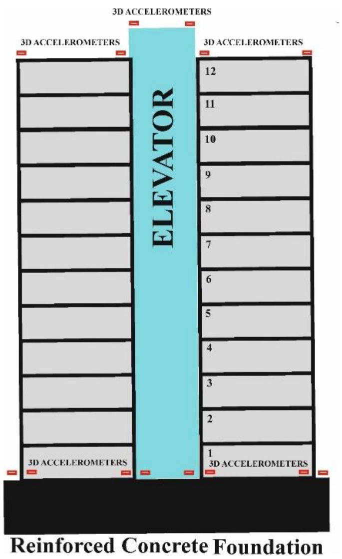

Fig. 3. Structure with 3D Accelerometers

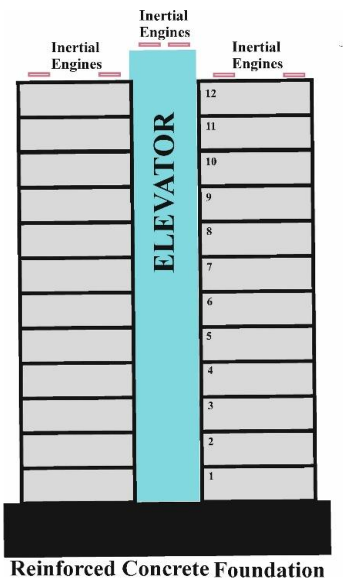

Fig. 4. Structure with Inertial Engines

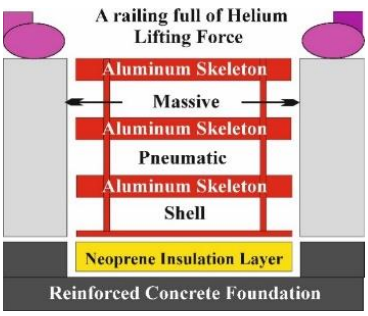

Fig. 5. System with active control of the dynamical reaction

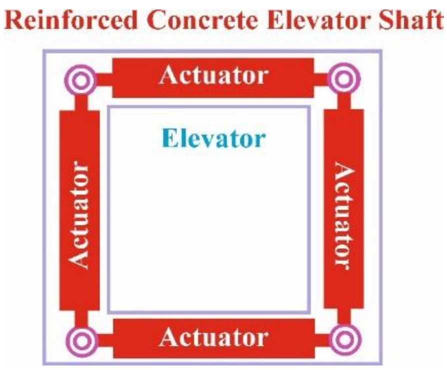

Fig. 6. System with passive contro of the dynamical reaction

Aluminum skeleton and Massive Pneumatic Shell

Development unites dynamically vulnerable (seismically vulnerable from 3 to 16 floors and wind vulnerable over 16 floors) buildings and facilities in which there are functioning elevator devices. The union is in Neural Network. Elevator shafts are the main element of active control in case of harmful external dynamic effects of seismic and wind nature. In Figure 5. inertial motors mounted on top of the elevator shaft are shown. If necessary according to an individual project to control the dynamic behavior of the building, additional inertial motors are placed on the roof of the building. Figure 6. illustrates a variant of the system with passive dynamic response control. Figure 3. shows the distribution of 3D accelerometers of an example elevator shaft in case of active control of the system. Figure 4. illustrates an example distribution of the Inertial Motors of an example building with 12 floors in an active control variant. Figure 1. It illustrates a structural model of a multilayered environment under the foundation of the example building with active management, and Figure 2. shows an example view of Quadruple symmetric real functions - medium particle velocity V(t) [μ/s].

Frequency Analysis for Arbitrary Real Functions from L_2. [1, 2, 3, 4, 5]

• **Theorem 1.** (The phenomenon “Symmetry” in the time domain corresponds to the phenomenon “Conjugation” in the frequency domain). The complex Fourier F(jω) spectra of the symmetric real functions in the first and second quadrants are conjugated as well as.

• **Theorem 2.** The complex Fourier F(jω) spectra of the symmetric real functions in the third and fourth quadrants are conjugated respectively.

• **Theorem 3** (The phenomenon “Anti Symmetry” in the time domain corresponds to the phenomenon “Anti Conjugation” in the frequency domain). The complex Fourier F(jω) spectra of the anti symmetric real functions in the first and third quadrant are anti conjugated as well as.

• **Theorem 4.** The amplitudes of the functions in first and second quadrants are both positive, while these of the amplitudes for the functions for third and four quadrants are both negative. The functions under investigation could be of arbitrary amplitudes – negative or positive. The corresponding complex Fourier F(jω) spectra also are of arbitrary type amplitudes – negative or positive.

• **Theorem 5.** (Frequency indistinguishable). Four quadruple symmetric real functions are frequency indistinguishable.

Theorems from 1 to 5 are presented in: [2] [Jivkov Venelin, Philip Philipoff, Anastas Ivanov, Mario Muñoz, Galerida Raikova, Mikhail Tatur, Philip Michaylov, (2013), “Spectral properties of quadruple symmetric real functions”, Applied Mathematics and Computation – Elsevier, impact factor = 1, impact factor = 1,766, 221 (2013) 344–350].

• **Theorem 6.** [6.1. Venelin Jivkov, Philip Philipoff, (2016), Quadruple Symmetric Real Signals Spectral Even and Odd Decomposition, Building Materials and Structures, UDK: 624.9.042.7, 699.841, doi: 10.5937/grmk1603003M, N3 2016, (in English), Jivkov, V., Philipoff, Ph., Quadruple Symmetric Real Signals Spectral Even and Odd Decomposition, Building materials and structures 59 (2016) 3 (63-77), ISSN 2217-8139 (Print) ISSN 2334-0229 (Online), UDK: 06.055.2:62-03+620.1+624.001.5(497.1) = 861 https://www.researchgate.net/publication/311340555_Quadruple_symmetric_real_signals_spectral_even_and_odd_decomposition ;
6.2. Венелин Живков, Симеон Панев, Филип Филипов, (2020), Разпространение на вълни в ограничени и неограничени пространства (Wave propagation in limited and unlimited spaces), “СОФТТРАДЕ“, ISBN 978-954-334-341-9, (in Bulgarian)]

The phenomenon “Symmetry” in the time domain corresponds to the phenomenon “Conjugation” in the frequency domain. The phenomenon “Anti Symmetry” in the time domain corresponds to the phenomenon “Anti Conjugation” in the frequency domain. The simultaneous operation of the Theorems 1 and 3 leads to even and odd decomposition of the Fourier complex spectrum of the common function $F^{common\ function}(j\omega)$ with length N in the time domain. This result represents spectral function, composed by the equivalent nonzero real and imaginary spectral parts with length N/2 in the frequency domain $R_{e}^{even\ left}(\omega)$ and $jI_{m}^{odd\ right}(\omega)$) as follows:

$$(F^{common\ function}(j\omega) = \ 2\left(R_{e}^{even\ left}(\omega) + jI_{m}^{odd\ right}(\omega)\right) \quad (1)$$

- **Theorem 7. Damping of structures in the finite element method. (Global damping matrix [C] of the finite element models by FEM).**

If in mechanical systems the frequency equation f(ω)=0 allows only SINGLE (unit) roots $0<\omega_1<\omega_2<\ldots<\omega_k<\ldots<\omega_n$, (single own frequencies, Eigen values), it than the matrix

$$[\mathrm{W}(\omega_1, \omega_2, \ldots, \omega_k, \ldots \omega_n)] = \begin{bmatrix} \omega_1 & \omega_1^3 & \omega_1^5 & \cdots & \omega_1^{2n-1} \\ \omega_2 & \omega_2^3 & \omega_2^5 & \cdots & \omega_2^{2n-1} \\ \omega_3 & \omega_3^3 & \omega_3^5 & \cdots & \omega_3^{2n-1} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \omega_n & \omega_n^3 & \omega_n^5 & \cdots & \omega_n^{2n-1} \end{bmatrix} =$$

$$= \omega_1 \omega_2 \ldots \omega_n \begin{bmatrix} 1 & \omega_1^2 & \omega_1^4 & \cdots & \omega_1^{2n-2} \\ 1 & \omega_2^2 & \omega_2^4 & \cdots & \omega_2^{2n-2} \\ 1 & \omega_3^2 & \omega_3^4 & \cdots & \omega_3^{2n-2} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & \omega_n^2 & \omega_n^4 & \cdots & \omega_n^{2n-2} \end{bmatrix} \qquad \text{(a1)}$$

is POSITIVE DEFINITE $detW(\omega) > 0.$ The linear algebraic system of equations constructed using the matrix [W]:

$$\{\xi\} = [W]\{a\} \qquad \text{(b2)}$$

connects the diagonal damping matrix of the finite element model $\{\xi\}$ with the unknown principal coordinates $\{a\}$ in the formula for constructing the global attenuation matrix **, [**Tceitlin A.I., Kusainov A.A. Internal Rubbing Methods for Dynamic Structure Design. —Alma-Ata: Nauka, 1987 (in Russian)**]:**

$$[C] = [M] \textstyle\sum_i a_i \left([M]^{-1}[K]\right)^i \qquad \text{(c3)}$$

(For example in formula (2) this is the matrix $[C_{yy}]$)

Indestructibility of the neural network's branches.

- **Theorem 8.** [Indestructibility of the neural network's branches.] The necessary and sufficient conditions for the indestructibility of the neural network's branches are:

A (The Kinetic energy of the Network) The velocities of each of the network nodes during dynamic impacts **TENDS** to **ZERO,** and

B (The Total Potential Energy of Deformations of the Network) The total potential energy of deformations of all nodes of the Network during dynamic impacts **TENDS** to a **MINIMUM**.

Conclusions

Theorems 1 – 8 forms the frequency conditions for creating of frequency analysis in space l_2 of national neural network for protection of buildings and facilities from seismic and wind loadings.

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References:

1. Ph. Philipoff, Ph. Michaylov, (2007), BELENE Nuclear Power Plant Numerical and Experimental Bedrock, Layers and Surface Signals, J. Applied Mathematical Modelling, Elsevier, impact factor = 4,4, Volume 31, Issue 9, September 2007, Pages 1889–1898 (in English)
2. Philipoff, Ph., D. Demirev, A. Yusuf, M. Islam, D.Stankov, D.Bankova, Ph. Michaylov, (2010), Some Psychology and Technical Aspects of a Rescue Operation in the Musala Peak Region (Rila Mountain), Procedia Social and Behavioral Sciences, Elsevier, WCPCG-2010. http://www.sciencedirect.com/science/article/pii/S1877042810014837

3, Jivkov Venelin, Philip Philipoff, Anastas Ivanov, Mario Muñoz, Galerida Raikova, Mikhail Tatur, Philip Michaylov, (2013), Spectral properties of quadruple symmetric real functions, Applied Mathematics and Computation – Elsevier, impact factor = 1, impact factor = 1,766, 221 (2013) 344–350.

4. Venelin Jivkov, Philip Philipoff, (2016), Quadruple Symmetric Real Signals Spectral Even and Odd Decomposition, Building Materials and Structures, UDK: 624.9.042.7, 699.841, doi: 10.5937/grmk1603003M, N3 2016, (in English), Jivkov, V., Philipoff, Ph., Quadruple Symmetric Real Signals Spectral Even and Odd Decomposition, Building materials and structures 59 (2016) 3 (63-77), ISSN 2217-8139 (Print) ISSN 2334-0229 (Online), UDK: 06.055.2:62-03+620.1+624.001.5(497.1) = 861 https://www.researchgate.net/publication/311340555_Quadruple_symmetric_real_signals_spectral_even_and_odd_decomposition
5. Venkatanathan Natarajan, Philip Philipoff, (2018), Observation of surface and atmospheric parameters using ''NOAA 18'' satellite: a study on earthquakes of Sumatra and Nicobar Is regions for the year 2014 (M > 6.0), Natural Hazards Volume 92, Issue 2, 1 June 2018, Pages 1097-1112 Springer Science+Business Media B.V., part of Springer Nature 2018, Received: 7 May 2015 / Accepted: 22 February 2018, Impact factor = 2.427.