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THREE MODERN STRATEGES FOR PROTECTION OF BUILDING STRUCTURES AGAINST EARTHQUAKES

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Key words: *Natural hazards; Transport crashes; Industrial accidents: Insurance approach.*

Abstract: *The main natural hazard, that is addressed in the report, are the strong earthquakes and the transport crashes over large scale bridges. Three main strategies to protect the buildings, the engineering structures and the infrastructure against strong motion earthquakes are developed in the report. The first strategy to protect buildings from earthquakes is to the development of facilities with passive or active management of the dynamical structural response. The active control approach is applied for protection of nuclear power plants facilities or protection of large scale bridges. Other strategy to protection buildings and human life is to develop earthquake forecasting theory and practice. Modern satellite technologies are used. Efforts are focused on studying changes in the ionosphere, underwater currents in the ocean, tides, electromagnetic emissions, thermal anomalies before the onset of severe earthquakes. The tired protection of buildings strategy against strong ground motions (earthquakes) is connected with insurance technologies. Assurance technologies are available for recovering buildings and facilities in the event of strong earthquakes.*

ТРИ СЪВРЕМЕННИ СТРАТЕГИИ ЗА ЗАЩИТА НА СГРАДИТЕ И СЪОРЪЖЕНИЯ СРЕЩУ ЗЕМЕТРЕСЕНИЯ

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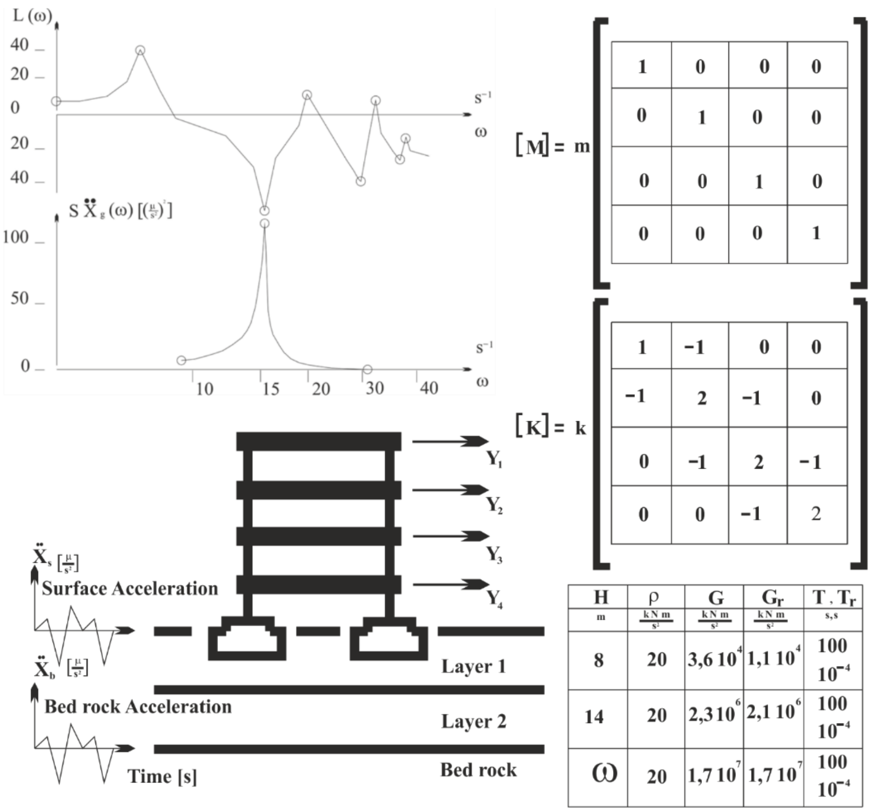
Ключови думи: *Природни бедствия; Транспортни катастрофи; Промишлени аварии; Застрахователни технологии.*

Резюме: *В доклада се разглежда риска от природни бедствия. Разработени са три основни стратегии за защита на сградите, инженерните съоръжения и инфраструктурата срещу силни земетресения. Първата стратегия за защита на сгради от земетресения е разработването на съоръжения с пасивно или активно управление на динамичната структурна реакция. Активният подход за контрол се прилага за защита на ядрени електроцентрали или за защита на мащабни мостове. Друга стратегия за защита на сградите и човешкия живот е разработването на теория и практика за прогнозиране на земетресения. Използват се модерни спътникови технологии. Усилията са насочени към изучаване на промените в йоносферата, подводните течения в океана, приливите, електромагнитните излъчвания, топлинните аномалии преди появата на силни земетресения. Третата стратегия за защита на сградите срещу силни земни движения (земетресения) е свързана със застрахователните технологии. Осигурителни технологии са насочени към възстановяване на сгради и съоръжения в случай на силни земетресения.*

1. Introduction - Passive or active control of the dynamical structural response. System shown in the Fig.1 illustrate passive control idea solution. Principle scheme of the active control system is shown on the Fig. 2.



$$[M] = m\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$[K] = k\begin{bmatrix} 1 & -1 & 0 & 0 \\ -1 & 2 & -1 & 0 \\ 0 & -1 & 2 & -1 \\ 0 & 0 & -1 & 2 \end{bmatrix}$$

H	ρ	G	G_r	T , T_r
m	$\frac{kN\,m}{s^2}$	$\frac{kN\,m}{s^2}$	$\frac{kN\,m}{s^2}$	s,s
8	20	$3,6\,10^4$	$1,1\,10^4$	100 10^{-4}
14	20	$2,3\,10^6$	$2,1\,10^6$	100 10^{-4}
ω	20	$1,7\,10^7$	$1,7\,10^7$	100 10^{-4}

Fig. 1. Passive control of the dynamical structural response – idea solution

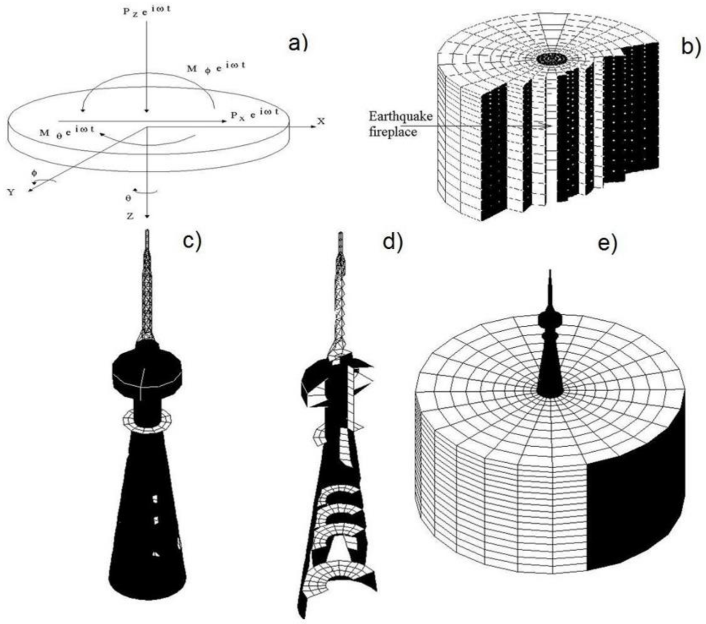
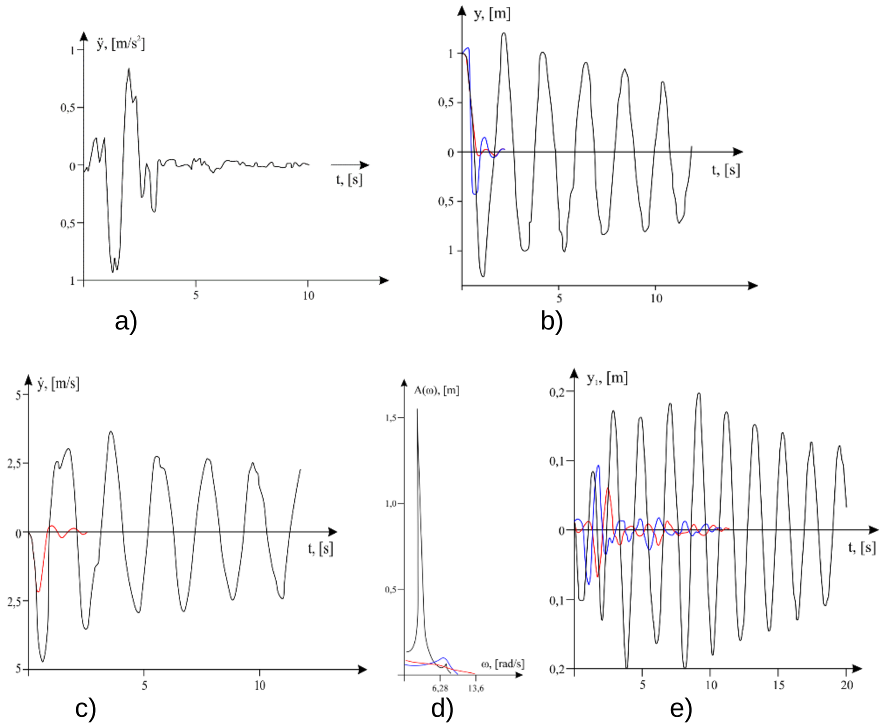


Fig. 2. Active control of the dynamical structural response – idea solution



a) b)

c) d) e)

Fig. 3. Numerical results of the tower shown in Fig. 2:
a) Acceleration of the tower base. b) Displacement of the steel antenna carrier – Active control of control - free oscillating antenna carrier. c) Antenna carrier active control velocity. d) System amplitude – frequency function e) Antenna carrier (pulse and optimal) active control – displacements.

Fig. 3. illustrate numerical results for the antenna carrier – tower system shown in the Fig.2. This picture (Fig.3) shows the great potential of the active control strategy.

2. Risk management of natural disasters, transport crashes and industrial accidents. July 2018 Greece was declared a national mourning for the fallen citizens in the great fires. 24 July 2018 an innocent man was shot in the center of Sofia. 14 August 2018, 12 o'clock, the Central part of the Viaduct Morandy Genoa-Italy is collapsed. 43 people are killed. Declared national mourning. 25 August 2018 17 people were killed in a motorway accident: Svoge-Bulgaria. Announced national mourning. At first glance, between these tragic events there is no connection. But that's only at first glance. All the tragic accidents quoted and many other tragic examples can be studied and connected in logic a scientific field with the most common name: Risk management of natural disasters, transport crashes and industrial accidents. Fig. 4 shows other example of automatic controlled system of dynamic response.

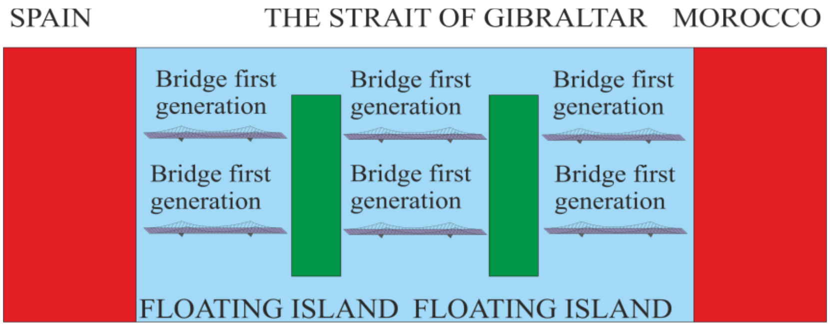


Fig. 4. Large Scale Bridge over the Gibraltar Strait with automatic controlled system of dynamic response

Matrix Equation of Motion (MEM) for automatically controlled system could be transformed into a form, which also takes account of the external loadings and the control impacts:

$$[M_{yy}]\{\ddot{Y}\}+[C_{yy}]\{\dot{Y}\}+[K_{yy}]\{Y\}=[M_{yx}]\{\ddot{X}\}+[C_{yx}]\{\dot{X}\}+[K_{yx}]\{X\}+[D]\{U\} \tag{1}$$

Here **D** represents the unknown control distribution matrix and **U** represents the unknown control impact vector. Equation (g) can be written in the form of state equation mode for describing the dynamical system. If introduced the state equation vector $\{Z\} = \{Y^T \dot{Y}^T\}^T$ and canonical state equation matrices and vectors **A, B** and **F,** than equation (g) becomes:

$$(2) \qquad \{\dot{Z}\} = [A]\{Z\} + [B]\{U\} + [F]\{Z_{input}\}$$

The canonical state equation matrices and vectors could be written as follows:

$$[A] = \begin{bmatrix} 0 & [In] \\ -[M]^{-1}[K] & -[M]^{-1}[C] \end{bmatrix},$$

$$[B] = \begin{bmatrix} 0 \\ \hline -[M]^{-1}[D] \end{bmatrix}$$

$$[F] = \begin{bmatrix} 0 \\ \hline [M_{yx}]\{\ddot{X}\} + [C_{yx}]\{\dot{X}\} + [K_{yx}]\{X\} \end{bmatrix},$$

$$(3) \qquad [Z] = \begin{bmatrix} Y \\ \hline \dot{Y} \end{bmatrix}$$

Unknown values of the terms of **B** and the signals of the control vector **U** can be obtained by minimization of the dynamical system quadratic criterion (2.4) of the quality **J:**

$$(4) \qquad \boldsymbol{J = \int_0^{\infty} [\{Z(t)\}^T [Q] \{Z(t)\} + \{u(t)\}^T [R] \{u(t)\}]\, dt}$$

Here **Q** is the state equation parameters matrix and **R** is the energy matrix.

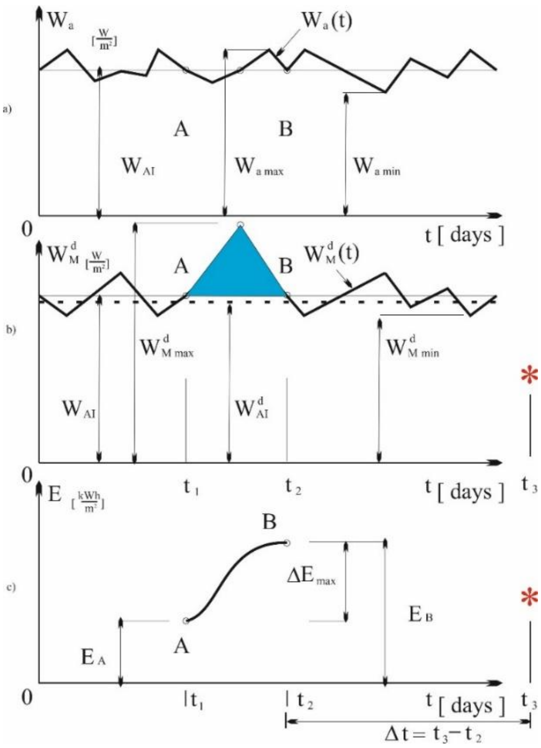
Next Fig. 5 illustrate second strategy to protection buildings and human life consists of developing earthquake forecasting theory and practice [1].

	Time	$\Delta_{N[-]}$	$\Delta_{d[-]}$	ΔE_{max}	Δt days	M	W	H	Latitude	Longitude	Place
1	28.03.99	0,150	0,337	4,42	12	6,6	244	15	30,512	79,403	Uharanchal India
2	28.10.05	0,080	0,430	3,47	25	7,6	238	26	34,539	73,588	Indo-Pakistan border
3	21.09.09	0,080	0,147	5,20	06	6,1	252	14	27,332	91,437	Bhrtan
4	18.09.11	0,080	0,156	4,80	04	6,9	262	50	27,730	88,155	Sikkim-India
5	25.04.15	0,154	0,259	3,11	23	7,8	260	8,22	28,230	84,713	Lanying Nepal
6	12.05.15	0,136	0,344	5,25	31	7,3	257	15	27,808	86,065	Kodari Nepal
7	16.09.15	0,135	0,512	4,10	10	8,3	210	22,4	-32,56	-70,00	Chily
8	15.04.16	0,220	0,480	4,20	31	7,0	265	10	32,050	132,01	Kumamato-Shi Japan
9	16.0416	0,163	0,634	9,00	16	7,8	218	19	79,900	0,37	Equador
10	28.04.16	0,107	0,202	2,00	03	7,0	280	27	-16,07	167,39	Vanuato

Fig. 5 (Table). Earthquake prediction results received by the authors

Modern satellite technologies are used in this theory. Efforts are focused on studying changes in the ionosphere, underwater currents in the ocean, tides, electromagnetic emissions, thermal anomalies before the onset of severe earthquakes.

Figure 6. Principal OLR signals before a) and after b) a big earthquake (descriptions are according to chapter 2 Nomenclature, c) Change of energy $\Delta\, E_{max}$



On the Fig. 6, a, b, are shown examples of variations of OLR signals. One of the figures represents variations of OLR signal WITHOUT any seismic phenomena for a two- year long period for the specific place on Earth with geographical coordinates – Latitude and Longitude. The other figure represents the OLR signal for the same place of the Earth with the same geographical coordinates, but for a time period of one year WITH occurrence of big seismic phenomena. The minimum and maximum values are as follows: W_{amin}, W_{amax} , W^d_{Mmin}, W^d_{Mmax} and the average integral values are as follows:

$$(5) \qquad W_{AI} = \frac{1}{T}\int_0^T W_a\ (t)\, dt \quad and \quad W^d_{AI} = \frac{1}{T}\int_0^T \ W^d_M(t)\, dt$$

These are exhibited in the two figures. Extensive analysis (hundred occurred earthquakes with M > 6) shows that the difference between the average integral OLR signal values and the arithmetical average values is less than 5%. This statement gives reason to accept:

$$(6) \qquad W_{AI} \approx \frac{1}{2}\,(W_{amin} + W_{amax}) \;\; and \;\; W^d_{AI} \approx \frac{1}{2}\,\left(W^d_{Mmin} + W^d_{Mmax}\right)$$

The variation of the energy of the OLR signal in the time interval $h = t_1 - t_2$ is shown in the figure 1 (c) where the variation ΔE_{max} is most significant. The points A and B match aligned values of:

$$(7) \qquad W^d_M\ (t_1) \equiv W_{AI}\, hence \;\; W^d_M(t_1) \equiv W^d_M(t_2) \equiv W_{AI}$$

The largest amount of change of energy $\Delta\, E_{max}$ in a year with an earthquake is determined by the expression:

$$(8) \qquad \Delta\, E_{max} = \int_{t_1}^{t_2} \ W^d_M(t)\, dt \, - W_{AI}\ (t_2 - t_1) \ \left[\frac{kWh}{m^2}\right]$$

The extent of variation of the radiation during the period of two years without any cataclysms is $\delta_N[-]$:

$$(9) \qquad \delta_N = \frac{W_{amax} - W_{amin}}{W_{AI}} \approx 2\,\frac{W_{amax} - W_{amin}}{W_{amax} + W_{amin}}\ ,$$

and the extent of variation of the radiation during the period with cataclysms is $\delta_d[-]$:

$$(10) \qquad \delta_d = \frac{W^d_{Mmax} - W^d_{Mmin}}{W^d_{AI}} \approx 2\,\frac{W^d_{Mmax} - W^d_{Mmin}}{W^d_{Mmax} + W^d_{Mmin}}\ ,$$

which are additional criteria for earthquake forecast. On the Fig. 6 (b) and (c) with star is marked the earthquake occurrence at time point t_3 .

Fig. 6. Viaduct Morandy in Genova-Italy after the crash - Genova

Fig. 7. Central part of crashed Viaduct Morandy

Fig. 8. Crash in motorway near Svoge – Bulgaria

424
25.07.18

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Уважаеми проф. Борисов,

СТРУКТУРНИ МЕТОДИ ЗА РЕШАВАНЕ НА НЯКОИ
ВЪЛНОВИ ГРАНИЧНИ ЗАДАЧИ

УПРАВЛЕНИЕ НА РИСКА ОТ ПРИРОДНИ БЕДСТВИЯ, ТРАНСПОРТНИ
ПРОИЗШЕСТВИЯ И ПРОМИШЛЕНИ АВАРИИ

София 25 юни 2018

С уважение:
Филип Филипов

Fig. 9. Succession for a new master program

Fig. 6 shows Viaduct Morandy after the crash at 14 August 2018, 12 o'clock. Fig. 7 shows Central part of crashed Viaduct Morandy. Fig. 8 illustrate Crash in motorway near Svoge – Bulgaria at 25 August 2018. The letter to VSU Rector Professor Senior Doctor of Sciences Borislav Borissov is written at 25 July 2018 – weeks before Viaduct Morandy and Svoge crashes - Fig. 9. It is example of Transport forecasting in the future. Other examples of earthquake forecasting – psychological approach are described in [2].

3. Assurance approach. The tired protection of buildings strategy against strong ground motions (earthquakes) is connected with insurance technologies. Assurance technologies are available for recovering buildings and facilities in the event of strong earthquakes.

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