



# TEMATYKA PRACY BADAWCZEJ

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# DYNAMIKA BUDOWLI - INŻYNIERIA SEJSMICZNA

## Trzęsienia ziemi - jedne z najbardziej niebezpiecznych i najmniej przewidywalnych obciążeń, jakimi mogą być poddane konstrukcje



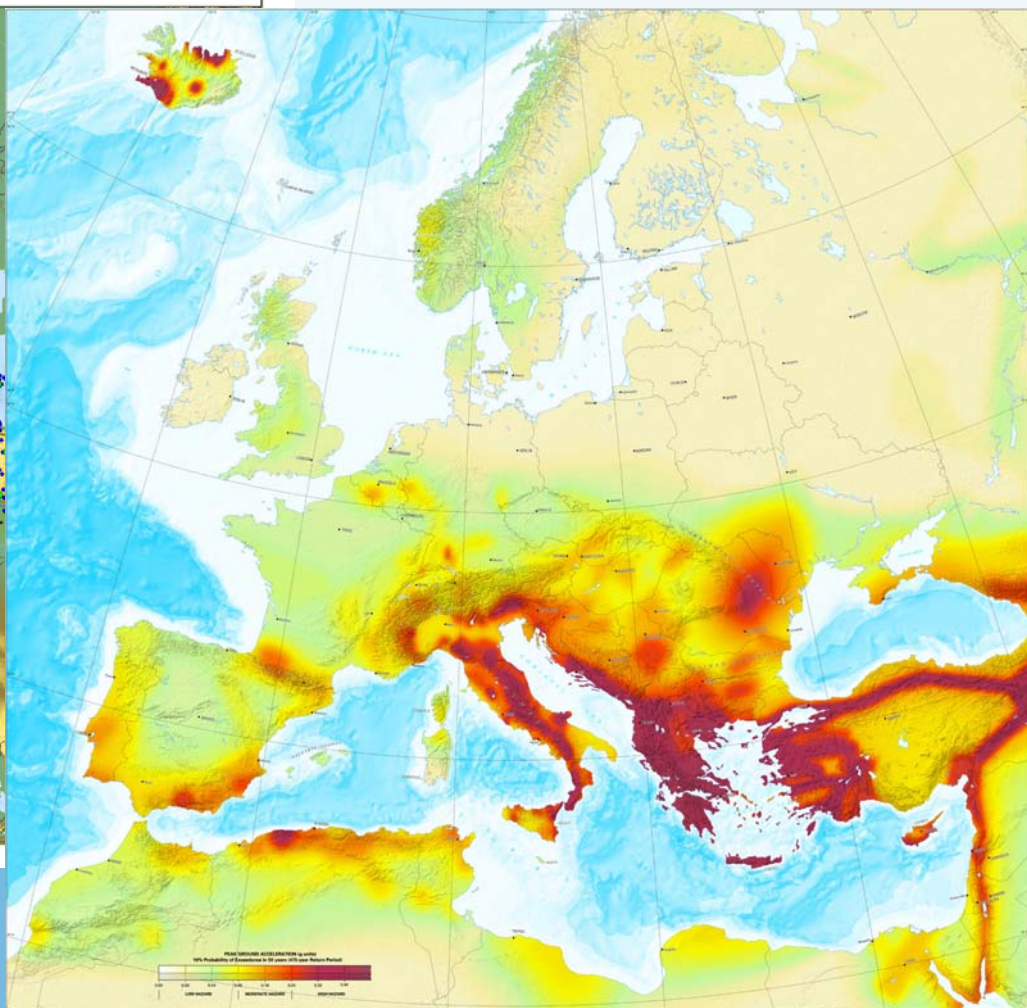
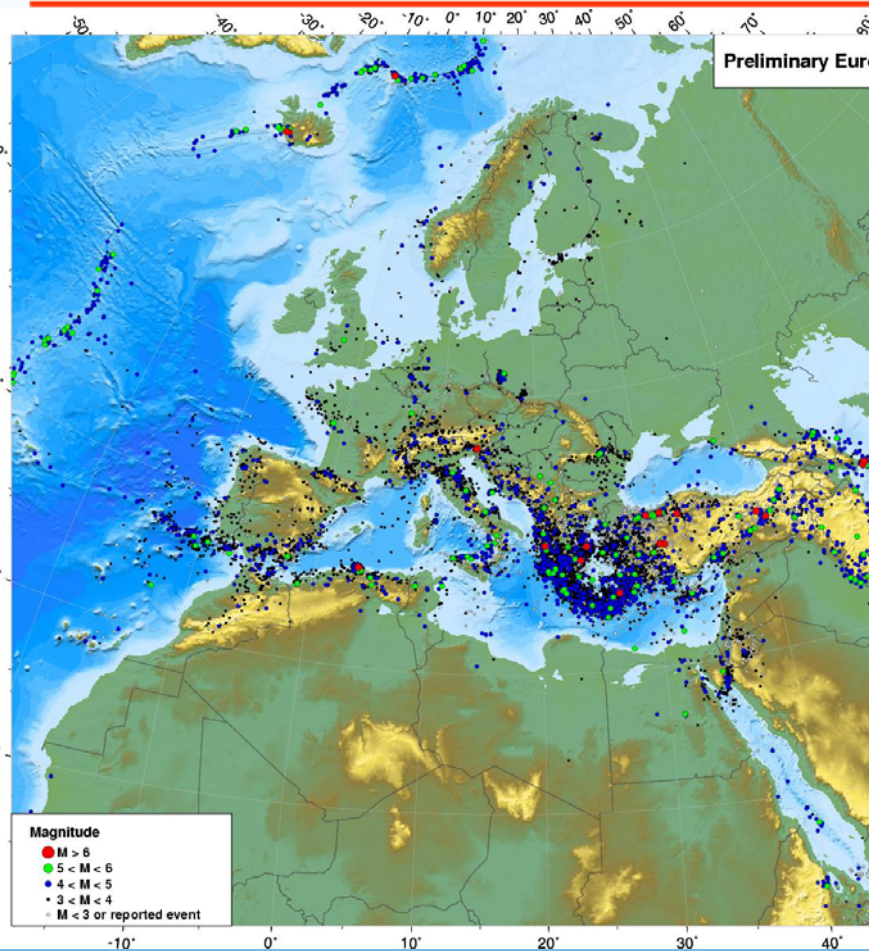


TABLE 4.6 Selected 20th Century Earthquakes with Fatalities Greater Than 10,000

Yr	M	D	Lat.	Long.	M	MMI	Deaths	Damage (USD millions)	Locale
1976	7	27	39.5 N	118 E	8	X	255,000 <sup>a</sup>	\$2,000	China: NE: Tangshan
1920	12	16	36.5 N	106 E	8.5	—	200,000		China: Gansu and Shanxi
1923	9	1	35.3 N	140 E	8.2	—	142,807	\$2,800	Japan: Toyko, Yokohama, Tsunami
1908	2	0	38.2 N	15.6 E	7.5	—	75,000		Italy: Sicily
1932	12	25	39.2 N	96.5 E	7.6	—	70,000		China: Gansu Province
1970	5	31	9.1 S	78.8 W	7.8	IX	67,000	\$500	Peru
1990	6	20	37 N	49.4 E	7.7	VII	50,000		Iran: Manjil
1927	5	22	37.6 N	103 E	8	—	40,912		China: Gansu Province
1915	1	13	41.9 N	13.6 E	7	XI	35,000		Italy: Abruzzi, Avezzano
1935	5	30	29.5 N	66.8 E	7.5	X	30,000		Pakistan: Quetta
1939	12	26	39.5 N	38.5 E	7.9	XII	30,000		Turkey: Erzincan
1939	1	25	36.2 S	72.2 W	8.3	—	28,000	\$100	Chile: Chillan
1978	9	16	33.4 N	57.5 E	7.4	—	25,000	\$11	Iran: Tabas
1988	12	7	41 N	44.2 E	6.8	X	25,000	\$16,200	CIS: Armenia
1976	2	4	15.3 N	89.2 W	7.5	IX	22,400	\$6,000	Guatemala: Tsunami
1974	5	10	28.2 N	104 E	6.8	—	20,000		China: Yunnan and Sichuan
1948	10	5	37.9 N	58.6 E	7.2	—	19,800		CIS: Turkmenistan: Ashabad
1905	4	4	33 N	76 E	8.6	—	19,000		India: Kangra
1917	1	21	8 S	115 E	—	—	15,000		Indonesia; Bali, Tsunami
1968	8	31	33.9 N	59 E	7.3	—	15,000		Iran
1962	9	1	35.6 N	49.9 E	7.3	—	12,225		Iran: NW
1907	10	21	38.5 N	67.9 E	7.8	IX	12,000		CIS: Uzbekistan: SE
1960	2	29	30.4 N	9.6 W	5.9	—	12,000		Morocco: Agadir
1980	10	10	36.1 N	1.4 E	7.7	—	11,000		Algeria: Elasm
1934	1	15	26.5 N	86.5 E	8.4	—	10,700		Nepal-India
1918	2	13	23.5 N	117 E	7.3	—	10,000		China: Guandong Province
1933	8	25	32 N	104 E	7.4	—	10,000		China: Sichuan Province
1975	2	4	40.6 N	123 E	7.4	X	10,000		China: NE: Yingtao

<sup>a</sup> The number may be as large as 655,000.

Source: NEIC. (1996). "Database of Significant Earthquakes," in *Seismicity Catalogs*, National Earthquake Information Center, Golden, CO. With permission.



Mapa epicentrow trzęsień ziemi  
i wstrząsów górniczych  
w latach 1998-2003

Mapa zagrożenia sejsmicznego Europy



## Historyczne trzęsienia ziemi na terenie Polski

od roku 1000 - około 80 wstrząsów sejsmicznych (Pagaczewski, 1972)

### Największe trzęsienia ziemi:

31 I 1259 KRAKÓW (Brama Krakowska) M ~ 6

5 VI 1443 WROCŁAW (Kotlina Żmigrodzka) M ~ 6

„Wieże i gmachy waliły się na ziemię, rzeki występowały z łożysk, a ludzie nagłym strachem zdjęci od zmysłów i rozumu odchodzili” (Długosz, 1443)

9 VIII 1662 KARPATY (Tatry) M ~ 6

„Zginęło wielu ludzi w pobliskich wsiach, a także w górach, gdzie była pełnia sezonu pasterskiego... Sławkowski Szczyt rozpadł się na części i runął z wielkim grzmotem w kierunku dolin”

22 VIII 1785 KARPATY (Barania Góra) M ~ 6

27 II 1786 KARPATY (okolice Cieszyna) M ~ 6

3 XII 1786 KARPATY (Myślenice) M = 5,7

11 VI 1895 SUDETY (Wzgórza Strzelińskie) M > 4,8

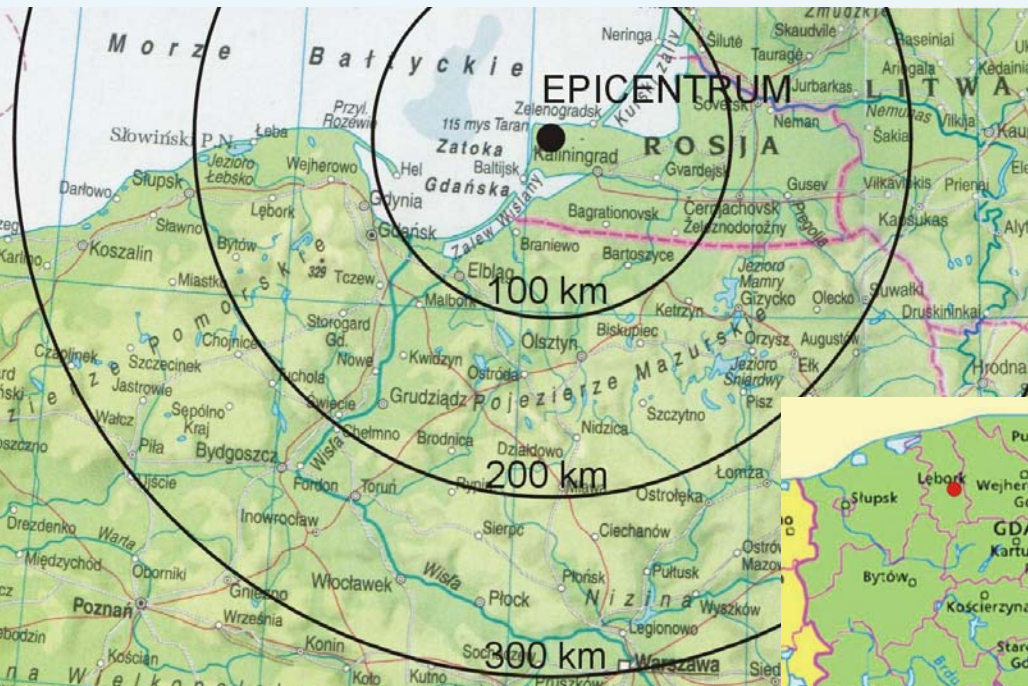
21 X 1901 PIENINY M > 4,5

23 III 1935 KARPATY (Czarny Dunajec) M = 4,3

29 VI - 6 VII 1992 KRYNICA (seria wstrząsów) M = 4,2

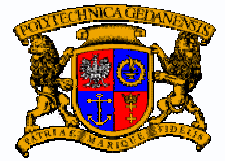
1 III - 3III 1993 KRYNICA (seria wstrząsów) M = 4,6

## Trzęsienie ziemi z 21 IX 2004 w Polsce północno-wschodniej



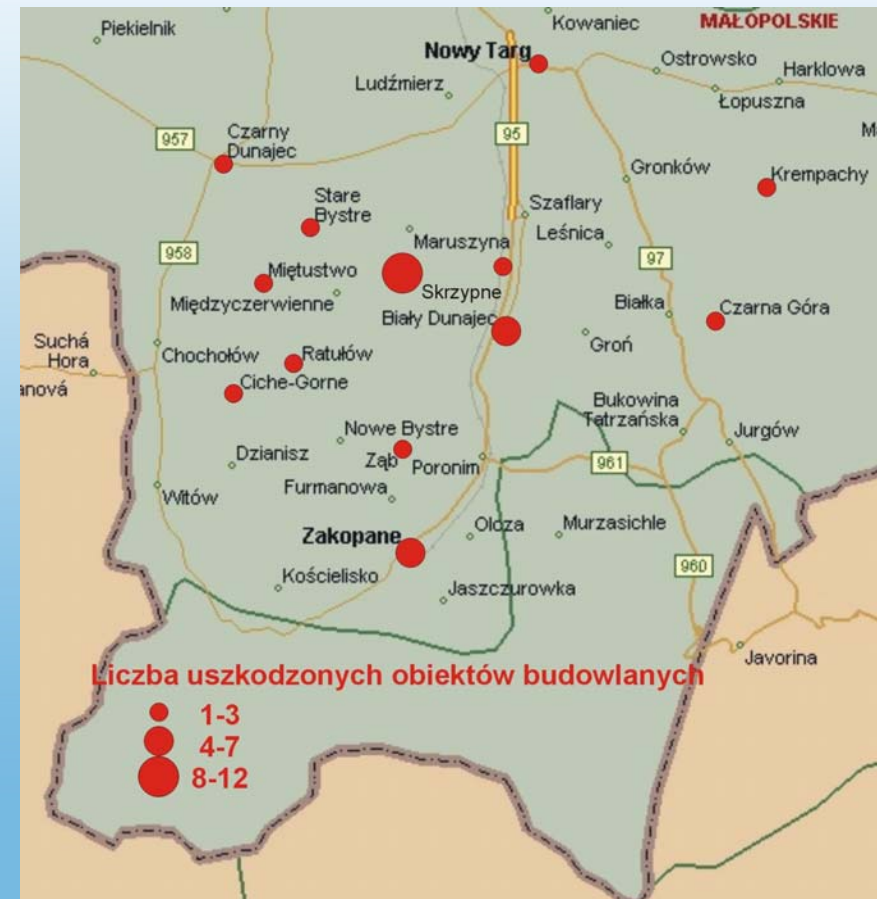
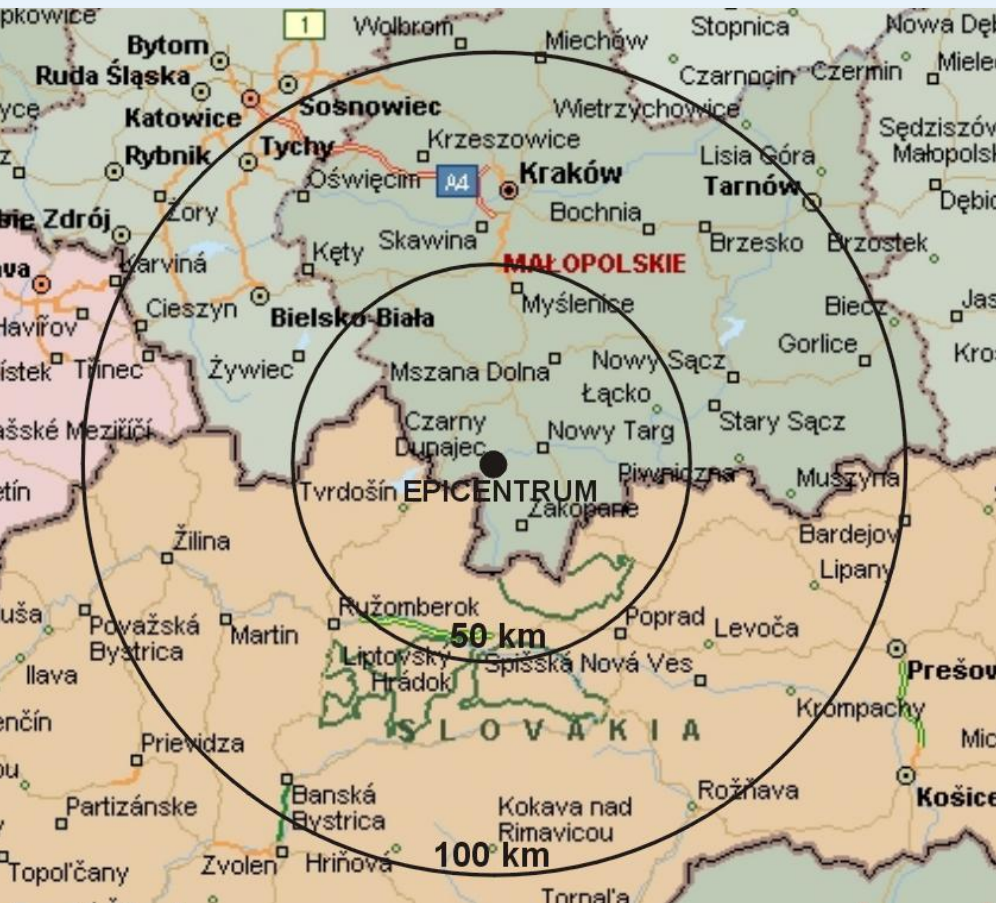








## Trzęsienie ziemi z 30 XI 2004 na Podhalu



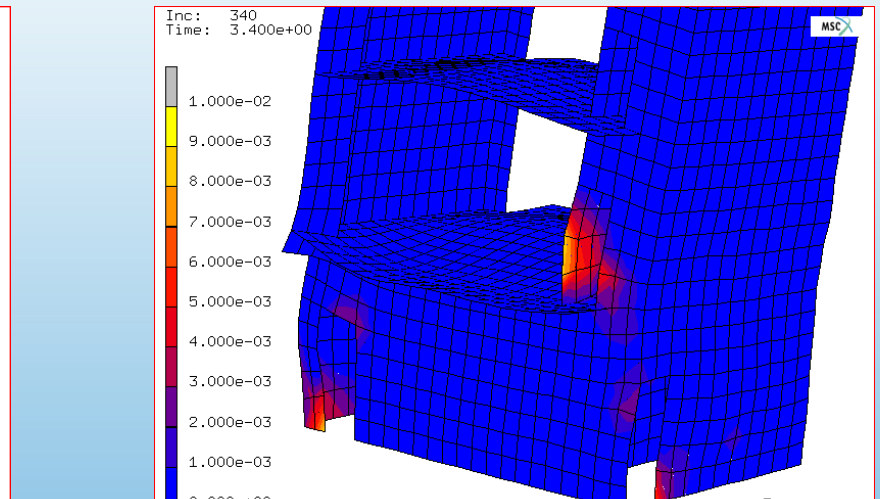
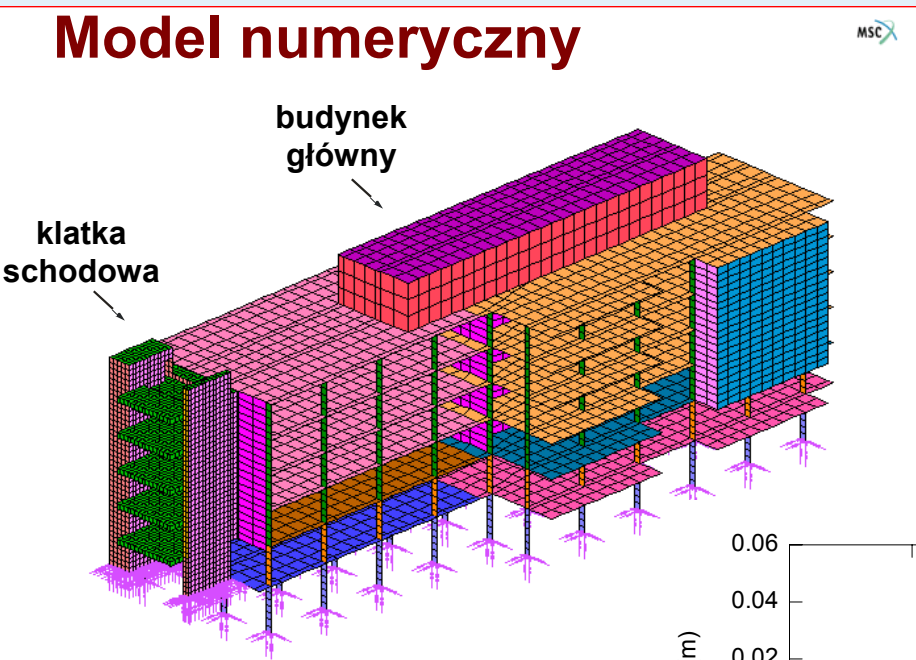




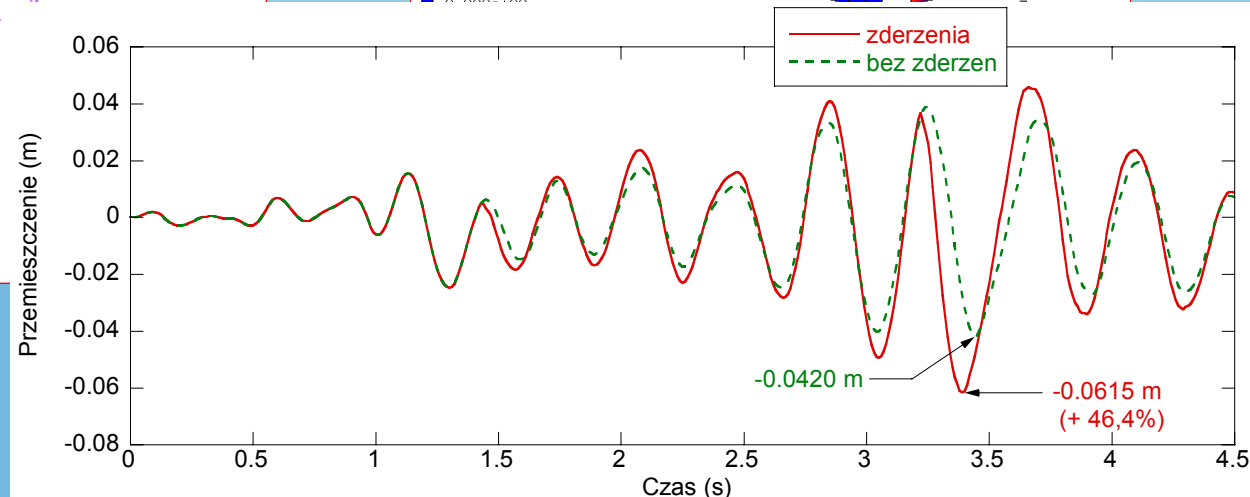


# Nieliniowa analiza zachowania się kolidujących ze sobą budynków o jednakowej wysokości podczas trzęsień ziemi (temat aktualnie realizowany)

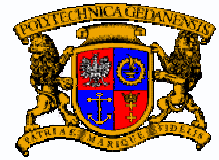
## Model numeryczny



MSC MARC







## Numeryczne modelowanie siły zderzenia w czasie kontaktu pomiędzy konstrukcjami budowlanymi poddanymi wymuszeniom sejsmicznym (temat aktualnie realizowany we współpracy z Uniwersytetem Hirosaki, Japonia)

- Model liniowy lepkosprężysty (Anagnostopoulos 1988)

$$F(t) = k\delta(t) + c\dot{\delta}(t)$$

$$c = 2\xi \sqrt{k \frac{m_1 m_2}{m_1 + m_2}}$$

$$\xi = \frac{-\ln e}{\sqrt{\pi^2 + (\ln e)^2}}$$

$\delta(t)$  - deformacja  
 $\dot{\delta}(t)$  - relatywna prędkość  
 $m_i$  - masa

- Model nieliniowy sprężysty (Hertz 1882)

$$F(t) = \beta \delta^{\frac{3}{2}}(t)$$

$\beta$  - parametr sztywności zderzenia

$k$  - wsp. sztywności zderzenia  
 $c$  - wsp. tłumienia zderzenia  
 $\xi$  - liczba tłumienia zderzenia  
 $e$  - współczynnik odbicia

- Model nieliniowy lepkosprężysty (Jankowski 2005)

$$F(t) = \bar{\beta} \delta^{\frac{3}{2}}(t) + \bar{c}(t) \dot{\delta}(t) \quad \text{dla } \dot{\delta}(t) > 0 \text{ (faza zbliżania)}$$

$$F(t) = \bar{\beta} \delta^{\frac{3}{2}}(t) \quad \text{dla } \dot{\delta}(t) \leq 0 \text{ (faza odbicia)}$$

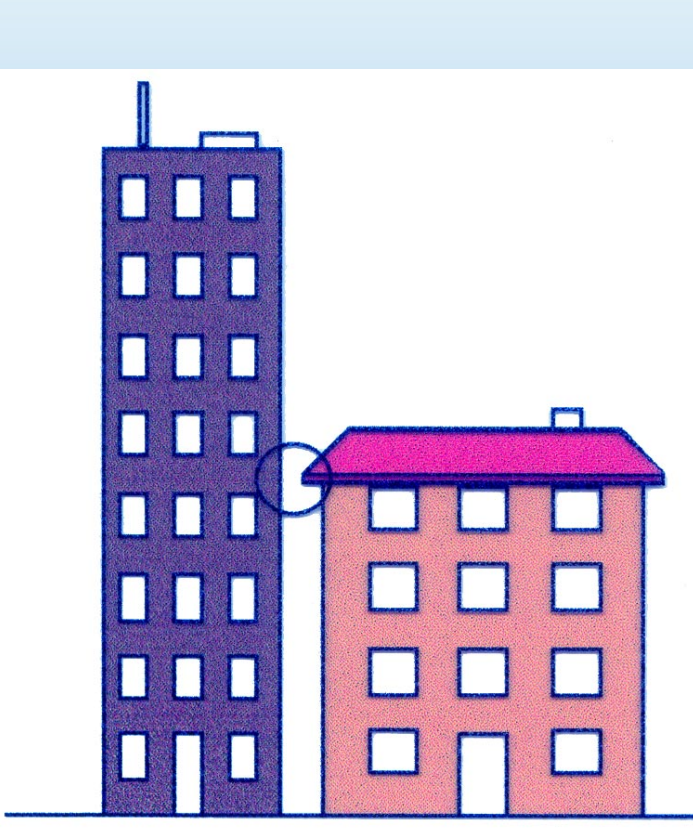
$$\bar{c}(t) = 2\bar{\xi} \sqrt{\bar{\beta} \sqrt{\delta(t)} \frac{m_1 m_2}{m_1 + m_2}}$$

$\bar{\beta}$  - parametr sztywności zderzenia

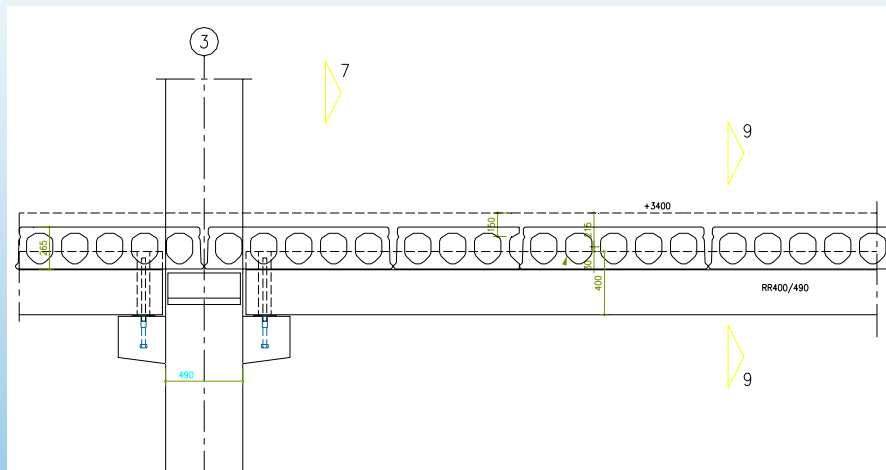
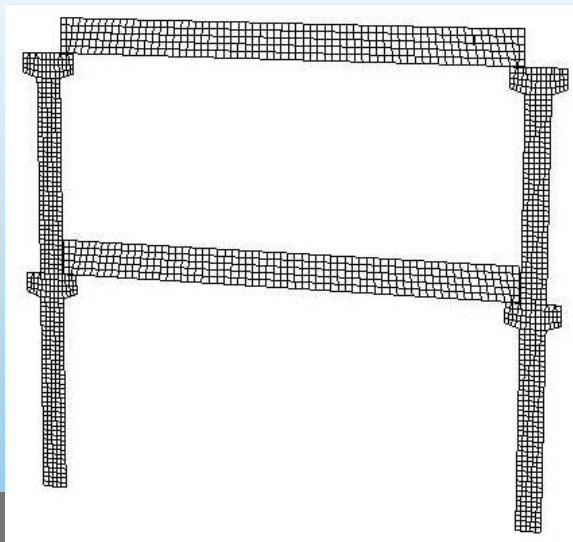
$\bar{\xi}$  - liczba tłumienia zderzenia



## Redukcja zderzeń pomiędzy konstrukcjami budowlanymi podczas trzęsień ziemi poprzez wypełnienie przerwy dylatacyjnej masą polimerową (temat planowany we współpracy z Politechniką Krakowską)



## Analiza odporności sejsmicznej konstrukcji prefabrykowanych (temat realizowany w ramach doktoratu mgr P. Piotrowskiego, Ergon Polska/Romania)



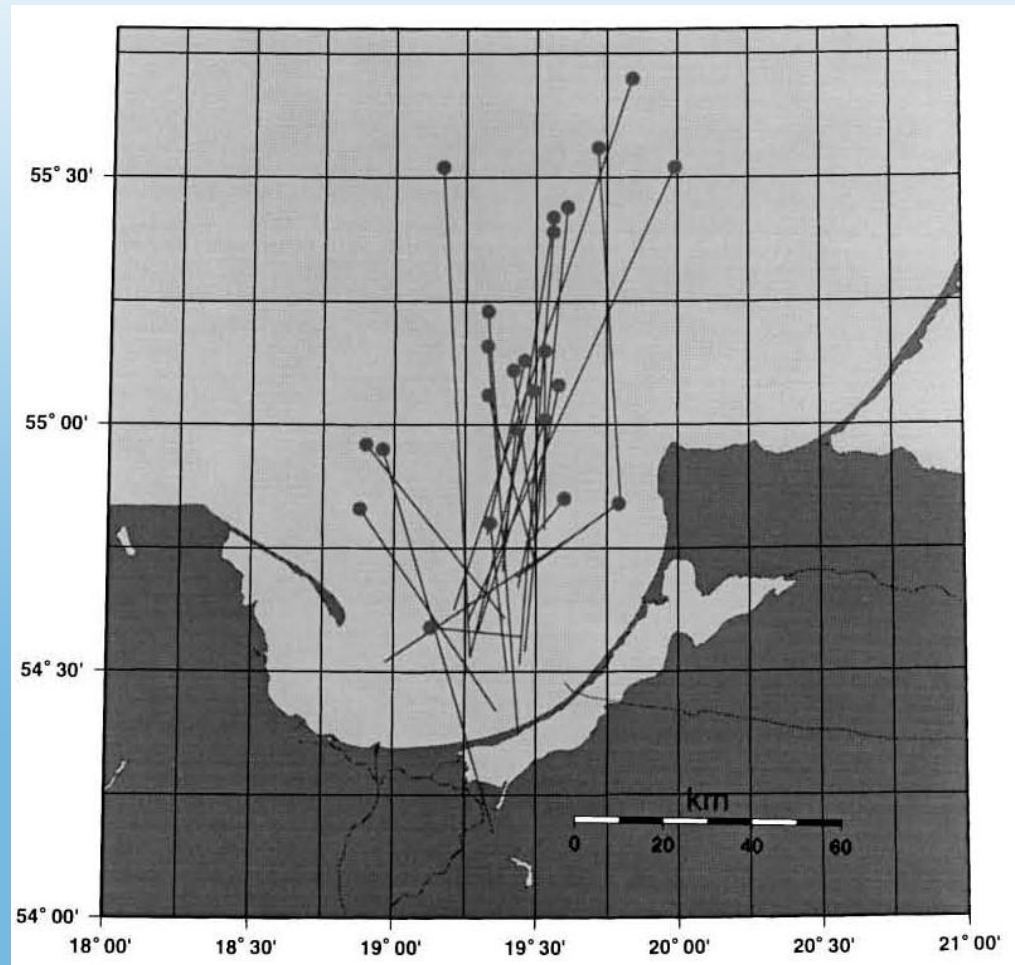
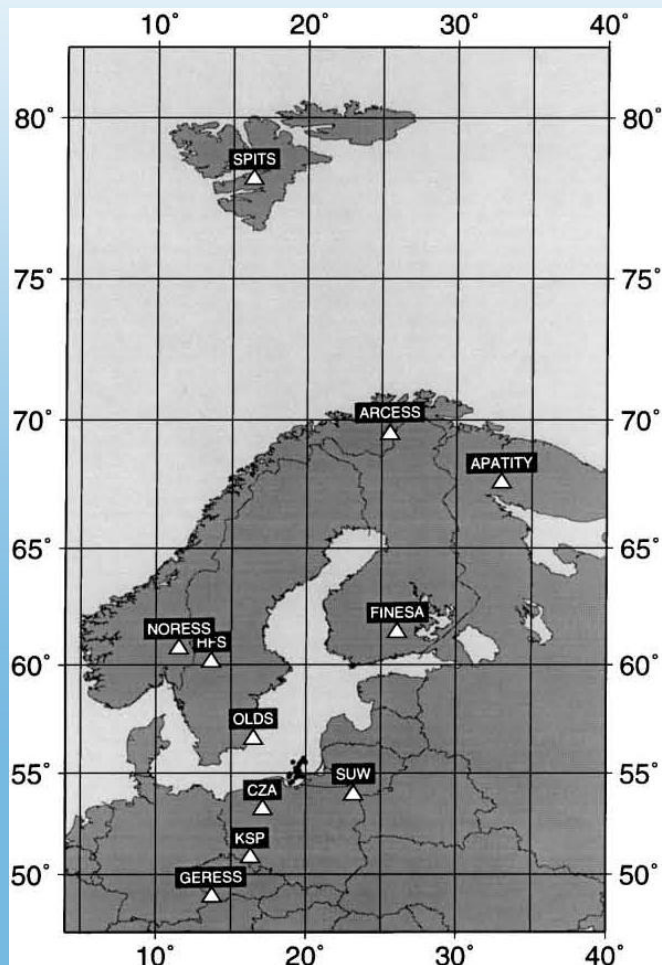
S, Mises  
SMRG, (fraction = -1.0)  
(Avg: 75%)

+	3.000e+08
+	4.589e+08
+	4.167e+08
+	3.750e+08
+	3.333e+08
+	2.917e+08
+	2.500e+08
+	2.083e+08
+	1.667e+08
+	1.250e+08
+	8.334e+07
+	4.168e+07
+	9.760e+03

PEBQ  
SMRG, (fraction = -1.0)  
(Avg: 75%)

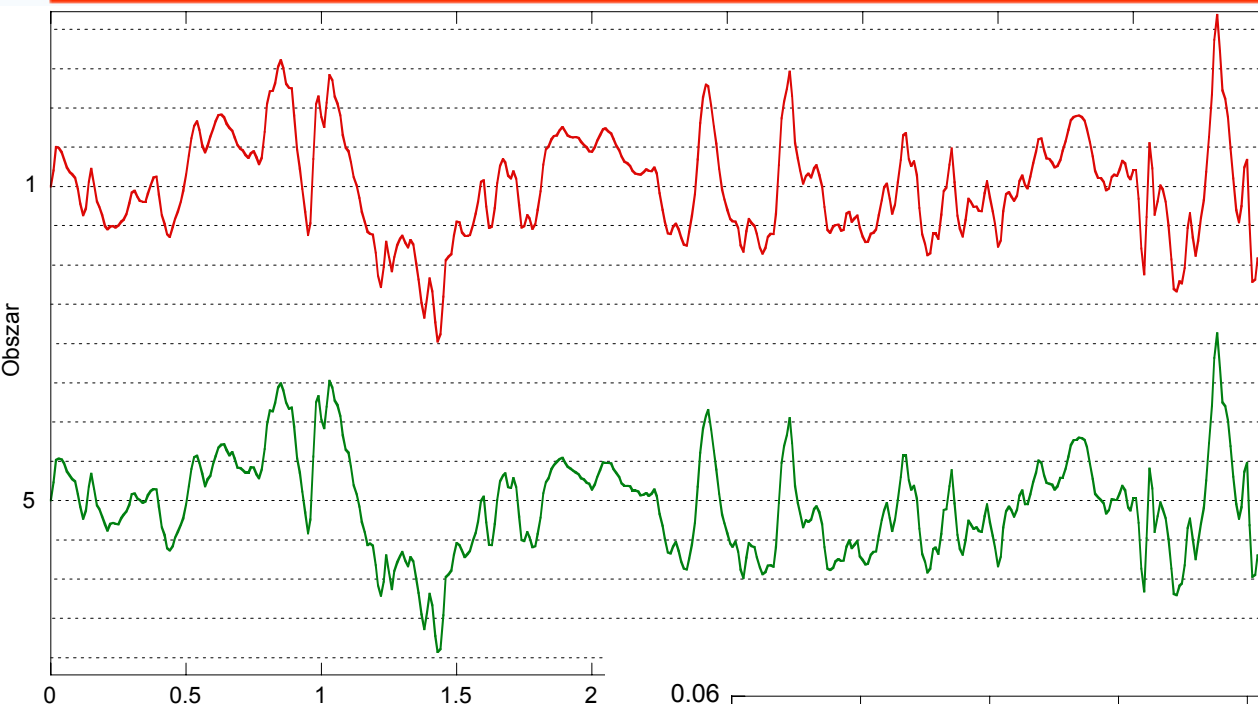
+	7.276e-02
+	6.870e-02
+	6.064e-02
+	5.457e-02
+	4.851e-02
+	4.244e-02
+	3.638e-02
+	3.032e-02
+	2.425e-02
+	1.819e-02
+	1.213e-02
+	6.064e-03
+	0.000e+00

## Badania sejsmiczności Zatoki Gdańskiej - stacja seismologiczna na Helu (temat planowany we współpracy z Instytutem Geofizyki PAN i Uniwersytetem Warmińsko-Mazurskim)

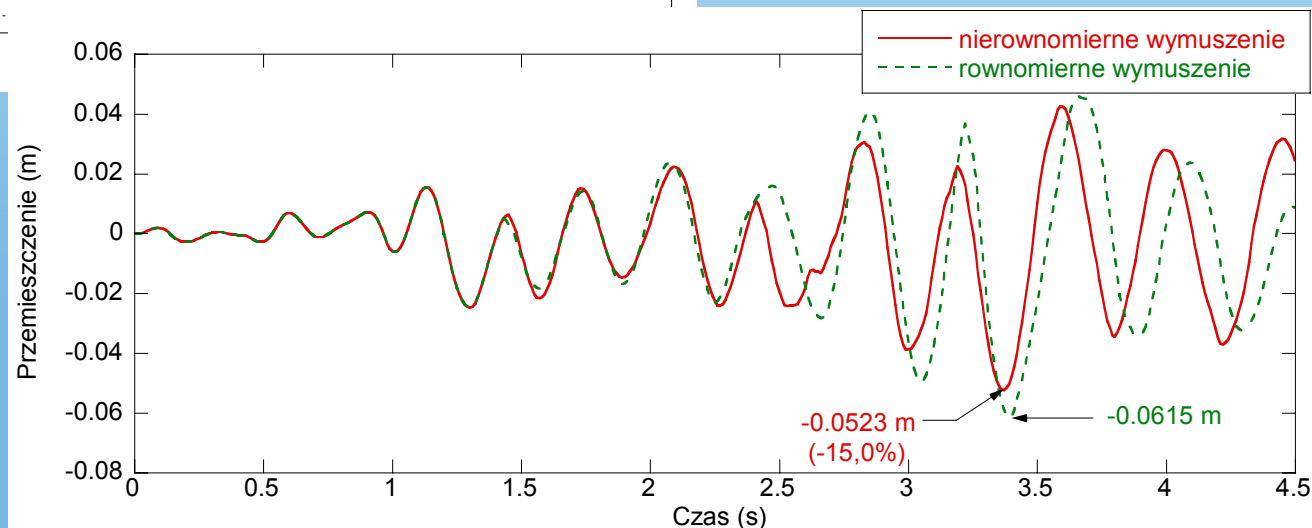


## **Eksperymentalne badania odporności sejsmicznej elementów infrastruktury energetycznej** (temat planowany we współpracy z Centrum Techniki Okrętowej, Politechniką Opolską i firmą HAPAM)





**Modelowanie  
stochastyczne  
efektu propagacji  
fali sejsmicznej  
i jego wpływ na  
konstrukcje budowlane  
podczas trzęsień ziemi  
(temat aktualnie  
realizowany)**

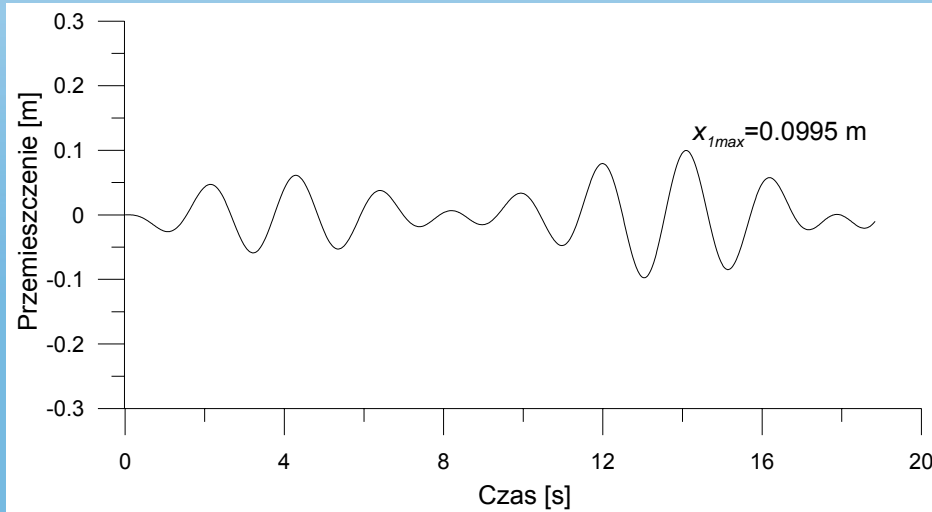
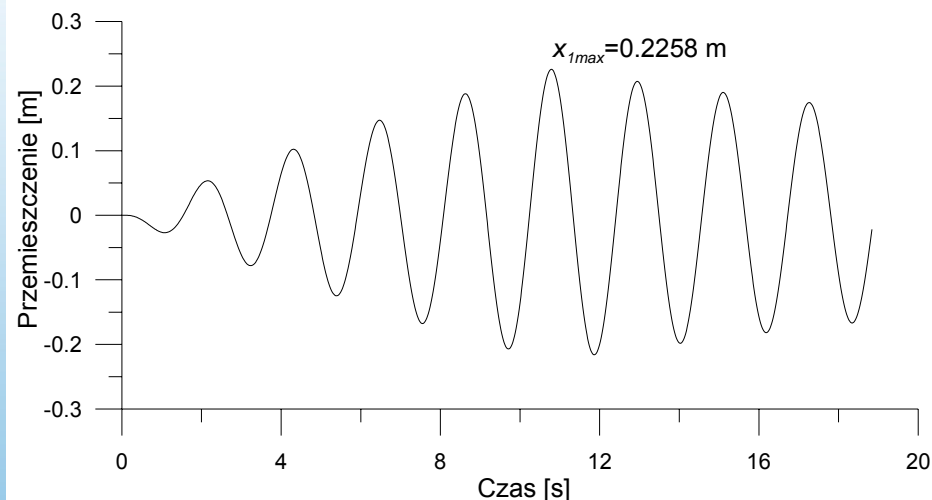
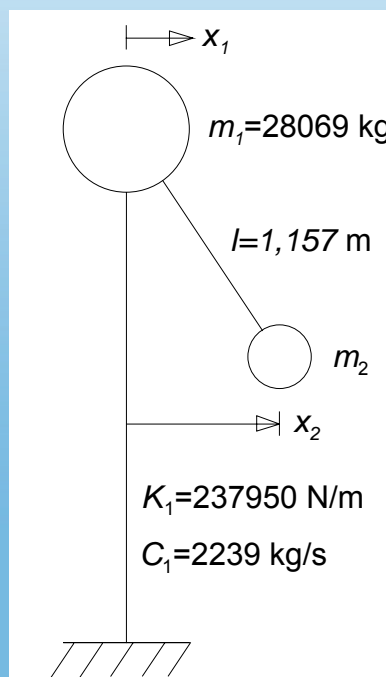




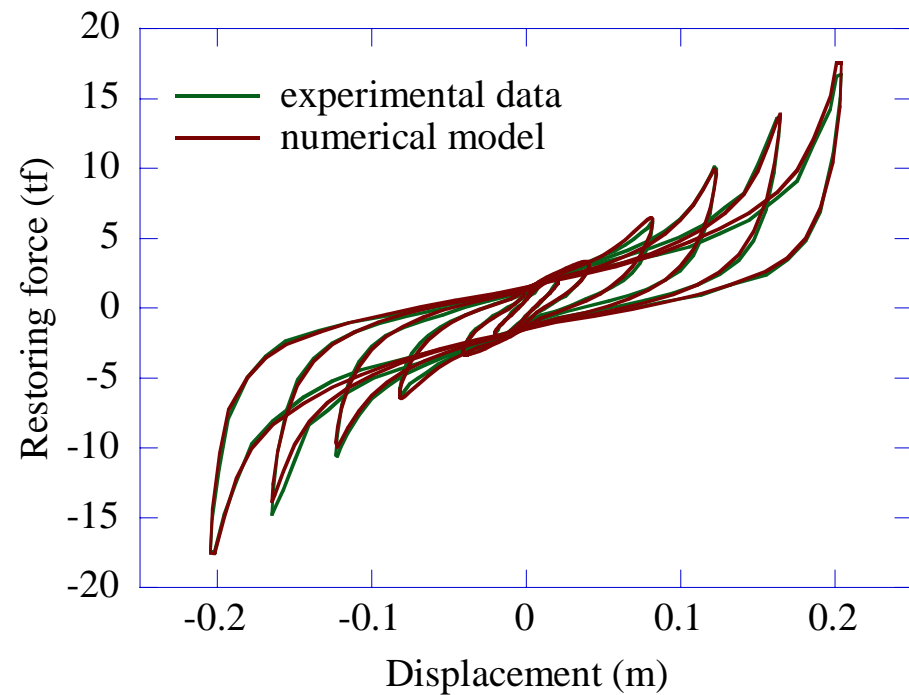
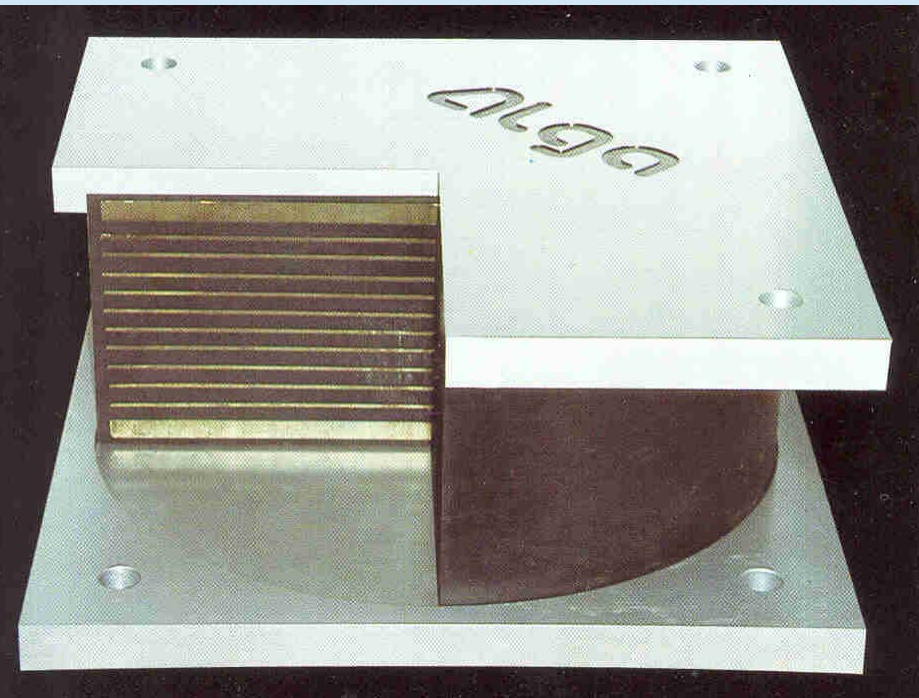
# DYNAMIKA BUDOWLI – INNE ZAGADNIENIA

## Zastosowanie tłumika wahadłowego do redukcji drgań komina stalowego poddanego działaniu wiatru

(temat zrealizowany  
we współpracy  
z prof. Cz. Szymczakiem  
i dr M. Kujawą)



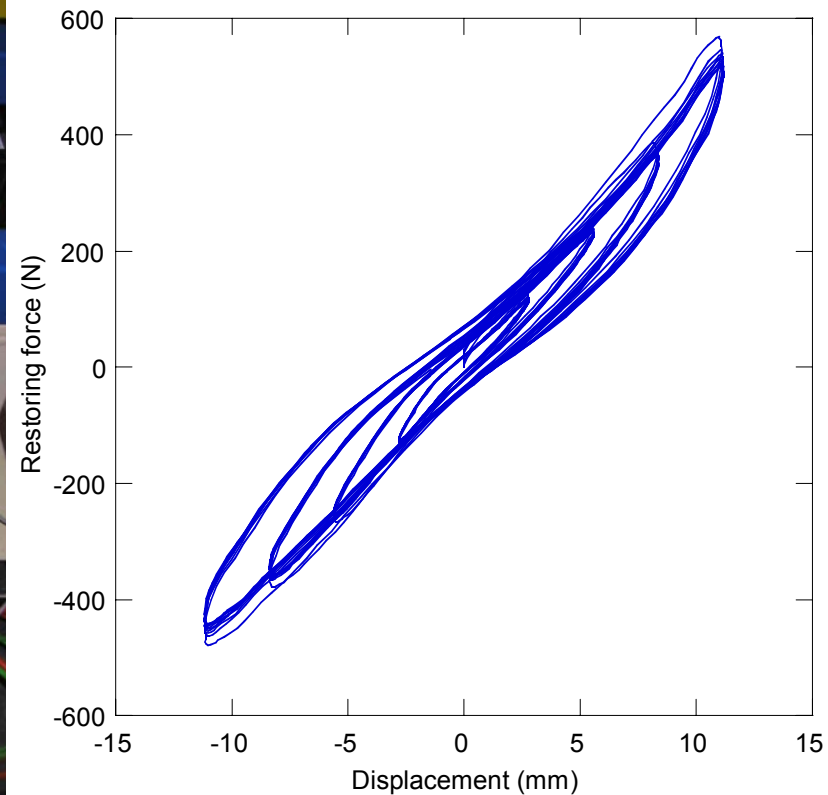
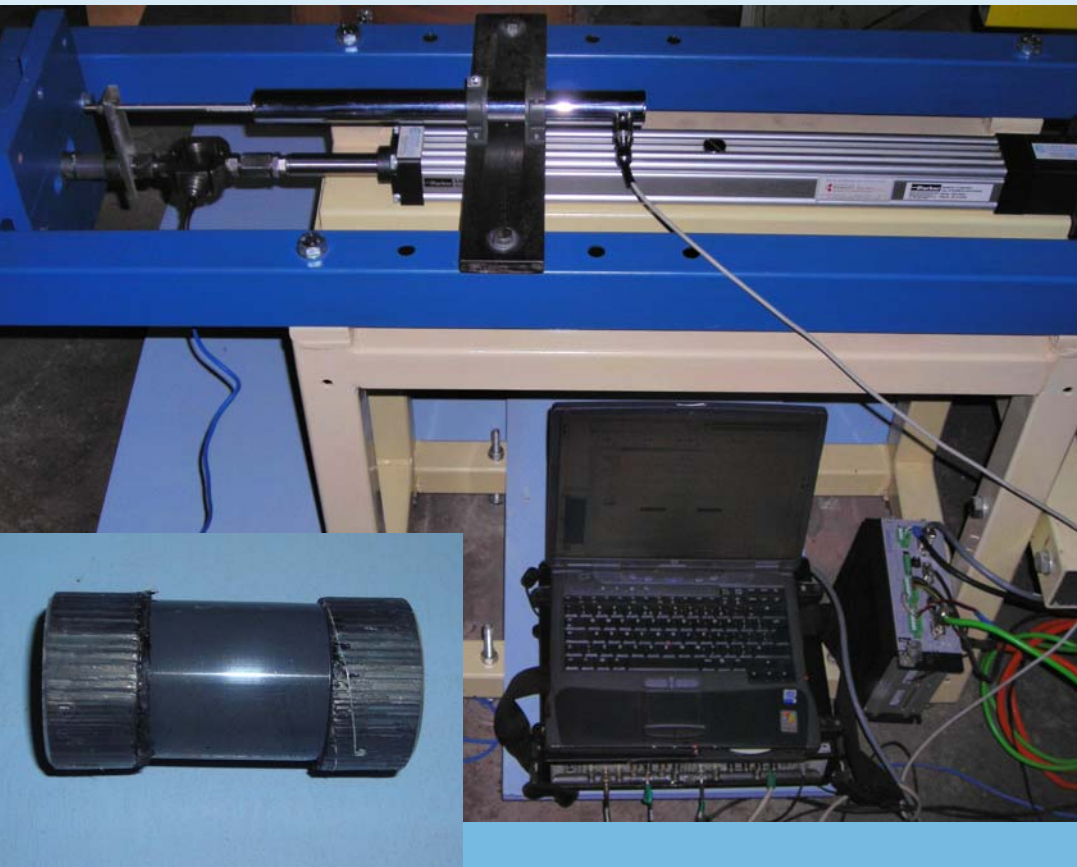
## Model numeryczny zachowania się łożyska z wysokotłumiącej gumy (HDRB) pod obciążeniem dynamicznym (temat częściowo zrealizowany)





## Eksperymentalne badania zachowania się elementów z masy polimerowej

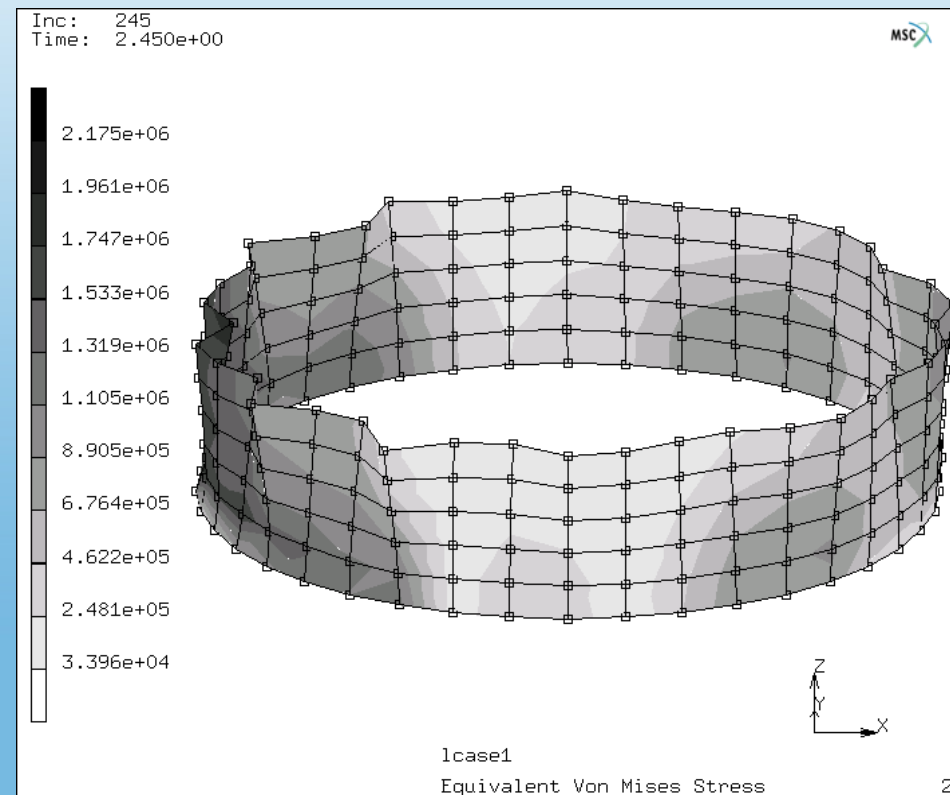
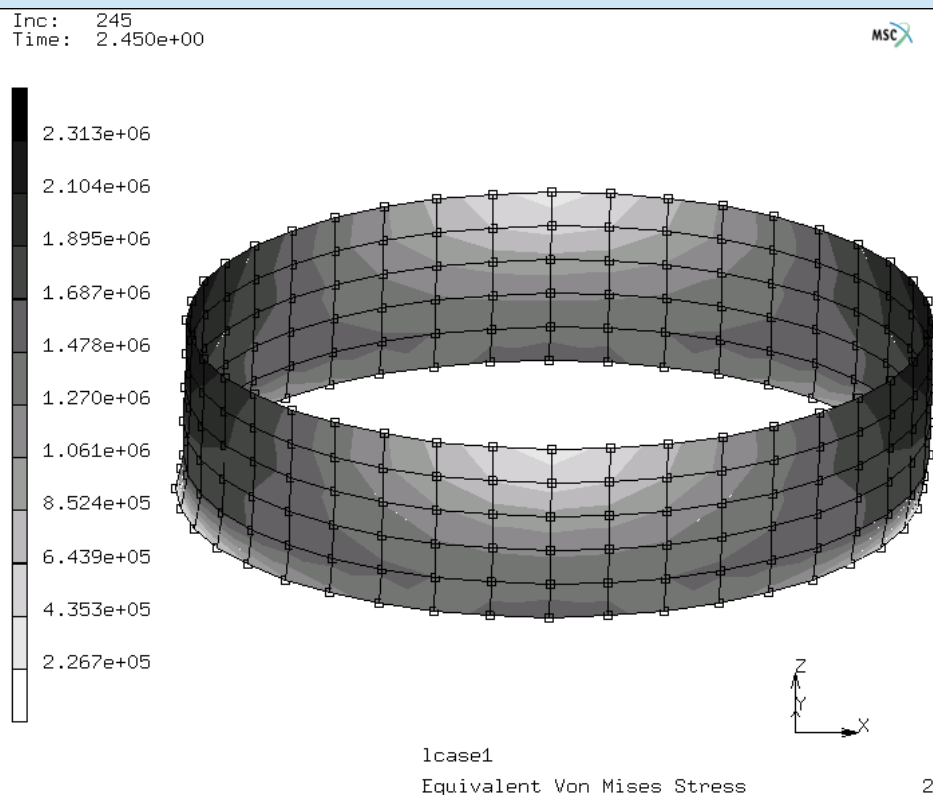
(temat realizowany we współpracy z Politechniką Krakowską)





# Dynamiczne oddziaływania ekstremalne (wybuchy, trzęsienia ziemi, itp.) na zbiorniki z uwzględnieniem imperfekcji geometrycznych i materiałowych w ujęciu stochastycznym

(temat planowany we współpracy z prof. P. Kłosowskim i dr hab. J. Górskim)



# Department of Structural Mechanics Faculty of Civil and Environmental Engineering Gdańsk University of Technology, Gdańsk, Poland



EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS  
Earthquake Engng Struct. Dyn. 2007, 35, 487–502 (2007)

## POUNDING OF SUPERSTRUCTURE SEGMENTS IN ISOLATED ELEVATED BRIDGE DURING EARTHQUAKES

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### SUMMARY

Part severe earthquakes indicate that pounding may cause considerable damage or even lead to collapse of colliding structures. The aim of this paper is to present an analysis of pounding between superstructure segments of an isolated elevated bridge induced by the propagating seismic waves. High-damping rubber bearings (HRBs), used as isolation devices, are modelled by proposed non-linear formulation and the significance of the bearing model for pounding is indicated. The results of the study show that pounding leads to the increase of dynamic forces on spans, depending on the gap size between superstructure segments. © 2005 John Wiley & Sons, Ltd.

KEY WORDS pounding; elevated bridge; earthquake excitation; high damping rubber bearing

### INTRODUCTION

The surveys on damage during past severe earthquakes show that pounding can lead to considerable damage or even collapse of buildings if the separation distance between them is not sufficient.<sup>1–3</sup> Similarly in bridges, collisions may occur between an abutment and girder adjacent girders or a girder and neighbouring structure due to their different phase vibrations. In the Loma Prieta earthquake (1992), pounding of the lower roadway and columns supporting an upper level deck of the Southern viaduct section at the China Basin<sup>4</sup> (California) led to significant damage to the decks and column sides. The different heights, and therefore, the difference of natural frequencies of neighbouring bridge members was identified as the cause of collision.<sup>4</sup> The influence of pounding of superstructure segments, supported on piers of equal height, on the structural response was confirmed on a highway bridge located 8 km away from Los Angeles.<sup>5</sup> The bridge was instrumented with a set of accelerometers and the collected records showed spikes, in some cases, of magnitude 10 times higher than the maximum acceleration of the earthquake input. The presence of spikes in the bridge response was explained by collisions induced by the seismic wave propagation effects.<sup>6</sup> The reports of damage to highway bridges during the Kobe earthquake (1995) also identify pounding due to fracture of bearing supports as a reason for local damage and a potential contribution of falling down of bridge decks (for example, Reference 6). Generally speaking, the forces induced by pounding of bridge components can be very large, resulting in significant additional loading transmitted to the lower part of the bridge. Moreover, the impact character of pounding forces increases the possibility of brittle fracture of structural members. Most of the research work done so far has been focused on pounding of inadequately separated buildings with different dynamic characteristics. The fundamental study using single-degree-of-freedom models of buildings was carried out by Angstadt<sup>7</sup> and others.<sup>8</sup> His results show that collisions usually amplify the structural responses. More detailed analyses were conducted on multi-degree-of-freedom beam mass

EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS  
Earthquake Engng Struct. Dyn. 2007, 35, 497–512

## Reduction of pounding effects in elevated bridges during earthquakes

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### SUMMARY

Pounding of adjacent superstructure segments in elevated bridges during severe earthquakes can result in significant structural damage. The aim of this paper is to analyse several methods of reduction of the effects of pounding on the structural response of adjacent bridge spans. The analysis is carried out using a detailed three-dimensional structural component model of an isolated highway bridge. The results show that the effects of pounding on the structural response of adjacent bridge spans can be significantly reduced by rigid and significantly depends on the gap size between superstructure segments. The smallest response can be obtained for very small gap sizes (e.g. gap size large enough to prevent collisions). Further analysis indicates that the bridge behaviour can be effectively improved by placing lead rubber bearings between segments and by stiff linking the segments one with another. The experimental results show that, for the structural application of such connections, lead transmission bearings may be accepted. © 2005 John Wiley & Sons, Ltd.

KEY WORDS pounding; elevated bridge; earthquake excitation; travelling seismic wave; rubber bumper; variable-stiffness shock transmission unit

### INTRODUCTION

During recent severe earthquakes, pounding of adjacent structural frames was observed in several elevated bridges. In the Loma Prieta earthquake of 1989, collisions between the lower roadway and piers supporting an upper-level deck of the Southern viaduct section of the China Basin in California led to substantial damage (13), in this case, the difference in the natural frequencies of adjacent frames of the bridge was the cause of pounding. Collisions between neighbouring superstructure segments, supported on identical piers, were observed in a highway bridge near Los Angeles which was instrumented with a set of accelerometers (2). Data records collected during the earthquake showed spikes of magnitude over 10 times higher than the maximum ground motion acceleration. These spikes confirmed the presence of pounding which was indicated

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online at <http://www.interscience.wiley.com>  
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Impact Force Spectrum for Damage Assessment of Earthquake-Induced Structural Pounding

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Keywords: structural pounding; earthquake; impact force; damage assessment

**Abstract.** Part earthquakes indicate that pounding between inadequately separated structures may cause considerable damage or even lead to collapse of colliding structures. The aim of this paper is to present an analysis of pounding between superstructure segments of an isolated elevated bridge induced by the propagating seismic waves. High-damping rubber bearings (HRBs), used as isolation devices, are modelled by proposed non-linear formulation and the significance of the bearing model for pounding is indicated. The results of the study show that pounding leads to the increase of dynamic forces on spans, depending on the gap size between superstructure segments. © 2005 John Wiley & Sons, Ltd.

KEY WORDS structural pounding; earthquake; impact force; non-linear model; hard contact law

### INTRODUCTION

Interactions between adjacent, inadequately separated structures or their parts, due to the out-of-phase vibrations, have been repeatedly observed during earthquakes. This phenomenon, often called as earthquake-induced structural pounding, may result in severe local damage at the contact points in case of inelastic ground motions (earthquake of 21 September 2004 in the east-coast Poland) or may lead to considerable destruction or even collapse of colliding structures during severe earthquakes. Rosenbath and Melli (1) reported, for example, that in the Mexico City earthquake of 1985, about 40% of the damaged structures experienced some level of pounding, 15% of them leading to structural collapse. During the 1980 Loma Prieta earthquake, over 200 pounding occurrences involving more than 500 buildings were observed at sites located over 90 km from the epicentre (2). Significant pounding damage was observed at expansion joints and abutments of multiple portions of a number of bridges during the 1994 Northridge earthquake at the Interstate 5 and State Road 14 interchange (3). The reports of damage to highway bridges during the Kobe earthquake of 1995 have identified pounding due to fracture of bearing supports as a reason for local damage and a potential contribution to falling down of bridge decks (4).

Due to the local shoring and high load prices in many cities, including those located on seismic zones, engineers often face the problem of constructing a new building very close to the existing old one. In such cases, the assessment of potential damage due to earthquake-induced pounding is of exceptional importance. Such an assessment, however, requires the knowledge of the maximum impact force value which can be expected during the time of design earthquake. Therefore, the aim of the present paper is to consider the concept of impact force response spectrum for two closely-spaced structures, which allows the plot of the peak value of pounding force as a function of the natural vibration period of a new structure. Such spectrum can be used by a designer as a practical tool to



Engineering Structures 22 (2004) 105–164



## A simple method of conditional random field simulation of ground motions for long structures

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### Abstract

The recently developed theoretical framework of conditional random fields is not widely used for engineering purposes due to its complexity and the difficulty of estimating the spatial covariance of fields. The paper presents a simple method of conditional simulation of open time variation of a ground motion. The frequency dependence of the spatial covariance function is simplified so that only the variation of the natural frequency of the earthquake is taken into account. Analytical models of conditional random fields for long structures, modelled by the 1D Cauchy (1946) and Kuznetsov (1965) earthquake models are presented. The simulation is performed in the time domain and three simplified procedures can be simultaneously considered by one specified record, conditional and unconditional simulation, an example. © 2005 Elsevier Science Ltd. All rights reserved.

Keywords: Conditional random field; ground motion; Long structures; stochastic modelling

### 1. Introduction

In recent years, the theory of random fields has been intensively studied (1,2) and applied to processes randomly occurring in space and time, such as earthquakes, hydrological flows, ocean waves, urban fields in meteorology, and so on. In earthquake engineering, models of stochastic modelling are often used to deal with the presentation of seismic waves (3,4). Simulation of spatial and temporal variation of earthquake fields by the probabilistic methodological approach, which turns a wave propagation through the soil into line, is a very complex task. Such methods require detailed knowledge of the fault site, rupture mechanisms, propagation paths (reflection, refraction, diffraction) from the epicentre, and local geological and topographical conditions (5–7), and these data are usually not fully available. Therefore, the stochastic approach has been proved to be useful. The incorporation of the seismic wave propagation

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## Pounding force response spectrum under earthquake excitation

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### Abstract

Earthquake-induced pounding between inadequately separated structures may cause considerable damage or even lead to a structure's total collapse. The assessment of the damage magnitude as well as the design of wave pounding mitigation method requires the knowledge of the maximum impact force value expected during the time of earthquake. The aim of the present paper is to propose the plot of impact force response spectrum for two adjacent structures, which allows the plot of the peak value of pounding force as a function of the natural vibration period of a new structure. The analysis has been conducted for elastic and inelastic (bilinear) structures under different ground motions. The analytical model is based on the concept of random fields. The accuracy of the model is verified by comparing the results of numerical analysis with the results of experiments conducted on pounding between different types of structures. The results of the study indicate that, compared to other models, the proposed non-linear viscoelastic model is the most precise one in simulating the pounding-induced structural responses. Copyright © 2005 John Wiley & Sons, Ltd.

KEYWORDS: structural pounding; earthquake; response spectrum; peak impact force

### 1. Introduction

The problem of pounding between inadequately separated structures, structural members, during earthquakes has attracted considerable attention for several years now. Its interest results from the fact that a growing amount of evidence can be found in reports about major earthquakes indicating that structural pounding may cause considerable damage or even lead to a structure's total collapse. For example (1), it has been recognized that the main reason leading to structural collapse in usually three multi-storey buildings caused by the difference in their dynamic characteristics (2). On the other hand, in the case of long bridge structures, pounding between adjacent superstructure segments is often induced due to the seismic wave propagation effect, which results in different seismic impact action on supports along the structure (3,4). The results of various numerical studies by using different structural models and applying various earthquake models indicate that pounding, due to incoming additional

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## Analytical expression between the impact damping ratio and the coefficient of restitution in the non-linear viscoelastic model of structural pounding

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### SUMMARY

Earthquake-induced structural pounding has been recently intensively studied with the help of different models of impact force. It has been verified through comparisons, that the non-linear viscoelastic model may be considered amongst the most accurate ones among them. The aim of this short paper is to derive an approximating formula relating the impact damping ratio, as a parameter of the model material, to the coefficient of restitution. The accuracy of the derived analytical formulation has been confirmed through the comparison with the results of numerical simulation. Copyright © 2005 John Wiley & Sons, Ltd.

KEY WORDS structural pounding; earthquake; non-linear viscoelastic model; impact damping; coefficient of restitution; increase the structural response

### INTRODUCTION

The reports about major earthquakes indicate that earthquake-induced pounding between inadequately separated structures, or structural members, may cause substantial damage or even contribute to structural collapse. For example, Reference (1). These relations have initiated the intensive study on pounding-involved behaviour of different types of structures during ground motions. Pounding itself is a complex phenomenon involving damage due to plastic deformation at contact points, local crushing or crushing, fracturing due to impact, friction, etc. That makes the analysis of this type of problem very difficult. Several simplified numerical models, such as the linear elastic (2), the linear viscoelastic (3,4), the non-linear elastic (5) and the non-linear viscoelastic model (6), have been applied to simulate pounding. Copyright © 2005 John Wiley & Sons, Ltd.

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## Non-linear viscoelastic modelling of earthquake-induced structural pounding

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### SUMMARY

Part severe earthquakes indicate that structural pounding may cause considerable damage or even lead to collapse of colliding structures if the separation distance between them is not sufficient. Because of its complexity, modelling of impact in an extremely difficult task, however, the precise numerical model of pounding is essential if a more accurate response is to be simulated. The aim of this short paper is to analyse a non-linear viscoelastic model of collision which allows more precise simulation of the structural pounding during earthquakes. The accuracy of the model is verified by comparing the results of numerical analysis with the results of experiments conducted on pounding between different types of structures. The results of the study indicate that, compared to other models, the proposed non-linear viscoelastic model is the most precise one in simulating the pounding-induced structural responses. Copyright © 2005 John Wiley & Sons, Ltd.

KEY WORDS structural pounding; earthquake; impact force; non-linear model; hard contact law

### INTRODUCTION

During severe earthquakes, pounding between neighbouring, inadequately separated buildings or bridge segments has been repeatedly observed. Rosenbath and Melli (1) reported that in the Mexico City earthquake of 1985 about 40% of the damaged structures experienced some level of pounding, 15% of them leading to structural collapse. Anagnostopoulos (2) mentioned that statements to say that evidence of pounding was found in 17% of buildings with major damage during the 1994 Northridge earthquake. However, it should have been a significant factor in the structural damage. During the 1995 Loma Prieta earthquake, over 200 pounding occurrences involving more than 500 buildings were observed

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# DYPLOMY STUDENCKIE

**Tytuł: Zniszczenia konstrukcji budowlanych podczas trzęsień ziemi XX w.**

Dyplomant: Bartosz Pietrzykowski

Rok: 2003



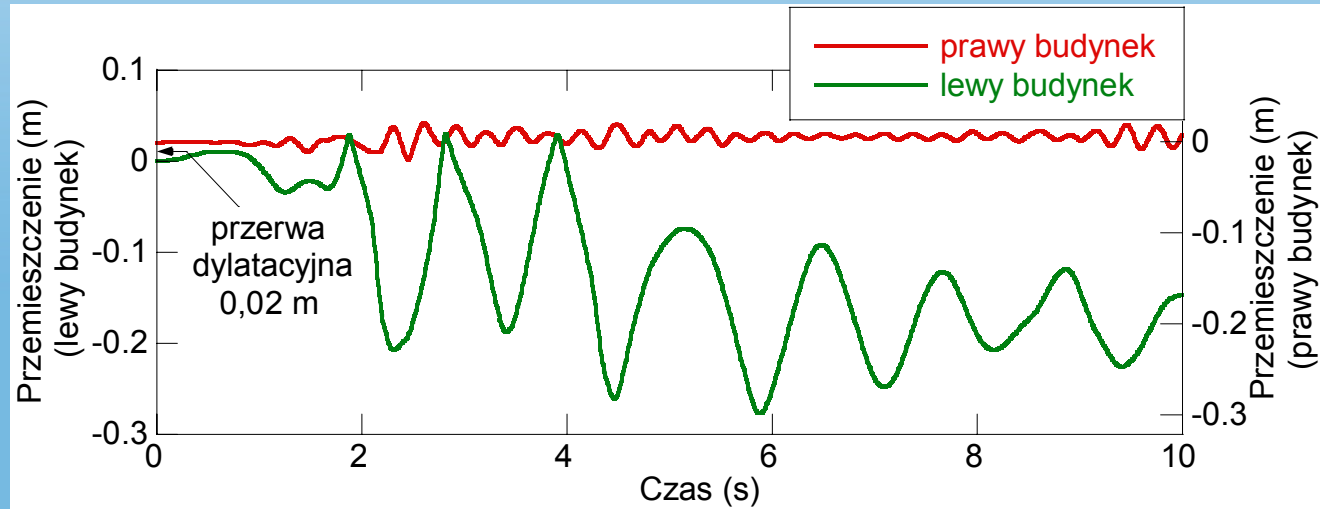
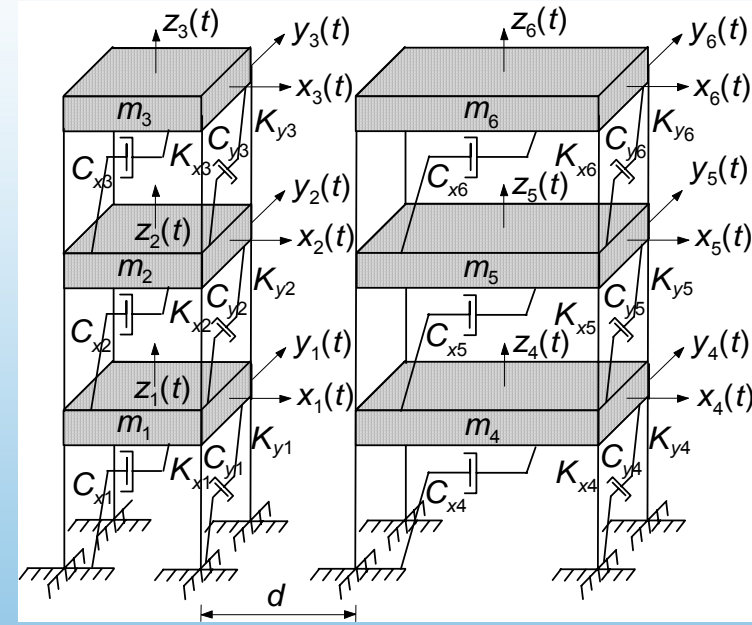


**Tytuł: Analiza zderzeń pomiędzy budynkiem głównym a wolnostojącą klatką schodową podczas trzęsienia ziemi El Centro**



Dyplomant:  
 Marek Kotwicki

Rok: 2004

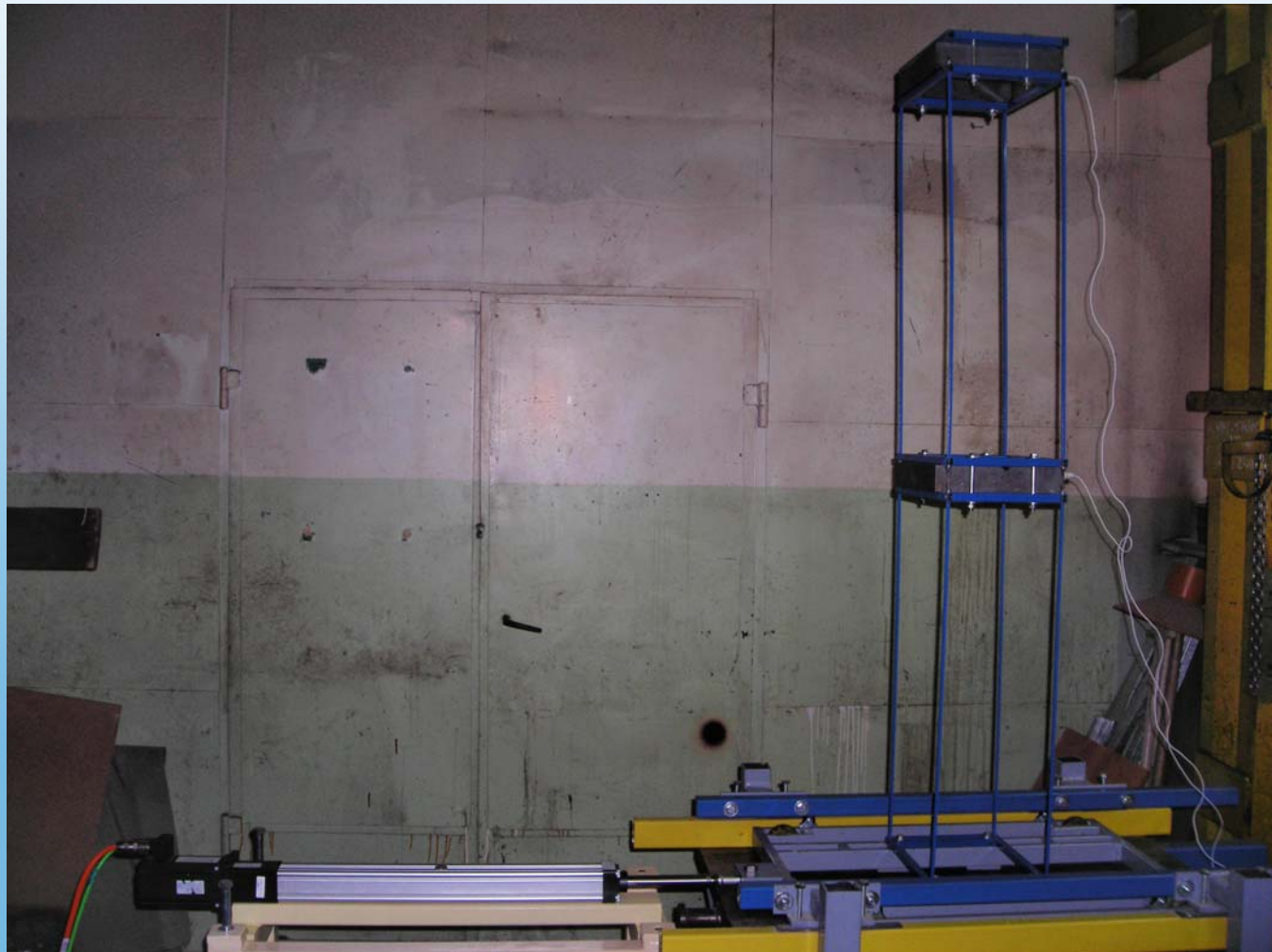


**Tytuł: Badania eksperymentalne na stole wstrząsowym dotyczące identyfikacji parametrów dynamicznych uszkodzonej konstrukcji**

Dyplomantka:

Kamila  
Siedlecka

Rok: 2008

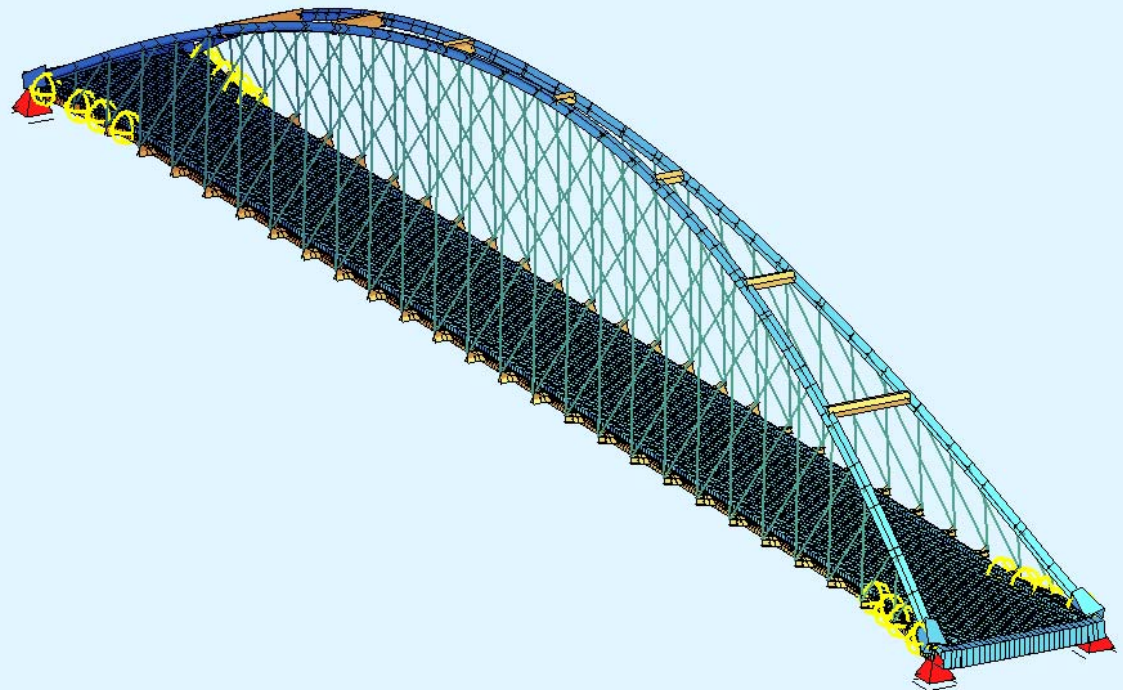


**Tytuł: Analiza zachowania się mostu na wyspie Wolin poddanego obciążeniom sejsmicznym i wstrząsom górniczym**

Dyplomant:

Przemysław Słomka

Rok: 2008







**DZIĘKUJĘ ZA UWAGĘ**  
**ZAPRASZAM DO WSPÓŁPRACY**