EFFECT OF THE NATURAL COMPONENTS OF THE EARTHQUAKES ON THE BUILDING RESPONSES

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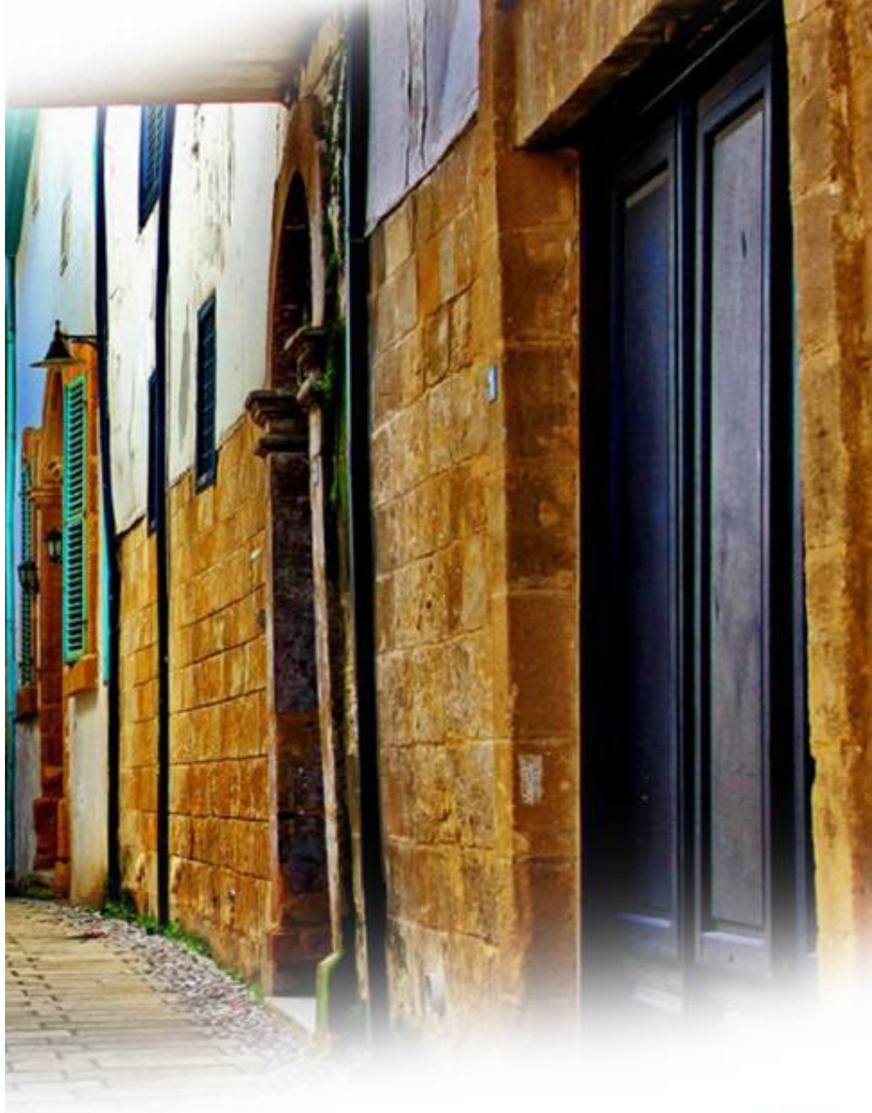

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Make changes, press Apply
Maximum earthquakes:
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1970-01-01
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Data Source:
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Show plate boundaries:
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View earthquakes as:
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IEB export: 36 earthquakes as a sortable table.

from 1970-01-01 to 2025-01-01, with magnitudes from 5 to 10, depths from 0 to 900 km, with priority for size, limited to 300, showing data from USGS.

CYPRUS REGION

TIP: To sort click on column headers. To sort by absolute time of event use Timestamp column.
TIP: Sort by up to 3 columns: hold shift key while clicking.
TIP: Table can often be pasted right into other apps such as Excel. Double-click to select all, then copy and paste.

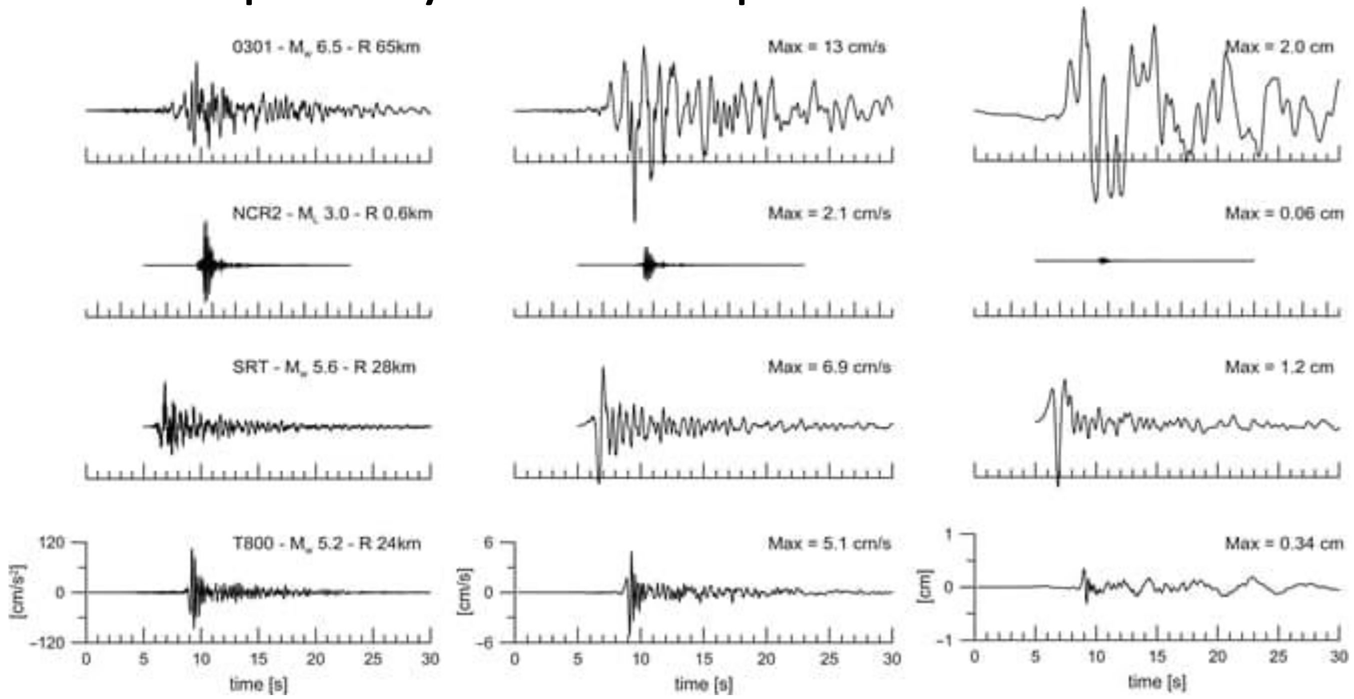
Download data as : Excel Binary NetCDF

Year	Month	Day	Time UTC	Mag	Lat	Lon	Depth km	Region	USGS ID	Timestamp
2021	01	21	14:27:06	5.0	35.0489	33.7163	62.9	1 km NE of Pérgamos, Cyprus	us7000d23a	[illegible]
2020	12	05	12:44:40	5.3	36.0777	31.8657	80.9	45 km WSW of Gazipaşa, Turkey	us7000cnf1	[illegible]
2018	09	12	06:21:48	5.3	36.1850	31.0583	50.0	59km SE of Tekirova, Turkey	us2000hdam	[illegible]
2015	04	15	08:25:11	5.3	34.8078	32.3311	10.0	6km WSW of Kissonerga, Cyprus	us200026mv	[illegible]
2015	08	18	21:19:44	5.0	35.6473	31.2871	47.3	115km SW of Gazipasa, Turkey	us1000339b	[illegible]
2013	12	28	15:21:04	5.9	36.0280	31.3100	40.7	77km SSW of Avsallar, Turkey	usc000ltax	[illegible]
2012	05	11	18:40:29	5.4	34.3040	34.1420	16.6	Cyprus region	usp000jkam	[illegible]
2009	12	22	06:06:23	5.3	35.7200	31.5110	63.5	Cyprus region	usp000h58a	[illegible]
2005	05	14	23:46:50	5.1	35.6870	31.5820	69.2	Cyprus region	usp000dqua	[illegible]
2003	05	03	11:22:40	5.5	36.8840	31.5360	135.3	western Turkey	usp000bwh3	[illegible]
1999	08	11	04:27:55	5.6	34.7910	32.9390	33.0	Cyprus region	usp0009cw5	[illegible]
1999	05	25	17:15:21	5.6	34.4780	32.1310	10.0	Cyprus region	usp00098rd	[illegible]
1999	08	17	15:06:27	5.1	34.8140	32.8590	33.0	Cyprus region	usp0009d7b	[illegible]
1997	01	13	10:19:26	5.7	34.3050	32.3260	33.0	Cyprus region	usp0007vtt	[illegible]
1996	10	09	13:10:52	6.8	34.5560	32.1260	33.0	Cyprus region	usp0007r4u	[illegible]
1996	10	09	14:19:37	5.7	34.5910	32.2080	33.0	Cyprus region	usp0007r50	[illegible]
1996	10	10	01:10:22	5.7	34.5600	32.2140	33.0	Cyprus region	usp0007r6q	[illegible]
1996	11	27	00:44:23	5.4	34.4990	32.0600	33.0	Cyprus region	usp00079km	[illegible]
1996	10	09	14:00:10	5.2	34.4960	32.0630	33.0	Cyprus region	usp0007r4z	[illegible]
1996	10	10	04:54:46	5.2	34.8480	32.2880	33.0	Cyprus region	usp0007r74	[illegible]
1996	10	09	16:22:37	5.1	34.4920	32.2270	33.0	Cyprus region	usp0007r5f	[illegible]
1996	12	02	04:08:48	5.0	34.4010	32.1840	33.0	Cyprus region	usp0007tux	[illegible]
1996	10	10	00:23:39	5.0	34.4950	32.1580	33.0	Cyprus region	usp0007r6j	[illegible]
1996	10	21	06:00:48	5.0	34.4580	32.3000	33.0	Cyprus region	usp0007rr4	[illegible]
1995	02	23	21:03:01	5.9	35.0460	32.2790	10.0	Cyprus region	usp0006du	[illegible]
1995	05	29	04:58:32	5.3	35.0390	32.2460	10.0	Cyprus region	usp0006y8m	[illegible]
1995	02	23	21:40:31	5.3	35.0430	32.3140	10.0	Cyprus region	usp0006te2	[illegible]
1993	03	22	11:03:43	5.4	34.6970	34.4020	32.1	Cyprus region	usp0005pyb	[illegible]
1991	12	05	20:21:55	5.2	36.1350	31.8070	114.9	western Turkey	usp000502z	[illegible]
1987	01	15	11:19:34	5.0	34.6780	33.9050	34.4	Cyprus region	usp00031pn	[illegible]
1984	03	28	16:15:05	5.0	34.7860	33.6060	34.4	Cyprus region	usp000232c	[illegible]
1979	05	28	09:27:32	5.9	36.4090	31.7510	98.0	western Turkey	usp00010ys	[illegible]
1979	12	31	06:21:34	5.3	36.1840	31.5100	79.0	western Turkey	usp00014sz	[illegible]
1977	06	01	12:54:49	5.7	36.2430	31.3440	67.0	western Turkey	usp0000p46	[illegible]
1976	01	12	17:50:24	5.1	34.3180	32.5290	33.0	Cyprus region	usp0000edf	[illegible]
1976	01	12	20:19:57	5.0	34.3860	32.4530	20.0	Cyprus region	usp0000edj	[illegible]

Listing 36

GROUND MOTIONS COMPONENTS

Ever since ground motions have been recorded in 1940 and it has been tried to develop ways which can quantify the earthquakes.



These cover characteristics such as **amplitude of motion**, **frequency content of motion**, **duration of motion**, etc

GROUND MOTIONS COMPONENTS

Commonly used and known as design basis ground motion parameters (DBGM):

- Peak ground acceleration (PGA) value
- Response spectrum
- Acceleration time history of a site

SELECTED GROUND MOTIONS COMPONENTS

Following parameters of the selected ground motions have been selected to study the effectiveness of the parameters:

- Peak ground acceleration (PGA)
- Peak ground velocity (PGV)
- Peak ground displacement (PGD)
- Pulse period (Tp)

In addition, in order to better understand the correlation between the selected parameters of PGA, PGV and PGD the ratio of **PGA/PGV** and **PGV/PGD** have been considered in this study.

SELECTED GROUND MOTIONS

In this direction, **100 pulse-like ground motions** have been selected whose pulse period ranges between the **0.5** and **13 sec**.

Table 1: Selected pulse-like ground motions

#	EQ Name	Year	Mag.	Tp (s)	Duration (s)	PGA (cm/s^2)	PGV (cm/s)	PGD (cm)	PGA/PGV (1/s)	PGV/PGD (1/s)
1	NORTHR_PAC175	1994	6.69	0.588	19.98	407.89	44.29	5.01	9.21	8.84
2	NORTHR_PKC360	1994	6.69	0.728	39.98	424.60	51.38	7.21	8.26	7.12
3	GREECE_K-KAL-NS	1986	5.4	0.789	15.20	158.31	12.79	1.31	12.38	9.76
4	SANSALV_GIC180	1986	5.8	0.805	9.02	412.84	62.29	13.09	6.63	4.75
5	NORTHR_SPV360	1994	6.69	0.931	47.80	914.30	76.27	17.67	11.99	4.31
6	KOBE_KJM090	1995	6.9	1.092	149.98	617.69	76.11	18.31	8.12	4.15
7	SANSALV_NGI180	1986	5.8	1.127	20.27	396.29	56.38	19.64	7.03	2.87
8	COYOTELK_G03140	1979	5.74	1.155	26.85	251.50	29.58	6.34	8.50	4.66
9	COYOTELK_G06230	1979	5.74	1.232	27.10	413.77	44.35	12.44	9.33	3.56
10	MORGAN_G06090	1984	6.19	1.232	30.00	286.71	36.49	5.95	7.86	6.13
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

In this study, the selected ground motions have been categorized as shown in the following table:

Table 2: categorized group of the ground motions

Ground Motions Components		
PGA/PGV	**PGV/PGD**	**Tp**
1<PGA/PGV<5	1<PGV/PGD<4	0.5<Tp<4
5<PGA/PGV<9	4<PGV/PGD<7	4<Tp<8
9<PGA/PGV<12.4	7<PGV/PGD<10	8<Tp<13

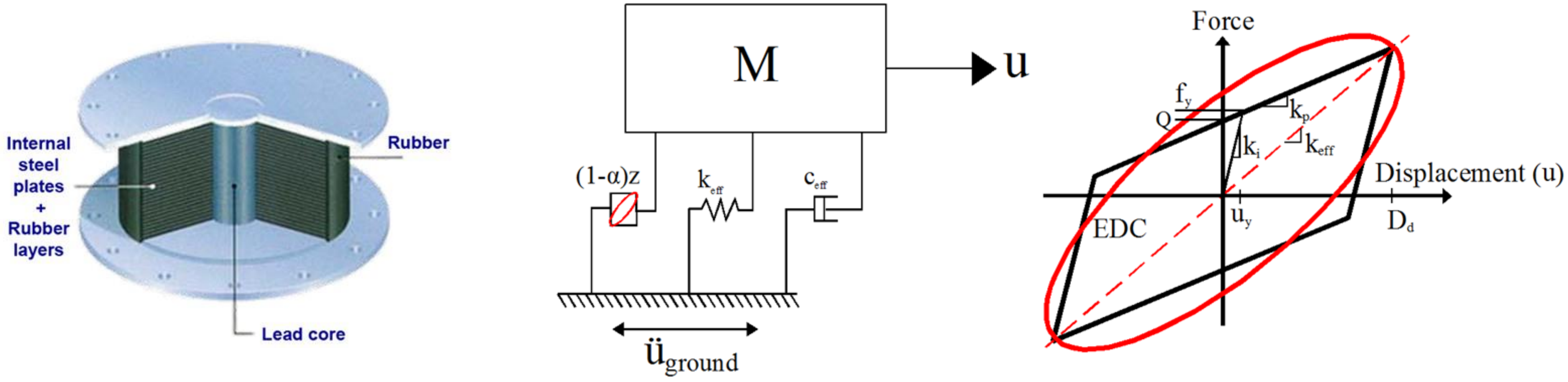
STUDY MODEL

In this investigation two different type of buildings, **Semi-Flexible** and **Flexible building** with and without seismic isolation system have been considered.

In this direction, based on ASCE, the building whose fundamental period is **less than 1** are in the category of **Semi-Flexible** building or else it is in the category of **Flexible building**

SEISMIC ISOLATION

Due to simplicity and with the highest efficiency compared to the other seismic isolation system, **Lead Core Rubber (LRB)** bearing have been selected as an isolator system to be used in the selected buildings.



(A) (B) (C)

Figure 1: a) Idealization of the LCRB system; b) Hysteretic model of the LCRB

ANALYITICAL MODEL

Stick Model:

The modeling and time history analyses of the considered buildings have been carried out using **MATLAB** considering elastic shear-beam stick model.

Fixed Base

Base Isolated

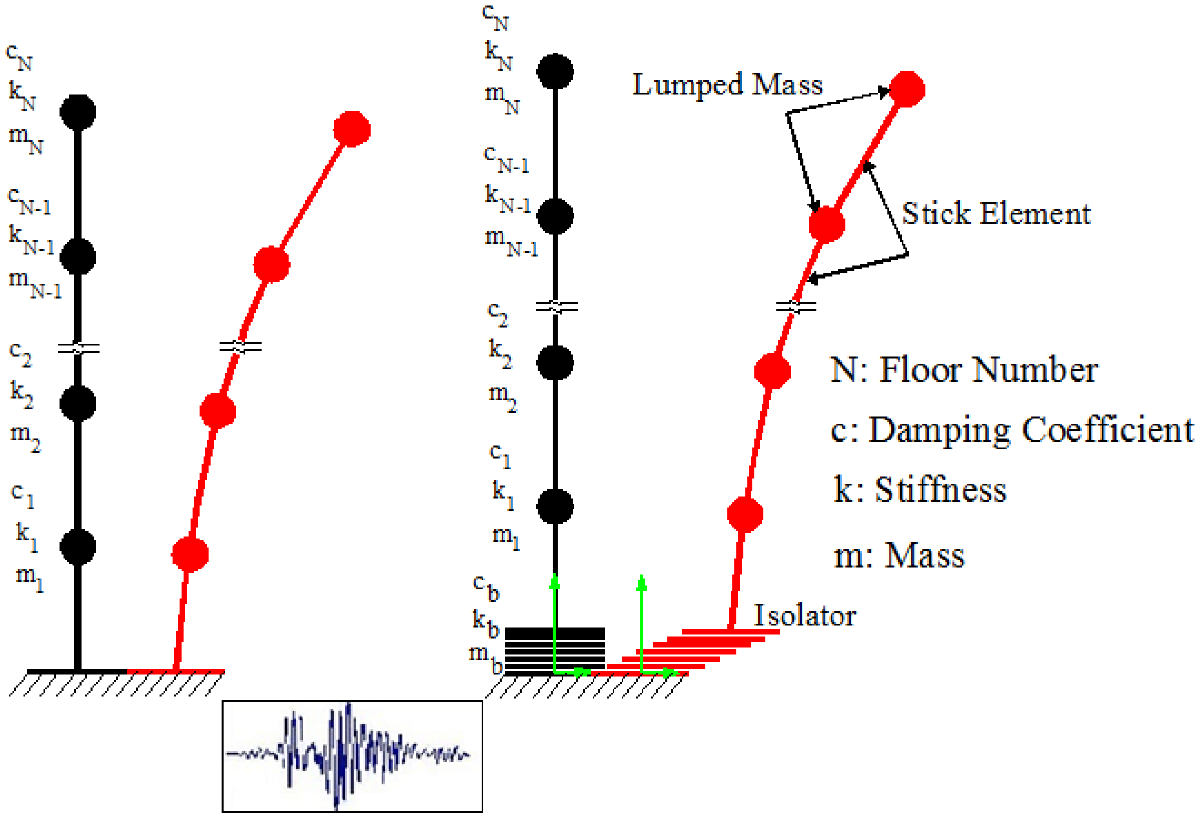


Figure 2: Stick model of fixed and seismic isolated building

SUPPER-STRCURE PROPERTIES

5- and **20-story** building with the following mass and stiffness properties have been investigated:

Table 3: Stiffness proportion and mass properties of the considered buildings (Fixed Base)

Floor level	Mass (ton)	Stiffness proportion	Stiffness (k) (N/cm)	Floor level	Mass (ton)	Stiffness proportion	Stiffness (k) (N/cm)	Damping ratio for steel structure (ξ_s)
5-story				20-story				
1	720	$k_1 = 1k$	1683×10^6	1-4	720	$k_1 = 1k$	1589×10^6	2 %
2	720	$k_2 = 0.8k$	1346×10^6	5-8	720	$k_2 = 0.8k$	1271.2×10^6	
3	720	$k_3 = 0.64k$	1075×10^6	9-12	720	$k_3 = 0.64k$	1016.7×10^6	
4	720	$k_4 = 0.51k$	860×10^6	13-16	720	$k_4 = 0.51k$	813.568×10^6	
5	360	$k_5 = 0.41k$	683×10^6	17-19	720	$k_5 = 0.41k$	650.854×10^6	
				20	360	$k_5 = 0.41k$	650.854×10^6	
Total	3240	-	-	Total	14040	-	-	

Table 4: Details of mass calculation for each story

Total floor area for a single story	$30\text{ m} \times 30\text{ m} = 900\text{ m}^2$
Story Dead load (Floor Dead load)	$650\frac{\text{kg}}{m^2} \times 900\, m^2 = 585000\frac{kg}{story}$
Other assumed mass	$53100\frac{\text{kg}}{story}$
ψ_{2i}LL where LL=300 $\frac{\text{kg}}{\text{m}^2}$	$0.3 \times 300\frac{kg}{m^2} \times 900\, m^2 = 81000\frac{kg}{story}$
Seismic mass (DL+ψ_{2i}LL)	$719100\frac{\text{kg}}{\text{story}} \cong 720000\frac{\text{kg}}{\text{story}}$

INPUT VARIABLITY OF THE ISOLATOPR

In put variability of the mechanical properties of the seismic isolation system:

From each mechanical property, 300 variables have been selected randomly and time history analysis has been implemented. Overall, 30000 analyses have been conducted for seismic isolation systems.

Table 5: Input uncertain variables mean, standard deviation and ranges

Variable parameters	mean	Standard deviation	Mechanical parameters Ranges
Isolator period (T_{eff})	4.012 s	0.475 s	$2\ s \leq T_b \leq 6\ s$
Damping Ratio (β_{eff})	0.1	0.0118	$0.05 \leq \beta_{eff} \leq 0.15$
Design displacement (D_d)	72.44 cm	6.544 cm	$45\ cm \leq D_d \leq 100\ cm$
Yielding displacement ($u_y = \frac{Q}{k_i - k_p}$)	1.5 cm	0.246 cm	$0.8\ cm \leq u_y \leq 2.56\ cm$

RESULTS AND DISCUSSION (TOP FLOOR ACCELERATION)

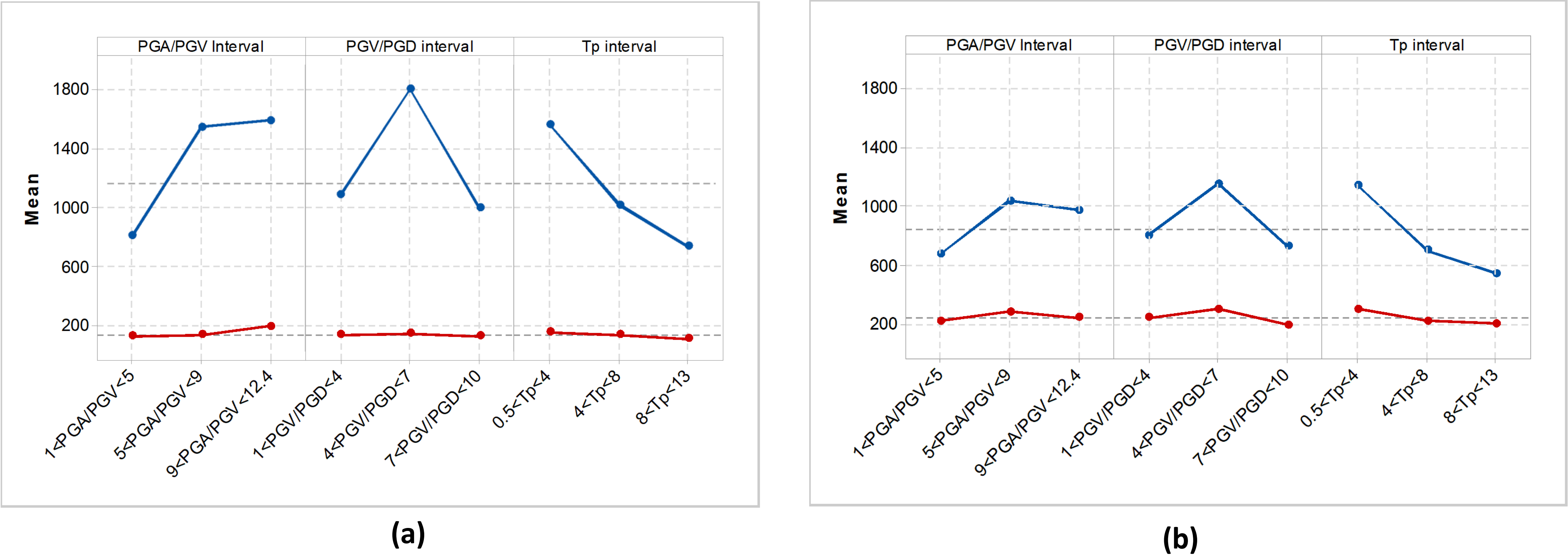
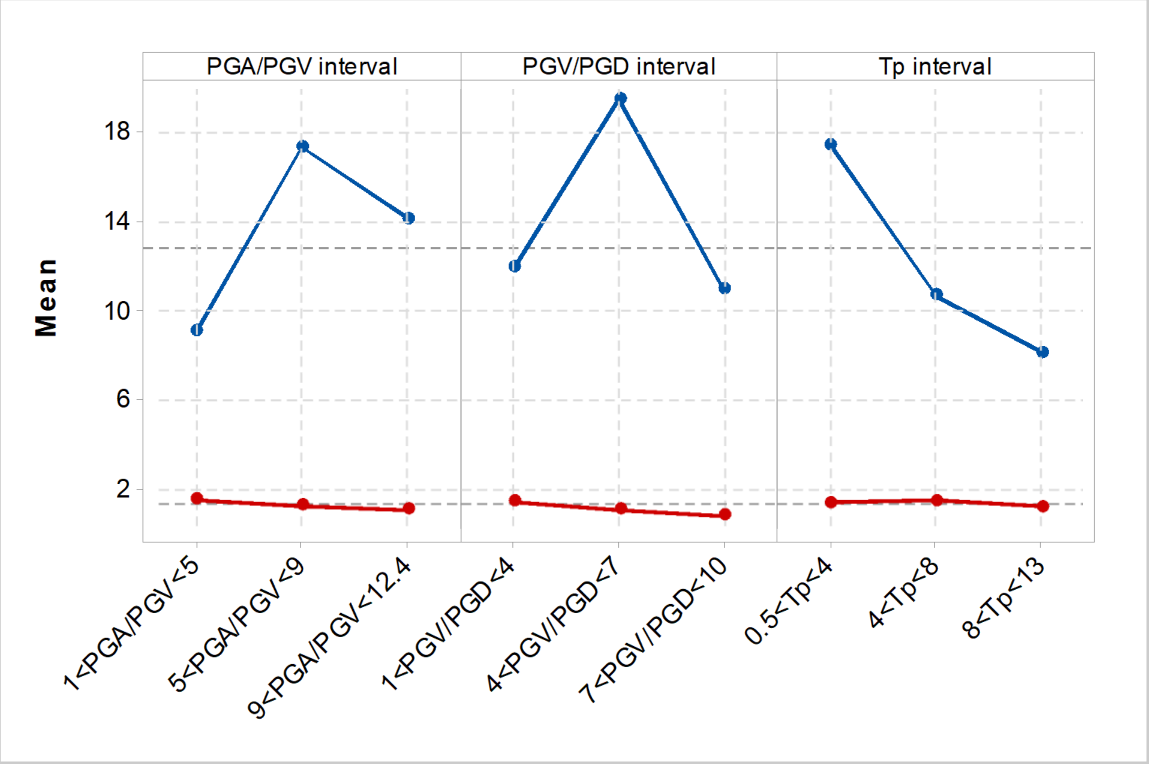
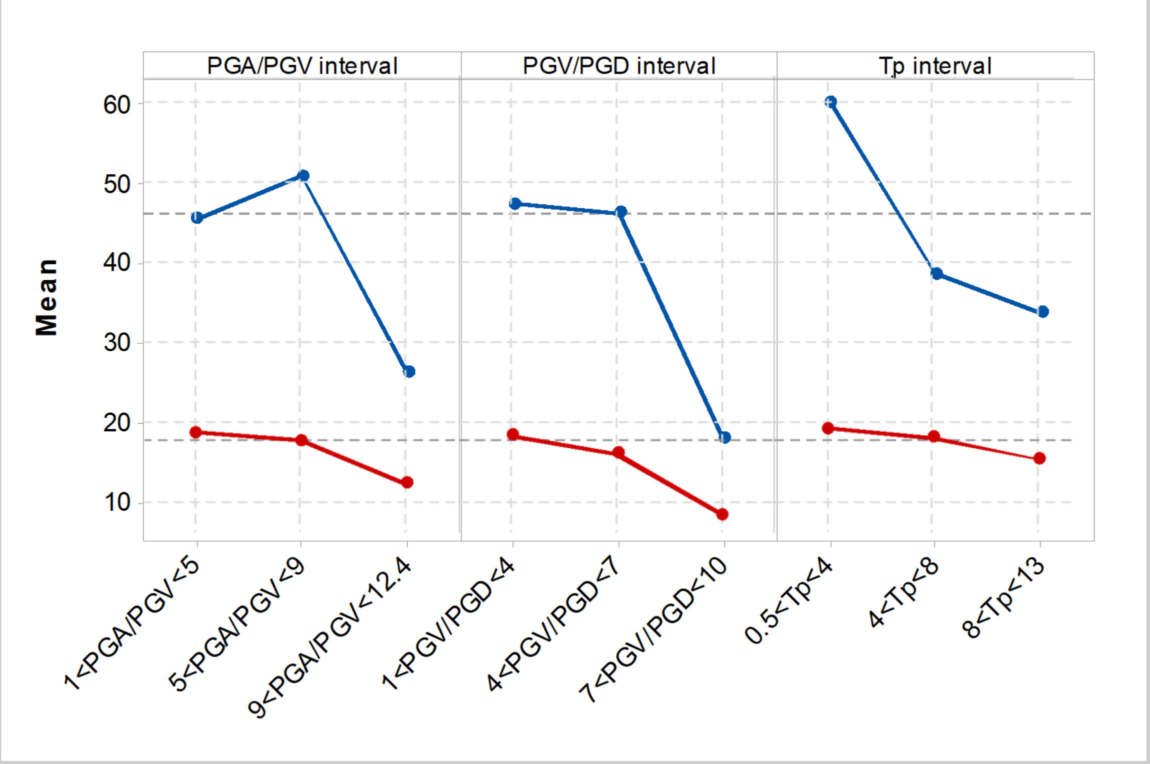


Figure 3: Effectiveness of ground motions parameters to the top floor **Acceleration a)** 5-story (rigid building) **b)** 20-story (flexible building) (**Blue:** **FB, Red: BIB)**

RESULTS AND DISCUSSION (TOP FLOOR DISPLACEMENT)



(a)



(b)

Figure 4: Effectiveness of ground motions parameters to the top floor **Displacement a)** 5-story (rigid building) **b)** 20-story (flexible building) (**Blue: FB, Red: BIB)**

RESULTS AND DISCUSSION (PROBABLITY FAILURE)

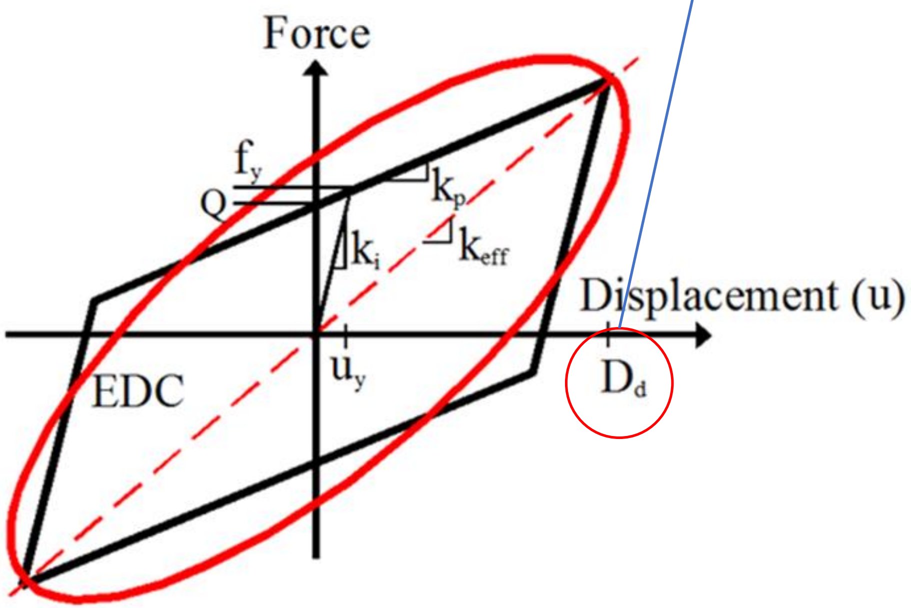
In following, probability failure of bearing responses for seismic isolated building have been discussed.

In order to evaluate the probability failure, bearing responses limited to the peak ground responses:

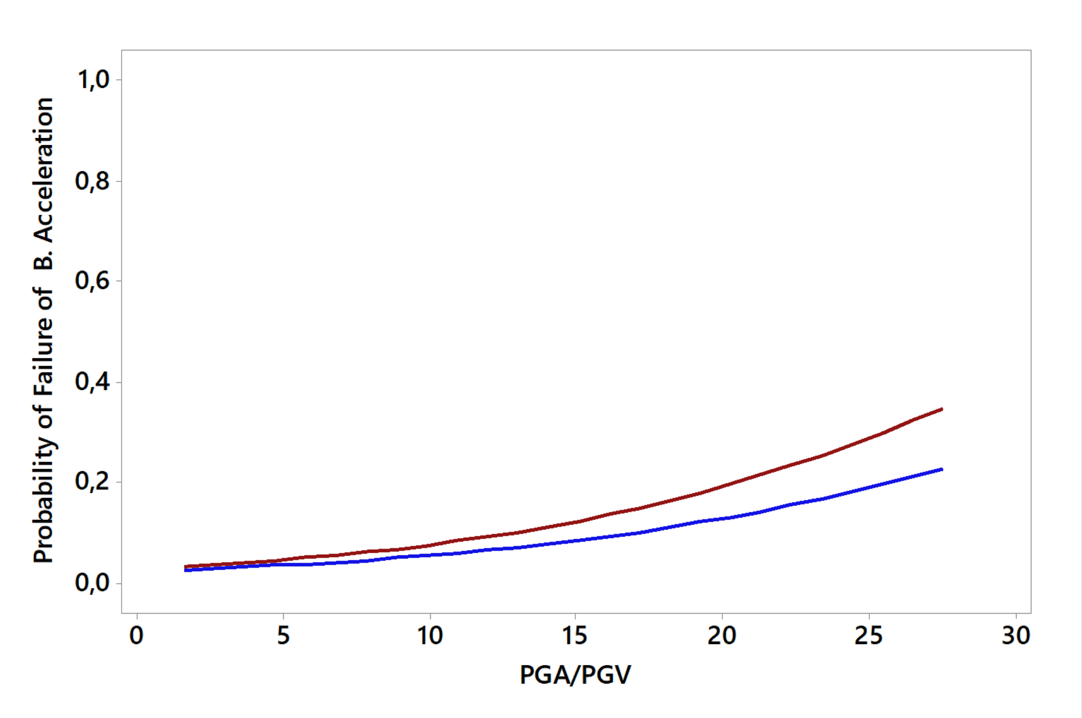
1) **Telecommunication buildings, hospitals,** and other important buildings usually maximum horizontal accelerations are limited to **300 cm/s^2** .
   But from contents to contents the limitation is different and depends on the operating system and varies between 250 cm/s^2 to 1000 cm/s^2.

RESULTS AND DISCUSSION (PROBABLITY FAILURE)

2) Performance limit for the **peak bearing displacement**



RESULTS AND DISCUSSION (PROBABLITY FAILURE)



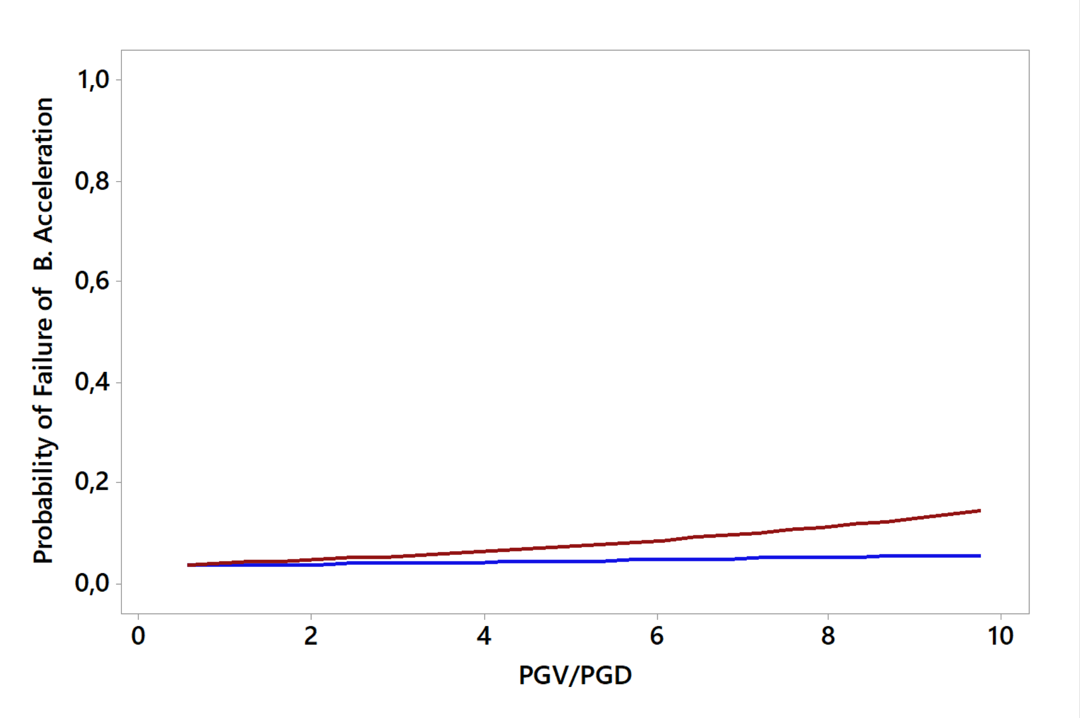


Figure 5: Probability failure of **Bearing Acceleration** based on PGA/PGV and PGV/PGD (**Blue: 5-story , Red: 20-story**)

RESULTS AND DISCUSSION (PROBABLITY FAILURE)

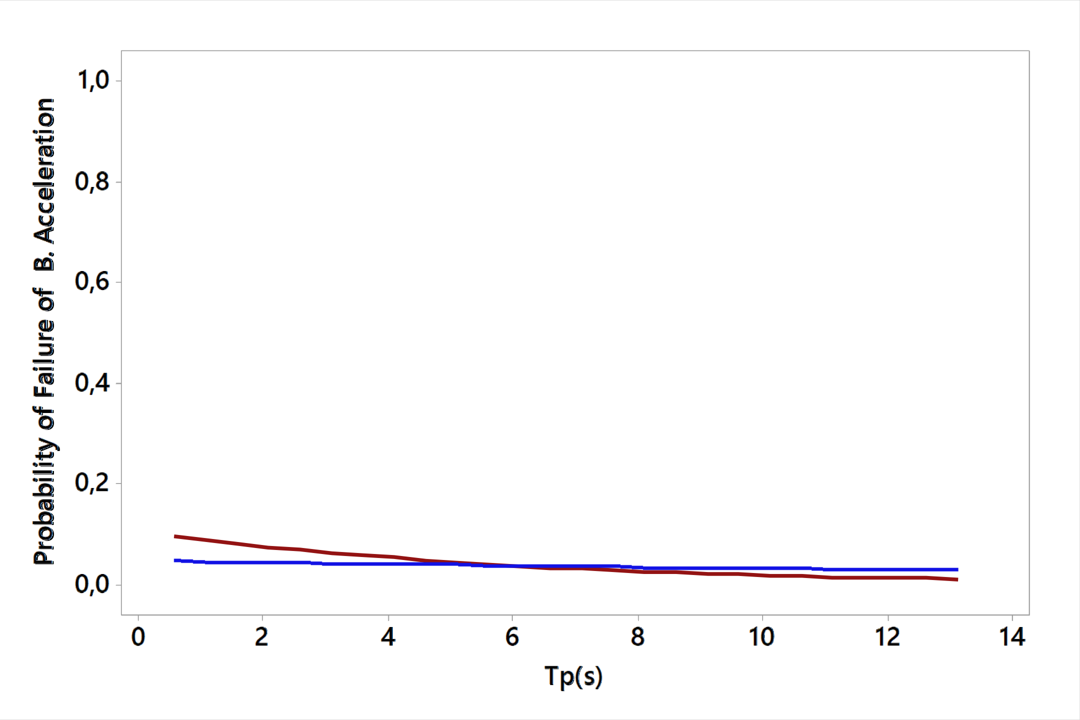


Figure 6: Probability failure of **Bearing Acceleration** based on Pulse-period (**Blue:** **5-story** **,** **Red:** **20-story**)

RESULTS AND DISCUSSION (PROBABLITY FAILURE)

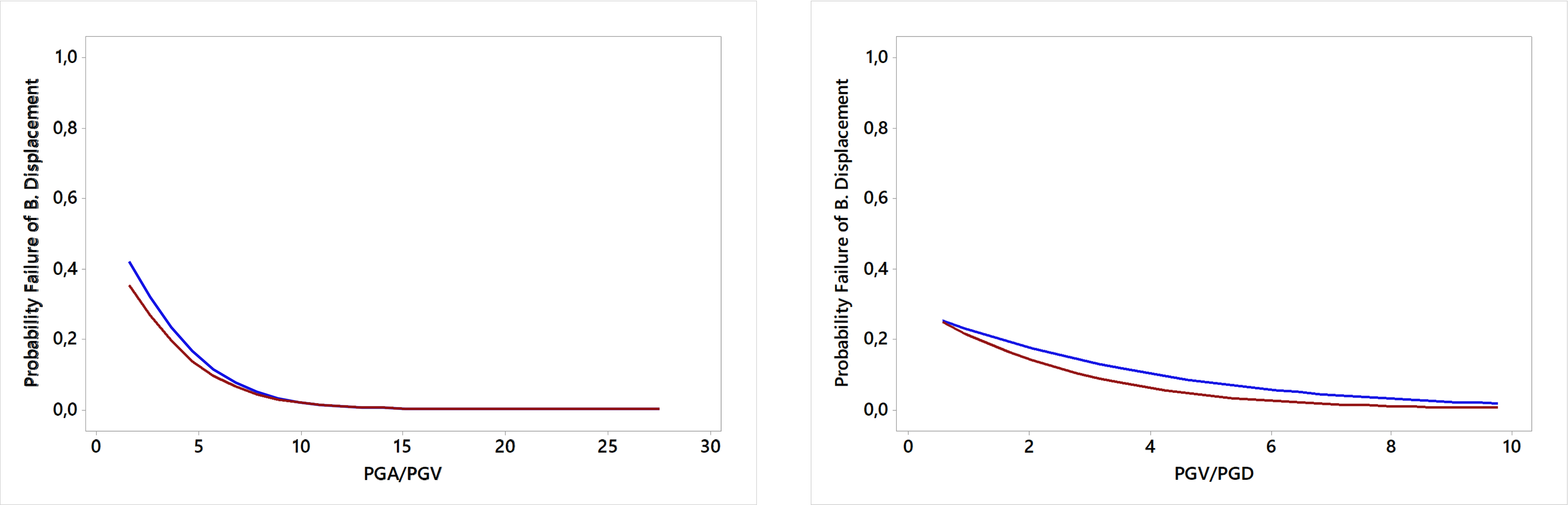


Figure 7: Probability failure of **Bearing Displacement** based on PGA/PGV and PGV/PGD (**Blue: 5-story , Red: 20-story**)

RESULTS AND DISCUSSION (PROBABLITY FAILURE)

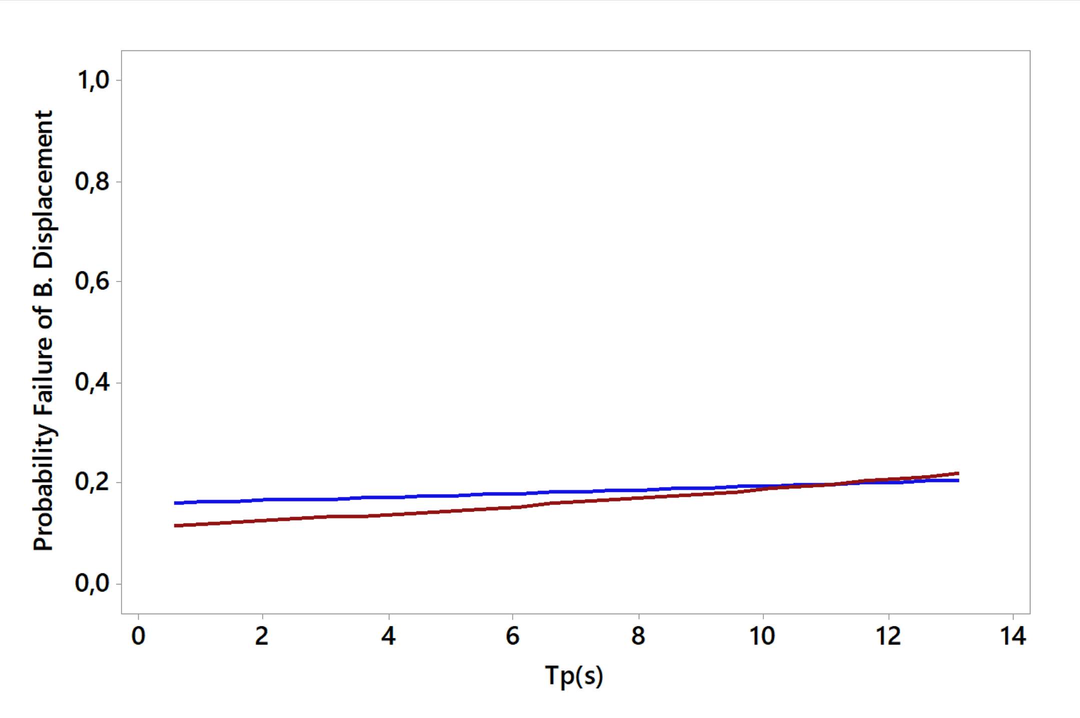


Figure 8: Probability failure of **Bearing Displacement** based on Pulse-period (**Blue:** **5-story** , **Red:** **20-story**)

CONCLUSION

Following table illustrates the **effectiveness** of the group of the ground motions to the top floor responses of the considered buildings:

			Top Floor Acceleration				Top Floor Displacement			
			FB building		BI building		FB building		BI building	
			Rigid	flexible	Rigid	flexible	Rigid	flexible	Rigid	flexible
Ground Motions Components	PGA/PGV	1<PGA/PGV<5								X
		5<PGA/PGV<9	X	X			X	X		X
		9<PGA/PGV<12.4	X	X						
	PGV/PGD	1<PGV/PGD<4						X		X
		4<PGV/PGD<7	X	X			X	X		X
		7<PGV/PGD<10								
	Tp	0.5<Tp<4	X	X			X	X		
		4<Tp<8								
		8<Tp<13								

Probability failure of the seismic isolated buildings:

	Bearing Acceleration		Bearing Displacement	
	Low-rise building	High-rise building	Low-rise building	High-rise building
PGA/PGV	20% for **higher** value of the ratio	35% for **higher** value of the ratio	35% for **lower** value of the ratio	40% for **lower** value of the ratio
PGV/PGD	0%	15% for **higher** value of the ratio	25% for **lower** value of the ratio	25% for **lower** value of the ratio
Tp	0%	10% for **lower** value of pulse period	20% for **higher** value of the ratio	20% for **higher** value of the ratio