



European Council
of
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REPUBLIC OF BULGARIA
Minister of Regional Development and Public Works



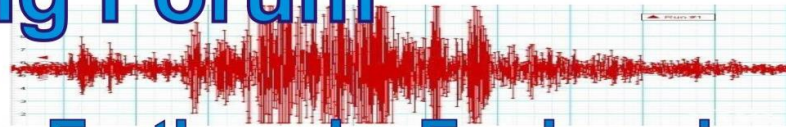
European Council
of Engineers Chambers

BEF
2021

Building Engineering Forum

20-21 October 2021, Sofia, Bulgaria

International Conference on Earthquake Engineering



**Renovation of public cultural heritage
buildings after the Zagreb earthquake
in 2020. – example of design**

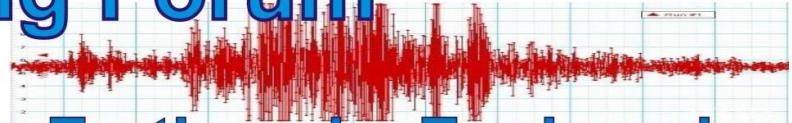
Krešimir Tarnik, Mag.ing.Aedif.



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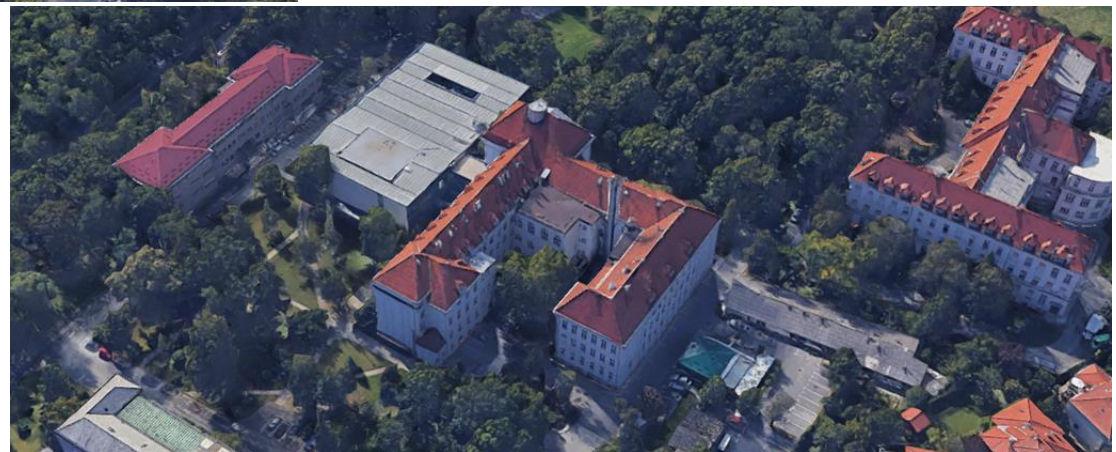


Faculty of Medicine, University of Zagreb, Dean's building.



The building in question is located within the complex of the Faculty of Medicine in the area of Šalata (Zagreb upper town) that spreads over an area of 110,316 m². The building is located southwest of the existing reception building. Construction of the first building of the Dean's Office began in 1911 and was completed in 1913. It was designed by Ignjat Fischer, as a two-story building with an asymmetrical U-floor plan.

Southern facade



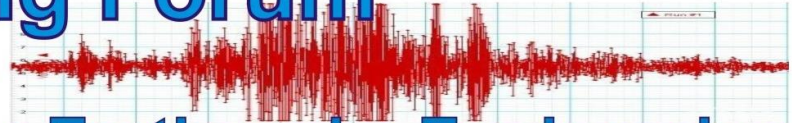
Northern facade



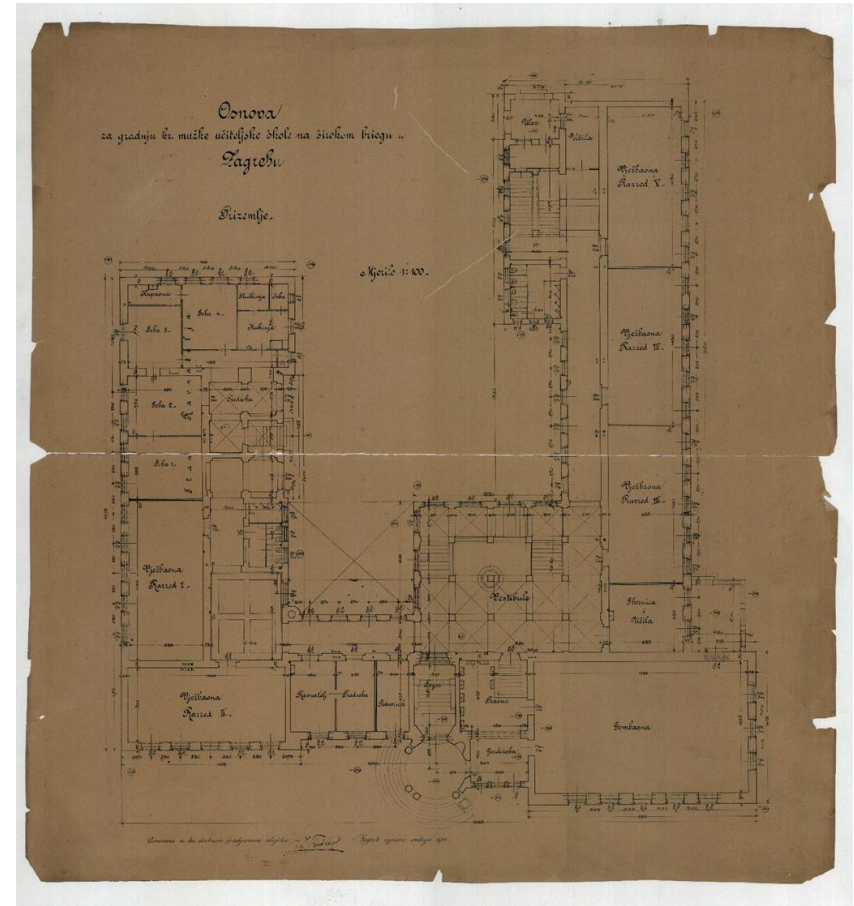
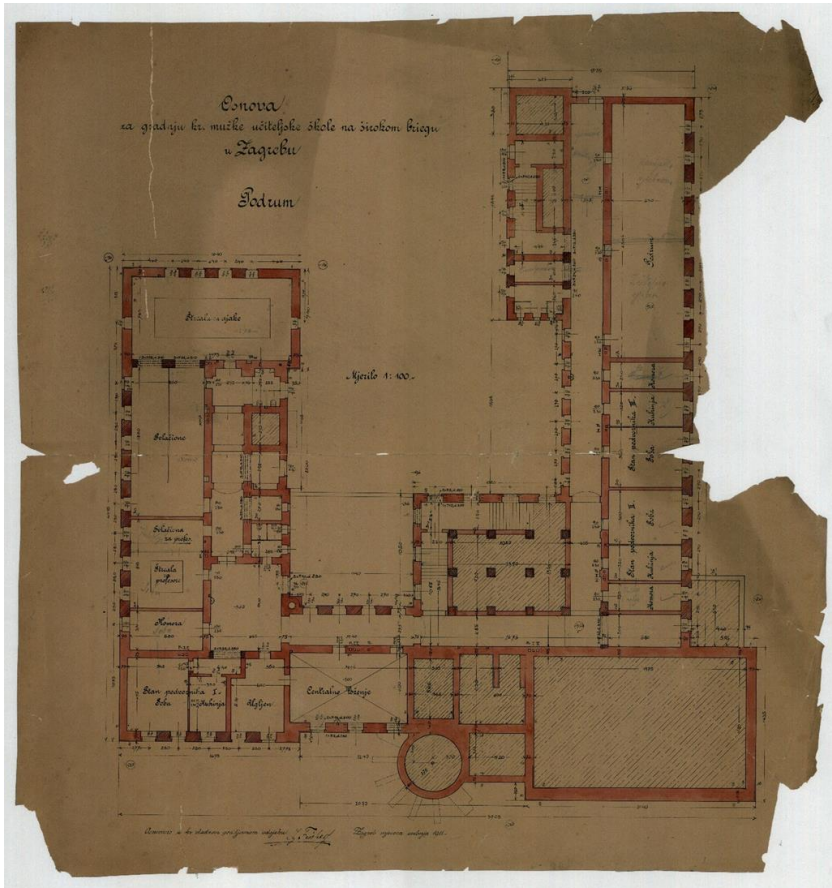
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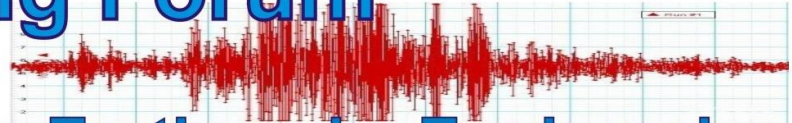




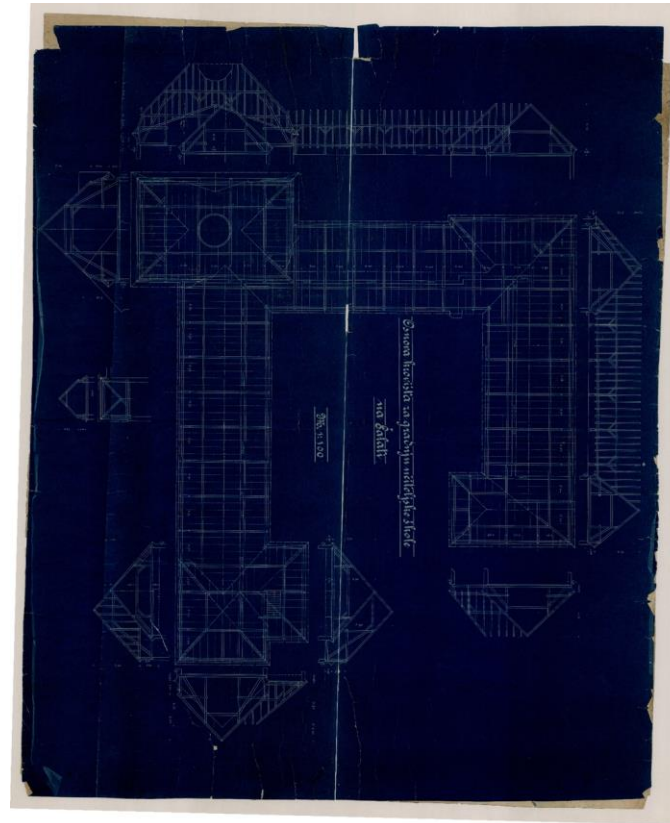
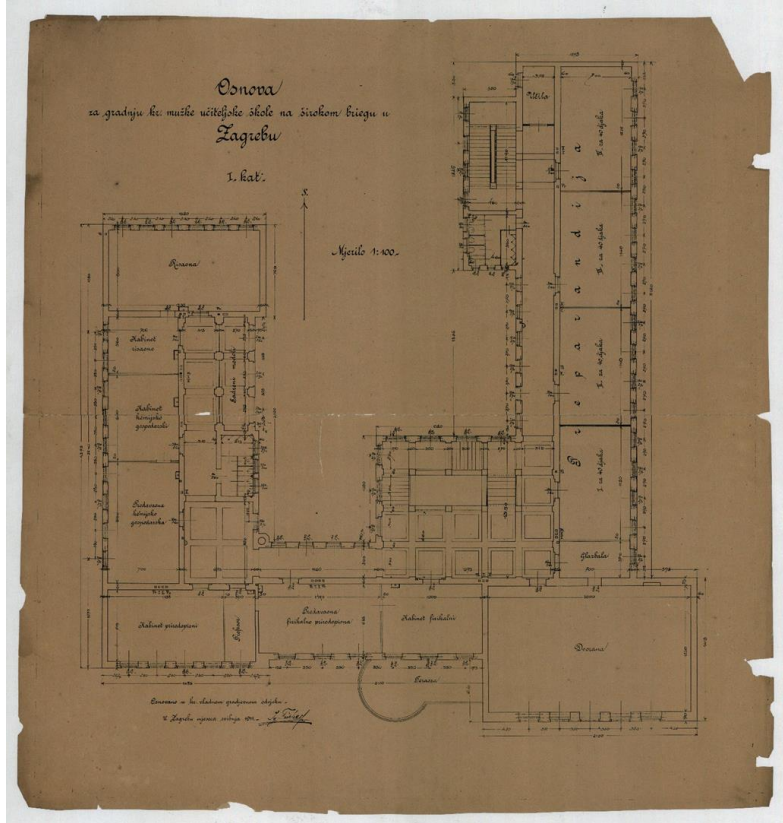
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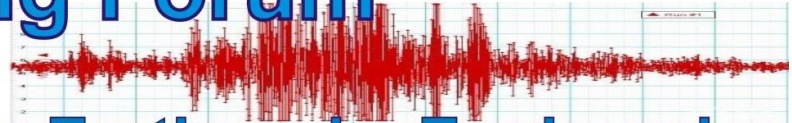
According to available archival blueprints dating from 1911, the building was constructed with concrete slabs and beams. The vertical load-bearing structure is made out of brick walls. Regarding the degree of conservation protection, the building is within the cultural and historical ensemble of the City of Zagreb and is listed as cultural heritage building.



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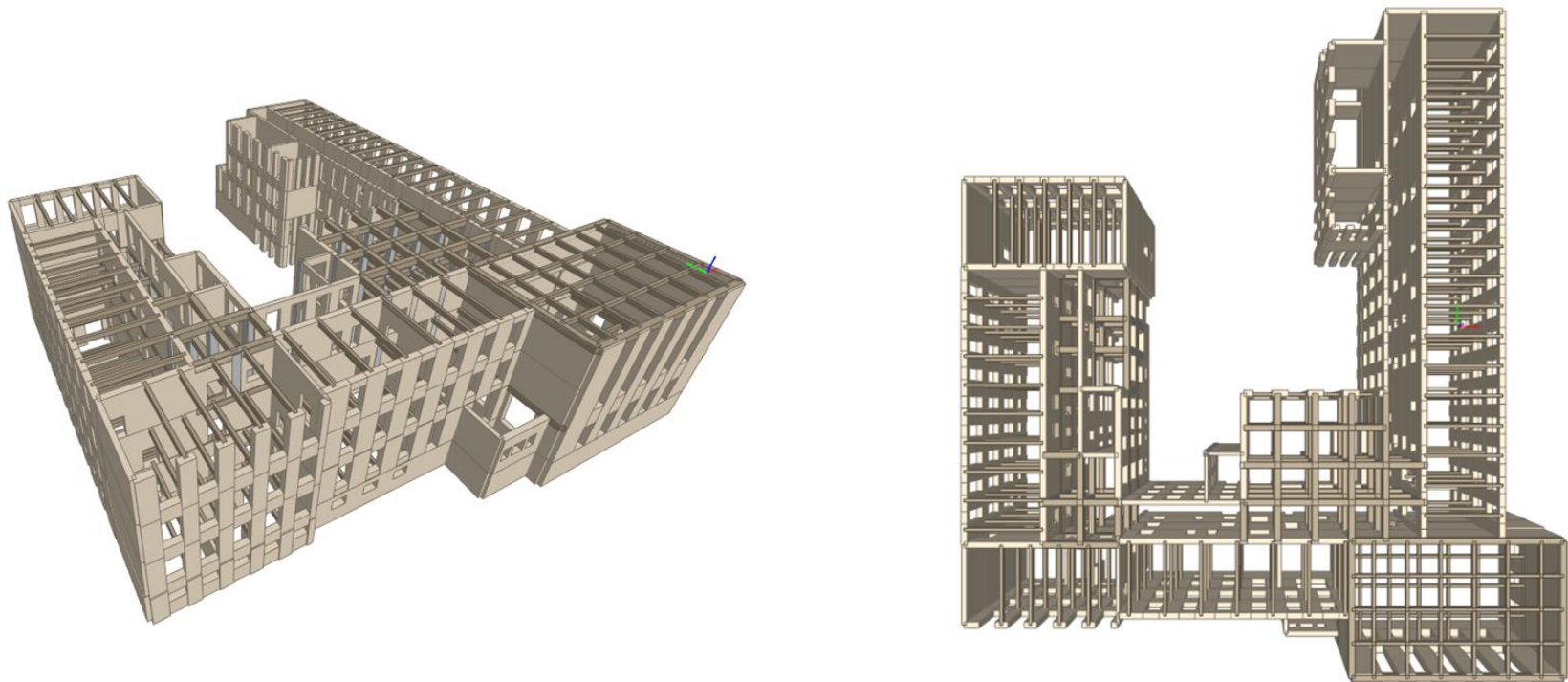
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Below is a 3D view of the structure to better understand the vertical and horizontal load-bearing system. The vertical elements are made of masonry elements characteristic of the time of construction such as solid brick in lime mortar, while the main horizontal bearing elements of the floor structure are made as thin reinforced concrete slabs load-bearing in one direction between raster of directed beams resting on the walls of the transverse direction. The floor slabs are $d = 16$ cm thick.

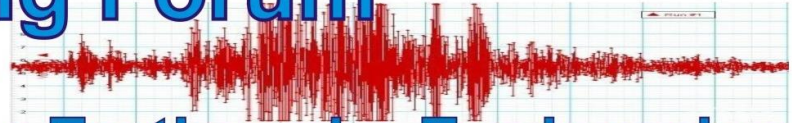




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FIRST STEP

1. Damage to load-bearing structures - Visual inspection of the condition of the structure

The following was observed:

- According to HRN EN 1998-3; Eurocode 8: Design of earthquake resistance of structures - Part 3: Assessment and reconstruction of buildings

The building complied with the "Requirement that there should be no demolition", ie there was no local or global demolition and the building retained structural integrity and remaining load-bearing capacity after the earthquake.

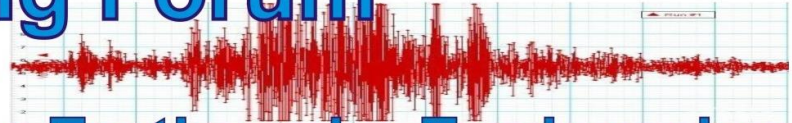
- The building did not fully comply with the "Limited Damage Requirement" in accordance with, ie there was damage and associated restrictions on use that will cause the cost of repairing load-bearing structures and construction works.
- No damage was noticed that would indicate the sagging of the foundation, ie the collapse of the soil under the foundation.
- No cracks were noticed in the load-bearing walls of the basement or in the mezzanine structure above the basement.
- The mezzanine structures above the floors did not suffer any damage, except in the mezzanine structure on the floors at the junction with the building marked 3b.



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- The roof structure has suffered damage, especially to the cornices and gable above the great hall which has been completely demolished.



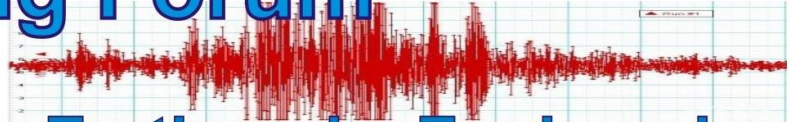
- Cracks 1-3 mm wide appeared in a large number of lintels (especially lintels in load-bearing walls).
- The walls of the staircase are damaged in terms of damage to the plaster and cracks in the masonry columns and in the arches that support the tendons of the stairs.
- Minor cracks appeared on the stair treads and landings, but their stability and load-bearing capacity were not endangered. The undercuts of some stair slabs have in several places a visible line of connection of the elements caused by seismic deformations.



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2. Damage to non-load-bearing parts of the building

The following was observed on non-load-bearing structures:

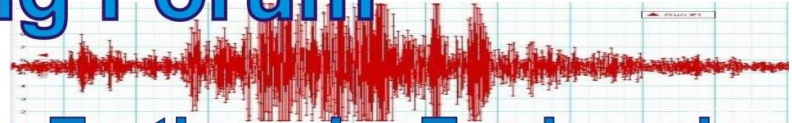
- Significant cracks (1-2 cm wide) appeared in part of the partition walls made of slag-concrete and foam concrete with slag infill, and cracks several millimeters wide appeared on most other partition walls.
- Certain partition walls have detached from the base structure and are swaying to the touch. These elements have been removed for security of use.
- Local cracks have appeared in the plaster on partition walls, joints of partition walls with load-bearing walls and mezzanine structures, in lintels, at the site of installation and the like.
- The plaster from the underlayment of the ceilings and walls and the corners at the joint with the walls was damaged and partially fallen off.
- Damaged ceilings of corridors and individual rooms
- Damaged almost all parapets and lintels above the window



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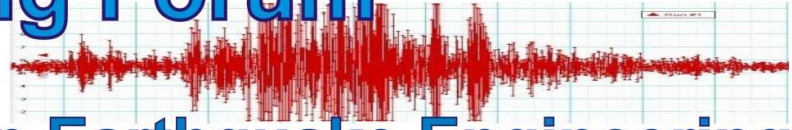
Faculty of Medicine, University of Zagreb, Dean's building.

3. Analysis of the existing condition and forming an opinion on the reasons for particular cracks.

- Cracks formed in the zone of openings in load-bearing walls
- Cracks formed at the junction of the ceiling structure and walls
- The main load-bearing walls without openings are the most damaged because they took on the greatest shear force from the earthquake. Cracks in the load-bearing walls are formed correctly in full X-cracks from the foundation to the cornice without eruption of the load-bearing structure outside the plane of the wall.
- The masonry pillars between the windows remained undamaged (!!!)
- Cracks in stair arches and columns
- The gable of the great hall - collapsed because it was built on a reinforced concrete beam resting upon masonry pillars without connecting to the concrete structure. The shift of the flexibly "soft" element at the top of which is the unbound mass is the cause of the catastrophic demolition of the most recognizable element of the building in question, which is also on the faculty logo.

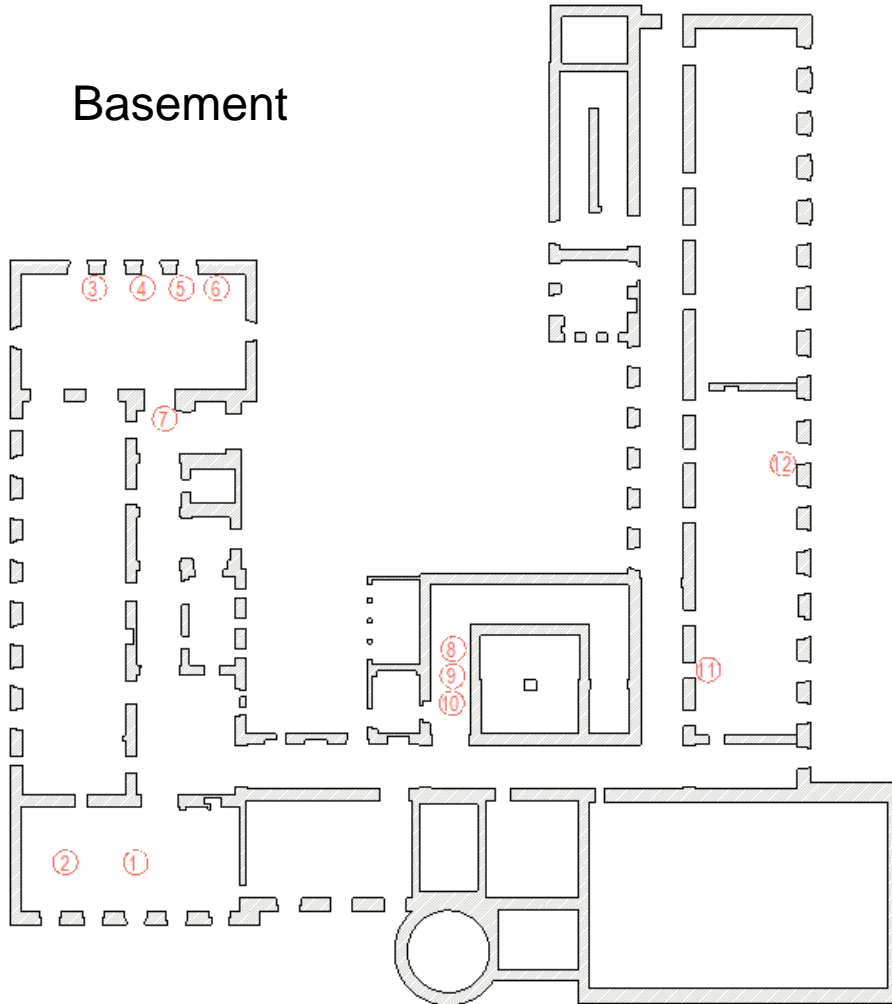
NEXT STEP

Mapping the damage



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Basement



Fotografija 1



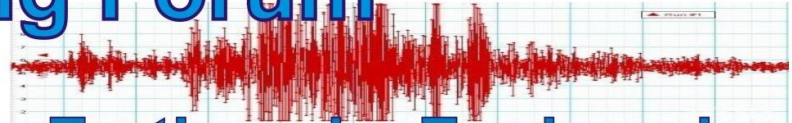
Fotografija 2



Fotografija 3

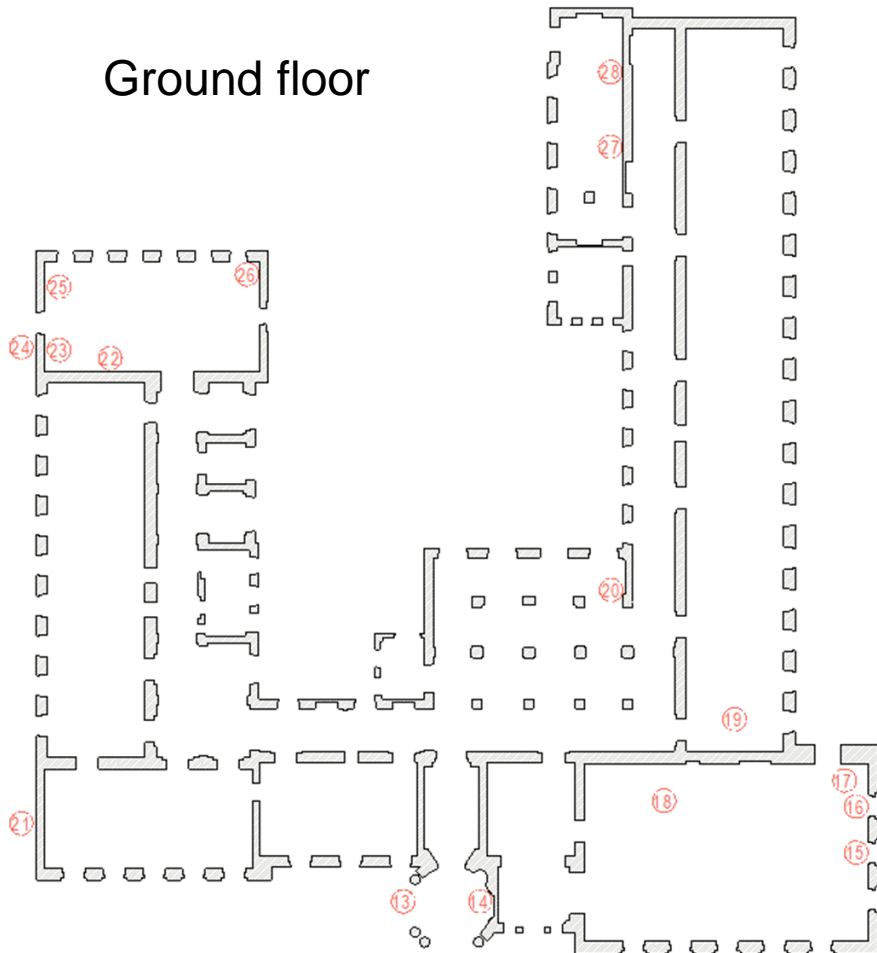


Fotografija 4



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Ground floor



Fotografija 13



Fotografija 14



Fotografija 15



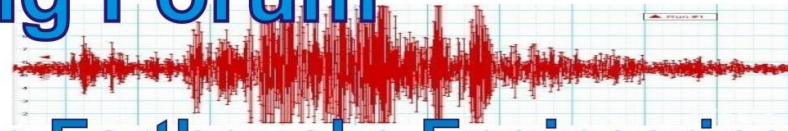
Fotografija 16



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Fotografija 17



Fotografija 18



Fotografija 21



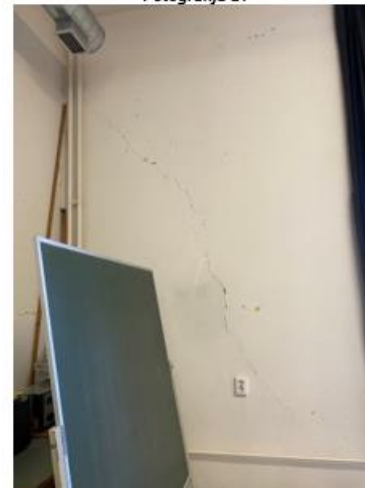
Fotografija 22



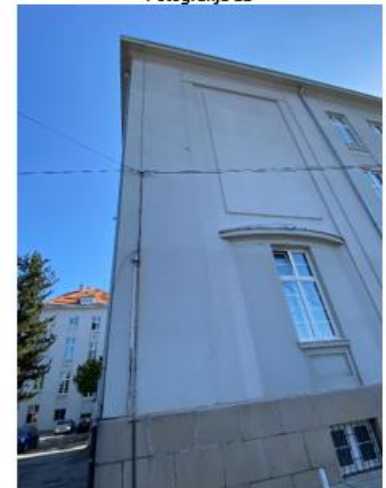
Fotografija 19



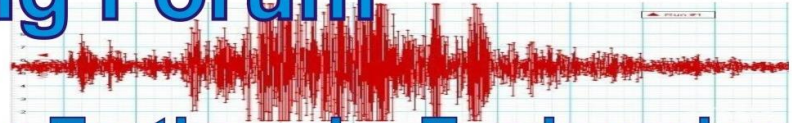
Fotografija 20



Fotografija 23

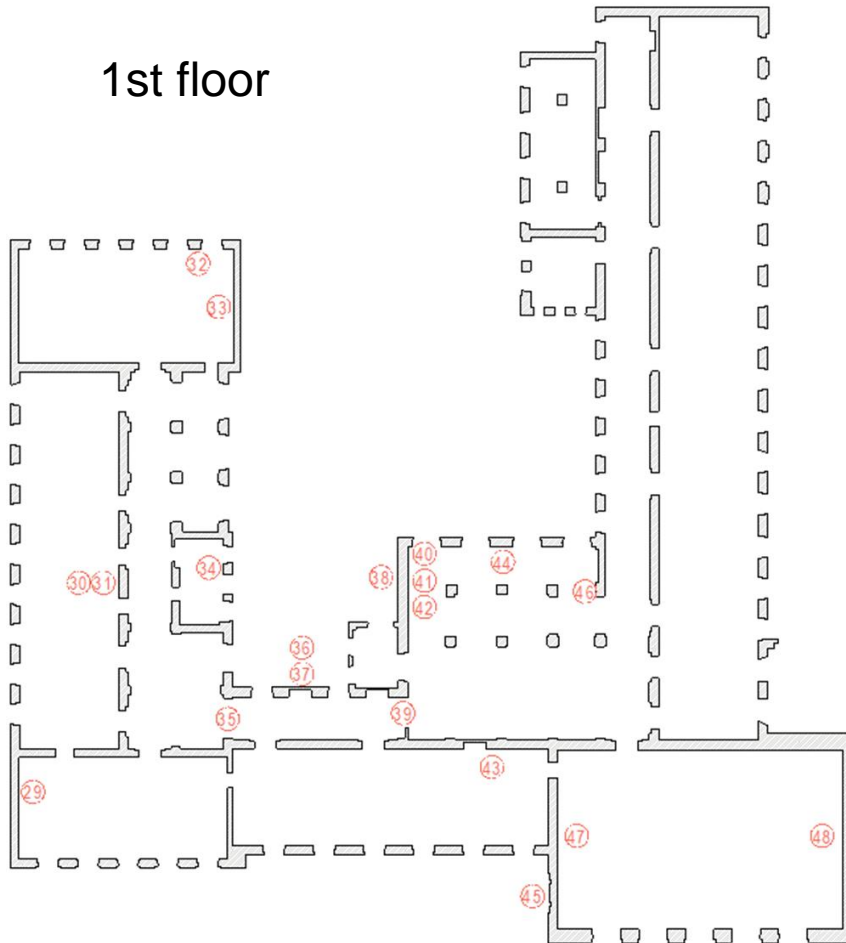


Fotografija 24

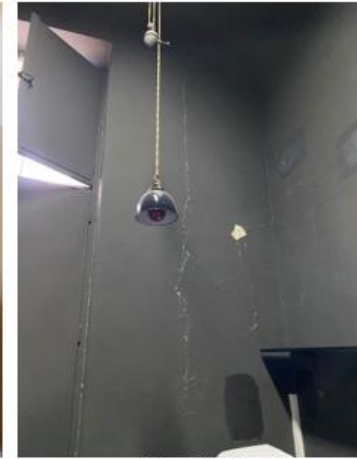


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1st floor



Fotografija 33



Fotografija 34



Fotografija 35



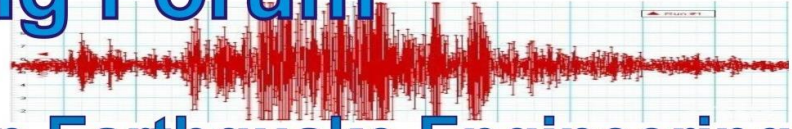
Fotografija 36



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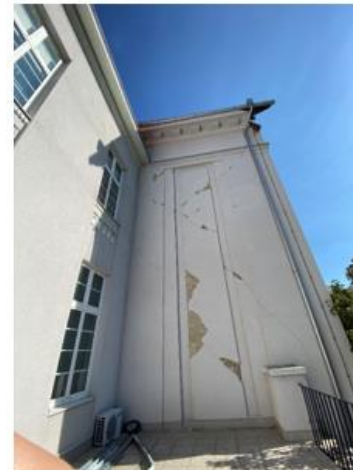
Faculty of Medicine, University of Zagreb, Dean's building.



Fotografija 41



Fotografija 42



Fotografija 45



Fotografija 46



Fotografija 43



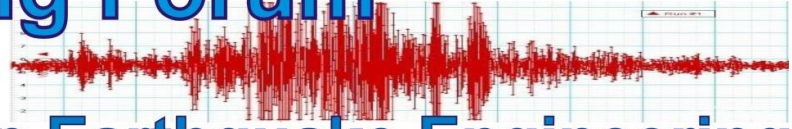
Fotografija 44



Fotografija 47

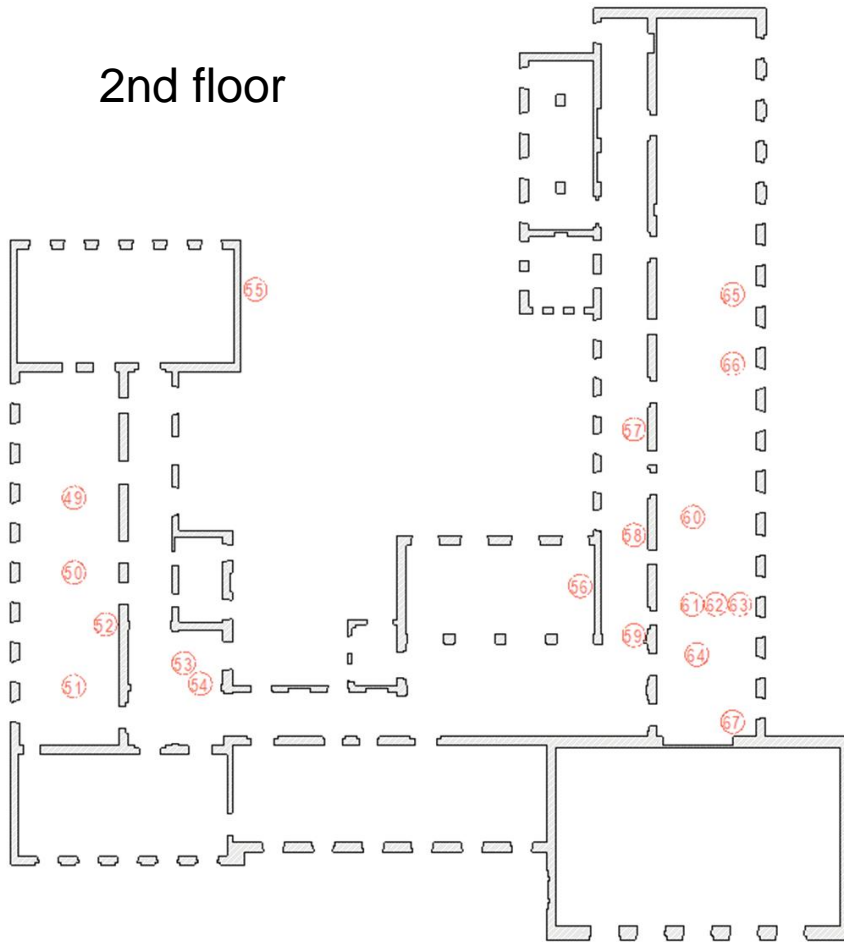


Fotografija 48



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2nd floor



Fotografija 53



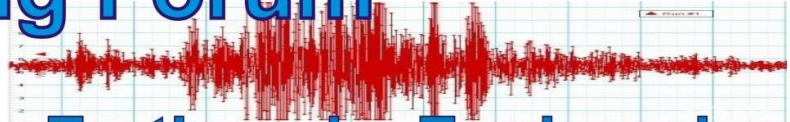
Fotografija 54



Fotografija 55



Fotografija 56



Faculty of Medicine, University of Zagreb, Dean's building.



Fotografija 57



Fotografija 58



Fotografija 65



Fotografija 66



Fotografija 59



Fotografija 60



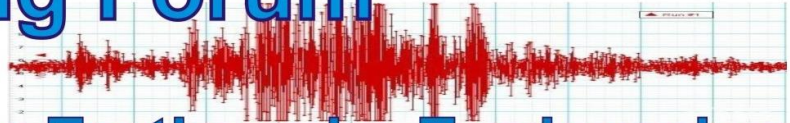
Fotografija 67



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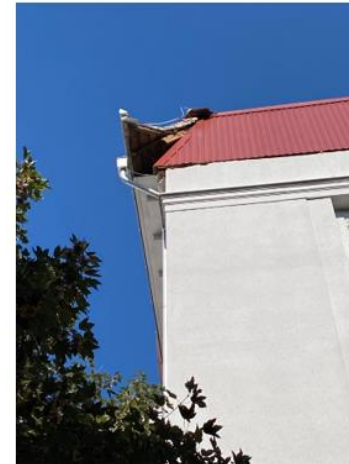
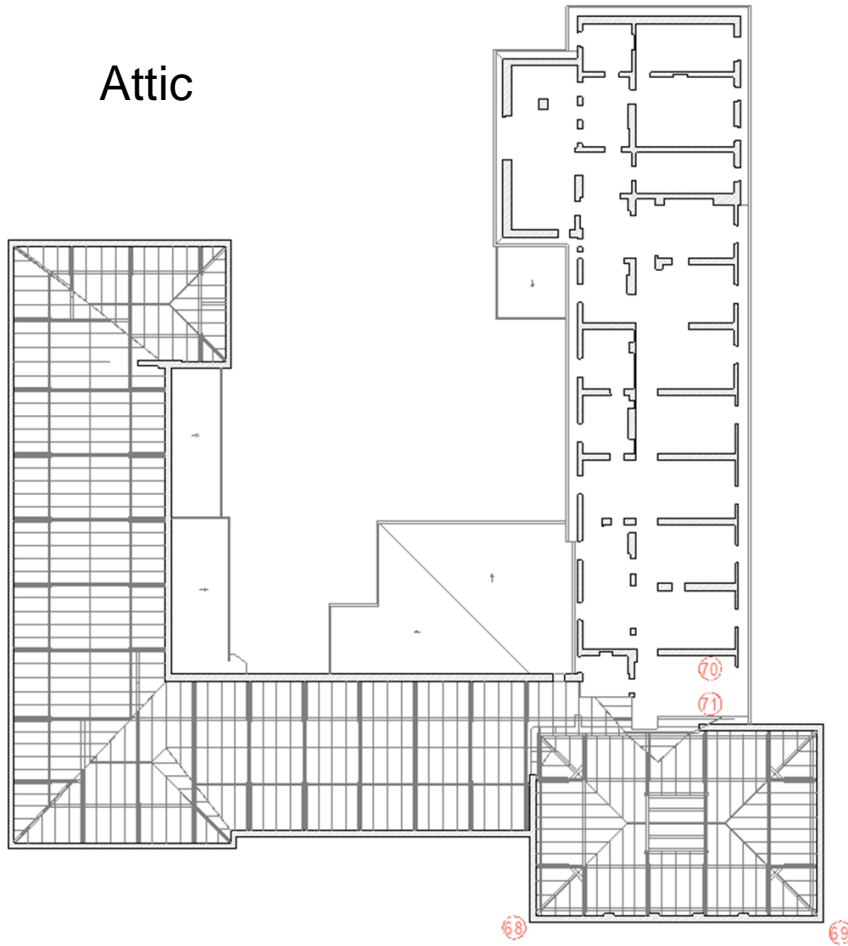
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Attic



Fotografija 68



Fotografija 69



Fotografija 70



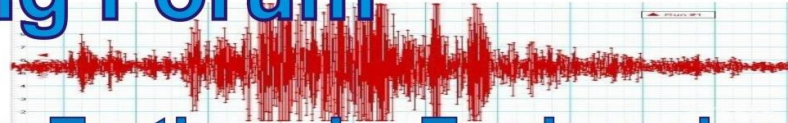
Fotografija 71



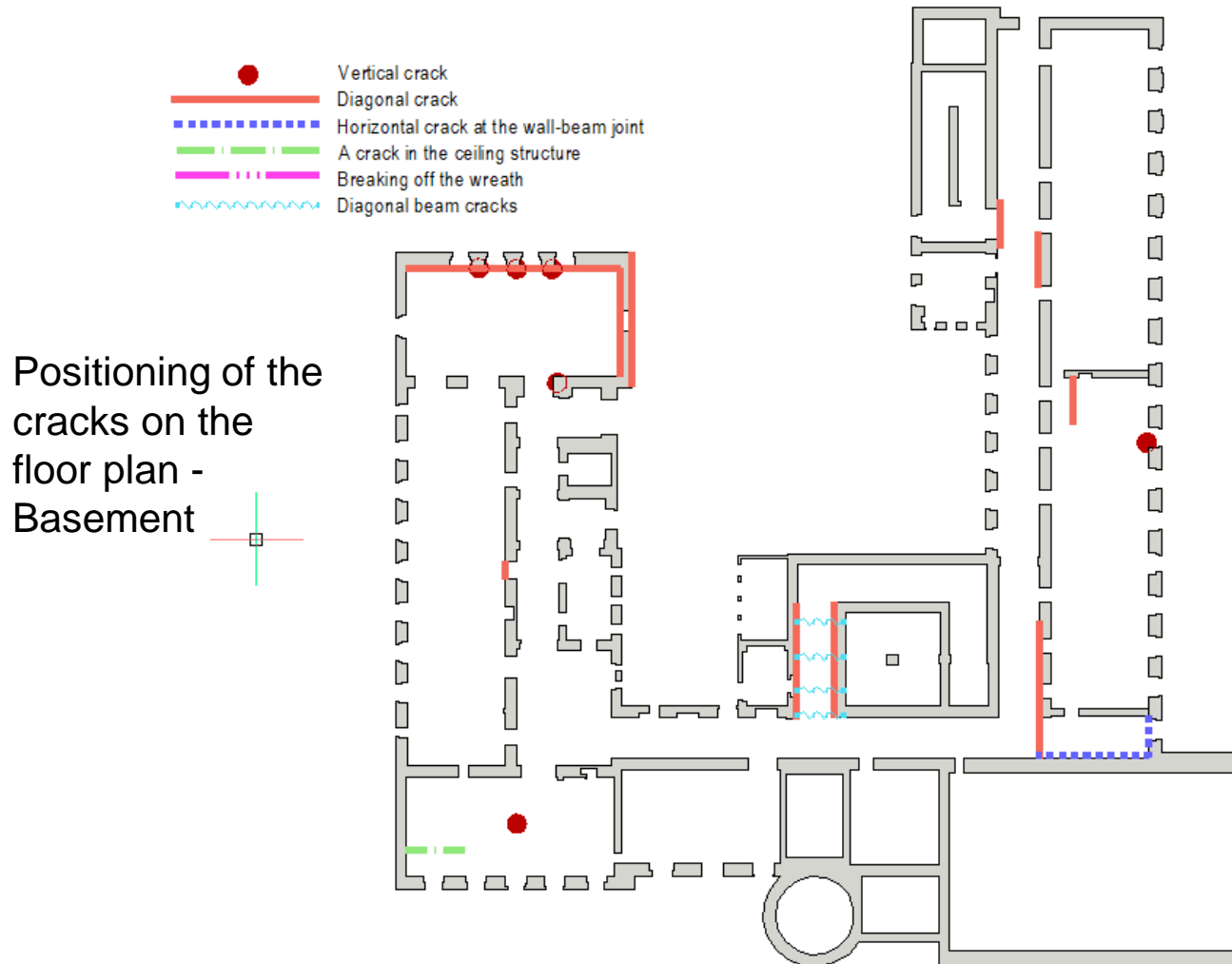
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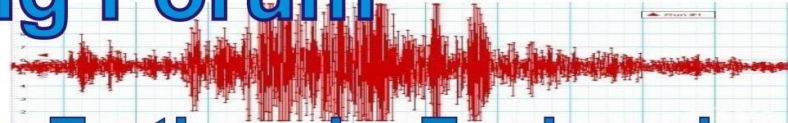




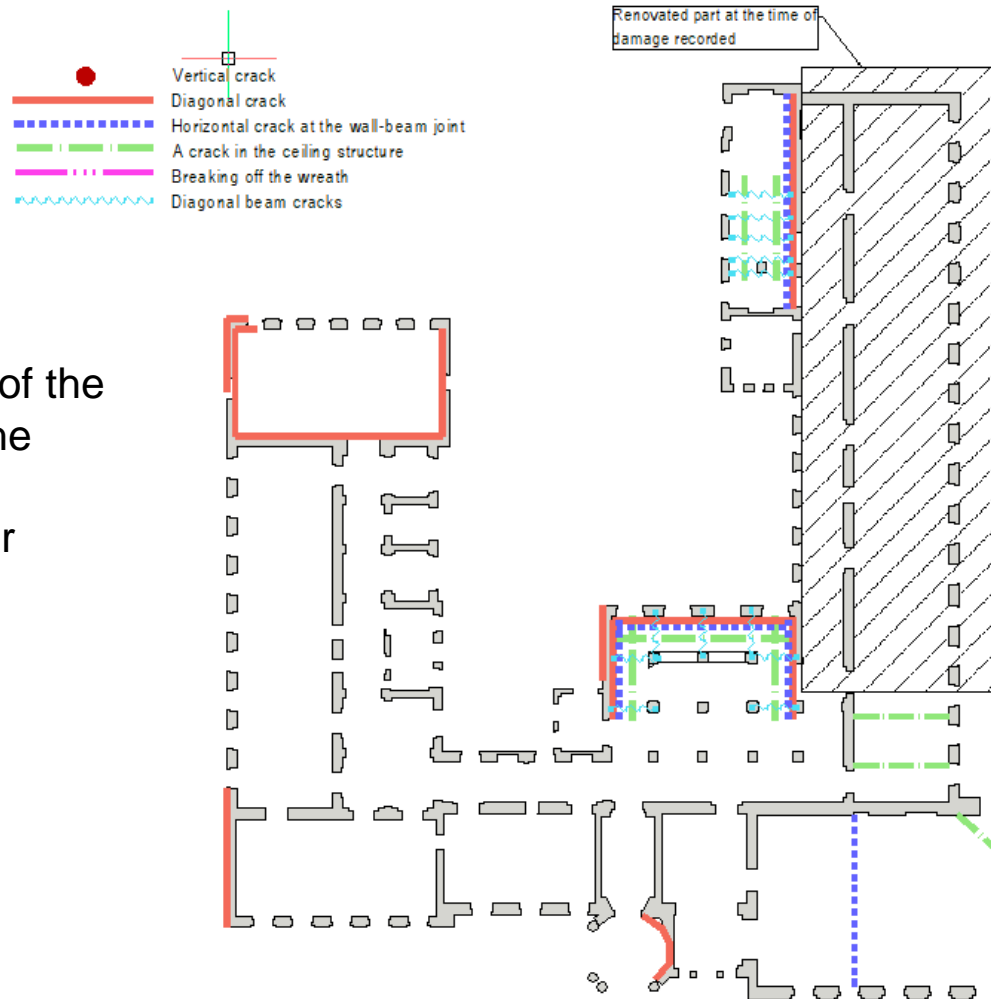
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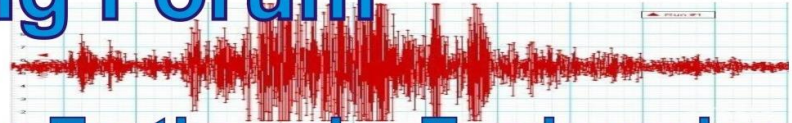
Positioning of the cracks on the floor plan – Ground floor



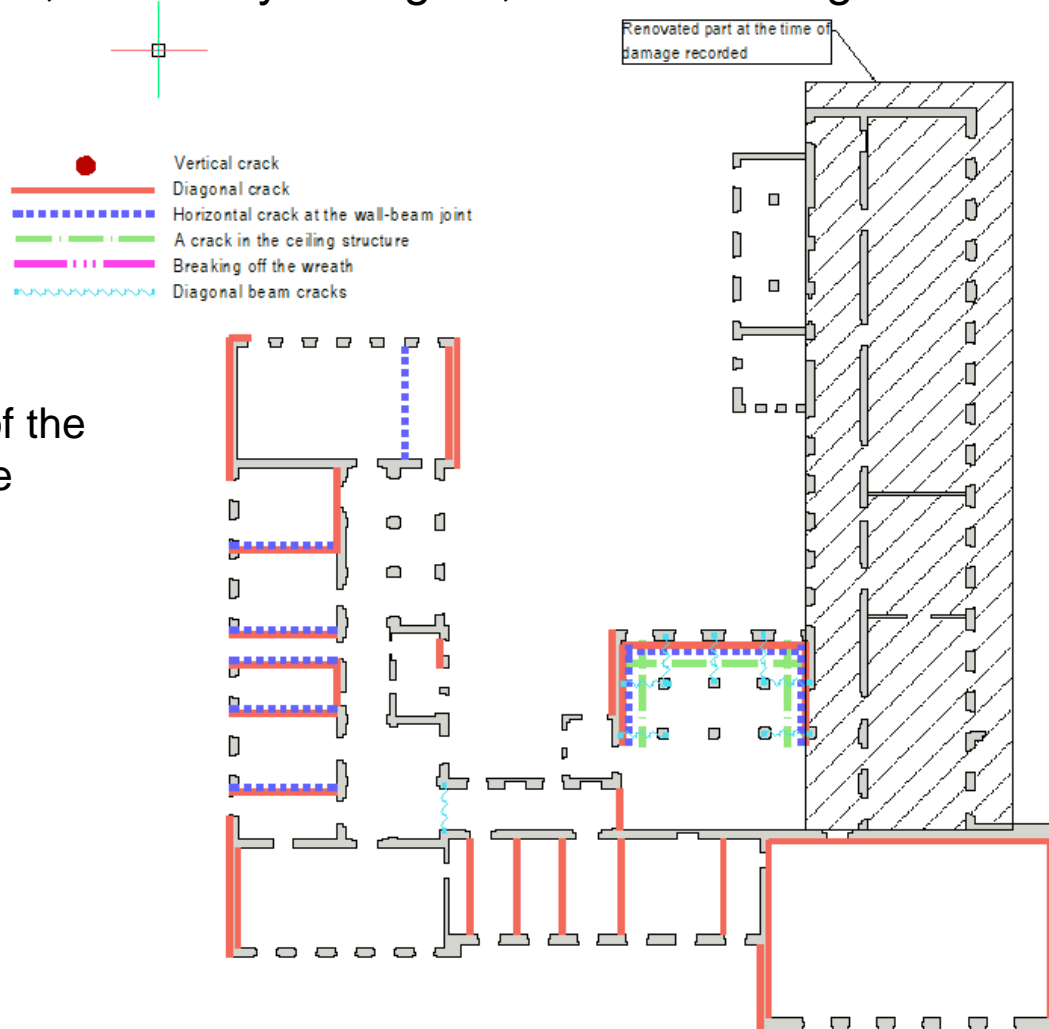
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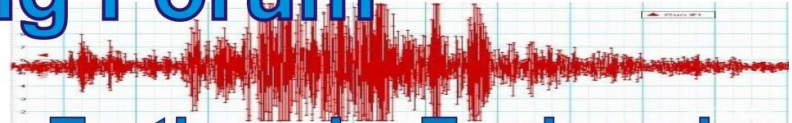
Positioning of the cracks on the floor plan – 1st floor



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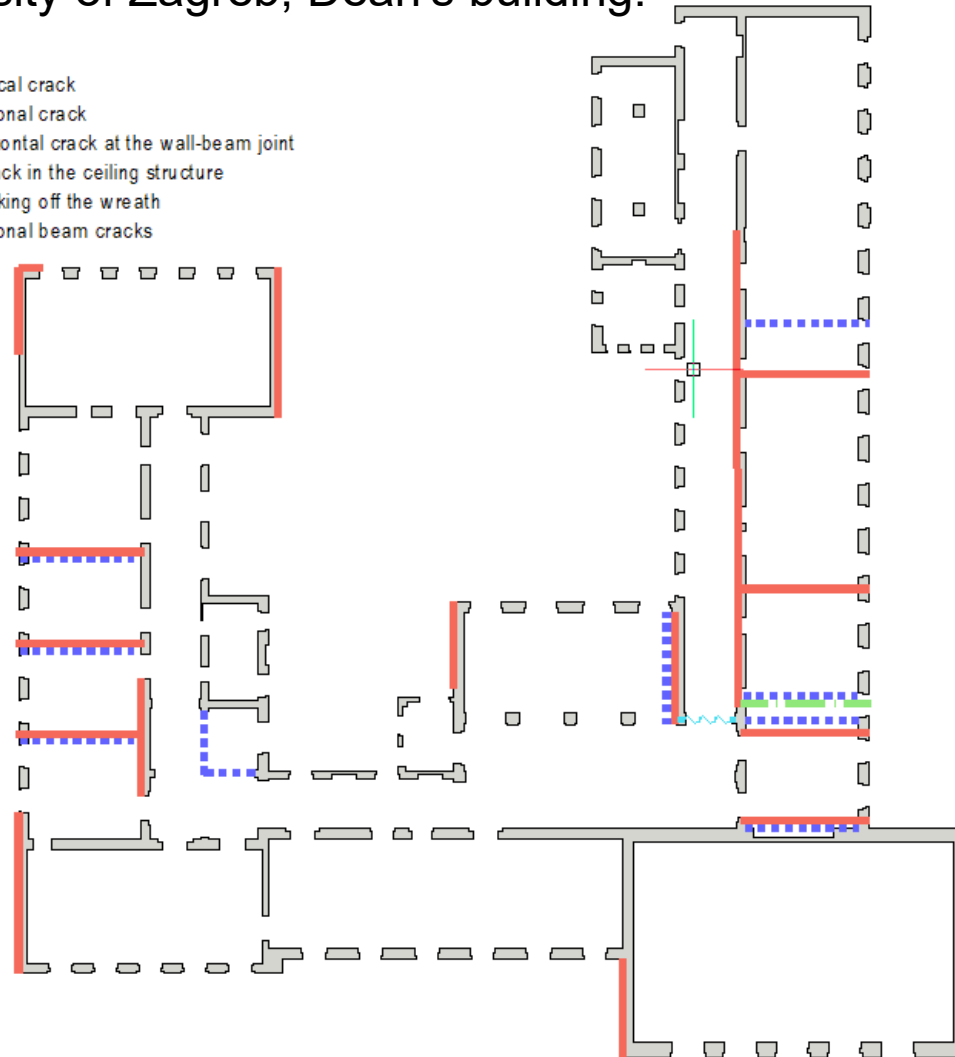
International Conference on Earthquake Engineering



Faculty of Medicine, University of Zagreb, Dean's building.

- Vertical crack
- Diagonal crack
- - - Horizontal crack at the wall-beam joint
- · - · - A crack in the ceiling structure
- · - · - Breaking off the wreath
- ~ Diagonal beam cracks

Positioning of the cracks on the floor plan – 2nd floor

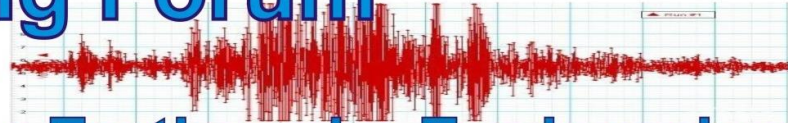




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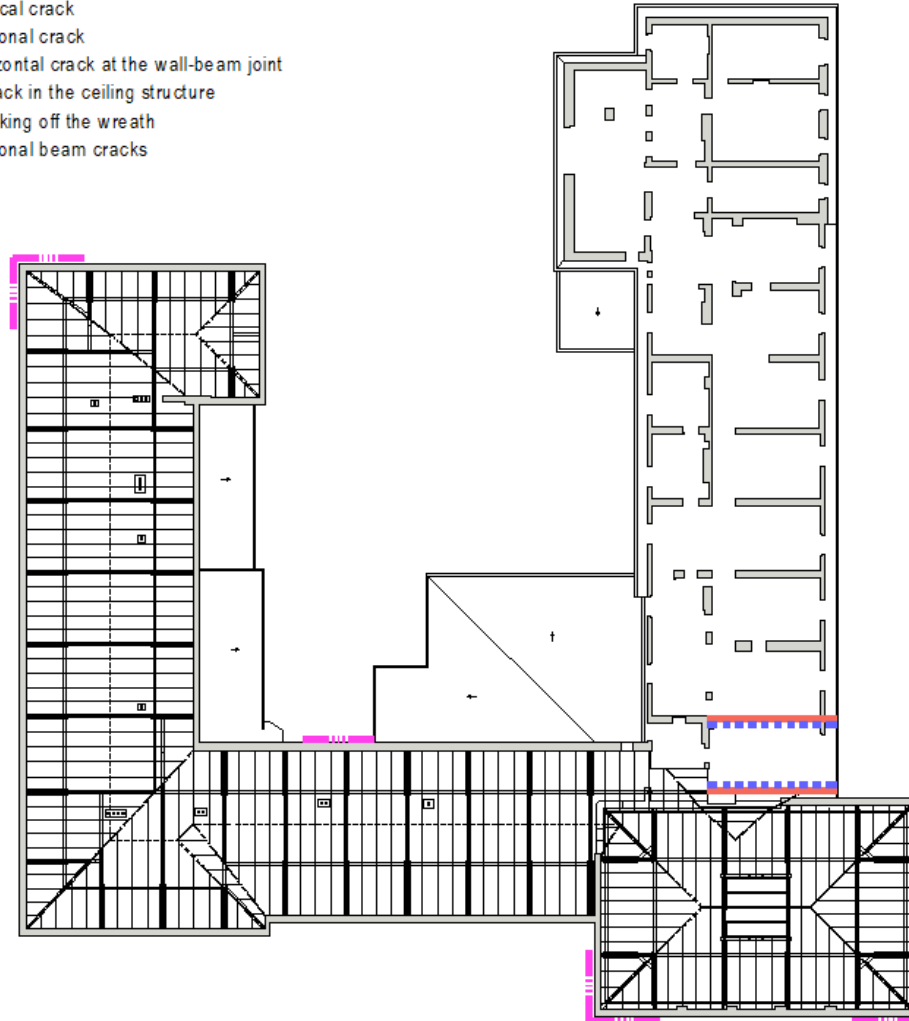
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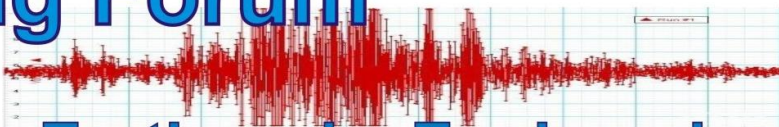


Faculty of Medicine, University of Zagreb, Dean's building.

- Vertical crack
- Diagonal crack
- - - Horizontal crack at the wall-beam joint
- · - · - A crack in the ceiling structure
- ▤ Breaking off the wreath
- ~ Diagonal beam cracks

Positioning of the cracks on the floor plan – Attic





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NEXT STEP - ASSESSEMENTS

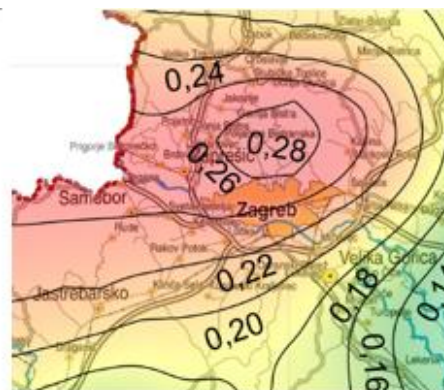
Location assessment – in accordance with HRN EN 1998-3

E.1 // Lokacija

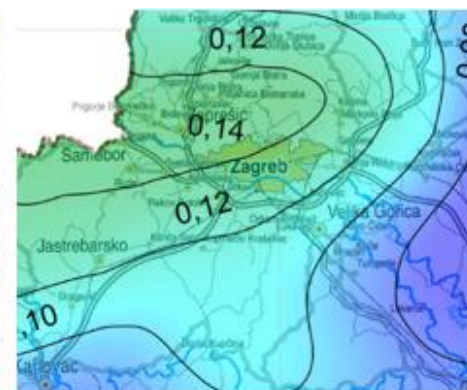
Prema seizmičkoj karti RH, građevina se nalazi u Zagrebu u zoni seizmičkog intenziteta s vršnim ubrzanjem tla:

Vršno ubrzanje tla prema seizmičkoj karti RH za predmetnu građevinu:

za povratno razdoblje od 475 godina (TNCR = 475 g.):	$a_{p,0.475}/g = 0,28$
za povratno razdoblje od 225 godina (TNCR = 225 g.):	$a_{p,0.225}/g = 0,18$
za povratno razdoblje od 95 godina (TNCR = 95 g.):	$a_{p,0.095}/g = 0,13$



Poredbeno vršno ubrzanje tla tipa A s vjerojatnosti premašaja 10% u 50 godina (povratno razdoblje 475 godina) izraženo u jedinicama gravitacijskog ubrzanja a



Poredbeno vršno ubrzanje tla tipa A s vjerojatnosti premašaja 10% u 60 godina (povratno razdoblje 95 godina) izraženo u jedinicama gravitacijskog ubrzanja a

E.2 // Razred važnosti građevine

Tablica 4.3 - Razredi važnosti i faktori važnosti za zgrade

Razred važnosti	Zgrade	Faktor važnosti
I	Zgrade manje važnosti za javnu sigurnost, npr. poljoprivredne zgrade itd.	0,8
II	Obične zgrade koje ne pripadaju drugim kategorijama	1,0
III	Zgrade čija je potrebna otpornost važna s obzirom na posljedice vezane s rušenjem (škole, vjeronaučne, kulturne institucije...)	1,2
IV	Zgrade čija je ojelovitost tijekom potresa od životne važnosti za civilnu zaštitu (bolnice, vatrogasne postaje, energetske itd.)	1,4

E.3 // Temeljno tlo:

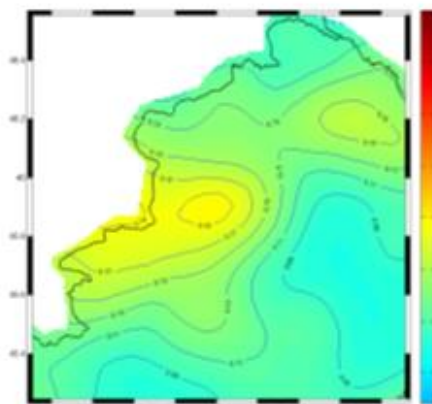
- Tlo kategorije C
- Vrijednosti parametara koje opisuju preporučeni elastični spektar odziva tipa 1

Tablica 3.2 - Vrijednosti parametara koji opisuju elastični spektar odziva tipa 1

Tip temeljnog tla	S	T_B (s)	T_C (s)	T_D (s)
A	1,00	0,15	0,40	2,00
B	1,20	0,15	0,50	2,00
C	1,15	0,20	0,60	2,00
D	1,35	0,20	0,80	2,00
E	1,40	0,15	0,50	2,00

E.4 // Faktor ponašanja:

Smjer X	Smjer Y
Nearmirano zide	Nearmirano zide
u skladu s normom HRN EN 1998-1:2011/NA:2011	u skladu s normom HRN EN 1998-1:2011/NA:2011
$q = 1,5$ - faktor ponašanja koji se usvaja	$q = 1,5$ - faktor ponašanja koji se usvaja

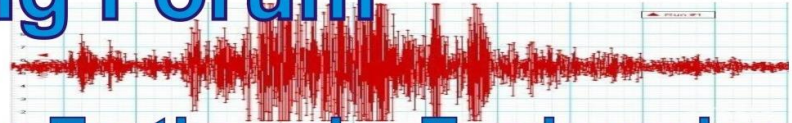


Vrijednost iz baze:
 $T_D = 95$ godina: $a_{p,0.095} = 0,13$ g
 $T_D = 225$ godina: $a_{p,0.225} = 0,18$ g
 $T_D = 475$ godina: $a_{p,0.475} = 0,25$ g

Očitane vrijednosti

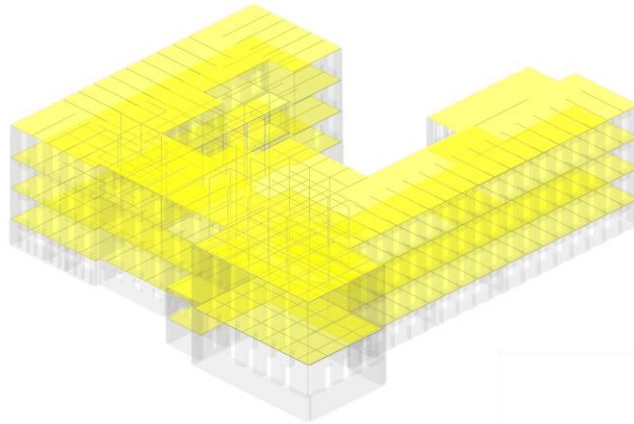
Sjeverozapadna Hrvatska. Karta potresnih područja. Poredbeno vršno ubrzanje tla tipa A s vjerojatnosti premašaja 80% u 50 godina (povratno razdoblje 225 godina) izraženo u jedinicama gravitacijskog ubrzanja a (ovaj skalu na desnoj strani).

Prethodno prikazani ulazni podaci za proračunski spektar će se koristiti kod kvazistatičkog proračuna građevine.

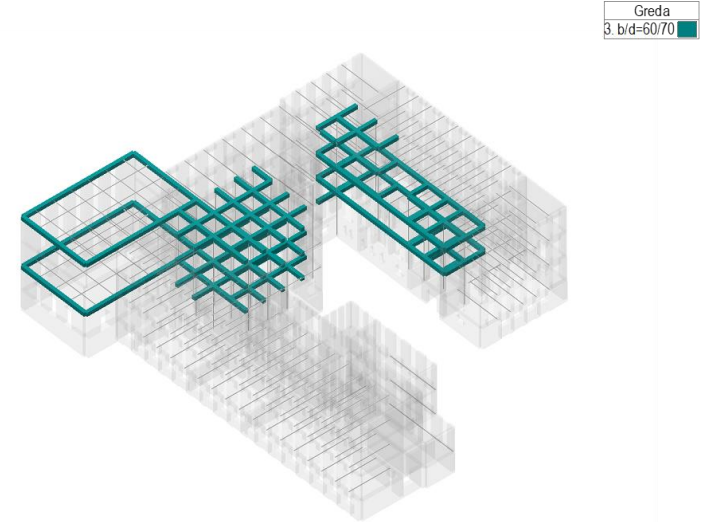


Faculty of Medicine, University of Zagreb, Dean's building.

Structural assessment– in accordance with HRN EN 1998-3

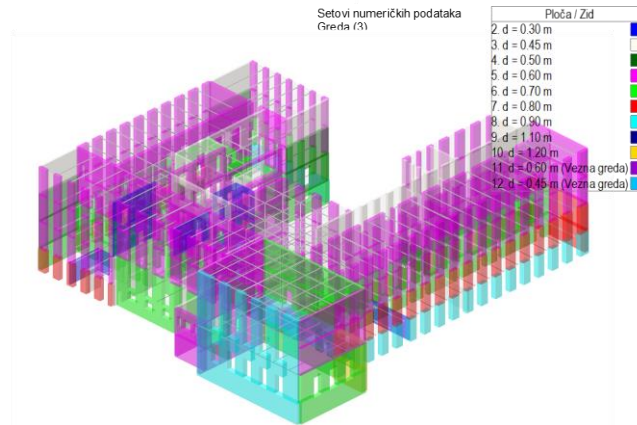


Ploča / Zid
1. d = 0.16 m



Greda
3. b/d=60/70

Setovi numeričkih podataka
Ploča / Zid (1)

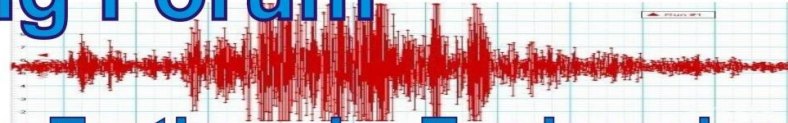


Setovi numeričkih podataka
Greda (3)

Ploča / Zid

- 2 d = 0.30 m
- 3 d = 0.45 m
- 4 d = 0.50 m
- 5 d = 0.60 m
- 6 d = 0.70 m
- 7 d = 0.80 m
- 8 d = 0.90 m
- 9 d = 1.10 m
- 10 d = 1.20 m
- 11 d = 0.60 m (Vežna greda)
- 12 d = 0.45 m (Vežna greda)

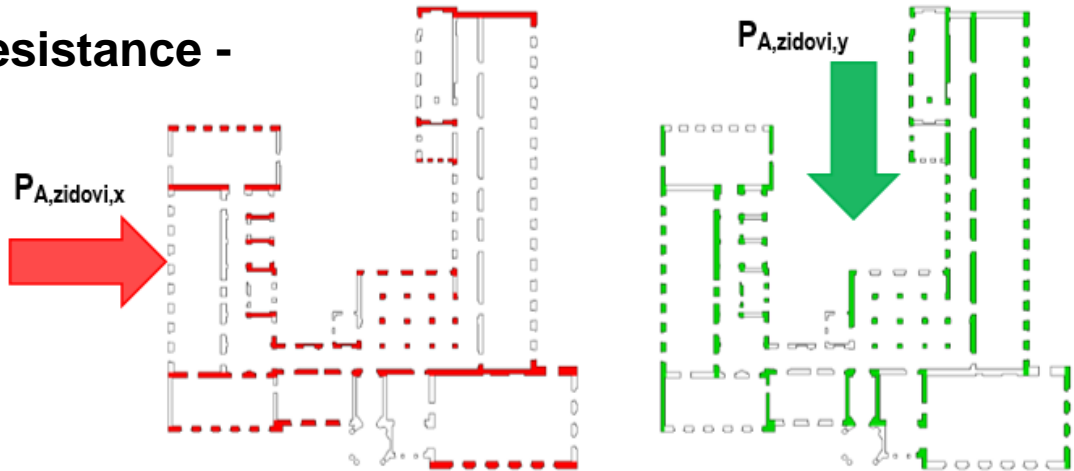
Setovi numeričkih podataka
Ploča / Zid (2-12)



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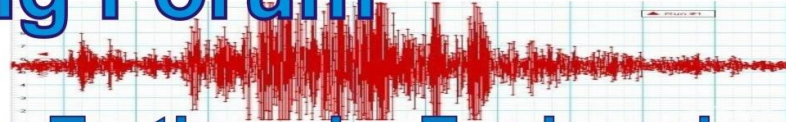
Rough analysis of seismic resistance - shear surface

Tlocna površina etaže prizemlja:	$A_{bruto} =$	1891	m ²
Ploščina zidova u x-smjera:	$A_{zidovi,x} =$	134	m ²
Ploščina zidova u y-smjera:	$A_{zidovi,y} =$	183	m ²
Postotak zidova u x-smjeru:	$p_{A,zidovi,x} =$	7,09%	
Postotak zidova u y-smjeru:	$p_{A,zidovi,y} =$	9,68%	
Proračun mase konstrukcije			
Okvirna težina po stropnoj konstrukciji	$q_{Ed} =$	15	kN
Broj etaža s punom masom	$n =$	4	
Masa konstrukcije	$M = A_{bruto} \cdot q_{Ed} \cdot n =$	113460	kN
Proračun seizmičke sile za svaki smjer			
Vršno ubrzanjetemeljnog tla za predmetnu lokaciju	$a_g/g =$	0,26	
Faktor ponašanja za neamirano zide	$q =$	1,5	
Faktor tla	$S =$	1,15	
Seizmičke sila x - smjer:	$S_{d,x}(T) = a_g \cdot S \cdot 2,5 / q =$	56540,90	kN
Seizmičke sila y - smjer:	$S_{d,y}(T) = a_g \cdot S \cdot 2,5 / q =$	56540,90	kN 50%
Proračun prosječnog posmičnog naprezanja zida za svaki smjer			
$T_{Ed,x}(T) = S_{d,x}(T) / p_{k,x} =$	0,80	kN/cm ²	= 7,98 MPa
$T_{Ed,y}(T) = S_{d,y}(T) / p_{k,y} =$	0,58	kN/cm ²	= 5,84 MPa
Proračun karakteristične posmična čvrstoća zida			
Karakteristična početna posmična čvrstoća prema literaturi	$f_{k,0} =$	0,1	MPa
Proračunsko tlačno naprezanje	$\sigma_d =$	0,358	MPa
	$f_{k} = f_{k,0} + 0,4 \cdot \sigma_d =$	0,024	kN/cm ²
Proračunska nosivost postojećeg zida na posmično naprezanje			
Koef. za potresnu proračunsku situaciju prema HRN 1998-1 [9.6.3]	$\gamma_M =$	1,5	
	$T_{Rd} = f_{k,0} / \gamma_M =$	0,016	kN/cm ²
Omjer zatečene otpornosti prema HRN EN 1998 ($T_{RCR} = 475 g.$)			
	$T_{Rd} / T_{Ed} =$	0,0203	
	$T_{Rd} / T_{Ed} =$	0,0277	



Zaključak: Seizmička otpornost postojeće građevine u x-smjeru je **2,03%** u odnosu na EC-8

Zaključak: Seizmička otpornost postojeće građevine u y-smjeru je **2,77%** u odnosu na EC-8



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Masonry resistance analysis - Unbounded masonry

PRORAČUN POSMIČNE NOSIVOSTI POSTOJEĆEG ZIDA PREMA HRN EN 1998

Proračunska nosivost postojećeg zida na poprečne sile	Karakteristična posmična čvrstoća zida
$V_{Rd} = f_{tk} \cdot L_e \cdot t / (\gamma_M \cdot FP_{RZ})$	$f_{tk} = f_{tk,0} + 0.4 \cdot \sigma_d$
f_{tk} - karakteristična čvrstoća zida	$f_{tk,0}$ - karakteristična posmična čvrstoća
t - debljina zida	σ_d - proračunsko tlačno naprezanje ($\sigma_d = N_{Ed}/(L_e \cdot d)$)
L_e - duljina tlačno naprežanog dijela zida	Duljina tlačno naprežanog dijela za neoređeni zid
γ_M - paracični kod sigurnosti materijala	$L_e = 3 \cdot [L/2 - (M_{Ed} / N_{Ed, min})] \leq L$
FP_{RZ} - faktor povjerenja za postojeću građevinu	

PRORAČUN NEOMEĐENOG ZIDA - X-SMJER

$f_{tk,0}$	0,1	[MPa]	preporuka prema literaturi
γ_M	1,50		koeffcijent za potresnu proračunsku situaciju prema HRN 1998-1 [9.6.3]
RZ	RZZ: uobičajeno znanje		Razine znanja HRN 1998-3 [3.3]
FP_{RZ}	1,20		faktora povjerenja koji određuju odgovarajuću razinu znanja HRN 1998-3 [3.3.1.(4)]

OKVIR	ZID	N_{Ed}	M_{Ed}	V_{Ed}	L	t	L_e	σ_d	f_{tk}	V_{Rd}	VRd > VEd	V_{Ed}/V_{Rd}	%
[Tower]	[Tower]	[kN]	[kNm]	[kN]	[m]	[m]	[m]	[kN/cm²]	[kN/cm²]	[kN]			
H_1	ZX101	5655,26	18762,6	4219,19	2056	90	2056	0,031	0,022	2285	Nije zadovoljeno	185%	
H_2	ZX102	890,15	3100,06	2354,98	603	60	603	0,025	0,020	399	Nije zadovoljeno	591%	
H_4	ZX103	410,96	655,95	186,76	144	80	144	0,036	0,024	155	Nije zadovoljeno	120%	
H_4	ZX104	454,68	152,13	224,36	125	80	125	0,045	0,028	157	Nije zadovoljeno	143%	
H_5	ZX105	235,49	91,29	382,72	63	80	63	0,047	0,029	80	Nije zadovoljeno	478%	
H_5	ZX106	2386,18	21194,5	3870,84	2273	70	2273	0,015	0,016	1414	Nije zadovoljeno	274%	
H_8	ZX107	143,45	351,99	277,18	216	30	216	0,022	0,019	68	Nije zadovoljeno	408%	
H_8	ZX108	220,65	254,27	166,09	205	45	205	0,024	0,020	100	Nije zadovoljeno	166%	
H_9	ZX109/1	1300,51	2779,34	2822,05	366	70	366	0,047	0,029	443	Nije zadovoljeno	562%	
H_9	ZX109/2	1556,84	3756,77	1629,51	362	70	362	0,061	0,035	487	Nije zadovoljeno	335%	
H_9	ZX110	822,93	354,01	178,52	178	70	178	0,066	0,036	252	Zadovoljeno	71%	
H_9	ZX111	501,87	694,93	667,74	131	70	131	0,055	0,032	162	Nije zadovoljeno	349%	
H_10	ZX112/1	3479,75	4420,56	3024,13	921	70	921	0,054	0,032	1131	Nije zadovoljeno	267%	
H_10	ZX112/2	1805,01	1457,19	1930,66	572	70	572	0,045	0,028	624	Nije zadovoljeno	310%	
H_10	ZX112/3	7663,58	23336,4	7762,63	1953	70	1953	0,056	0,032	2463	Nije zadovoljeno	315%	
H_10	ZX113	2351,23	9293,02	5508,39	591	120	591	0,033	0,023	916	Nije zadovoljeno	601%	
H_10	ZX114/1	913,74	4681,98	1792,08	968	60	968	0,016	0,016	528	Nije zadovoljeno	341%	
H_10	ZX114/2	317,26	124,88	127,11	101	60	101	0,052	0,031	104	Nije zadovoljeno	122%	
H_13	ZX115	1167,44	6256,41	4223,56	1051	60	1051	0,019	0,017	610	Nije zadovoljeno	693%	
H_13	ZX116/1	345,06	263,92	277,99	126	50	126	0,055	0,032	112	Nije zadovoljeno	249%	
H_13	ZX116/2	573,37	2915,57	1892,54	530	50	530	0,022	0,019	275	Nije zadovoljeno	689%	
H_13	ZX117	486,2	318,56	249,6	119	60	119	0,068	0,037	148	Nije zadovoljeno	169%	
H_19	ZX118	406,19	996,38	631,32	134	60	134	0,051	0,030	135	Nije zadovoljeno	394%	
H_20	ZX119	257,27	1204,71	1259,99	364	30	364	0,024	0,019	118	Nije zadovoljeno	1069%	
H_22	ZX120	1667,57	4562,28	1634,97	718	60	718	0,039	0,025	610	Nije zadovoljeno	268%	

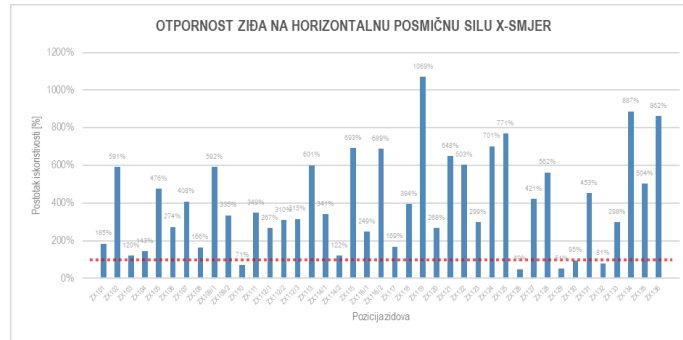
H_24	ZX121	517,35	3140,32	1663,98	425	60	425	0,020	0,018	257	Nije zadovoljeno	648%
H_24	ZX122	428,88	1358,82	941,28	182	60	182	0,039	0,026	156	Nije zadovoljeno	603%
H_26	ZX123	2298,13	11826,9	3134,3	1384	70	1384	0,024	0,019	1049	Nije zadovoljeno	296%
H_29	ZX124	719,24	3042,99	2011,42	762	30	762	0,031	0,023	287	Nije zadovoljeno	701%
H_32	ZX125	992,85	7349,95	2943,52	363	80	363	0,034	0,024	382	Nije zadovoljeno	771%
H_32	ZX126	798,02	286,35	115,06	168	60	168	0,079	0,042	233	Zadovoljeno	49%
H_39	ZX127	1659,41	6524,36	2376,58	502	70	502	0,047	0,029	564	Nije zadovoljeno	421%
H_40	ZX128	609,44	3392,1	1653,31	634	45	634	0,021	0,019	294	Nije zadovoljeno	562%
H_42	ZX129	149,34	132,26	27,7	77	50	77	0,039	0,026	55	Zadovoljeno	51%
H_42	ZX130	204,78	350,09	69,76	100	50	100	0,041	0,026	73	Zadovoljeno	95%
H_46	ZX131	952,46	3281,34	1728,42	340	90	340	0,031	0,022	382	Nije zadovoljeno	453%
H_46	ZX132	367,56	129,22	98,03	80	90	80	0,051	0,030	122	Zadovoljeno	81%
H_47	ZX133	1345,9	6650,48	1413,72	527	60	527	0,043	0,027	475	Nije zadovoljeno	298%
H_52	ZX134	246,91	2660,23	1655,14	527	45	527	0,010	0,014	187	Nije zadovoljeno	887%
H_54	ZX135	2307,86	18729,3	5120,8	1131	80	1131	0,026	0,020	1016	Nije zadovoljeno	504%
H_55	ZX136	623,86	5934,37	2963,2	527	70	527	0,017	0,017	344	Nije zadovoljeno	862%

$\sum V_{Rd} = 74811,1$ $\sum V_{Ed} = 19646$ $\sum V_{Ed} / \sum V_{Rd} = 381\%$

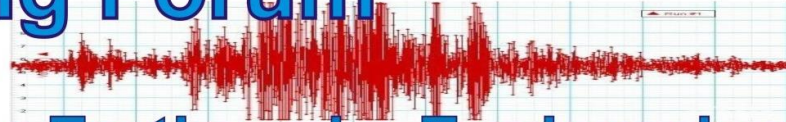
Srednja vrijednost nosivosti - postignuti omjer u odnosu na EN 1998 iznosi - X-SMJER : **402%**

Interpretacija rezultata:
vršno ubrzanjem temeljnog tla za predmetnu lokaciju $a/g = 0,26$

Zaključak: Seizmička otpornost postojeće građevine u x-smjeru je **6,47%** u odnosu na EC-8



X
direction



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PRORAČUN POSMIČNE NOSIVOSTI POSTOJEĆEG ŽIDA PREMA HRN EN 1998

Proračunska nosivost postojeg zida na poprečne sile	Karakteristična posmična čvrstoća zida
$V_{Rd} = f_{yk} \cdot L_c \cdot t / (\gamma_M \cdot FR_{PZ})$	$f_{yk} = f_{k,0.5} + 0.4 \cdot \sigma_d$
f_{yk} - karak. posmična čvrstoća zida	$f_{k,0.5}$ - karakteristična poština posmična čvrstoća
t - debljina zida	σ_d - proračunsko tlačno naprezanje ($\sigma_d = N_{Ed}/L_c \cdot d$)
L_c - duljina tlačno napravnog dijela zida	Duljina tlačno napravnog dijela za neomeđeni zid
γ_M - parajalni koef. sigurnosti materijala	$L_c = 3 \cdot [L/2 - (M_{Ed} / N_{Ed, min})] \leq L$
FR_{PZ} - faktor povjerenja za postojeću građevinu	

PRORAČUN NEOMEĐENOG ŽIDA - Y SMJER

$f_{k,0.5}$	0,1	[MPa]	preporuka prema literaturi
γ_M	1,50		koeficijent za potresnu proračunsku situaciju prema HRN 1998-1 [9.6.3]
RZ -	RZZ ubičajeno znanje		Razine znanja HRN 1998-3 [3.3]
FR_{PZ}	1,20		faktora povjerenja koji određuju odgovarajuću razinu znanja HRN 1998-3 [3.3.1.4]

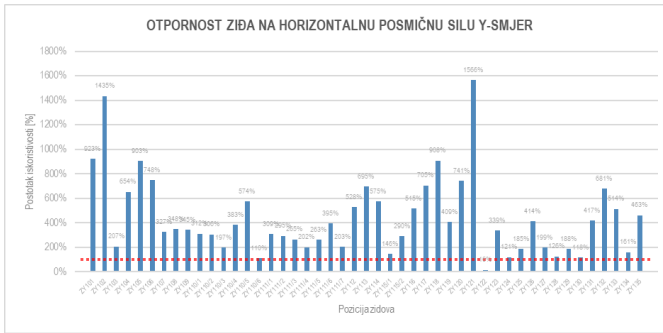
OKVIR [Tower]	ZID [Tower]	N_{Ed} [kN]	M_{Ed} [kNm]	V_{Ed} [kN]	L [m]	t [m]	L_c [m]	σ_d [N/m ²]	f_{yk} [N/m ²]	V_{Rd} [kN]	VRd > Ved	V_{Ed}/V_{Rd} %
V_1	ZY101	2144	5475	7177	775	70	775	0,040	0,026	778	Nije zadovoljeno	923%
	ZY102	707	761	3550	203	80	203	0,044	0,027	247	Nije zadovoljeno	1435%
	ZY103	776	42	503	160	80	160	0,061	0,034	244	Nije zadovoljeno	207%
	ZY104	755	60	1480	132	80	132	0,071	0,039	226	Nije zadovoljeno	654%
	ZY105	2435	6955	7861	846	70	846	0,041	0,026	870	Nije zadovoljeno	903%
V_5	ZY106	446	1969	1470	584	30	584	0,025	0,020	196	Nije zadovoljeno	748%
V_7	ZY107	10795	31740	11274	2695	70	2695	0,057	0,033	3447	Nije zadovoljeno	327%
V_10	ZY108	433,06	1101,88	562,97	263	45	263	0,037	0,025	162	Nije zadovoljeno	348%
	ZY109	71,71	176,5	121,28	77	45	77	0,021	0,018	35	Nije zadovoljeno	345%
V_12	ZY110/1	449,79	316,62	422,96	143	45	143	0,070	0,038	136	Nije zadovoljeno	312%
	ZY110/2	655,59	951,99	604,82	207	45	207	0,070	0,038	197	Nije zadovoljeno	306%
	ZY110/3	532,29	406,24	300,19	136	45	136	0,087	0,045	162	Nije zadovoljeno	197%
	ZY110/4	332,62	653,7	450,38	175	45	175	0,042	0,027	118	Nije zadovoljeno	383%
	ZY110/5	192,65	243,63	413,42	117	45	117	0,037	0,025	72	Nije zadovoljeno	574%
	ZY110/6	178,26	75,52	65,86	80	45	80	0,050	0,030	60	Nije zadovoljeno	110%
V_15	ZY111/1	184,63	57,3	196,22	90	45	90	0,046	0,028	64	Nije zadovoljeno	309%
	ZY111/2	1622,5	3089,42	1575,39	697	45	697	0,052	0,031	535	Nije zadovoljeno	295%
	ZY111/3	922,7	246,78	815,21	265	70	265	0,050	0,030	308	Nije zadovoljeno	265%
	ZY111/4	234,73	112,42	157,1	66	70	66	0,051	0,030	78	Nije zadovoljeno	202%
	ZY111/5	447,2	275,1	400,57	136	70	136	0,047	0,029	152	Nije zadovoljeno	263%
	ZY111/6	983,26	1582,01	1673,92	527	70	527	0,027	0,021	423	Nije zadovoljeno	395%
	ZY111/7	371,97	187,23	268,43	127	70	127	0,042	0,027	132	Nije zadovoljeno	203%
V_16	ZY112	1771,77	7819,19	3817,91	846	70	846	0,030	0,022	723	Nije zadovoljeno	528%
V_20	ZY113	306,7	1229,9	1021,96	473	30	473	0,022	0,019	147	Nije zadovoljeno	695%
V_21	ZY114	1413,83	8543,09	2846,61	724	45	724	0,043	0,027	495	Nije zadovoljeno	575%
V_22	ZY115/1	201,03	50,1	95,12	61	60	61	0,055	0,032	65	Nije zadovoljeno	146%
	ZY115/2	1852,54	10352,7	1977,11	808	60	808	0,038	0,025	681	Nije zadovoljeno	290%

V_24	ZY116	765,47	3004,18	2120,6	724	60	724	0,018	0,017	411	Nije zadovoljeno	515%
V_25	ZY117	1296,29	7404,31	3308,69	724	45	724	0,040	0,026	469	Nije zadovoljeno	705%
V_26	ZY118	623,61	4653,57	2673,14	467	60	467	0,022	0,019	294	Nije zadovoljeno	908%
	ZY119	3107,38	21897,7	4654,35	1345	60	1345	0,039	0,025	1139	Nije zadovoljeno	409%
V_31	ZY120	791,36	4134,36	3090,58	724	60	724	0,018	0,017	417	Nije zadovoljeno	741%
	ZY121	390,58	217,98	2205,72	139	70	139	0,040	0,026	141	Nije zadovoljeno	1568%
V_29	ZY122	1857,62	12210	148,69	1404	70	1404	0,019	0,018	959	Zadovoljeno	16%
	ZY123	2151,34	7935,29	3314,12	1123	80	1123	0,024	0,020	977	Nije zadovoljeno	339%
V_34	ZY124	377,09	137,67	160,51	110	80	110	0,043	0,027	133	Nije zadovoljeno	121%
	ZY125	83,65	446,9	537,12	227	80	227	0,047	0,029	291	Nije zadovoljeno	185%
	ZY126	3284,93	29203	5514,04	1356	80	1356	0,030	0,022	1333	Nije zadovoljeno	414%
	ZY127	479,46	256,27	277,99	85	70	85	0,081	0,042	140	Nije zadovoljeno	199%
	ZY128	1419,65	889,14	540,03	290	70	290	0,070	0,038	428	Nije zadovoljeno	126%
V_36	ZY129	2559,21	2830,56	1504,5	592	70	592	0,062	0,035	799	Nije zadovoljeno	188%
	ZY130	2679,74	2564,42	1031,07	715	70	715	0,054	0,031	874	Nije zadovoljeno	118%
	ZY131	1595,73	1384,43	2067,57	362	70	362	0,063	0,035	495	Nije zadovoljeno	417%
	ZY132	579,97	1624,16	1321,8	168	70	168	0,049	0,030	194	Nije zadovoljeno	681%
	ZY133	655,25	1156,63	1179,06	168	90	168	0,043	0,027	230	Nije zadovoljeno	514%
V_39	ZY134	621,36	263,36	326,88	130	90	130	0,053	0,031	203	Nije zadovoljeno	161%
	ZY135	2880,7	20293,7	5355,9	1330	70	1330	0,031	0,022	1157	Nije zadovoljeno	463%

Srednja vrijednost nosivosti - postignuti omjer u odnosu na EN 1998 iznosi - Y-SMJER : **441%**

Interpretacija rezultata:
 vršno ubrzanjem temeljnog tla za predmetnu lokaciju **ag/g = 0,26**

Zaključak: Seizmička otpornost postojeće građevine u y-smjeru je **5,90%** u odnosu na EC-8



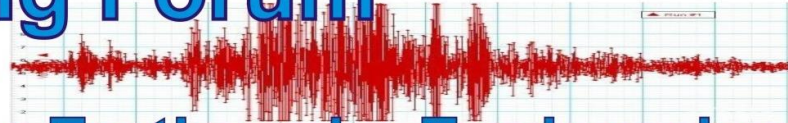
Y
direction



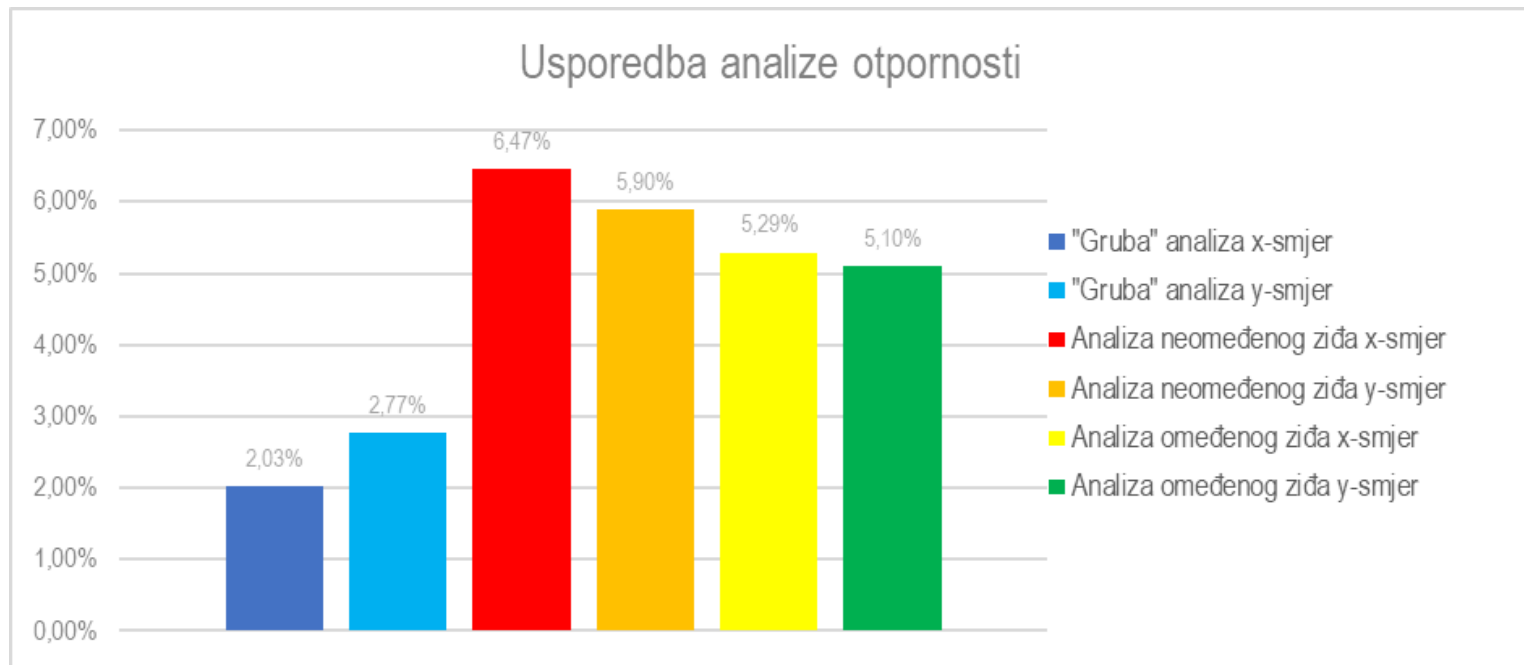
Building Engineering Forum

20-21 October 2021, Sofia, Bulgaria

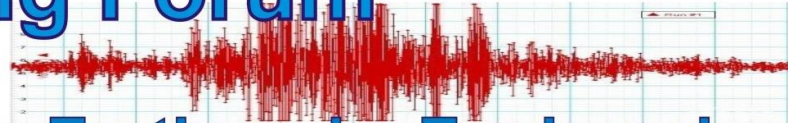
International Conference on Earthquake Engineering



Faculty of Medicine, University of Zagreb, Dean's building.

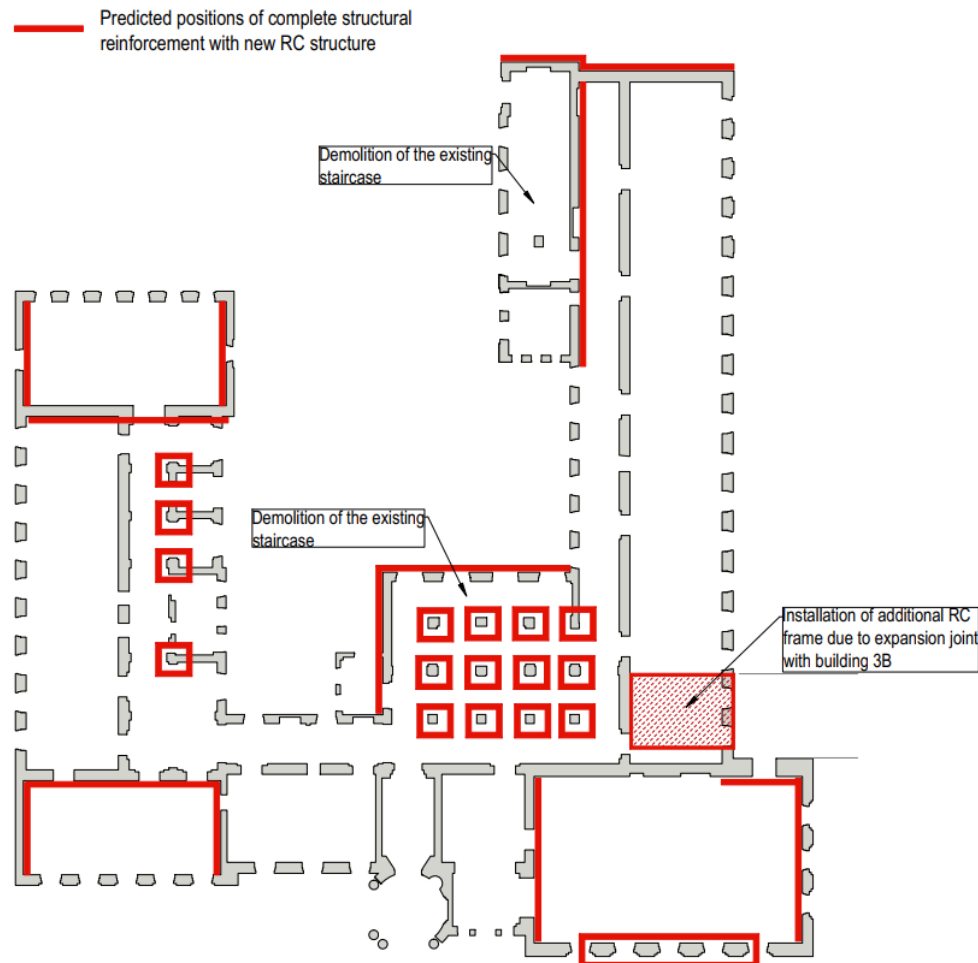


Comparative analysis of masonry resilience as a percentage of full "EC8" earthquake resistance



Faculty of Medicine, University of Zagreb, Dean's building.

The concept of structural renovation of a damaged building

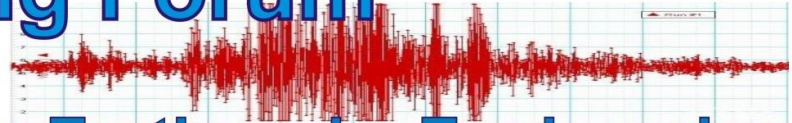




Building Engineering Forum

20-21 October 2021, Sofia, Bulgaria

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Faculty of Medicine, University of Zagreb, Dean's building.

What's next?

This study is being evaluated by the competent conservation department.

After a positive assessment, a seismic reconstruction project is to be prepared following the conservation department conditions of design.

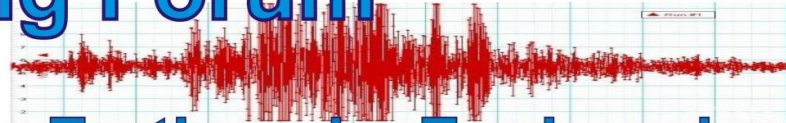
God willing, soon, or at least before the next earthquake.



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**Thank you for your patience.
Shaken greetings from Croatia**

U.O.I.G. Tarnik

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