Utjecaj nekih parametara na ponašanje i graničnu nosivost višedijelnih kamenih stupova pri statičkom opterećenju i potresu

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Research Article
Effect of the Drum Height on the Seismic Behaviour of a Free-Standing Multidrum Column
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Composites Part B
Effect of the drum height on the bearing capacity of composite multi-drum column under static load
Effect of the joint type on the bearing capacity of a multi-drum column under static load
FREE-STANDING MULTI-DRUM COLUMN
Effects of several bolt parameters on the bearing capacity of a composite multi-drum stone column under an earthquake

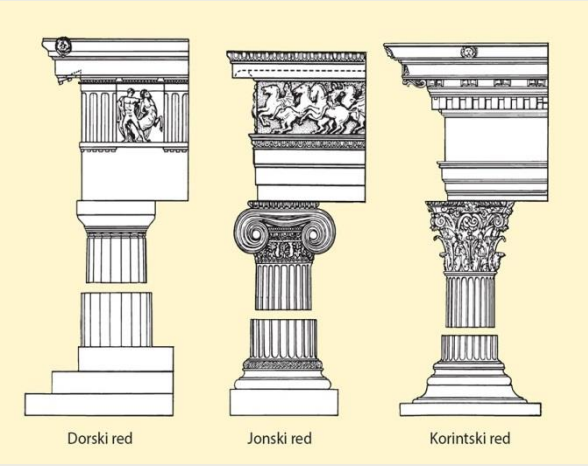
Sadržaj:

1. Uvod

Kameni stupovi

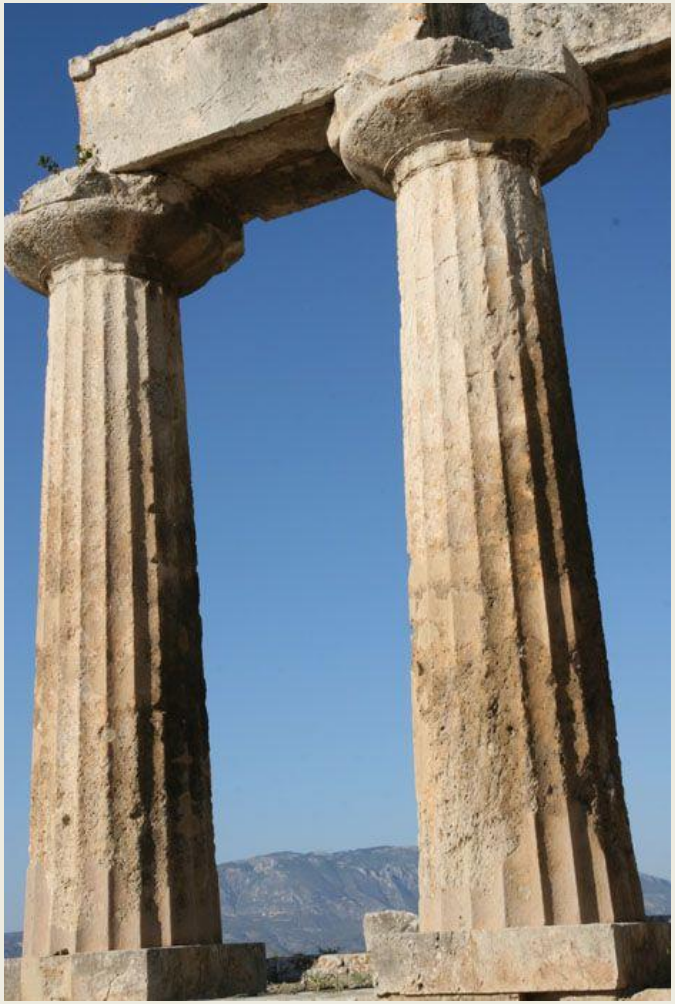
https://www.google.hr/search?biw=1680&bih=895&tbm=isch&sa=1&ei=ATAqW5u9A8m9sQHR8ZKIBQ&q=greek+architecture+colum

http://www.ancient-origins.net/ancient-places-europe/best-preserved-roman-temple-emperors-founding-fathers-elite-connections-021292



https://nova-akropola.com/lijepe-umjetnosti/arhitektura/grcki-hram/

1. Uvod



Stup iz jednog kamenog bloka

http://www.grece-bleue.net/photos-corinthe.html

Stup iz više kamenih blokova

https://www.robertharding.com/preview/832-3727071/doric-columns-temple-poseidon-ruins-greek-city-delos/

1. Uvod

https://www.trover.com/d/1fePp-marcus-aurelius-column-rome-italy

http://johnapgnt.com/inside-st-peters-basilica/

- Slobodnostojeći stupovi
- Niz povezanih stupova – "kolone"
- Dio konstrukcijske cjeline

http://www.goddess-athena.org/Museum/Temples/Nashville2/IMG_0008.html

1. Uvod

http://www.touregypt.net/featurestories/columns.htm

Egipatski hramovi

https://en.wikipedia.org/wiki/Parthenon#/media/File:The_Parthenon_in_Athens.jpg

Partenon – Atenska akropola

https://www.architecture.com/Explore/5ofthebest/5ofthebestlandmarksRome.aspx

Pantheon - Rim

https://commons.wikimedia.org/wiki/File:Vatican.JPG

Trg sv. Petra - Vatikan

1. Uvod

http://daniela-dental.com/en/dental-tourism/

Dioklecijanova palača - Split

http://www.dumus.hr/hr/kulturno-povijesni-muzej/o-muzeju/

Knežev dvor - Dubrovnik

1. Uvod

Višedijelni kameni stupovi

Složene kompozitne konstrukcije – specifičan oblik zidanih konstrukcija

https://www.ancient.eu/image/1316/column-flutes-propylaea/

Sljubnice

(suha, kameno brašno, mort i sl.)

https://www.entouriste.com/journey-palestine/ancient-columns-at-the-herodian-ruins-of-palestine/

Trnovi

(drvo, olovo i sl.)

https://www.ancient.eu/column/ /

1. Uvod

Na ponašanje i graničnu nosivost višedijelnih kamenih stupova utječu mnogi važni parametri, kao što su:

- Geometrija, vitkost i rubni uvjeti stupa
- Rješenja vrha (kapitela) i dna stupa
- Svojstva materijala i preciznost izrade kamenih blokova, te preciznost obrade spojnih ploha blokova u sljubnicama
- Vrsta i svojstva materijala u sljubnicama između kamenih blokova
- Brojni parametri eventualnih trnova u sljubnicama
- Vrsti opterećenja (statičko, dinamičko, udar) i njihovim karakteristikama
- Interakciji s ostalim nosivim elementima konstrukcije (zidovi, grede, svodovi, temelji i sl.) i itd.

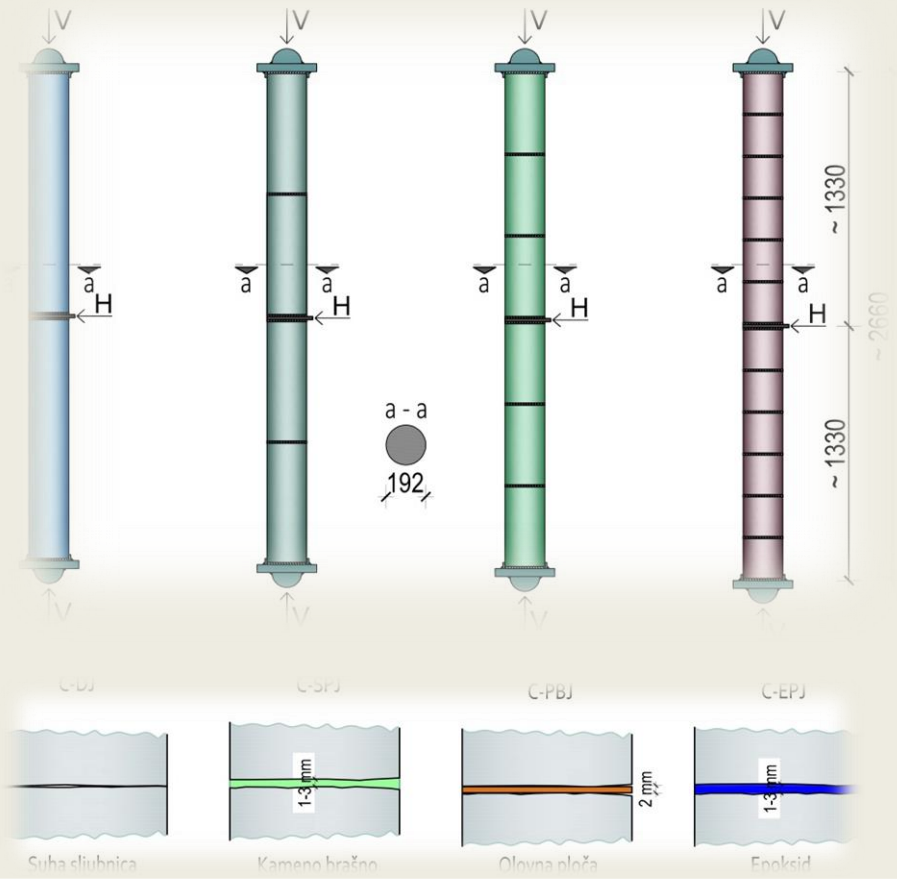
2. Postojeće spoznaje

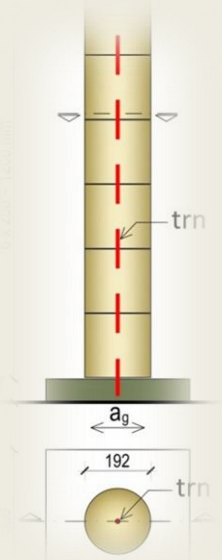
https://www.researchitaly.it/en/news/science-hub-the-napster-of-scientific-research/

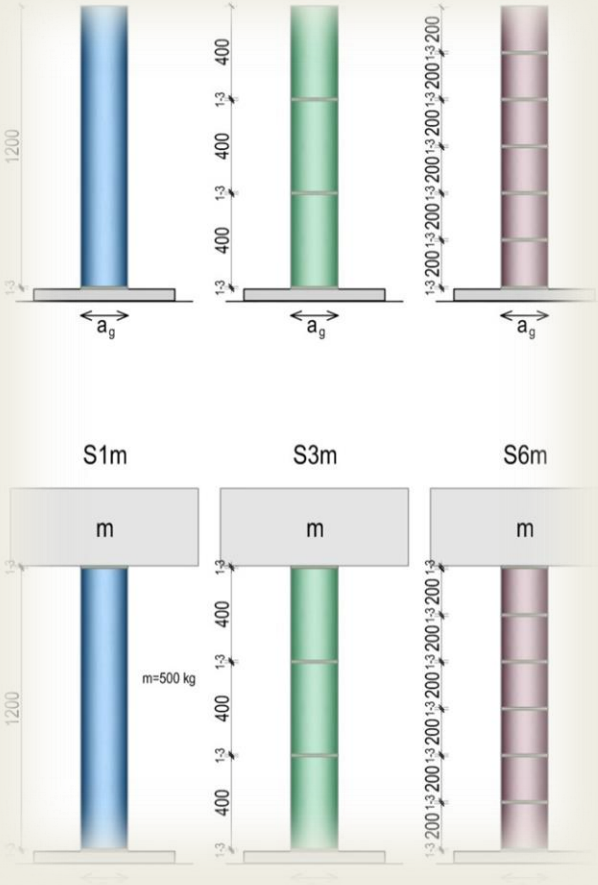
- Istraživanja vezana za ponašanje i nosivost kamenih stupova pod opterećenjem su još uvijek vrlo rijetka
- Najveći broj istraživača s područja Grčke i Italije
- Ostali istraživači uglavnom s područja Mediterana

3. Cilj i svrha istraživanja

Utjecaj nekih parametara na ponašanje i graničnu nosivost višedijelnih kamenih stupova pri statičkom opterećenju i potresu





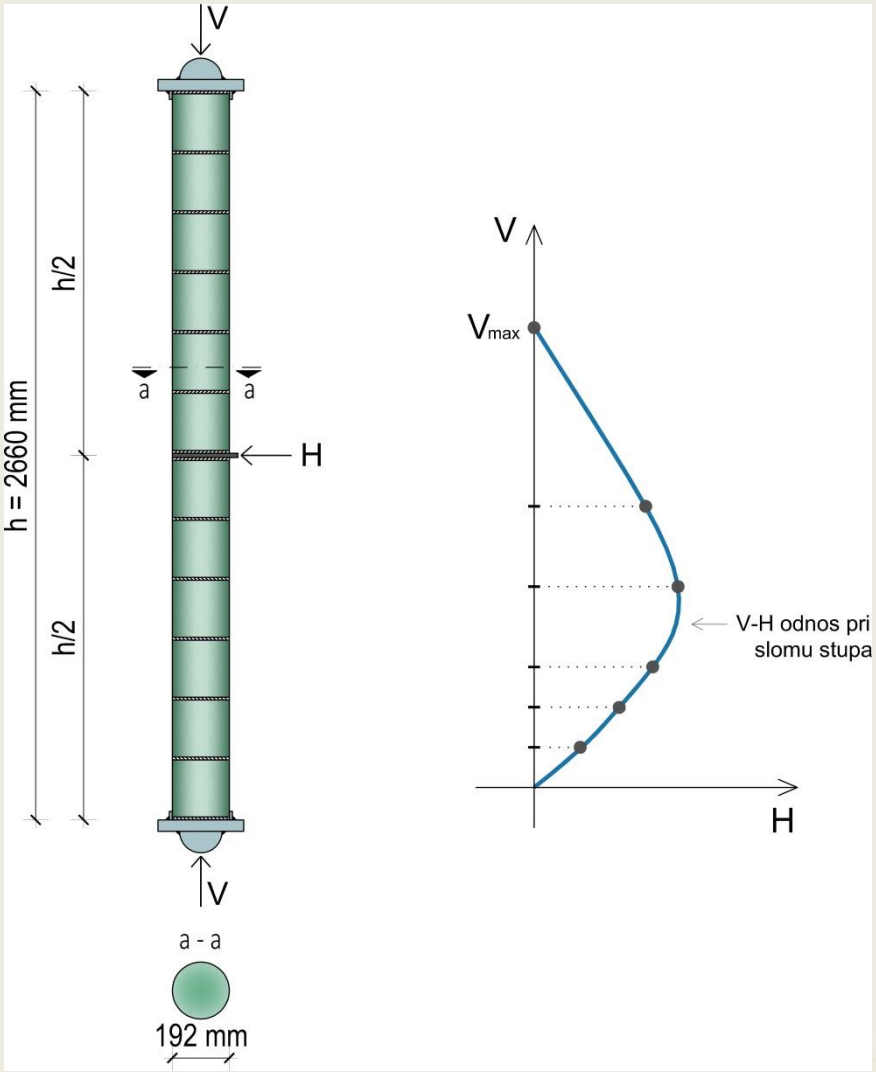


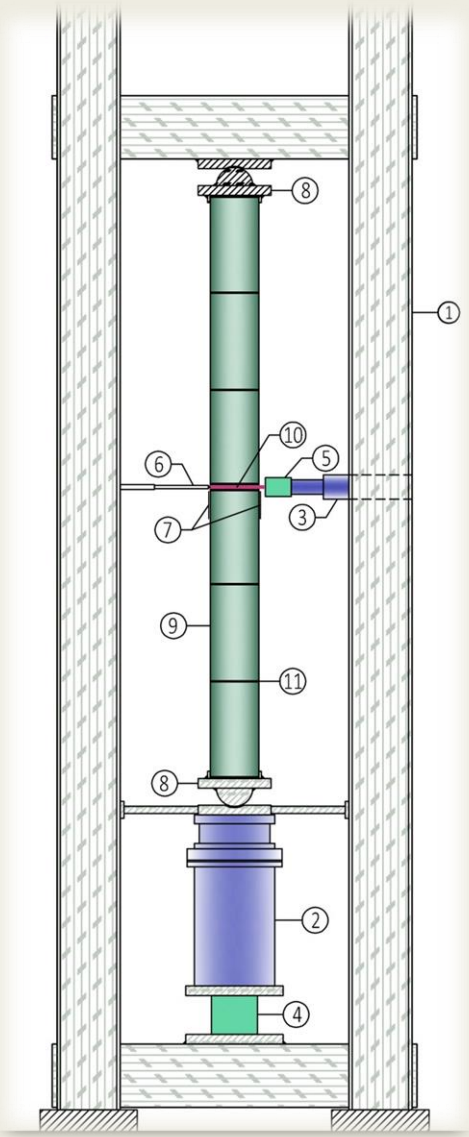
4. Metodologija istraživanja

http://www.wise-project.eu/highlights-hr/

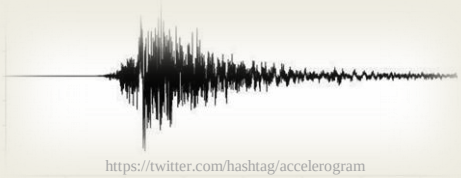
- Eksperimenti provedeni na temelju prethodno detaljno izrađenih planova i programa istraživanja.
- Zasebno istraživanje određenih parametara višedijelnih kamenih stupova, pri čemu su svi ostali njihovi parametri zadržani konstantnim (jednakim).
- Visoka pouzdanost primjene dobivenih rezultata na umanjenim modelima za višedijelne kamene stupove u stvarnoj veličini u praksi.

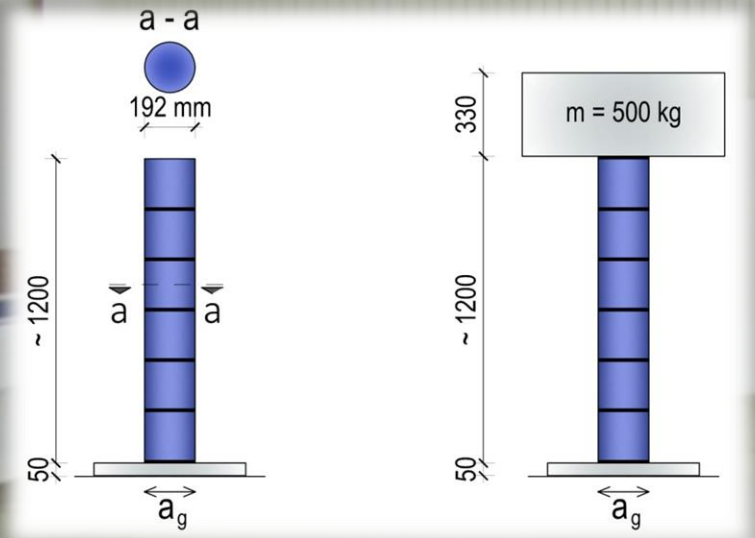
○ *Statička ispitivanja*





○ *Dinamička ispitivanja*





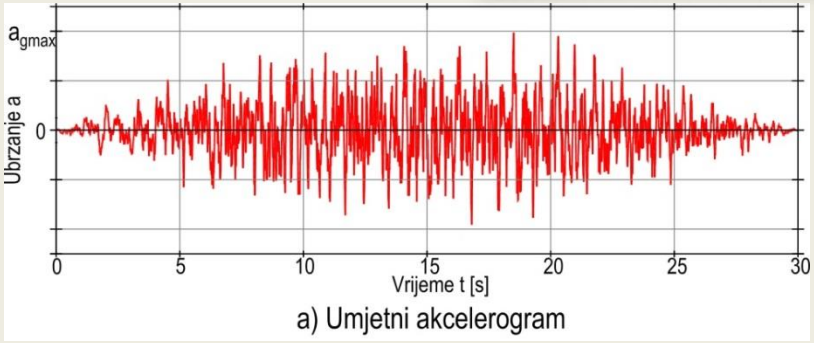
- mogućnost ispitivanja stvarnih građevina i njihovih modela tlocrtnih izmjera do 4 x 4 m
- najveća masa do 20 tona
- najveći pomaci ±150 mm,
- najveća ubrzanja ±3 g
- najveća frekvencija 30 Hz
- najveća visina uzorka do 9 m

○ *Mjerna oprema*

- Quantum-x mx 840A i računalni program Catman easy (HBM) za kontinuirano snimanje i prikupljanje podataka sa svih senzora
- Davač (senzor) pomaka - LVDT (HBM) za praćenje horizontalnog i vertikalnog pomaka stupa
- Elektro-otporne mjerne trake za praćenje deformacija (HBM)
- Davač (senzor) pomaka (Uni Measure) za praćenje horizontalnog pomaka stupa
- Akcelerometar (Measurment Specialties) za mjerenje ubrzanja.

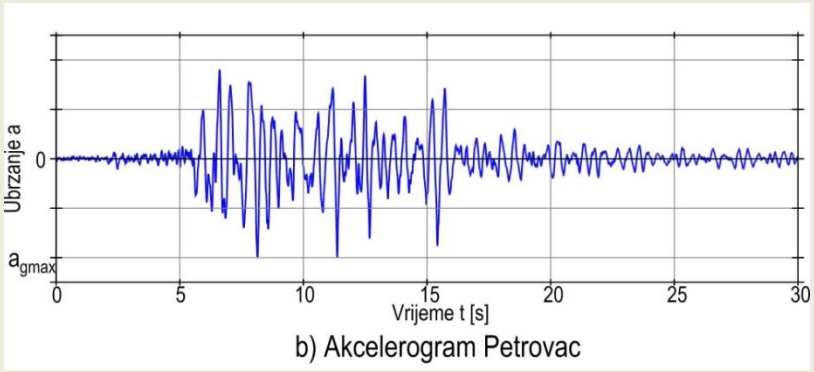
5. Akcelerogrami korišteni u dinamičkim ispitivanjima

- Potresi dugog trajanja s relativno dužim predominantnim periodom



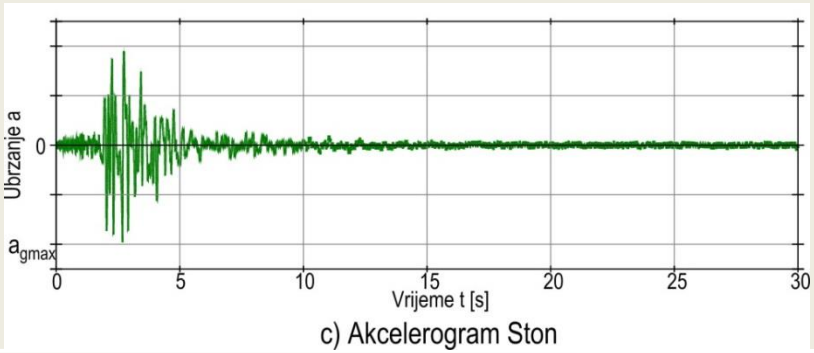
a) Umjetni akcelerogram

- Potresi srednje dugog trajanja s dužim predominantnim periodom

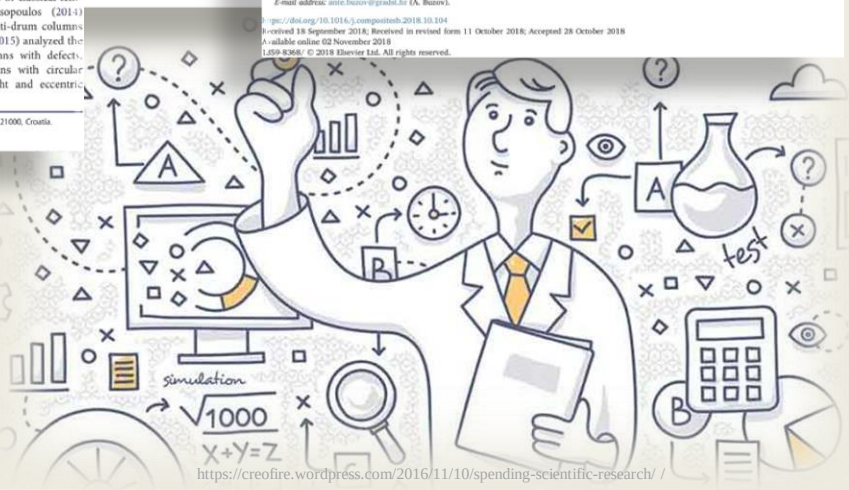


b) Akcelerogram Petrovac

- Potresi kratkog trajanja s malim predominantnim periodom (tzv. udarni potresi)



c) Akcelerogram Ston



https://creofire.wordpress.com/2016/11/10/spending-scientific-research/ /

6. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

Composites Part B 148 (2018) 243–251

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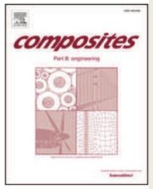
journal homepage: www.elsevier.com/locate/compositesb



Effect of the drum height on the bearing capacity of composite multi-drum column under static load

A. Buzov*, J. Radnić, N. Grgić, G. Baloević

University of Split, Faculty of Civil Engineering, Architecture and Geodesy, 21000, Split, Croatia

ARTICLE INFO

Keywords:
Multi–drum column
Bearing capacity
Effect of the drum height
Static load

ABSTRACT

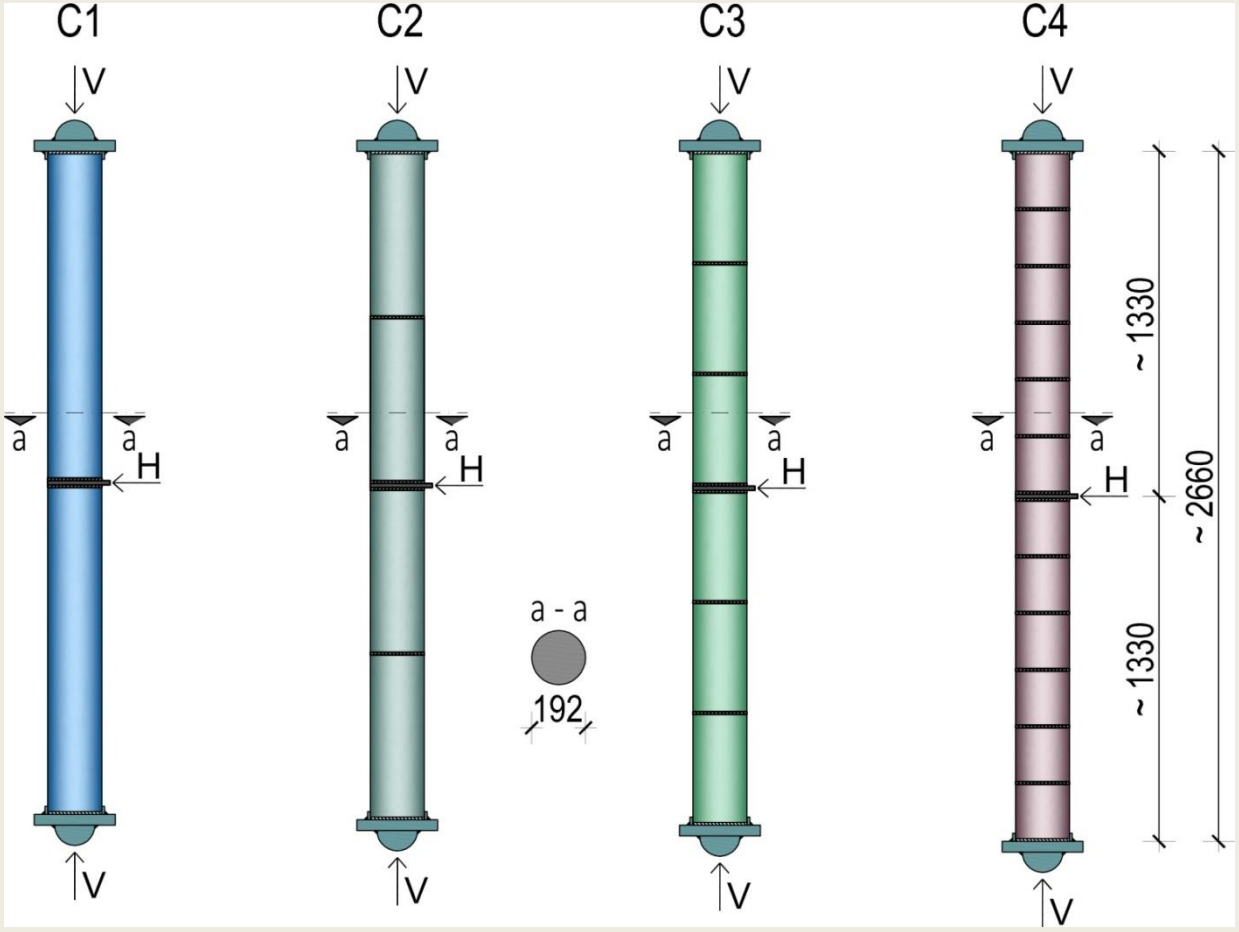
The results of a experimental study on the effect of the drum height on the bearing capacity of composite multi-drum column under axial compression force and lateral horizontal force were presented. Small scale columns with two, four, six and twelve drums were tested. It was concluded that an increased number of drums reduces bearing capacity, flexural and shear stiffness, and increases horizontal and vertical deformability of columns. The reason is the simultaneous increase of the joints number, which are the weakest point in column. The column loaded by axial force only had a brittle failure, and by combined axial force and lateral force more ductile failure.

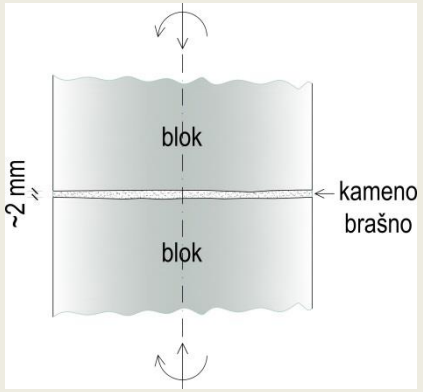
1. Introduction

Stone columns are important structural elements in masonry buildings. They are primarily intended to carry the vertical load, but like the rest of the drums, but it is hollow and contains particles. It was found that the damper could reduce the motion of the column up to 40%.

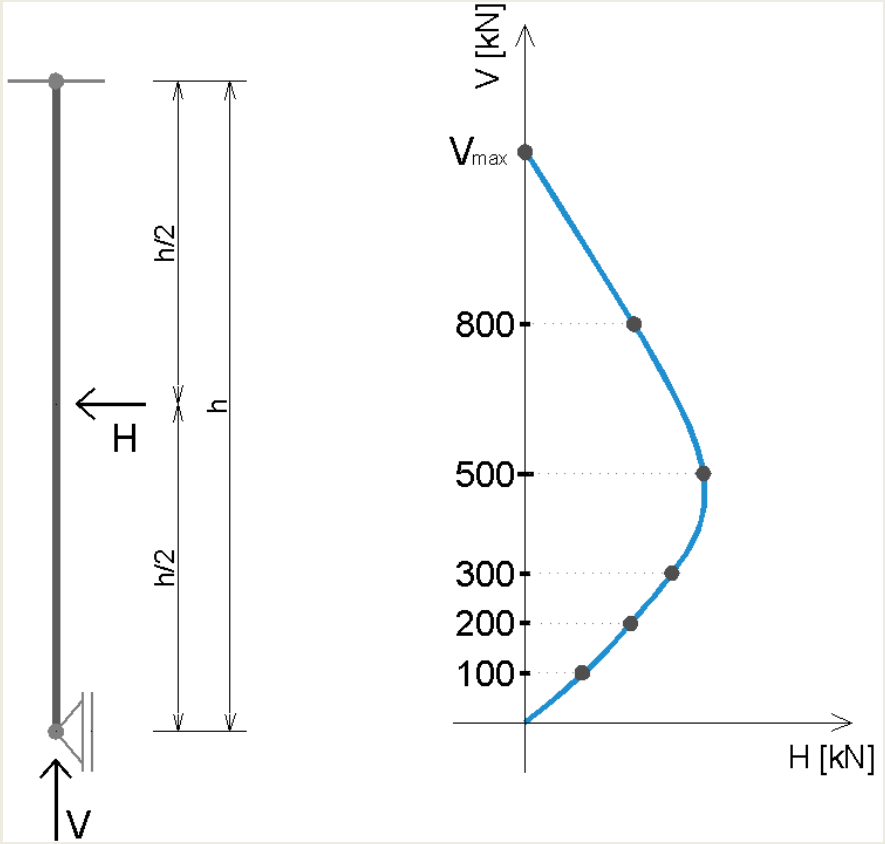
Drosos and Anastasopoulos [3] experimentally studied the seismic

6. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

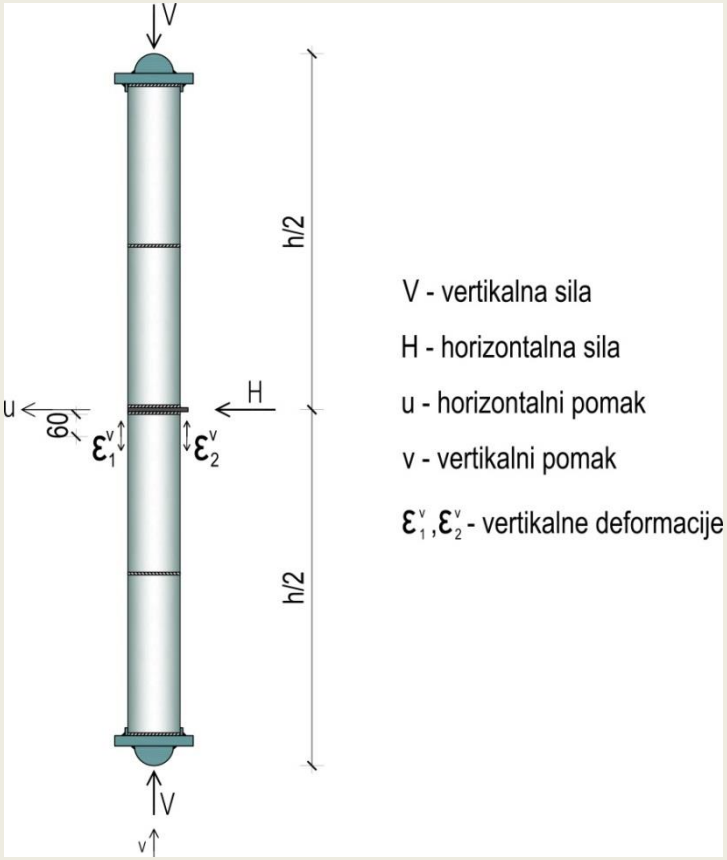




6. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

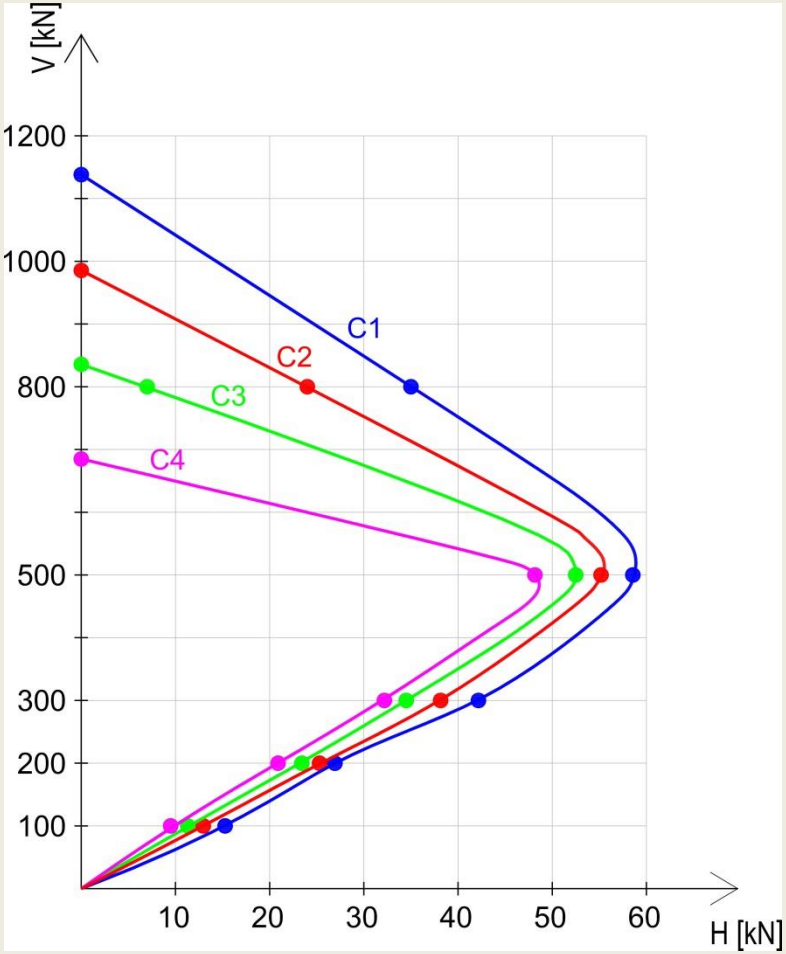


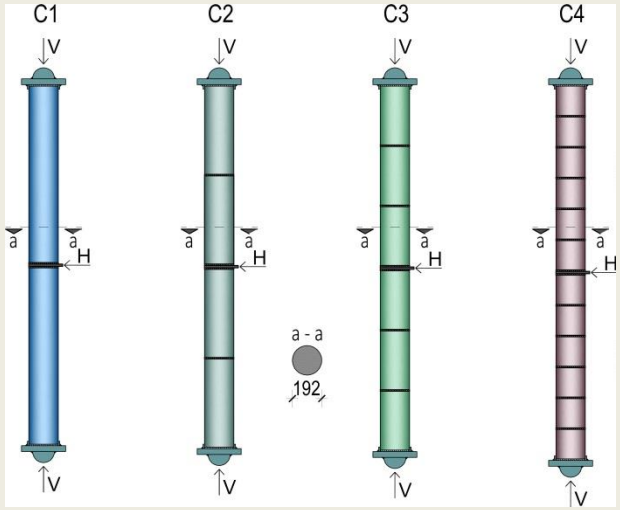
Shema opterećenja stupova silama V, H



Mjerene veličine

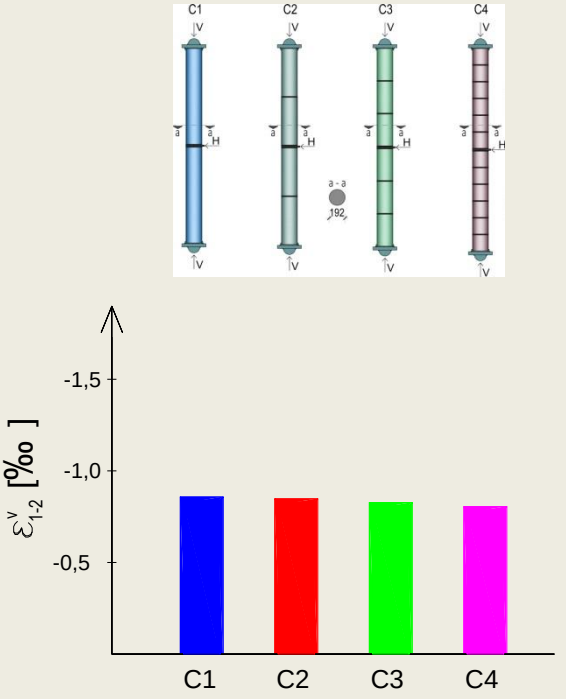
6. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju



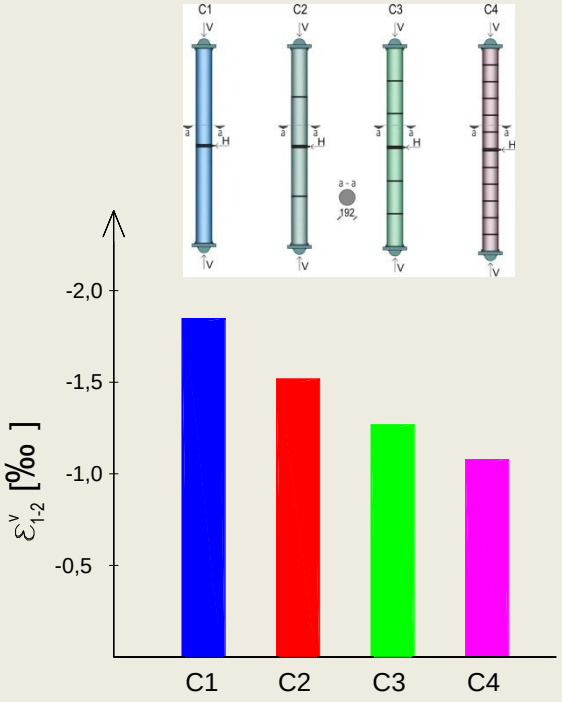


Granična nosivost testiranih stupova u funkciji veze V-H

6. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju



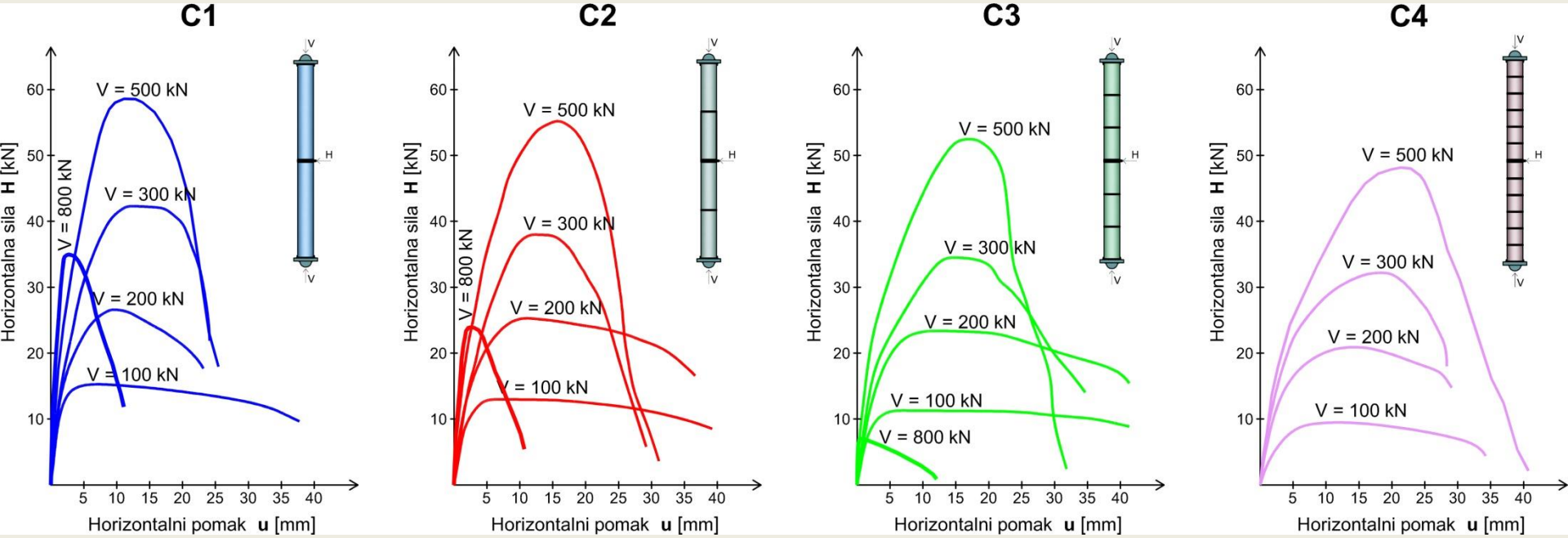
Za V=500 kN



Maksimalna deformacija

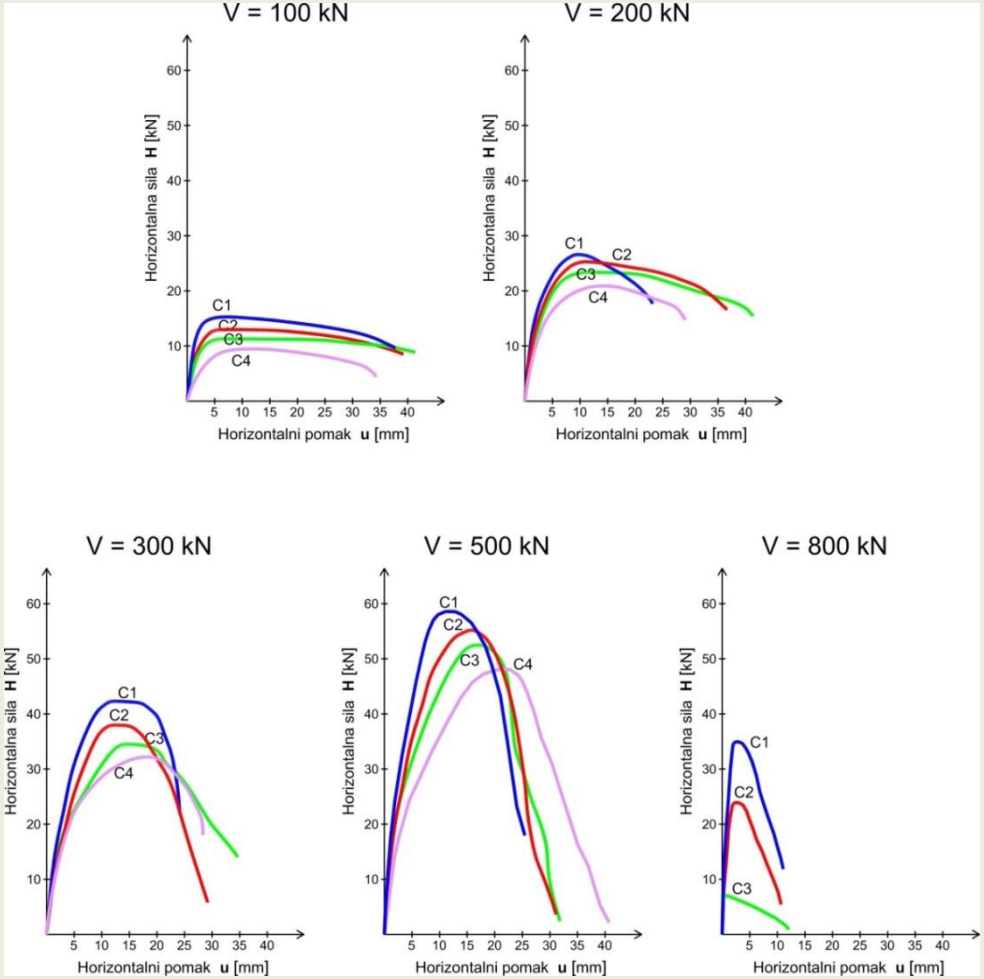
Prosječna vertikalna deformacija centrično opterećenih stupova

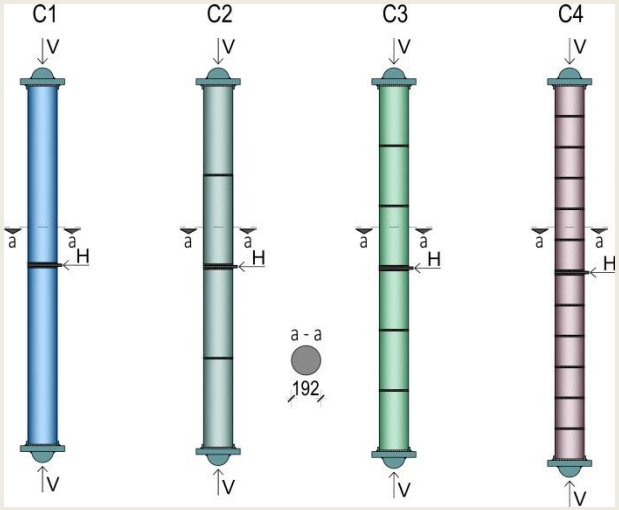
6. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju



Veza horizontalna sila (H) – horizontalni pomak (u)

6. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju





Veza horizontalna sila (H) – horizontalni pomak (u)

C2 – centrični tlak

C3 – centrični tlak

C3 – ekscentrični tlak

V = 300 kN + H

6. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

Glavni zaključci

S povećanjem broja blokova u stupu

Smanjenje granične nosivosti stupa na centrični i ekscentrični tlak

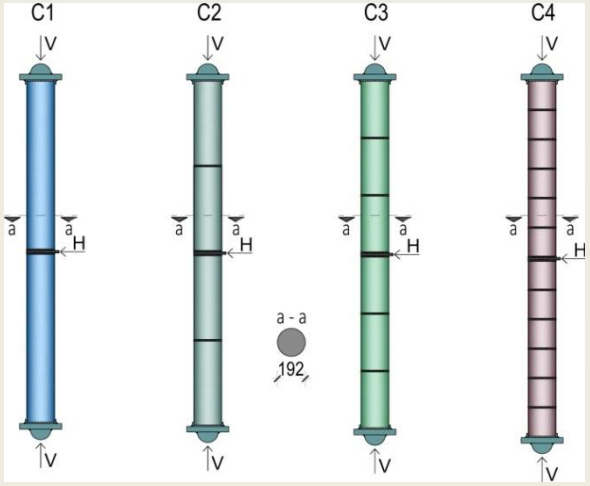
Povećanje horizontalne i vertikalne deformabilnosti stupa

Smanjenje savojne krutosti stupa

6. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

Glavni zaključci

Veći broj blokova → Veći broj sljubnica → Slaba karika u stupu



Stup formiran od dvanaest blokova po visini (C4) imao je za oko 40 % manju graničnu nosivost na centrični tlak od stupa s dva bloka po visini (C1).

7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

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Hindawi

Research Article

Effect of the Drum Height on the Seismic Behaviour of a Free-Standing Multidrum Column

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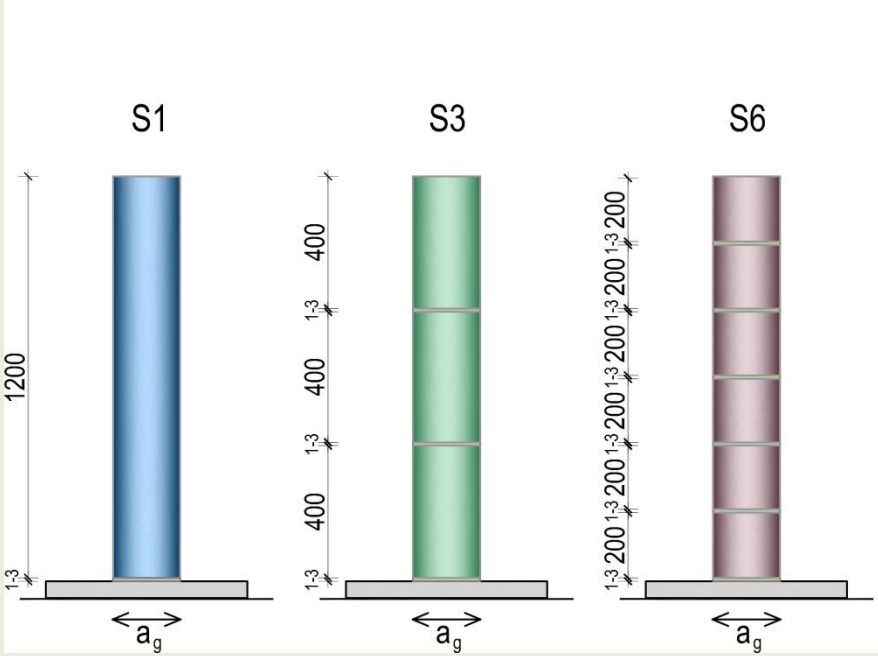
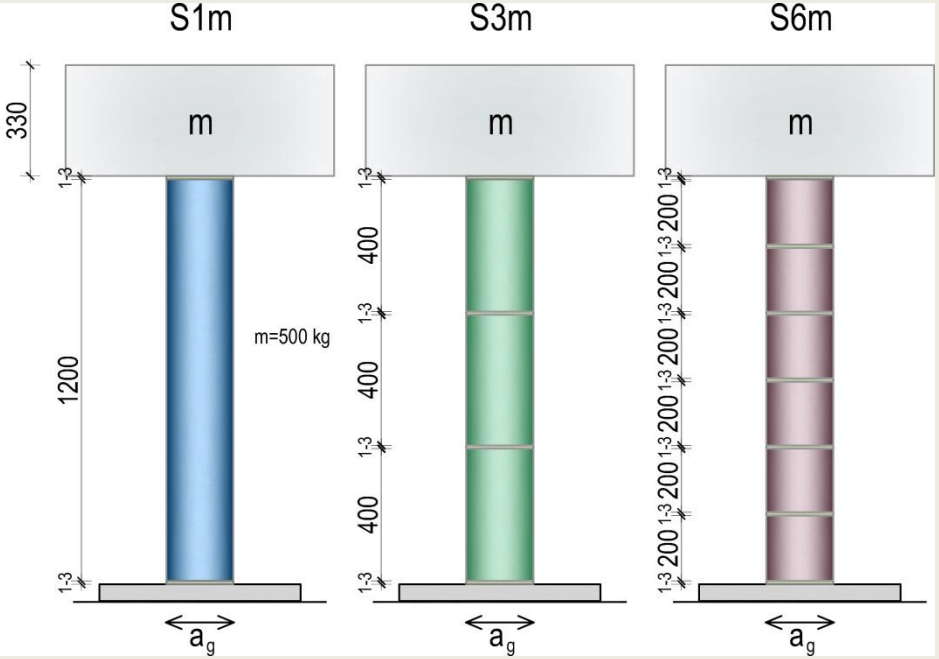
The results of a shake-table study on the effect of the drum height on the seismic behaviour and bearing capacity of small-scale free-standing multidrum columns are presented. Columns of equal height with one, three, and six drums through their height

7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

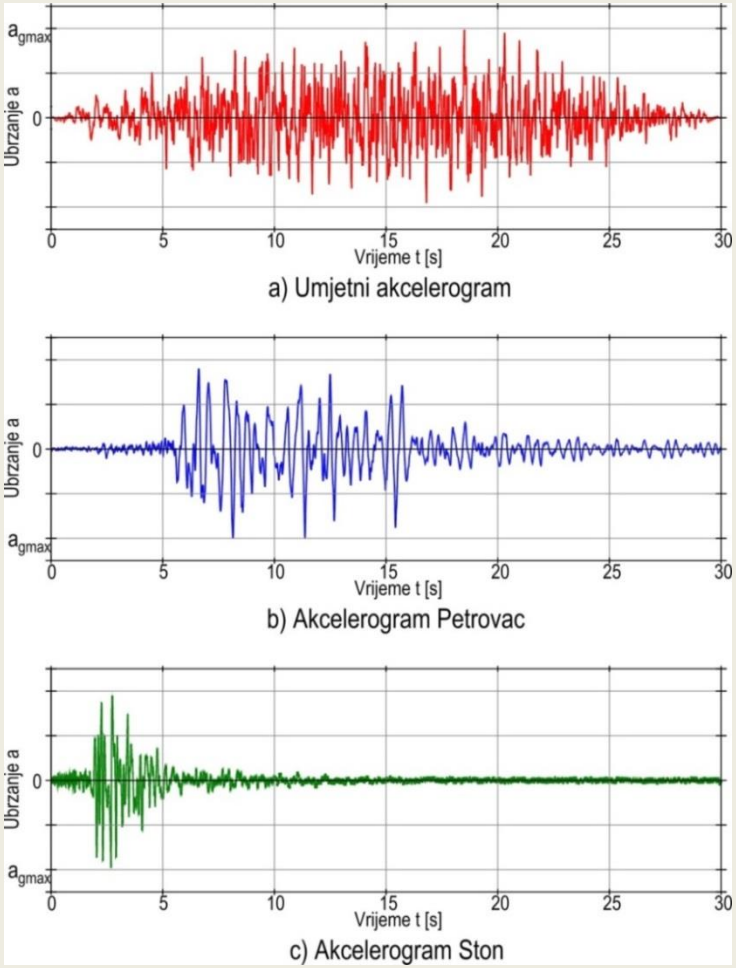


Stupovi opterećeni samo vlastitom težinom

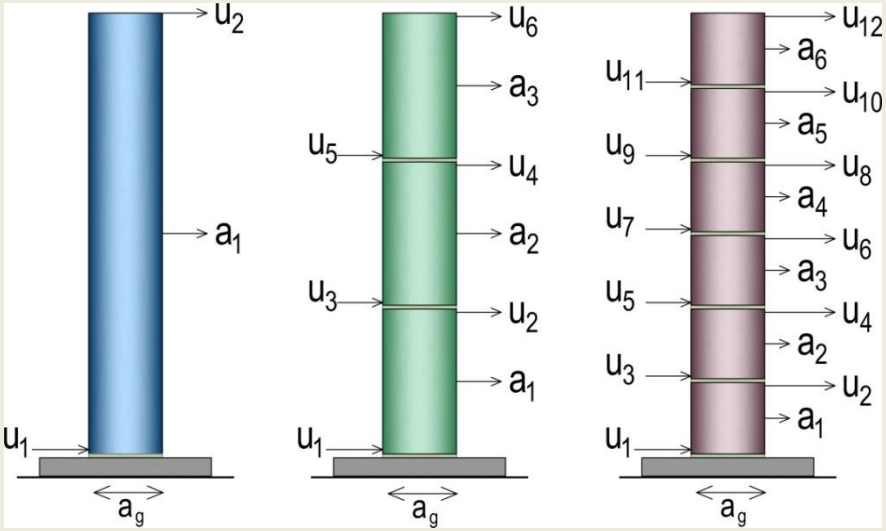


Stupovi opterećeni vlastitom težinom i dodatnom masom na vrhu

7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu



Aplicirani akcelerogrami



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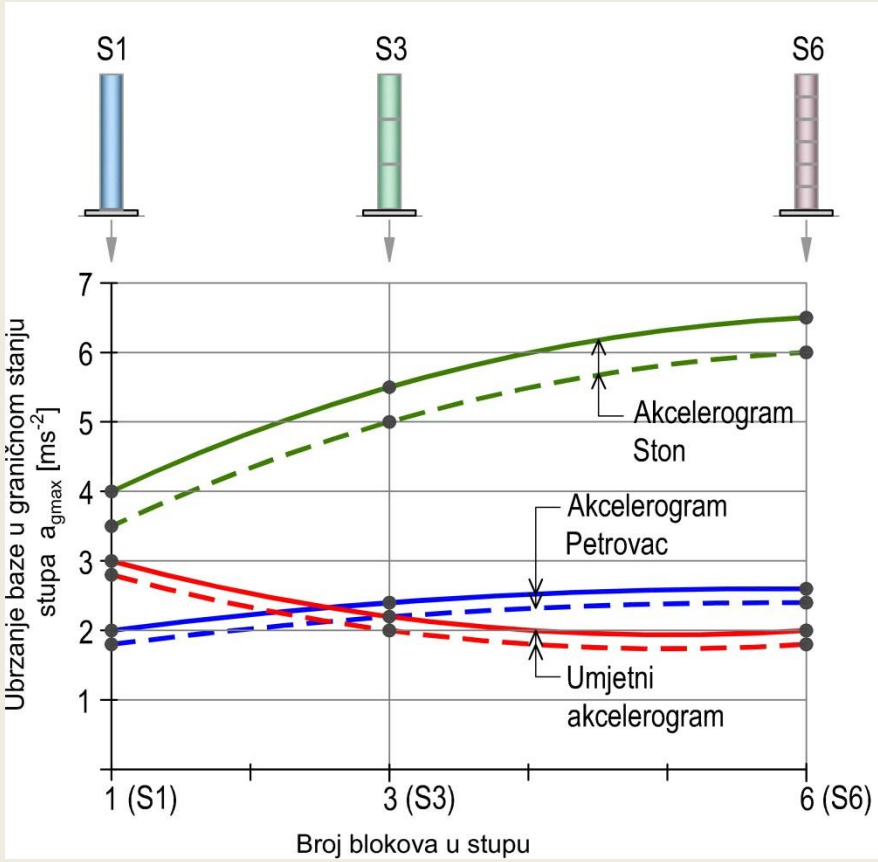
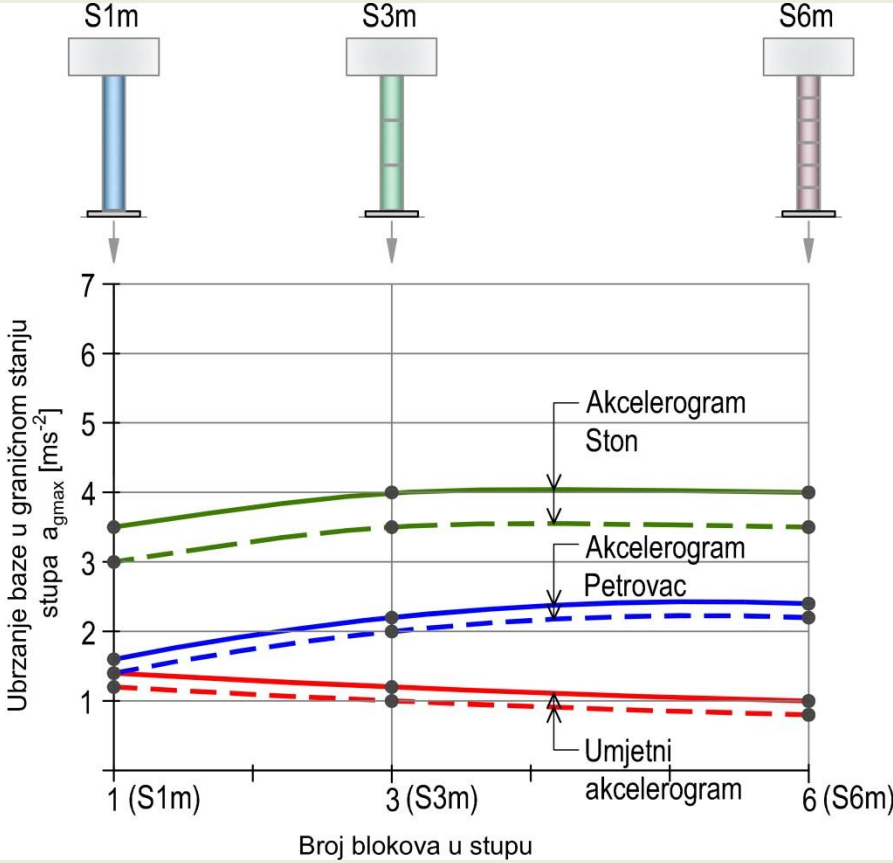
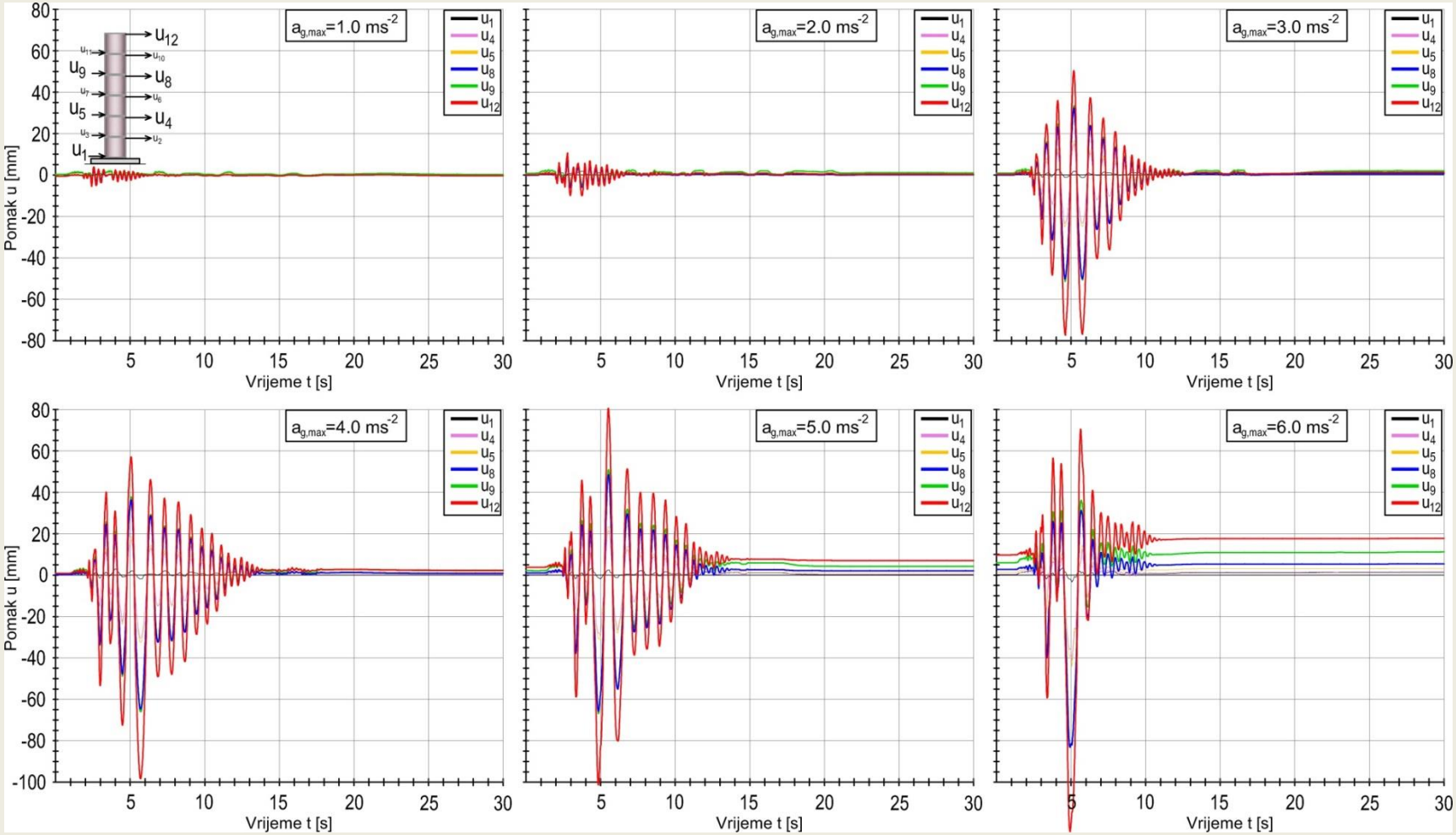




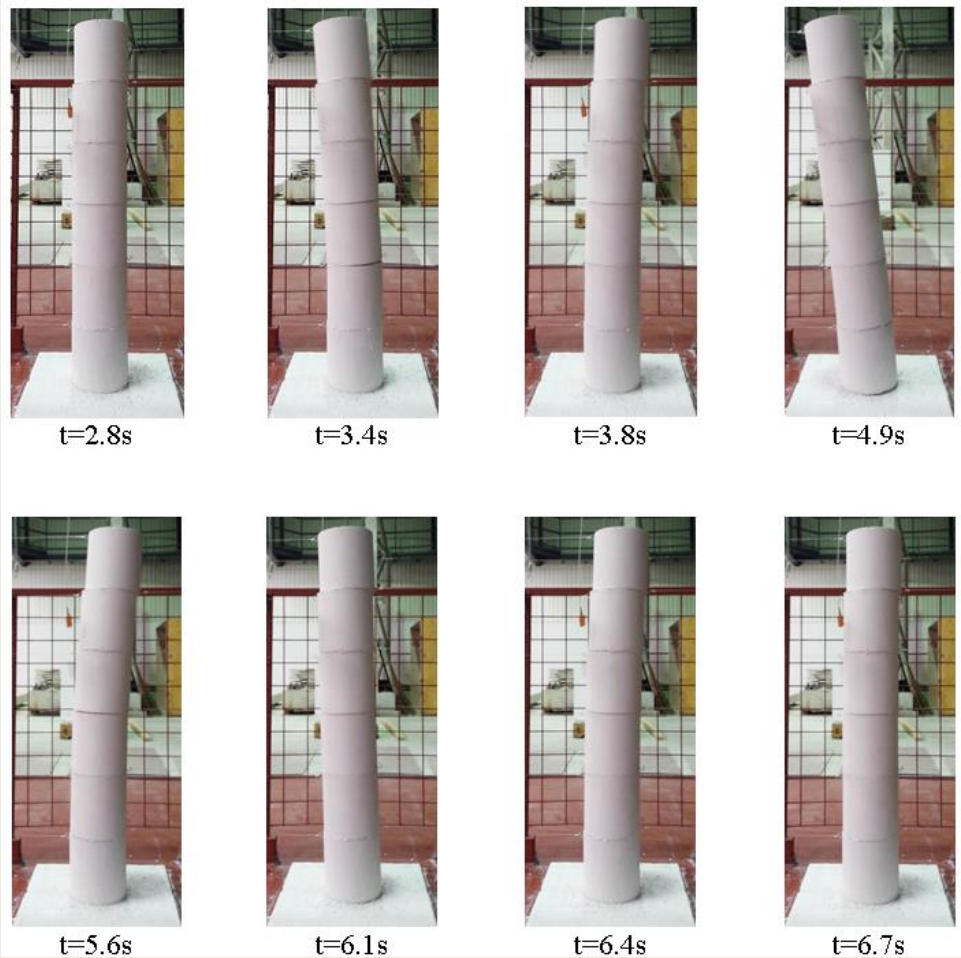
Maksimalno ubrzanje podloge a_{gmax} za granično stanje ispitivanih stupova

7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu



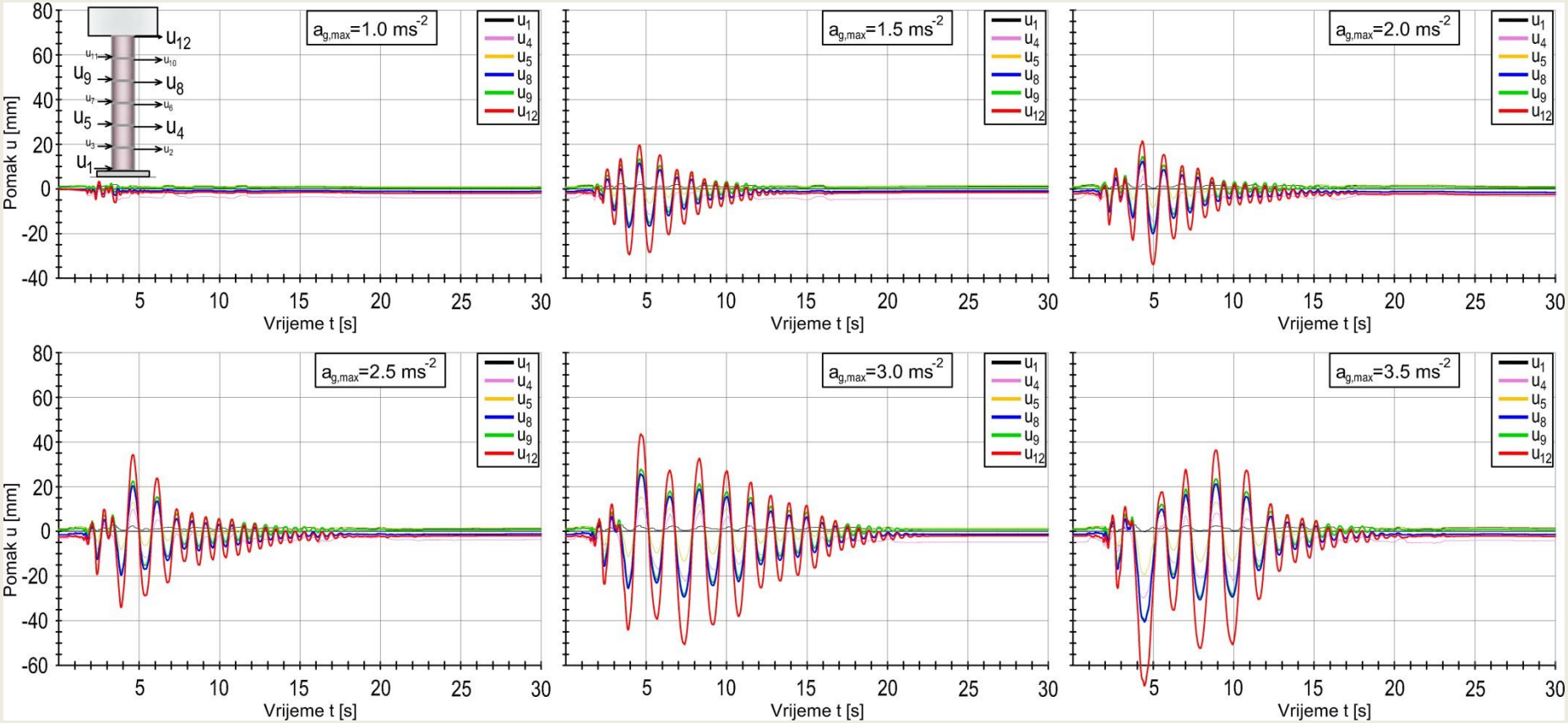
Horizontalni pomaci stupa S6 za akcelerogram Ston pri nekim a_{gmax}

7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu



Položaj stupa S6 za akcelerogram Ston pri a_{gmax} = 6.0 ms^{-2}

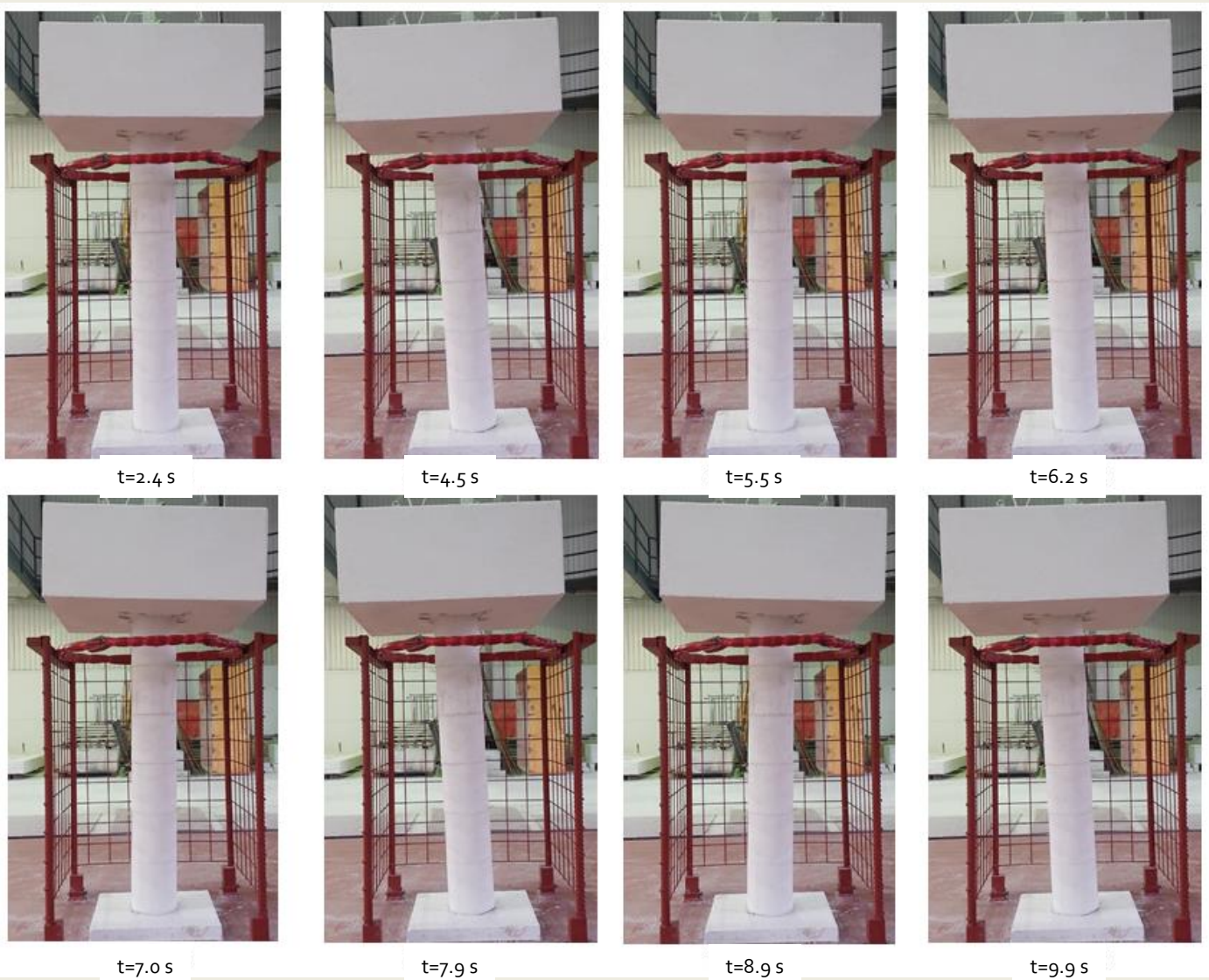
7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu



Horizontalni pomaci stupa S6m za akcelerogram Ston pri nekim a_{gmax}

7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

Položaj stupa S6m za akcelerogram Ston pri a_{gmax} = 3.5 ms^{-2}



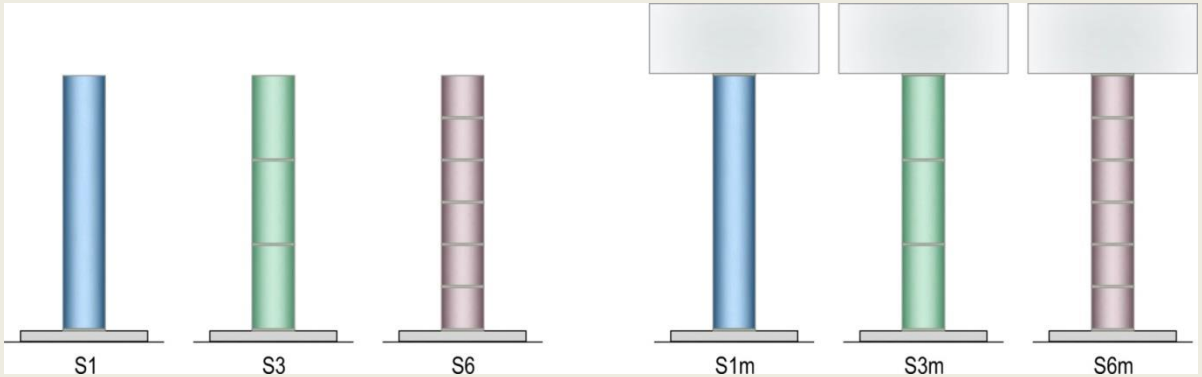
S1m – Ston

S3m – Petrovac

7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

Glavni zaključci

- Broj blokova u višedijelnom stupu značajno utječe na njegovu krutost, otpornost i graničnu nosivost pri potresu.
- Stupovi opterećeni samo vlastitom težinom i jednaki stupovi dodatno opterećeni masom na vrhu imali su sličnu zakonitost utjecaja broja blokova na njihovu graničnu nosivost.
- Utjecaj broja blokova u stupu na njegovu graničnu nosivost ovisio je o apliciranom akcelerogramu (tipu potresa).

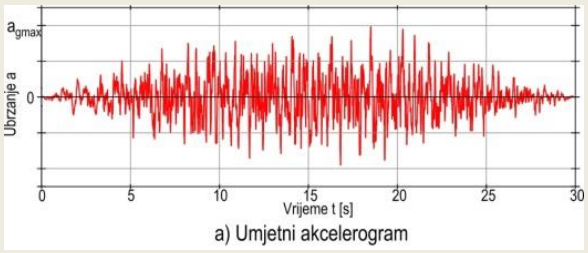


7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

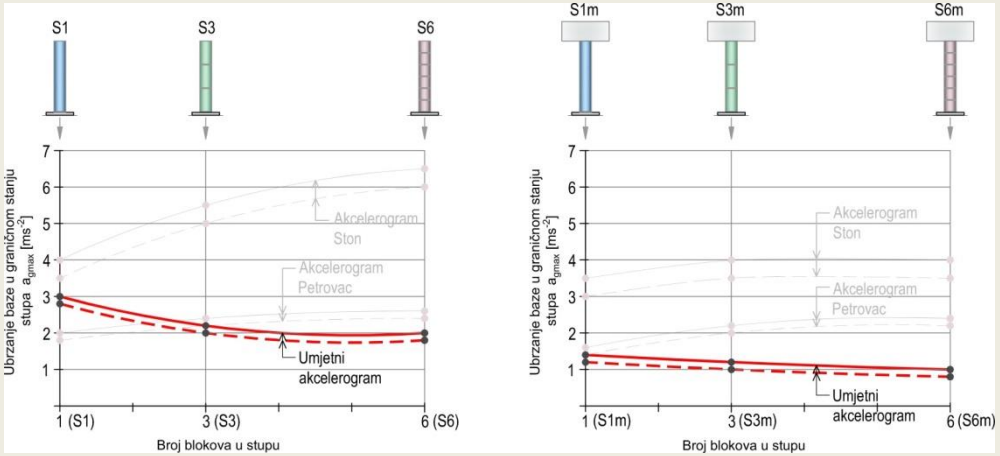
Glavni zaključci

Dugotrajno djelovanje s visokim spektralnim brzinama i pomacima

Smanjenje granične nosivosti / krutosti stupa



a) Umjetni akcelerogram

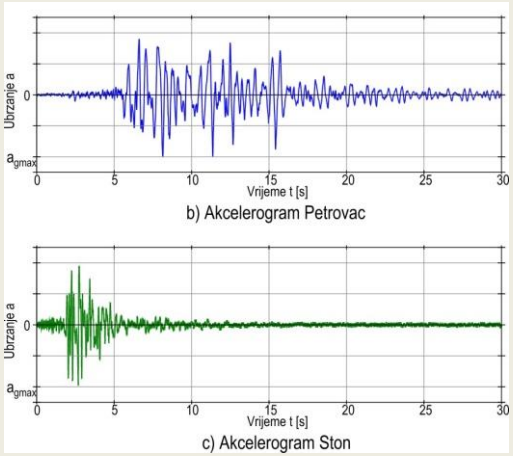


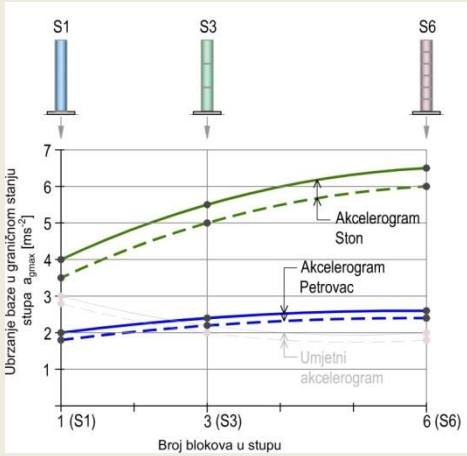
7. Istraživanje utjecaja broja blokova u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

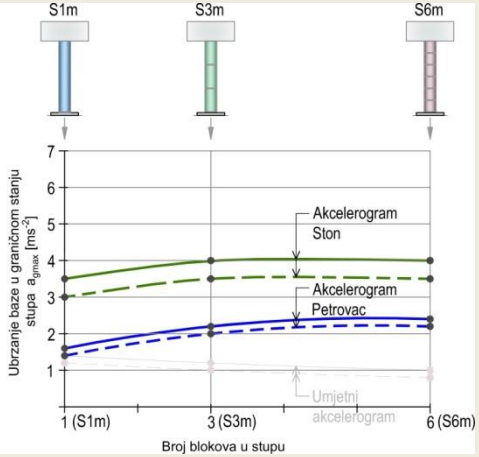
Glavni zaključci

Kraće djelovanje s nižim spektralnim brzinama i pomacima (udarni potresi)

Povećanje granične nosivosti / krutosti stupa







8. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

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Effect of the joint type on the bearing capacity of a multi–drum column under static load

A. Buzov, J. Radnić, N. Grgić, and G. Baloević

Faculty of Civil Engineering, Architecture and Geodesy, University of Split, Split, Croatia

ABSTRACT

The results of an experimental study on the effect of the joints between the blocks on the ultimate bearing capacity of a multi-drum column loaded to centric vertical force and horizontal force in the middle of its height are shown. The column is approximately 2.5 m high, with one hinge at the top and another hinge at the bottom. Four types of joints between the blocks were considered: a dry joint (column C-DJ) and joints with stone powder (column C-SPJ), lead (column C-PBJ), and epoxy (column C-EPJ). The applied vertical and horizontal forces, horizontal displacement, vertical strains, and horizontal circumferential strains in the middle of the column height, as well as shortening of the column, were measured. Under axial compression, ratios between the ultimate load bearing capacities of tested columns were C-EPJ: C-DJ: C-SPJ: C-PBJ = 1: 0.68: 0.59: 0.51. The bearing capacity of the tested columns with regard to the horizontal force depended on the level of the applied centric compression force. Columns with soft joints (C-PBJ, C-SPJ) had the largest shortening and the largest horizontal displacements for the equal forces.

KEYWORDS

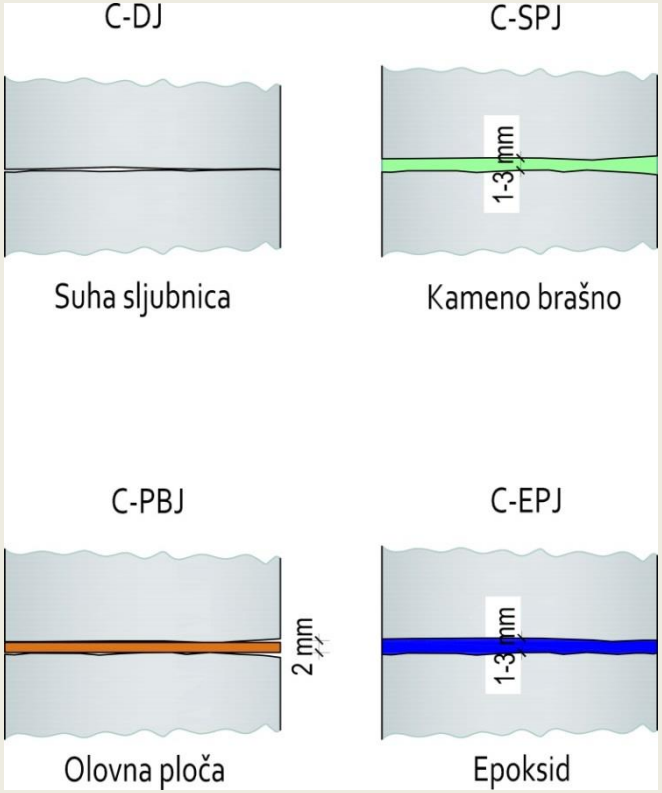
bearing capacity; deformability; joint effect; multi–drum column; static load

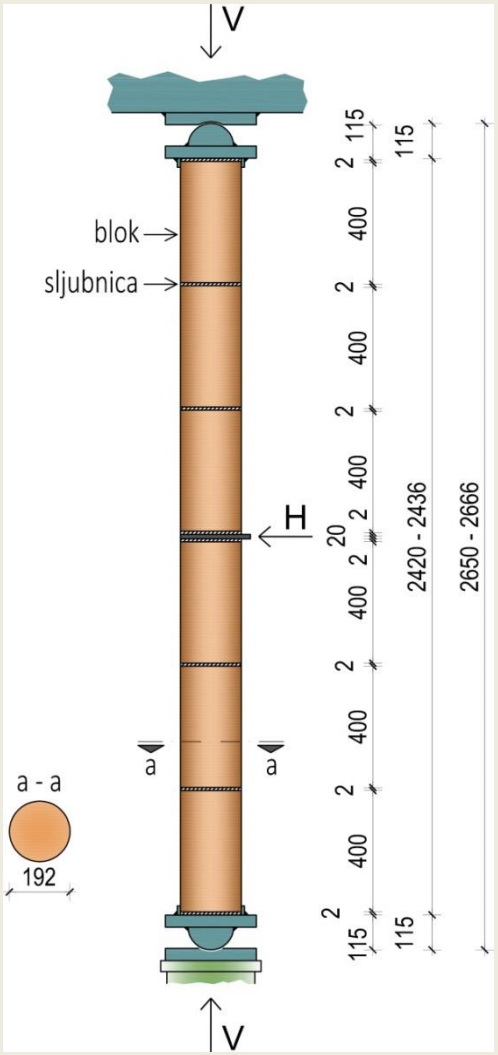
1. Introduction

Stone columns are important structural elements in

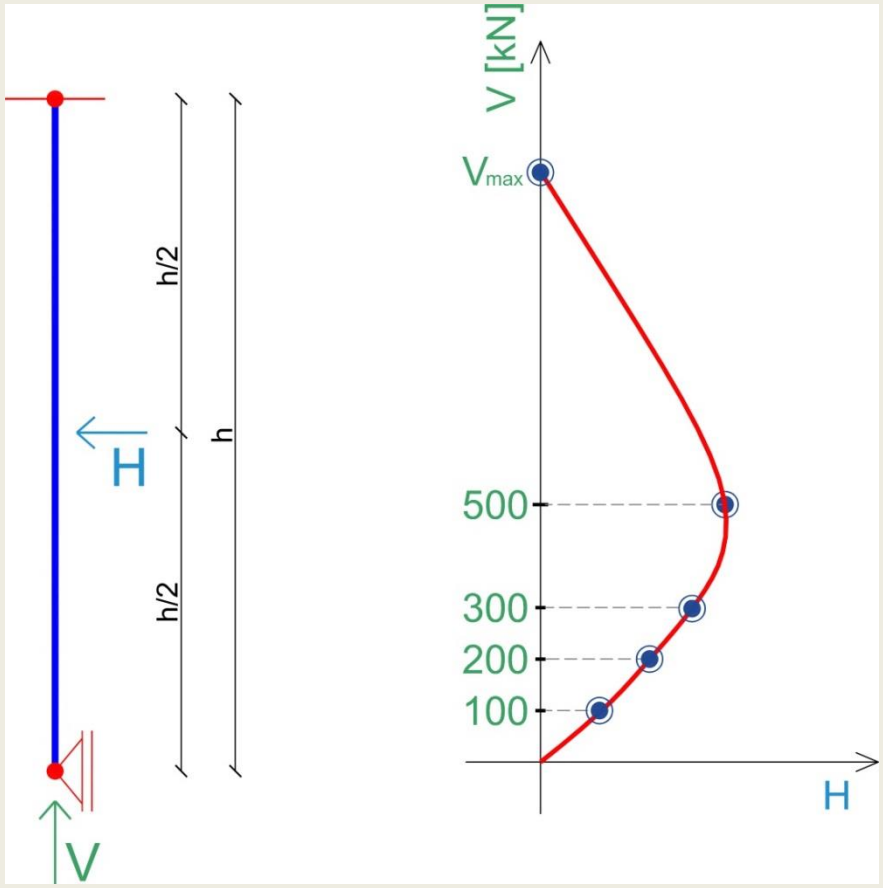
with the possible retrofit concept. Atalić, Uroš, and Šavor (2012) studied the influence of contact stresses

8. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

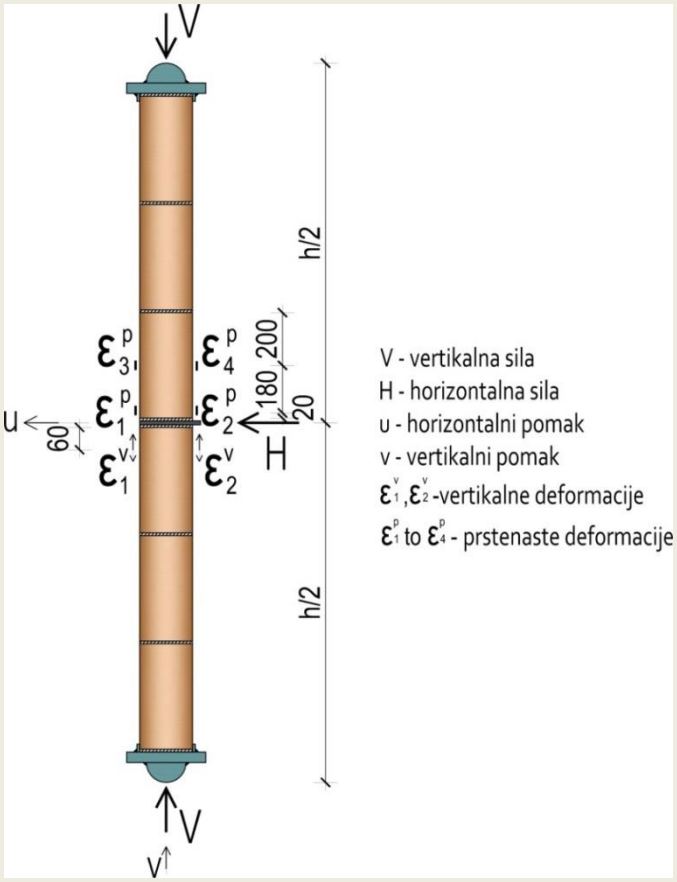




8. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

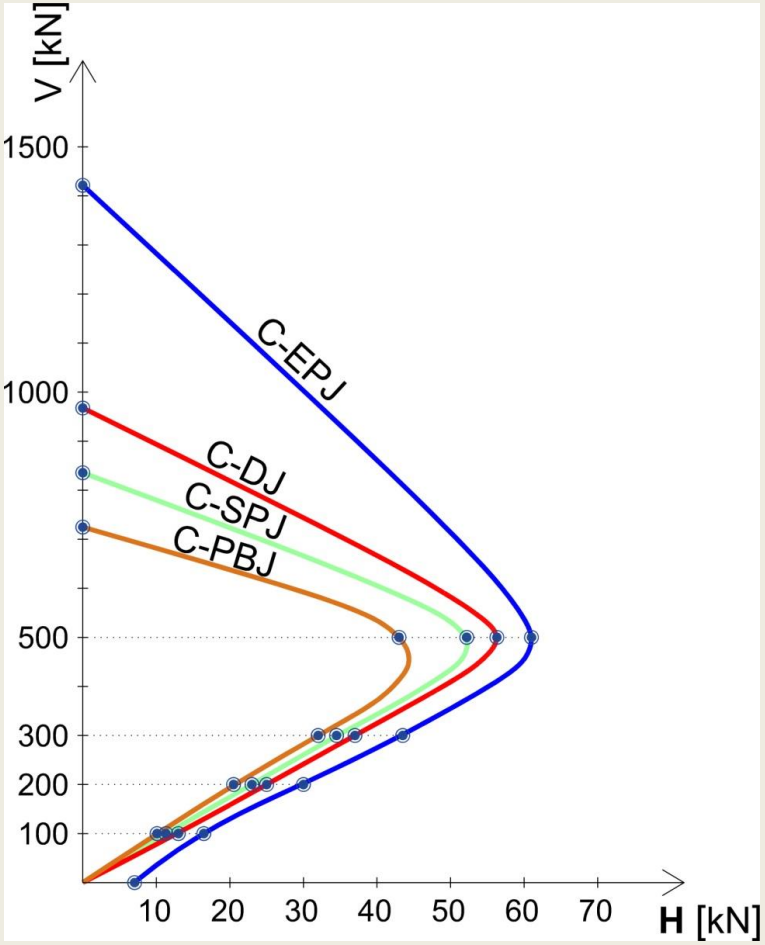


Shema opterećenja stupova silama V, H

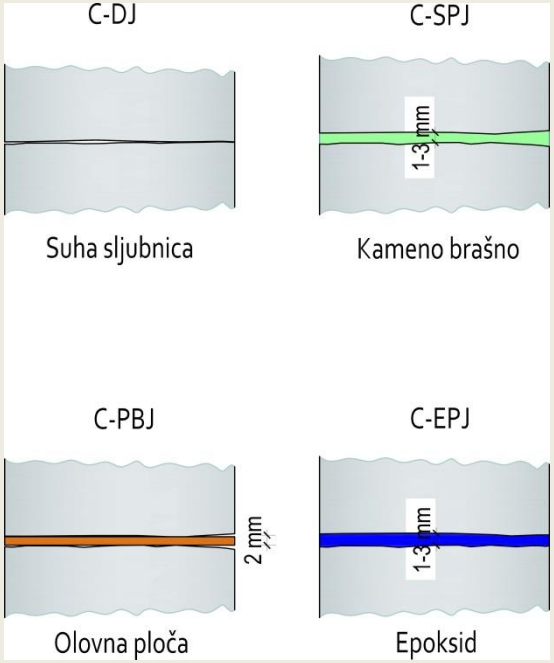


Mjerene veličine

8. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

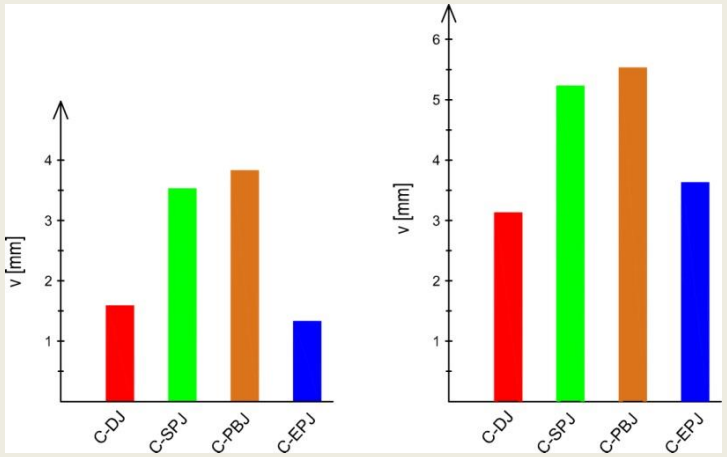


Nosivost stupova



Tip sljubnice

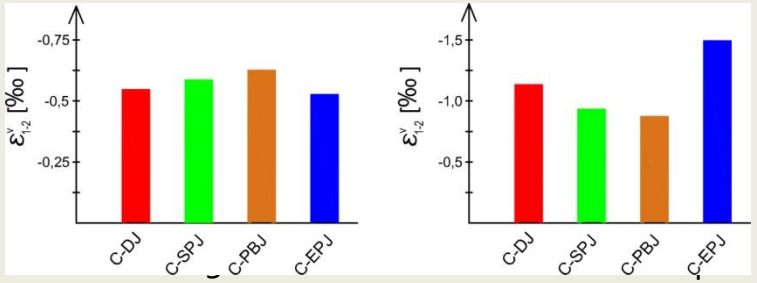
8. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju



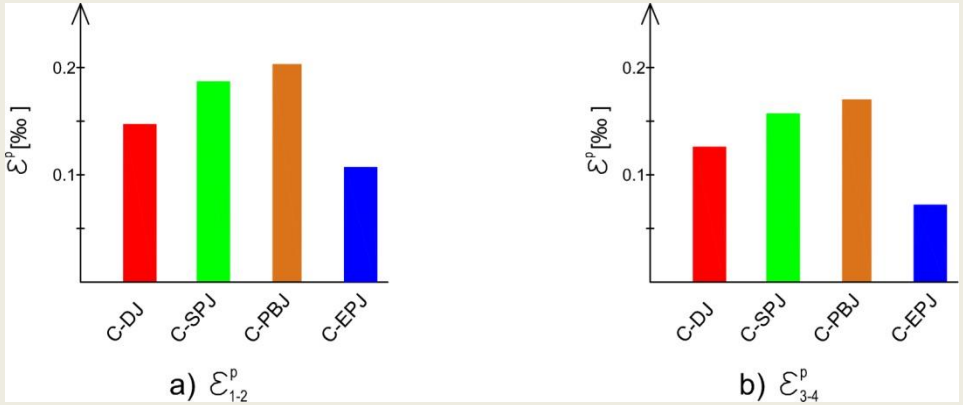
Pri V=500 kN

Pri slomu stupa

Vertikalni pomak dna stupova

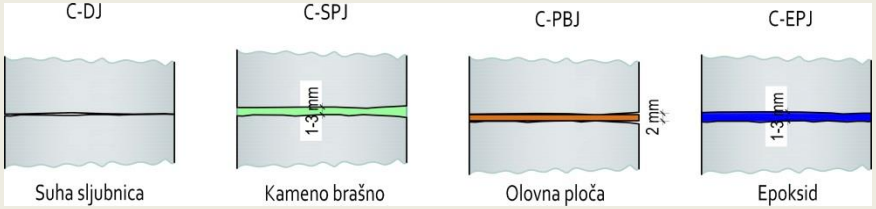


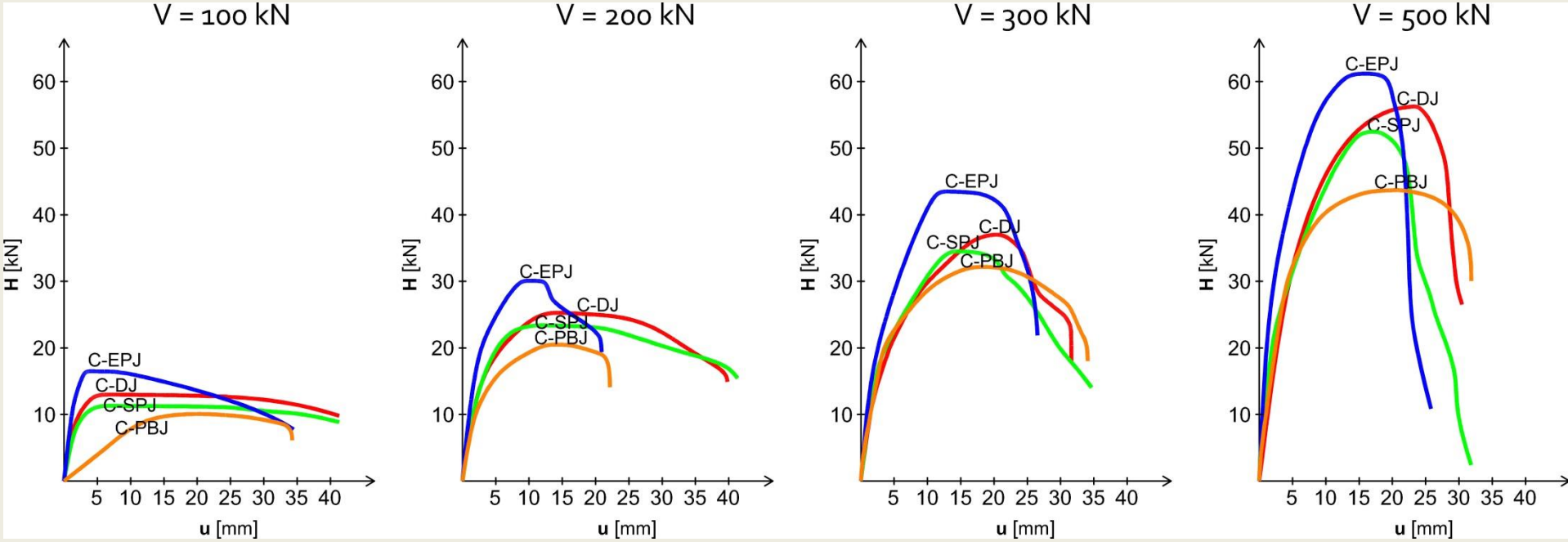
Prosječna vertikalna deformacija za djelovanje samo sile V



Prosječne prstenaste deformacije stupova pri V = 500 kN

8. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju





Veza horizontalna sila (H) – horizontalni pomak (u)

8. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju






CDJ – centrični tlak

CEPJ – centrični tlak

CEPJ – ekscentrični tlak_ V = 500 kN + H

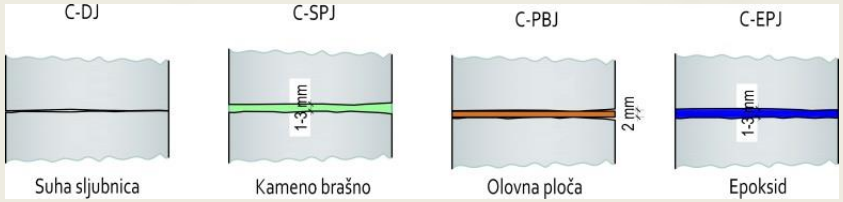
CDJ – ekscentrični tlak_ V = 500 kN + H

8. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

Glavni zaključci

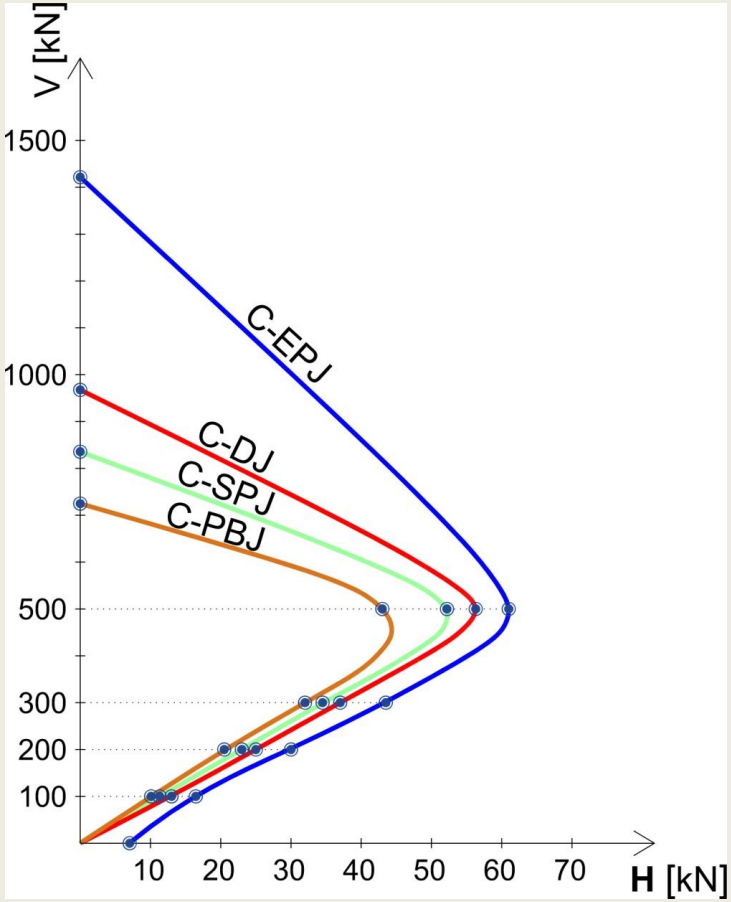
Kvaliteta obrade spojnih ploha kamenih blokova i tip sljubnice ima veliki utjecaj na nosivost kamenog stupa izloženog vertikalnoj centričnoj sili i savijanju.

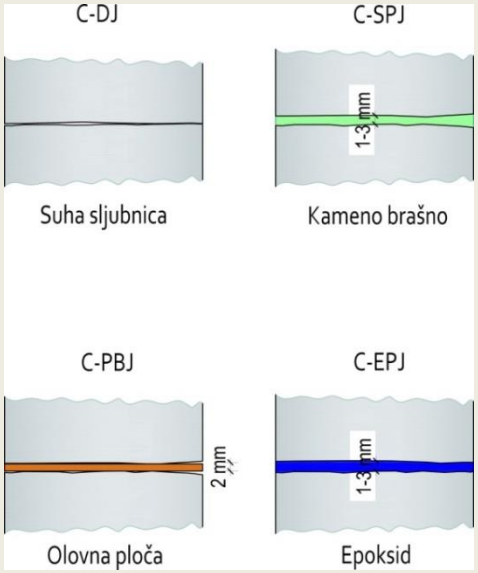
Epoksidna sljubnica (C-EPJ)		Suha sljubnica (C-DJ)		Kameno brašno (C-SPJ)		Olovna ploča (C-PBJ)
1,0	:	0,68	:	0,59	:	0,51



8. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri statičkom opterećenju

Glavni zaključci





9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

EFFECT OF THE JOINT TYPE ON THE SEISMIC BEHAVIOUR OF A FREE-STANDING MULTI-DRUM COLUMN

A. Buzov[a*], J. Radnić[a], N. Grgić[a], G. Baloević[a]

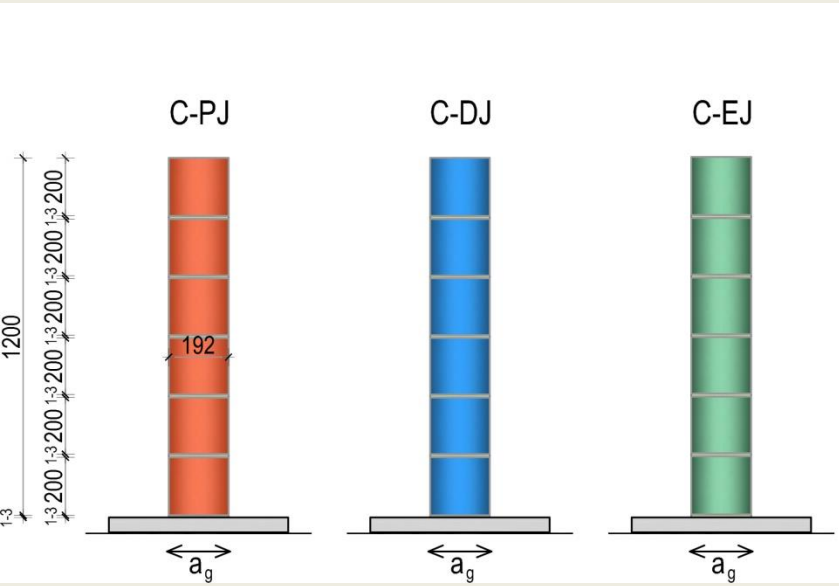
[a]University of Split, Faculty of Civil Engineering, Architecture and Geodesy, 21000 Split, Croatia

*Corresponding author: Tel. +385 21 303336, Fax. +385 21 465117, e-mail: ante.buzov@gradst.hr

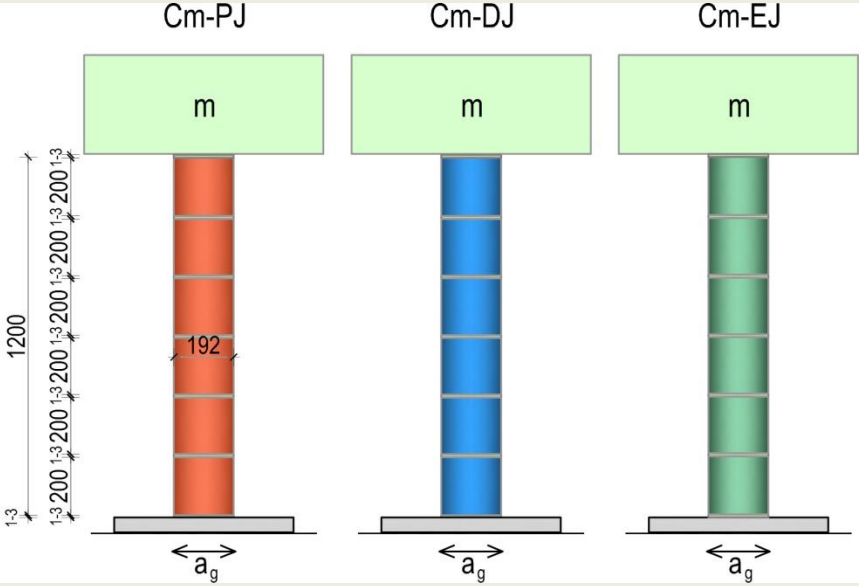
Abstract:

The results of a shake-table study of the effects of the joint type on the seismic behaviour of

9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu



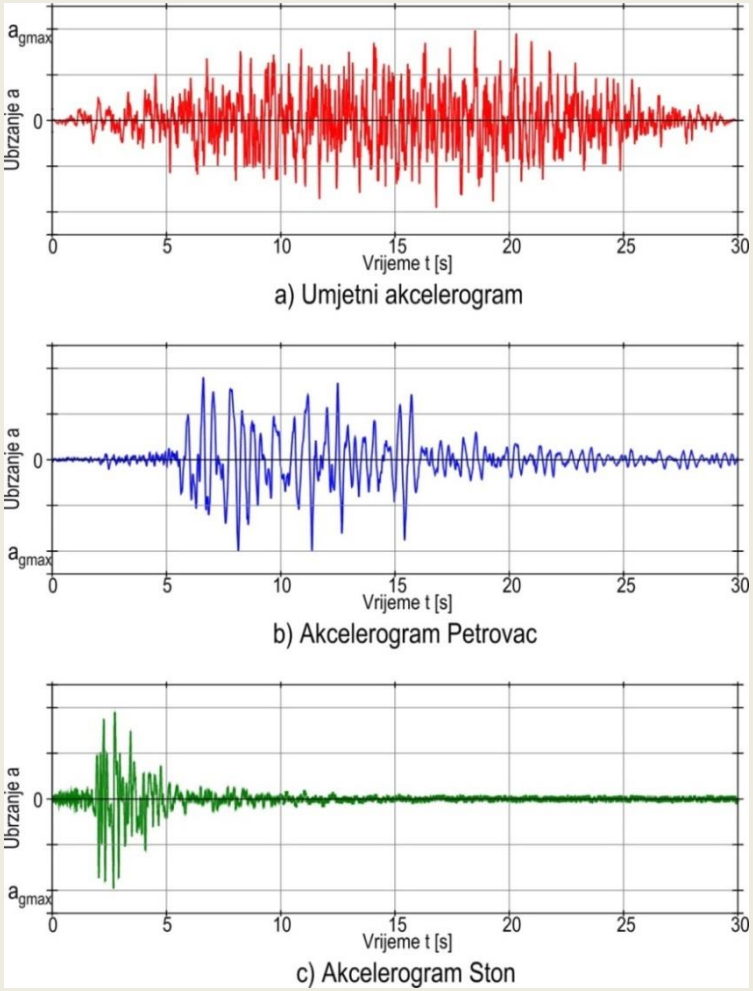
Stupovi opterećeni samo vlastitom težinom



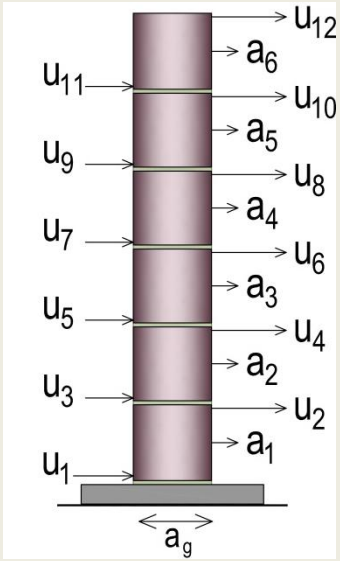
Stupovi opterećeni vlastitom težinom i dodatnom masom na vrhu

Tip sljubnice

9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

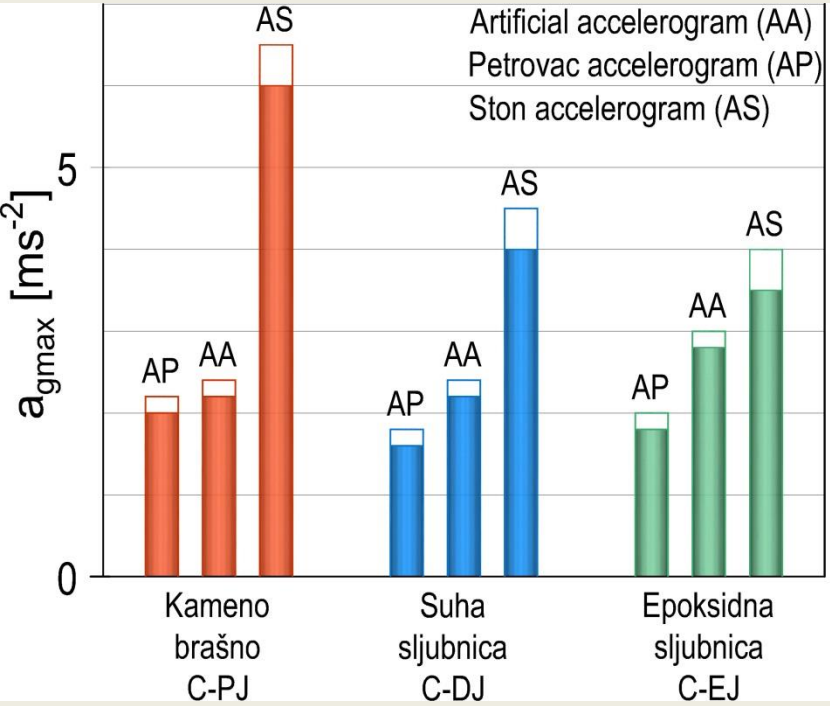


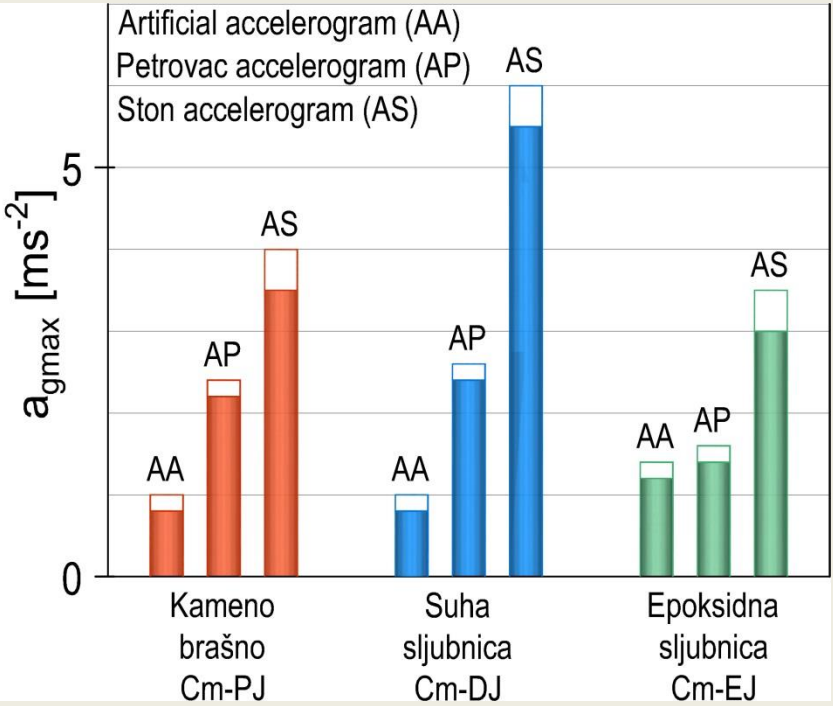
Aplicirani akcelerogrami



Mjerene veličine

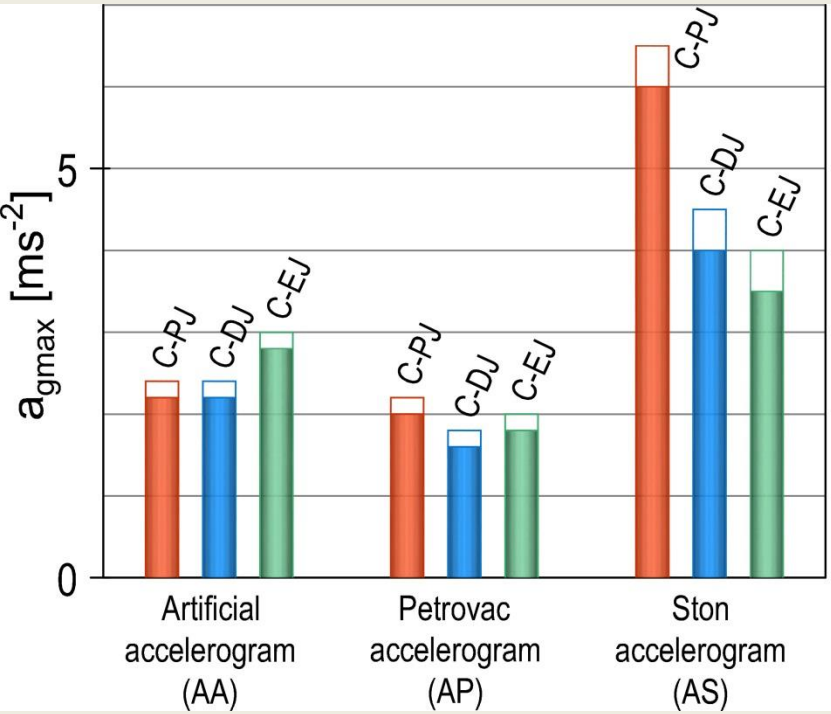
9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

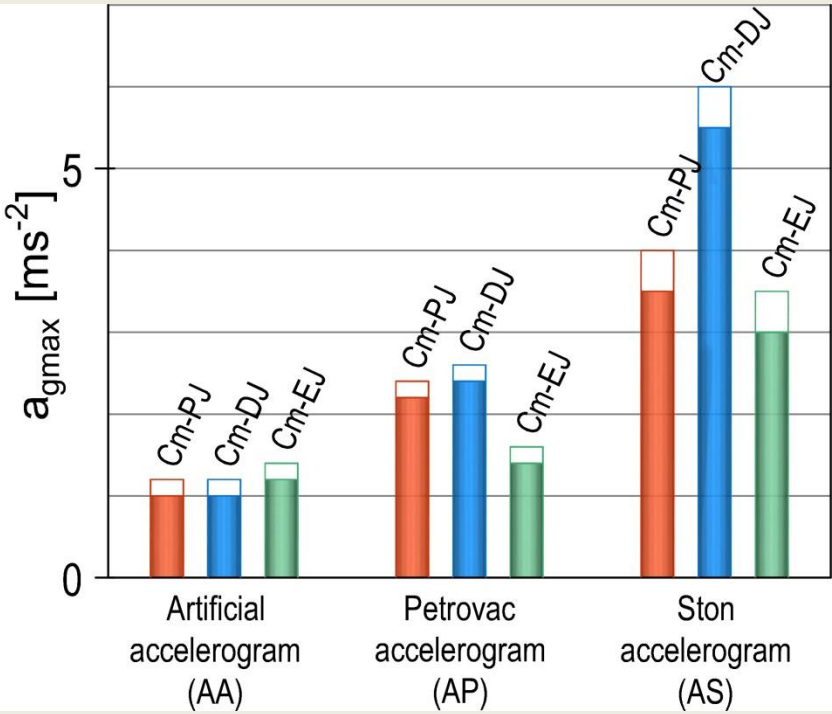




Maksimalno ubrzanje podloge a_{gmax} za granično stanje stupova

9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

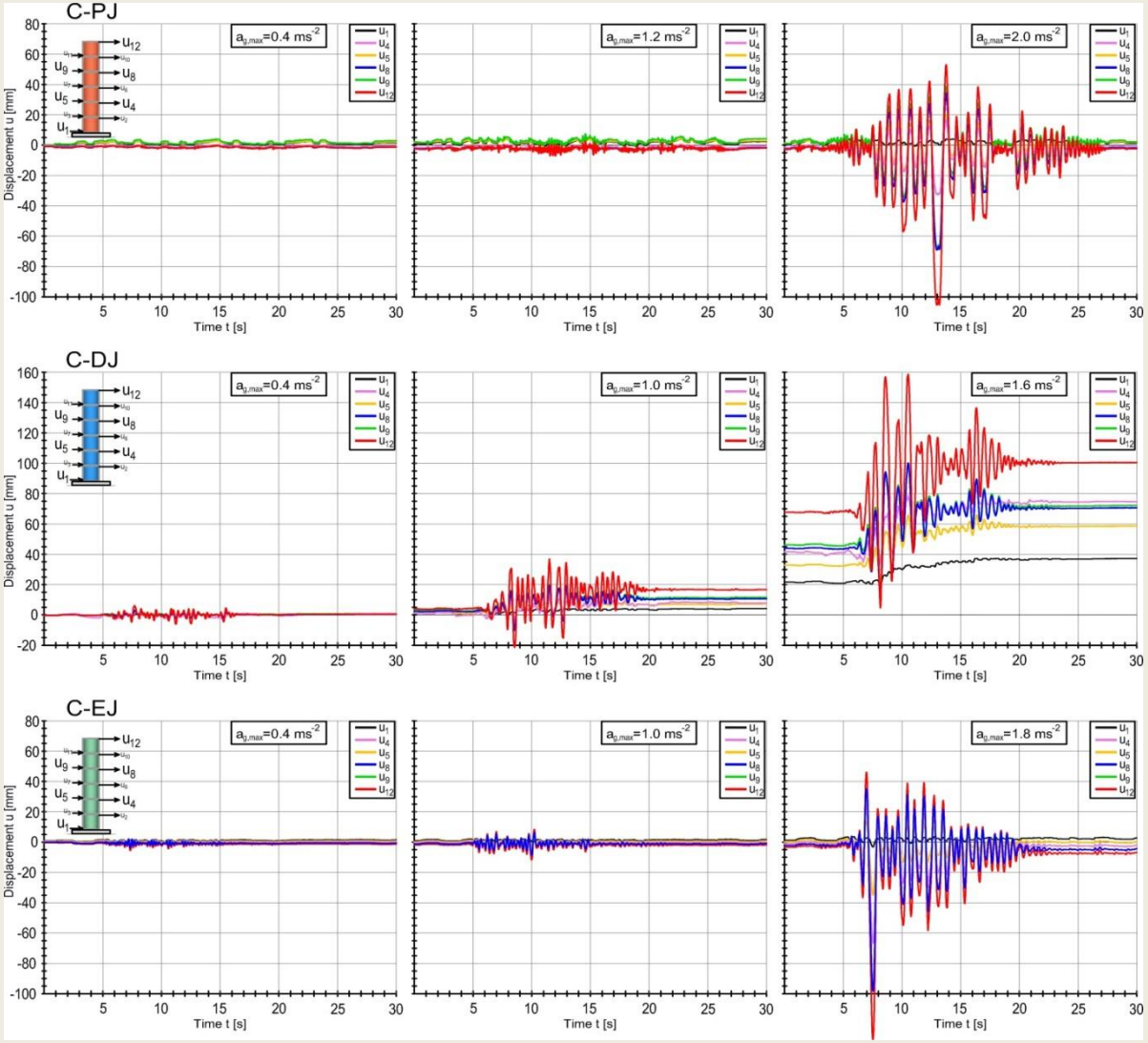




Maksimalno ubrzanje podloge a_{gmax} za granično stanje stupova

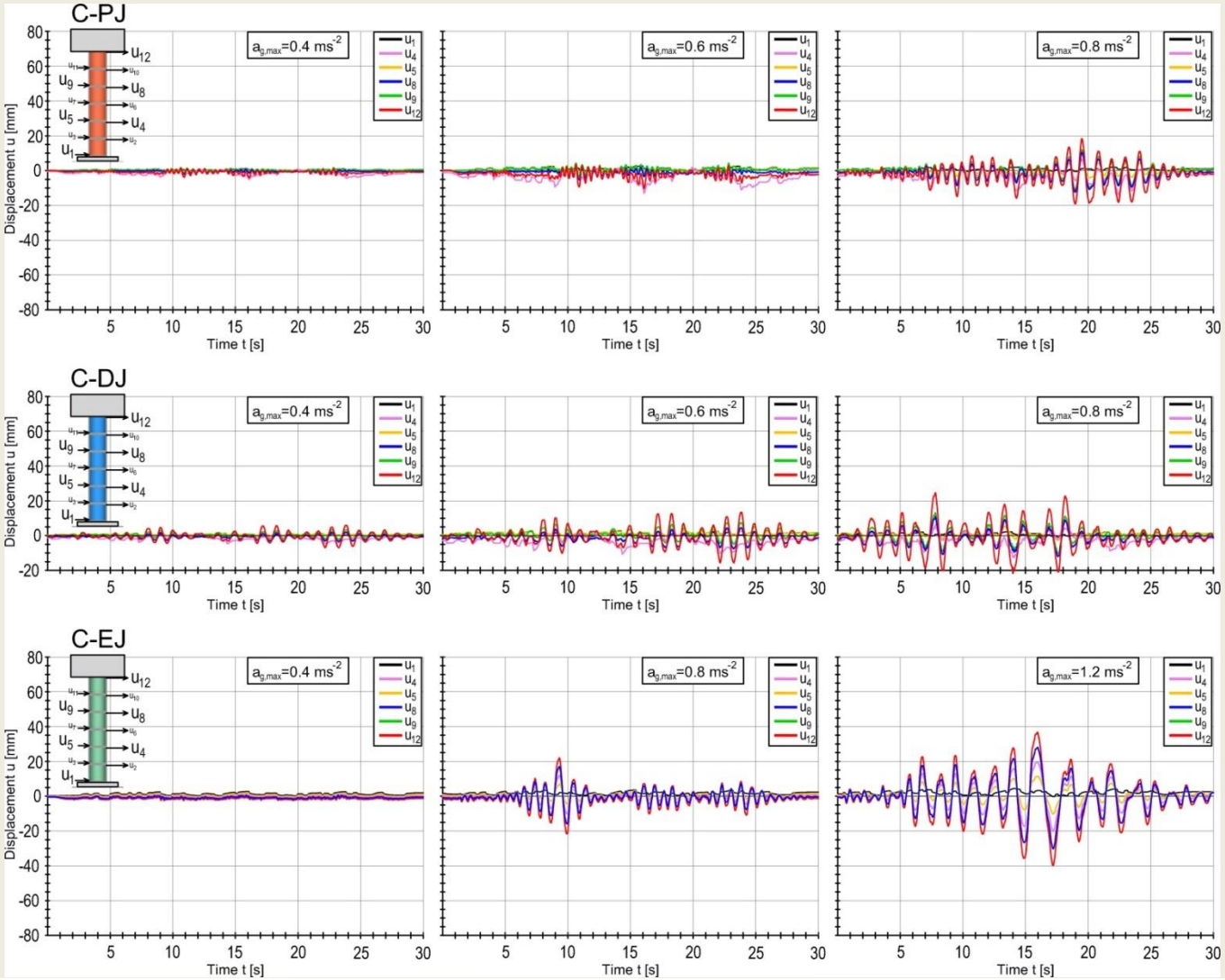
9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

Horizontalni pomaci stupova C-PJ, C-DJ i C-EJ za akcelerogram Petrovac



9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

Horizontalni pomaci stupova Cm-PJ, Cm-DJ i Cm-EJ za Umjetni akcelerogram



9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

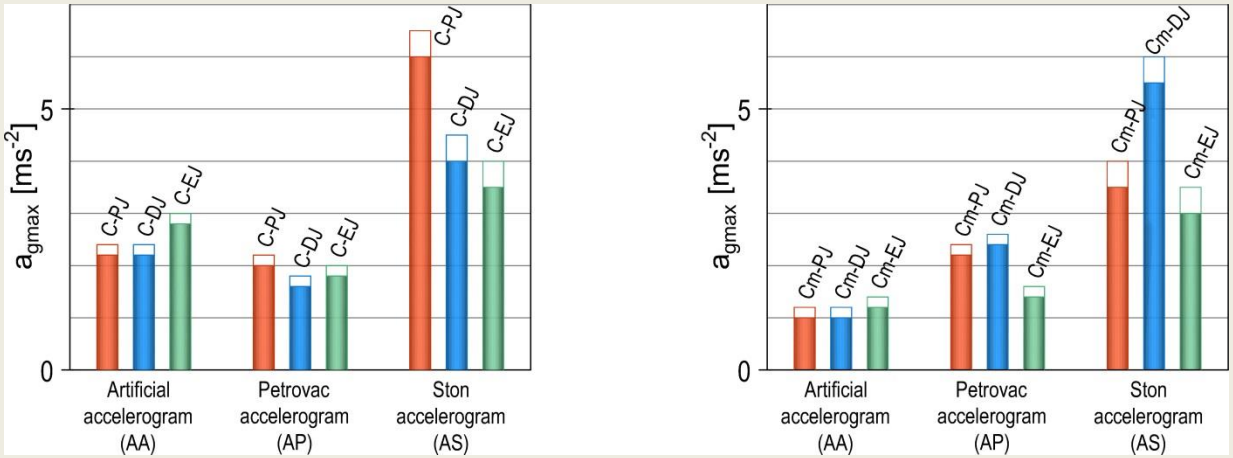
Pomaci stupa C-DJ (suha sljubnica) za akcelerogram Petrovac pri a_{gmax} = 1.6 ms^{-2}

C-DJ – Ston

9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

Glavni zaključci

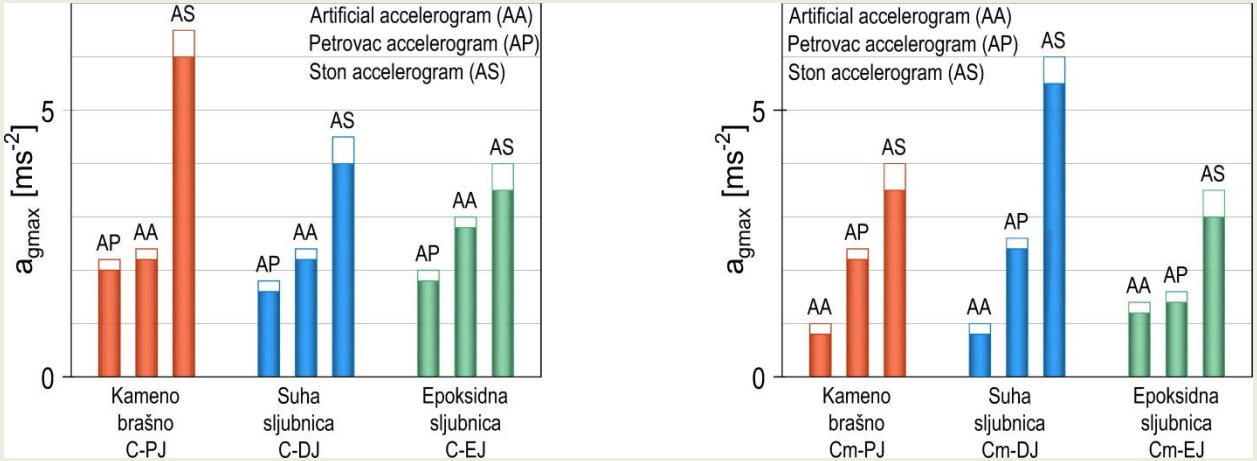
Nosivost višedijelnog stupa, osim o tipu potresa, značajno ovisi o tipu sljubnice.



9. Istraživanje utjecaja tipa sljubnica u višedijelnom kamenom stupu na njegovo ponašanje i nosivost pri potresu

Glavni zaključci

- Meke sljubnice (suha, s kamenim brašnom, itd.) su najnepovoljnije za potrese koji uzrokuju velike pomake te unose veliku energiju u konstrukciju.
- Krute sljubnice (epoksidna sljubnica, itd.) te stup iz jednog monolitnog bloka su najnepovoljniji za potrese kratkog trajanja koji unose manju energiju u konstrukciju.



10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu

Composites Part B 162 (2019) 250–258

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Effects of several bolt parameters on the bearing capacity of a composite multi-drum stone column under an earthquake

A. Buzov*, J. Radnić, N. Grgić

University of Split, Faculty of Civil Engineering, Architecture and Geodesy, 21000, Split, Croatia

ARTICLE INFO

Keywords:
Bolt parameters
Composite multi-drum stone column
Bearing capacity
Shake table

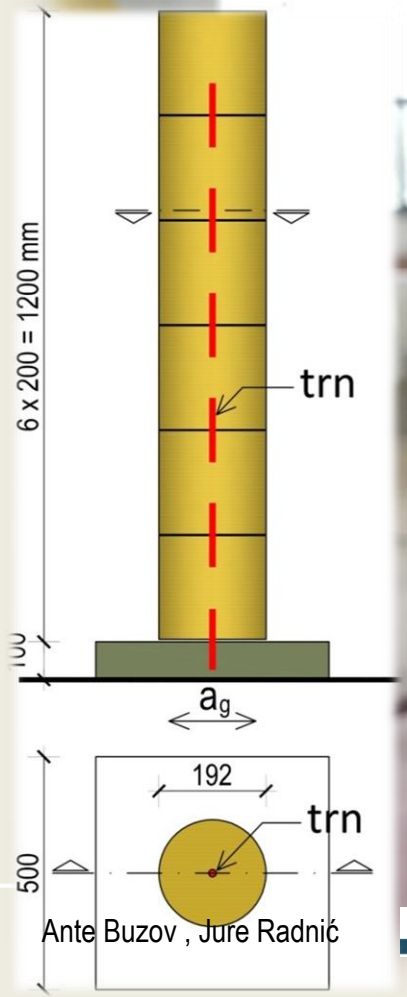
ABSTRACT

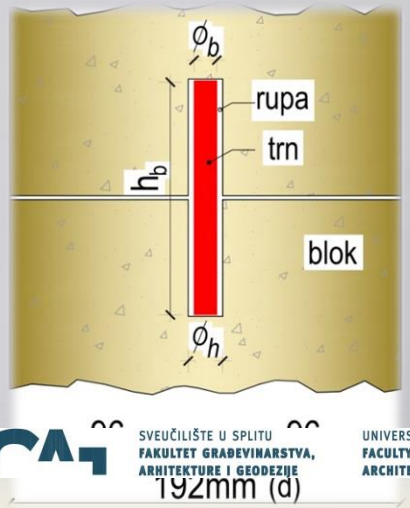
The paper presents some results of a shake-table study on the effects of several bolt parameters on the bearing capacity of a composite free-standing multi-drum stone column under an earthquake. In each test, a small-scale column with six blocks per height was exposed to different horizontal base accelerations until the column collapsed. Firstly, the effect of five different materials for the bolts were investigated on the column bearing capacity. Then, the effects of bolt length, bolt diameter and the ratio of the hole diameter to the bolt diameter on the column bearing capacity were investigated. Based on the test results, the main conclusions of the study are presented.

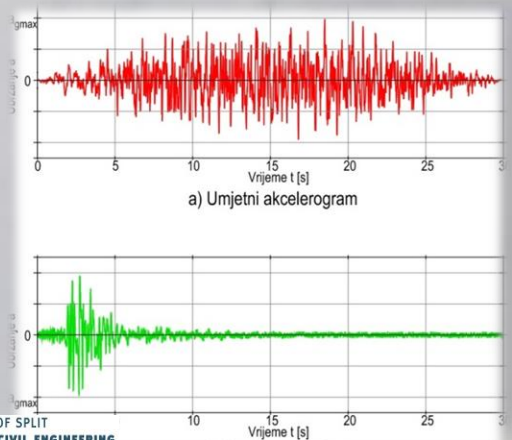
1. Introduction

The use of bolts for connecting stone blocks in numerous historic stone buildings least to a far past. The widest application of the bolts has been in the construction of multi-part stone columns and arches. possible advantages or disadvantages of retrofitting columns with metallic shear links that replace the wooden poles that were installed in ancient times. Vintzileou and Toumbakari [3] experimentally studied the dowel action of titanium bars connecting marble fragments at different angles. Psycharis et al. [4] numerically investigated a column-

10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu







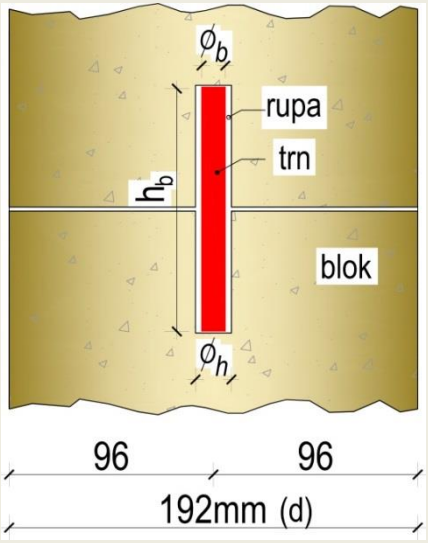
10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu

Utjecaj materijala trna: - drvo
- olovo
- guma
- aluminij
- inox

Utjecaj dužine trna (olovo/inox)

ϕ_b= 12 mm, ϕ_h= 14 mm

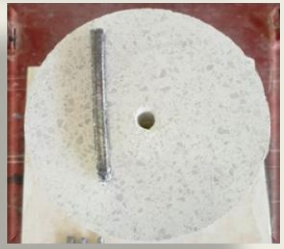
h_b=72 mm, h_b=120 mm, h_b=168 mm



Utjecaj promjera trna (olovo/inox)

ϕ_h= 14 mm , h_b=120 mm

ϕ_b= 12 mm, ϕ_b= 20 mm



Utjecaj promjera rupe za trn (olovo/inox)

ϕ_b= 12 mm, h_b=120 mm

ϕ_h= 14 mm, ϕ_h= 22 mm

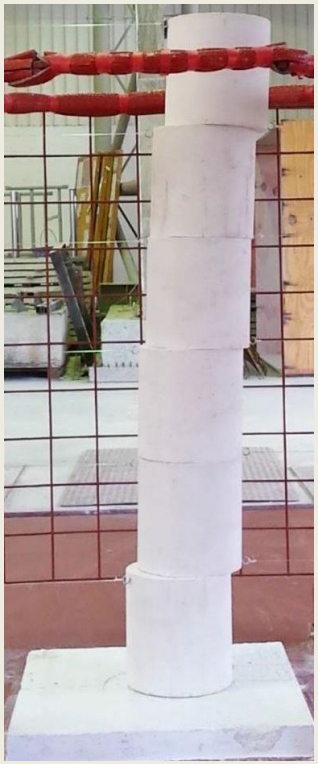
Stup bez trna – Ston

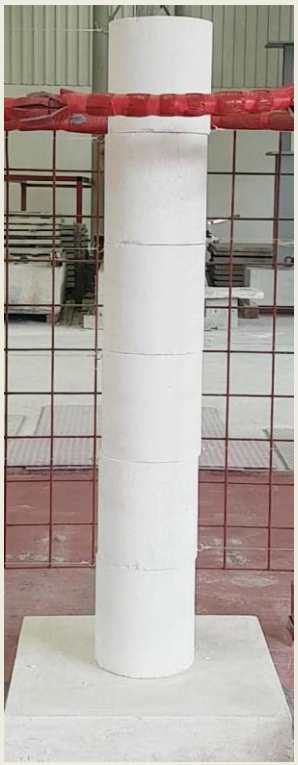
Stup s trnom – Ston

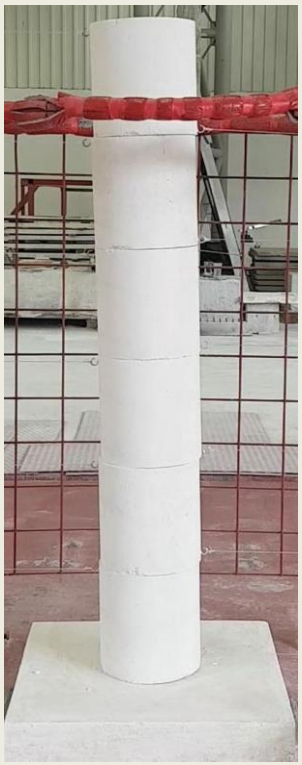
10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu


t = 13,4 s


t = 17,3 s


t = 17,7 s


t = 18,2 s

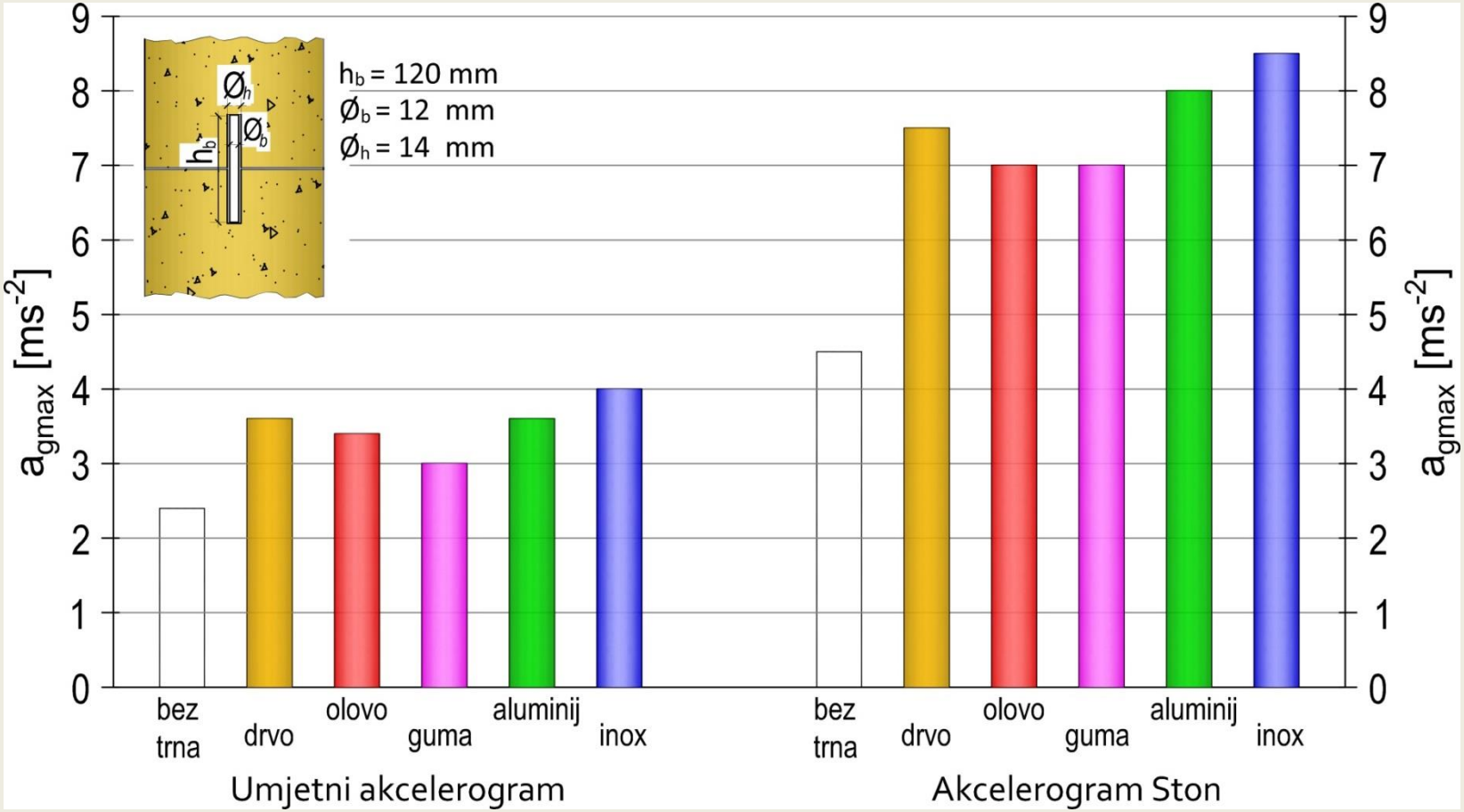

t = 19,8 s


t = 21,2 s

Pomaci stupa bez trna i s trnom iz inox-a za umjetni akcelerogram pri a_{max} = 2,2 ms^{-2}

10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu

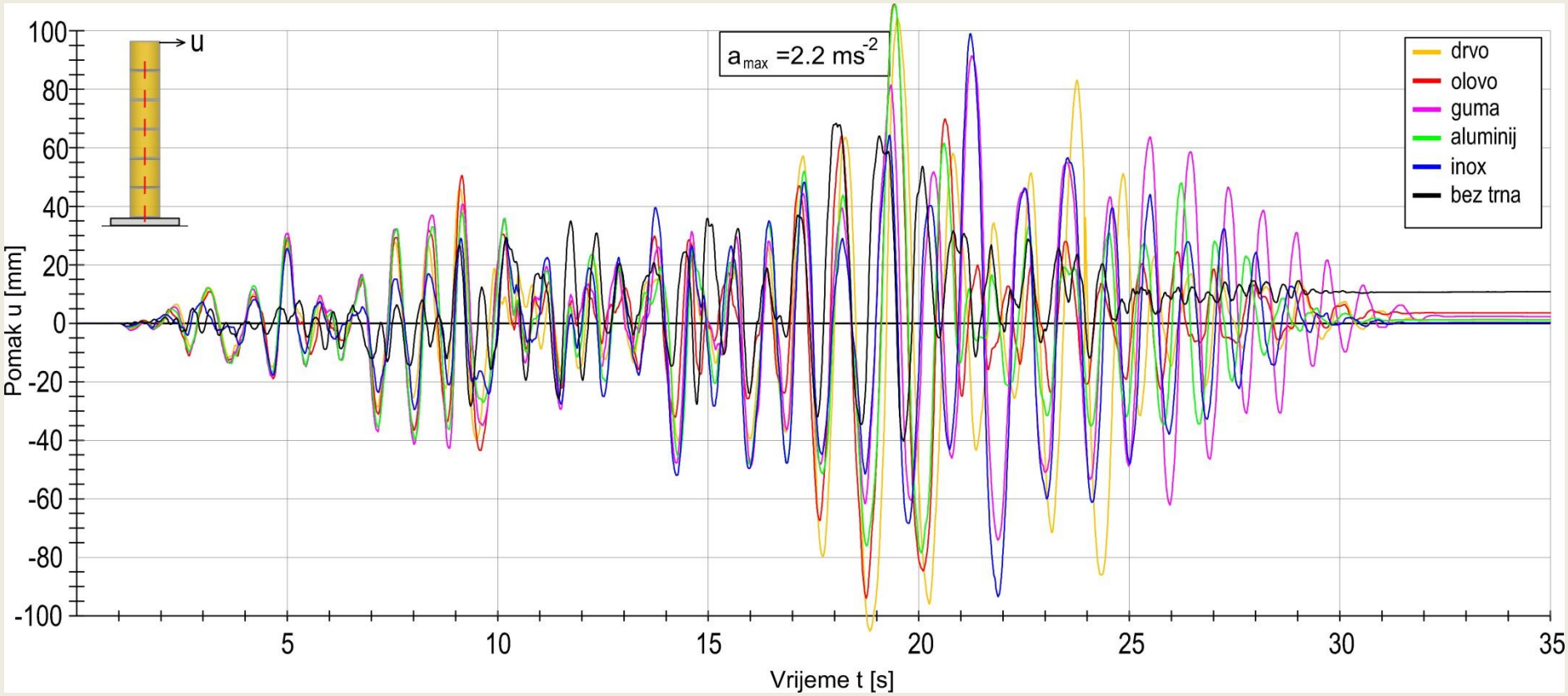
Utjecaj materijala trna



10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu

Utjecaj materijala trna

h_b=120 mm
ϕ_b= 12 mm
ϕ_h= 14 mm

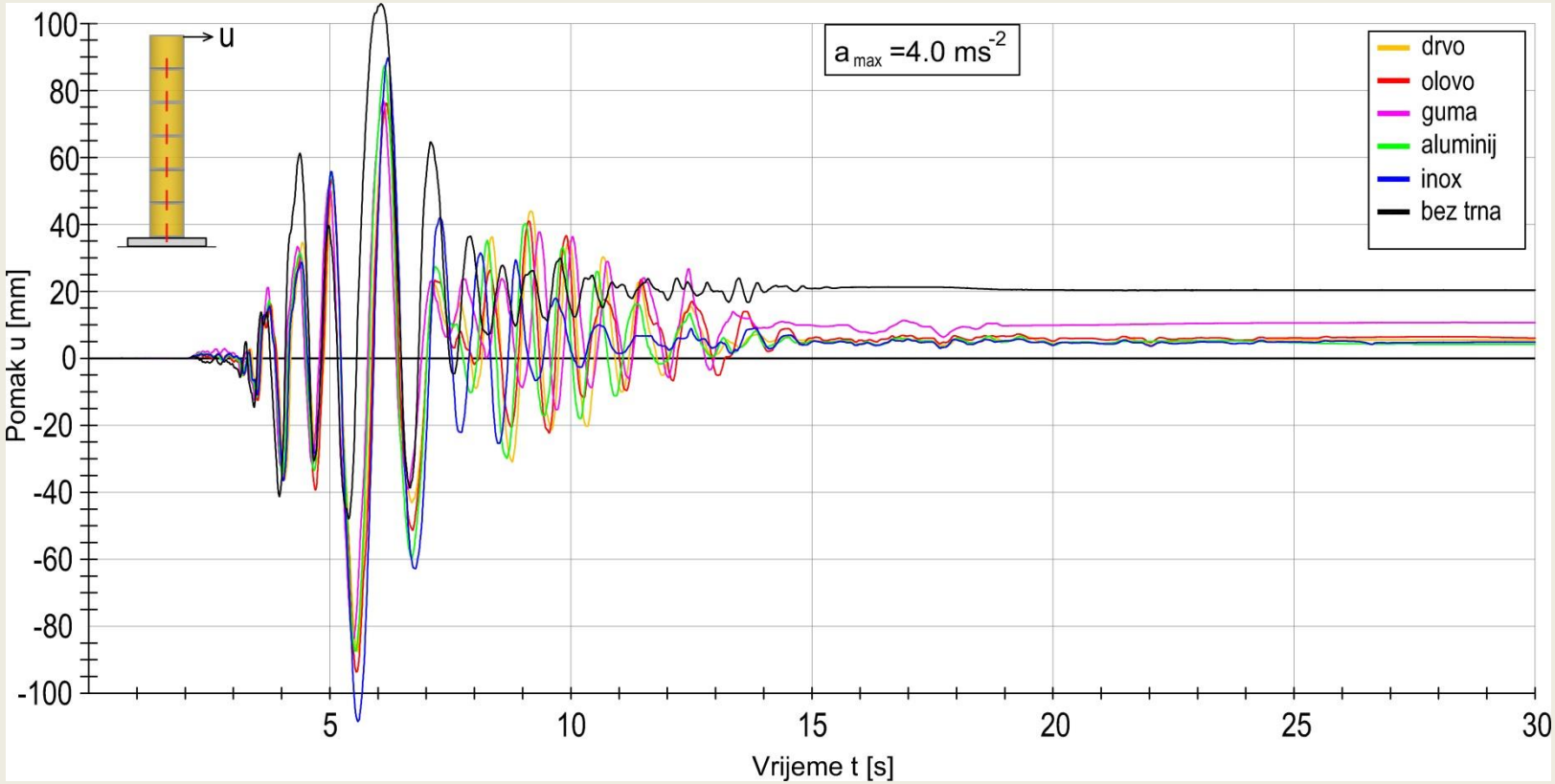


Horizontalni pomak vrha stupa za umjetni akcelerogram pri a_{gmax} = 2,2 ms^{-2}

10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu

h_b=120 mm
ϕ_b= 12 mm
ϕ_h= 14 mm

Utjecaj materijala trna



Horizontalni pomak vrha stupa za akcelerogram Ston pri a_{gmax} = 4,0 ms^{-2}

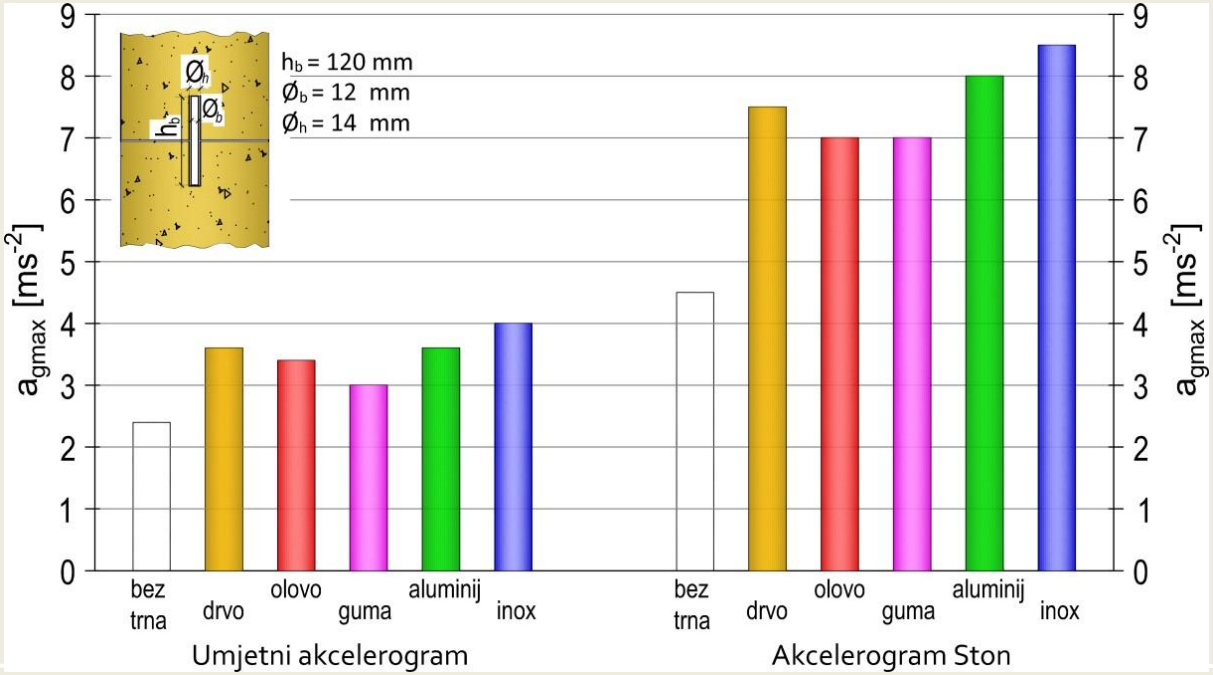
10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu

Utjecaj materijala trna

Glavni zaključci

- Utjecaj materijala za trn nije bio značajan. Posmična nosivost trna nije prekoračena – slom stupa nastupio je u svim slučajevima prevrtanjem/rotacijom stupa, tj. izvlačenjem trna.

- U slučaju većih posmičnih potresnih sila, utjecaj gradiva za trn može biti značajan.

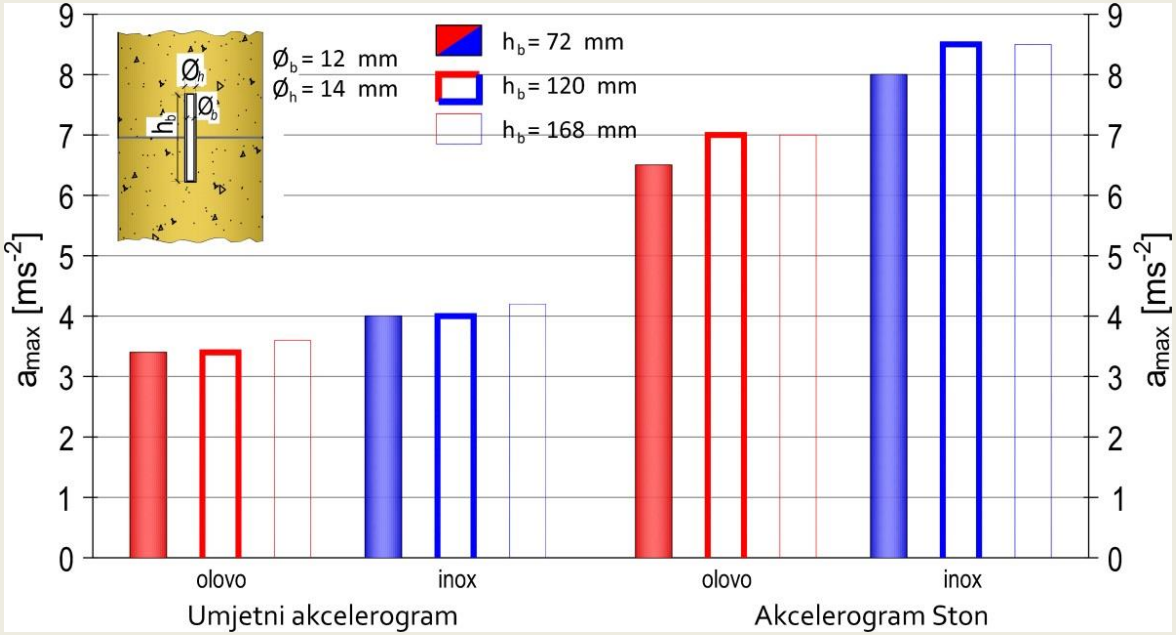


10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu

Utjecaj dužine trna

Glavni zaključci

- Utjecaj dužine trna je vrlo mali.
- Ukoliko bi se osigurala prionjivost trna i bloka, odnosno nošenje trna na vlak, utjecaj dužine trna može biti značajan.

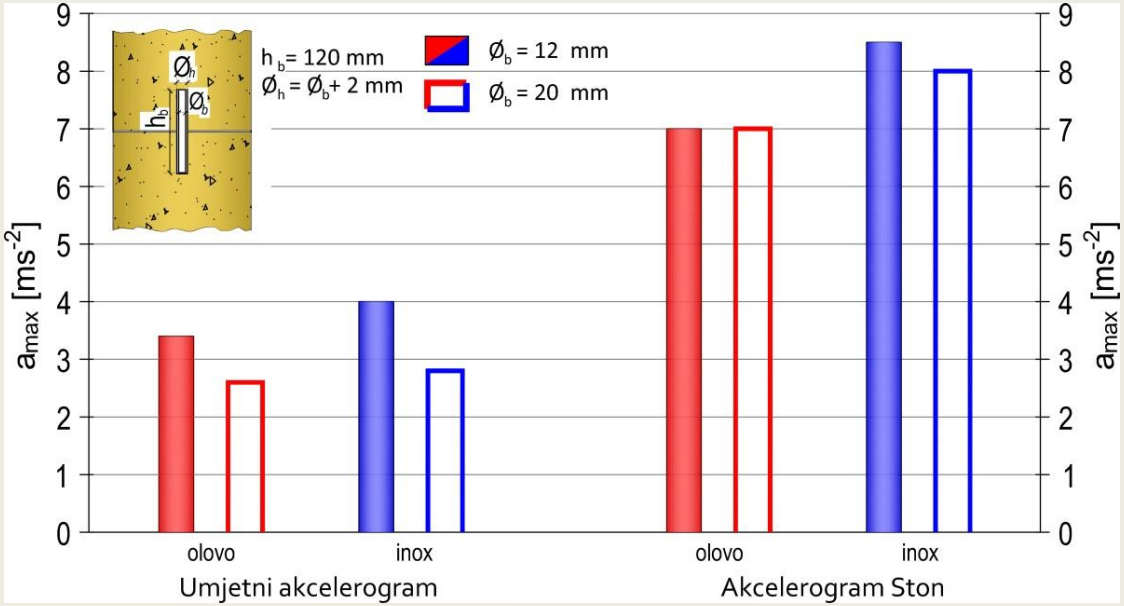


10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu

Utjecaj promjera trna

Glavni zaključci

- Za potrese dugog trajanja s dužim predominantnim periodom trn većeg promjera rezultira većom krutosti stupa i generiranjem većih potresnih sila u stupu.
- Za potrese kratkog trajanja s malim predominantnim periodom, utjecaj promjera trna je zanemariv.

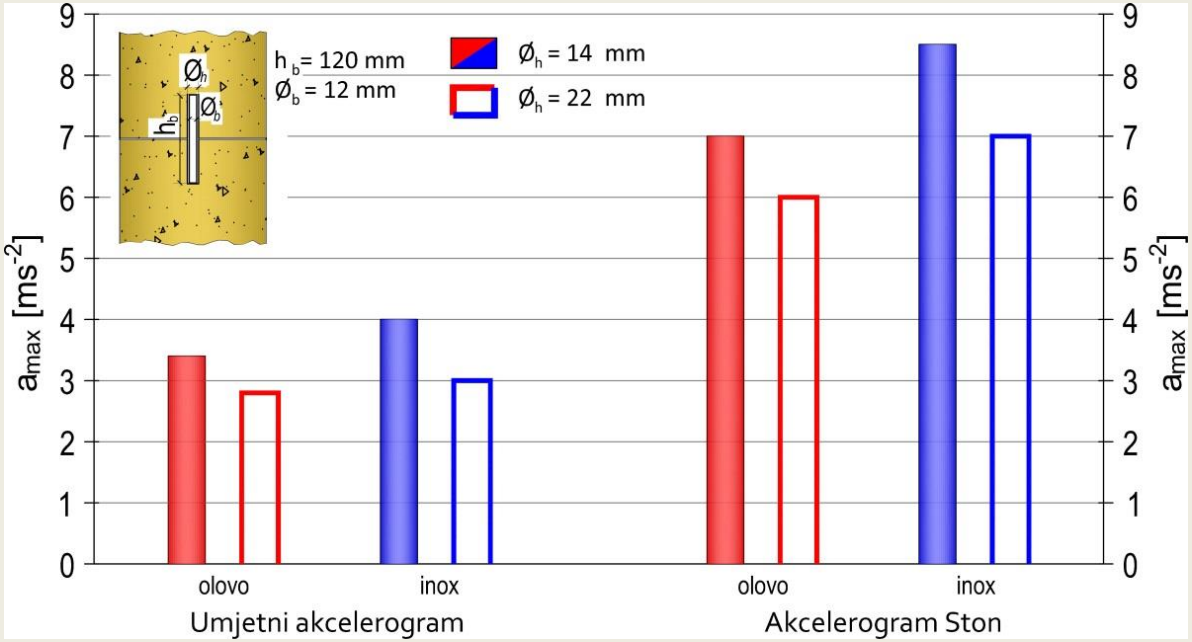


10. Utjecaj nekih parametara trnova na nosivost višedijelnih kamenih stupova pri potresu

Utjecaj promjera rupe za trn

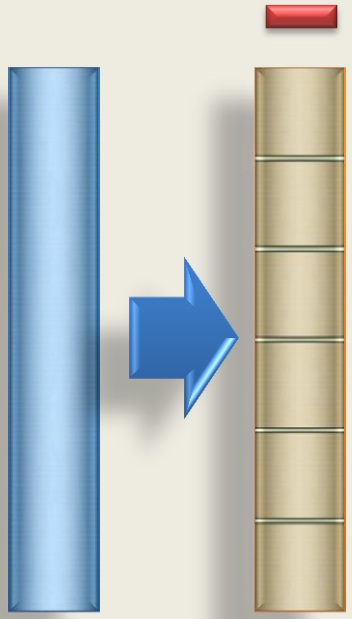
Glavni zaključci

- Utjecaj promjera rupe za trn u odnosu na promjer trna je značajan.
- Veći promjer rupe omogućava veće relativne pomake između susjednih blokova, što rezultira većim potresnim silama i ekscentricitetima vertikalnih sila u višedijelnom stupu.



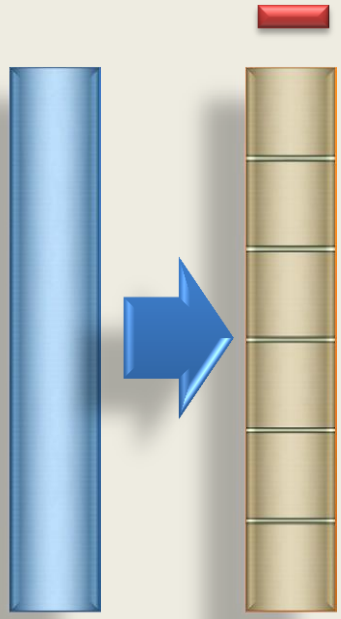
11. Zaključci

Utjecaj broja blokova

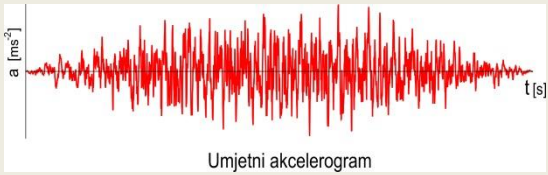


Smanjenje krutosti i otpornosti, povećanje deformacija.

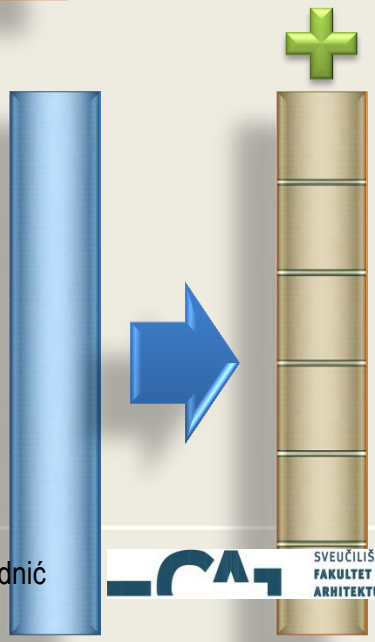
Smanjenje nosivosti stupa pri centričnoj i ekscentričnoj statičkoj sili.



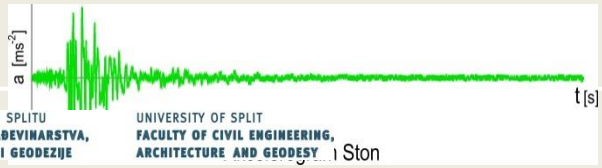
Smanjenje nosivosti za potrese koji pobuđuju veće pomake i unose veću energiju



Umjetni akcelerogram



Povećanje nosivosti za udarne potrese (potresi kratkog trajanja i kratkog predominantnog perioda)



11. Zaključci

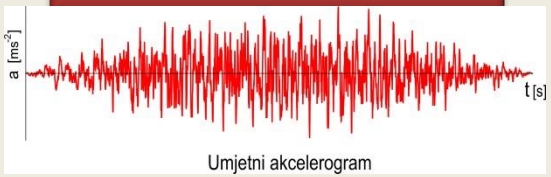
Utjecaj tipa sljubnice

”Meke” sljubnice (suha sljubnica, kameno brašno, slabi mort, i sl.)

Smanjenje krutosti i otpornosti višedijelnog kamenog stupa, povećanje deformacija

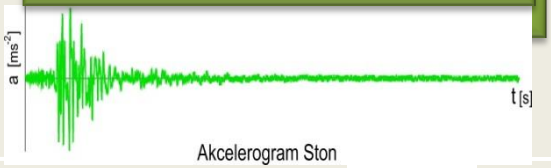
Smanjenje nosivosti stupa pri centričnoj i ekscentričnoj statičkoj sili

Smanjenje nosivosti stupa za potrese koji u njega unose veću energiju



Umjetni akcelerogram

Povećanje nosivosti za udarne potrese (potresi kratkog trajanja i kratkog predominantnog perioda)



Akcelerogram Ston

11. Zaključci

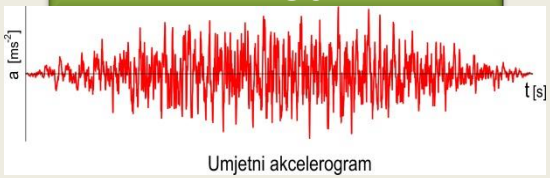
Utjecaj tipa sljubnice

”Krute” sljubnice (jaki mort, epoksid i sl.)

Povećanje krutosti i otpornosti višedijelnog kamenog stupa, smanjenje deformacija

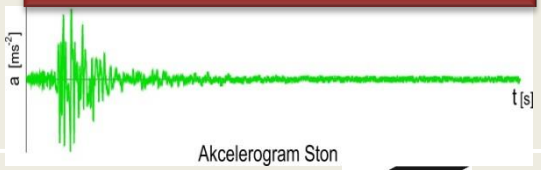
\+ Povećanje nosivosti stupa pri centričnoj i ekscentričnoj statičkoj sili

\+ Povećanje nosivosti stupa za potrese koji u njega unose veću energiju



Umjetni akcelerogram

\- Smanjenje nosivosti za udarne potrese (potresi kratkog trajanja i kratkog predominantnog perioda)

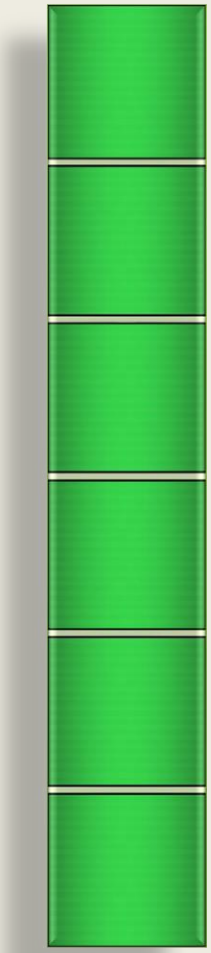


Akcelerogram Ston

11. Zaključci

Utjecaj nekih parametara trnova

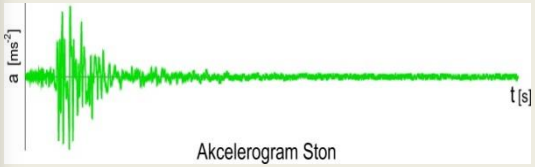
Značajno veći horizontalni pomaci između susjednih blokova stupa



VS

Značajno veća nosivost

Preuzimanje horizontalnih poprečnih sila; Posebno za udarne potrese



11. Zaključci

Utjecaj materijala trna

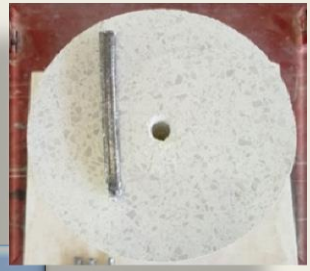
Ima veliki utjecaj kada su stupovi opterećeni potresima koji u njima generiraju velike poprečne sile, u odnosu na momente savijanja.

Utjecaj dužine trna

Nema praktičnog značaja kada trn nema prionjivost s blokom, tj. kada ne može nositi vlak. U suprotnom utjecaj bi bio značajan.

Utjecaj promjera trna

Može biti značajan u slučaju potresa koji generiraju velike poprečne sile.

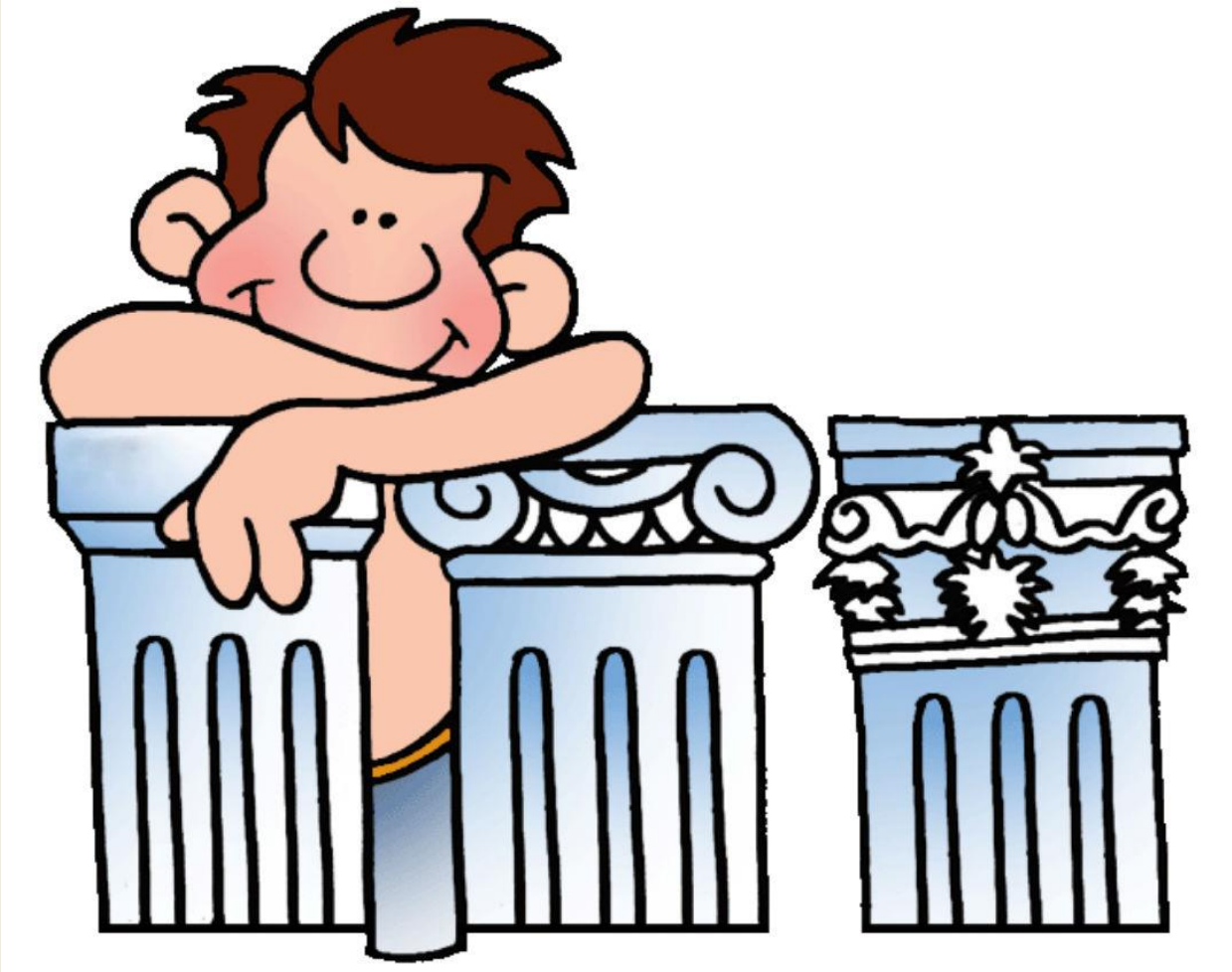


Utjecaj promjera rupe za trn

S povećanjem promjera rupe za trn u odnosu na promjer trna, povećava se horizontalna deformabilnost stupa a time i potresne sile u njemu, što je nepovoljno.

12. Kontinuitet daljnjih istraživanja

- Utjecaj dobivenih rezultata na umanjenim modelima pri njihovoj primjeni na višedijelne stupove u stvarnoj veličini
- Utjecaj različitih rubnih uvjeta i geometrije stupova, te utjecaj različitih gradiva za blokove
- Utjecaj vertikalne komponente ubrzanja potresa
- Utjecaj dodatnih tipova potresa
- Utjecaj preciznosti izrade spojnih ploha blokova
- Utjecaj drugih tipova sljubnica
- Utjecaj interakcije s drugim konstrukcijskim elementima i sl.



Hvala na pažnji !

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