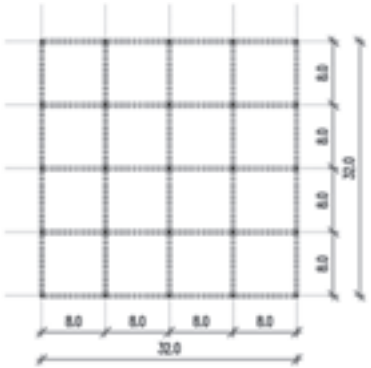
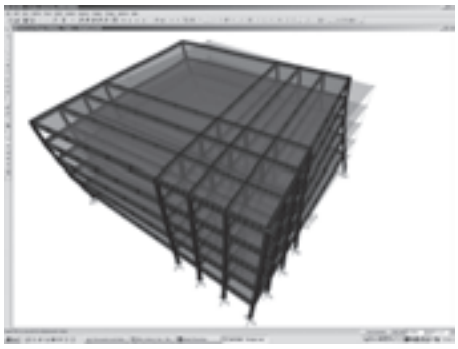
Konstrukcijski sistem iz stebrov in gred (okvirna konstrukcija)

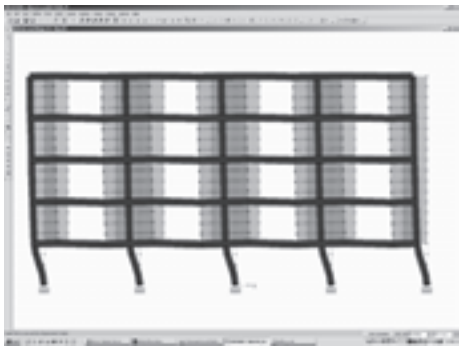


Tloris regularne konstrukcije.
Layout of a regular structure.

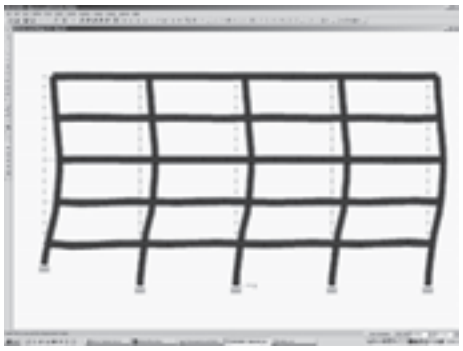
Regularna konstrukcija tipični okvir. Nihajni čas je 1,8 s.
Regular structure typical frame. Oscillation time is 1,8 s.



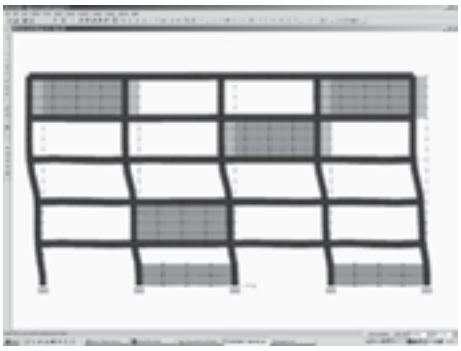
Prostorska okvirna konstrukcija z neregularno tlorisno razporeditvijo (torzija). Nihajni čas je 2,1s.
Spatial frame structure with irregular layout distribution (torsion). Oscillation time is 2,1 s.



Okvirna konstrukcija z mehko pritlično etažo. Nihajni čas je 0,58 s.
Frame structure with soft ground floor. Oscillation time is 0,58 s.

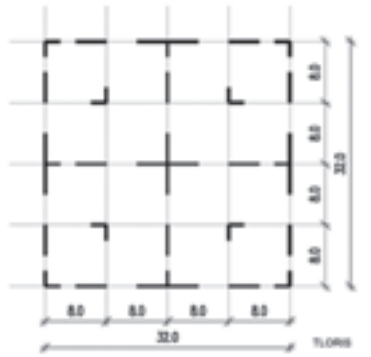


Okvirna konstrukcija s kratkim stebrom. Nihajni čas je 1,6 s.
Frame structure with short column. Oscillation time is 1,6 s.

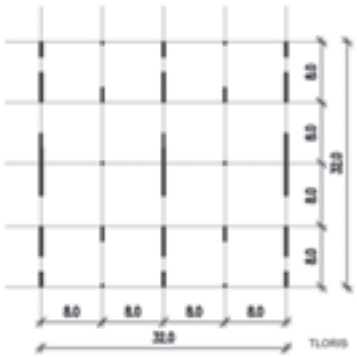


Ravninska okvirna konstrukcija z neregularno razporeditvijo parapetov. Nihajni čas je 0,94 s.
Planar frame structure with irregular distribution of parapets. Oscillation time is 0,94 s.

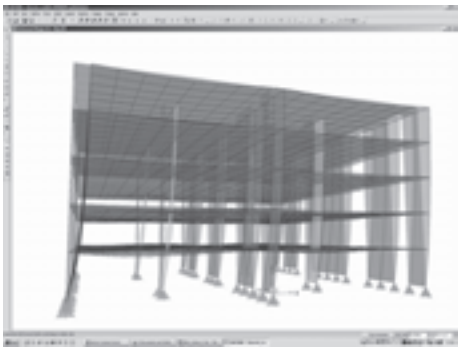
Konstrukcijski sistem iz sten (stenasta konstrukcija)



Stenasta konstrukcija, 1,5 % površine sten v vsaki smeri. Nihajni čas je 0,42 s.
Wall structure, 1,5 % of wall in all directions. Oscillation time is 0,42 s.



Stenasta konstrukcija.
(šibka vzdolžna smer smer X).
Wall structure.
(weak longitudinal direction direction X).



Nihanje stenaste konstrukcije s šibko vzdolžno smerjo pri potresu v vzdolžni smeri. Nihajni čas je 2,9 s.
Oscillation of wall structure with weak longitudinal direction in an earthquake with longitudinal direction. Oscillation time is 2,9 s.

Vojko Kilar, Tomaž Slak

PRIMERJAVA OBNAŠANJA REGULARNIH IN NEREGULARNIH KONSTRUKCIJ PRI POTRESNI OBREMENITVI

COMPARISON OF THE BEHAVIOUR OF REGULAR AND IRREGULAR STRUCTURES UNDER EARTHQUAKE LOADS

raziskava, *research*

povzetek

Vrsta predpisov, zahtev, smernic in priporočil v predpisih o gradnji stavb na potresnih območjih poudarja pomembnost tako v tlorisu kot v po višini čim bolj pravilnih (to ne pomeni nujno simetričnih) konstrukcij stavb. Kot negativne se obravnavajo vsake večje prekinitve vertikalnih nosilnih elementov kot tudi vsake večje spremembe togosti v posameznih etažah. Ob pregledu sodobnih konstrukcij stavb pa lahko ugotovimo, da se kreativnost sodobnega arhitekturnega izraza običajno izogiba uporabi preprostih regularnih oblik in se rada zateka k oblikam, ki so s konstrukcijskega stališča neregularne. Uporaba neregularnih konstrukcij v predpisih sicer ni izrecno prepovedana, pomembno pa se je zavedati, da so takšne konstrukcije načeloma dražje, manj varne in posledično nekonkurenčne.

doseženi cilji, namen in rezultati

V predstavljeni raziskavi smo izbrali dva pri nas najobičajnejša konstrukcijska sistema: a) AB okvir in b) AB stenasto konstrukcijo ter pet najtipičnejših oblik neregularnosti: 1) nepravilnosti pri razporeditvi nosilnih elementov v tlorisu, 2) mehke etaže, 3) kratki stebri, 4) neenakomerna razporeditev polnil in 5) različna nosilnost v dveh pravokotnih smereh. V predstavljeni fazi raziskave smo se omejili na elastičen dinamičen račun časovnega poteka odziva. Uporabljena akcelerograma sta si po maksimumih podobna, po frekvenčni sestavi pa zelo različna. Prikazan je maksimalni horizontalni pomik na vrhu konstrukcij, maksimalni relativni pomik ter maksimalni moment in prečna sila v stebru. Pri primerjavah je pomembna predvsem primerjava pomikov med različnimi nepravilnostmi pri isti obtežbi in pri istem konstrukcijskem sistemu, saj so dobljene razlike posledica neregularne zasnove, ki je predmet raziskave. Računalniške simulacije so pokazale, da nepravilnosti in skoki v togosti povzročajo povečanje napetosti in neugodnih strižnih ali torzijskih obremenitev. Še posebej je to nevarno kadar takšne napetosti nastanejo v stebrih nižjih nadstropij ali kadar se vzpostavi lokalni porušni mehanizem. Četudi elementom, v katerih je prišlo do prekoračitev napetosti, lahko povečamo dimenzije in jih močneje armiramo, so to še vedno mesta v konstrukciji, kjer bo v primeru močnega potresnega sunka lahko prišlo do hujših poškodb.

problematika v arhitekturi, umestitev obravnavane teme v te tokove in njen pomen

Neregularnim konstrukcijam se je potrebno izogibati že v fazi zasnove konstrukcije, saj so takšne stavbe dražje in potresno manj varne. V prid arhitektom-projektantom lahko rečemo le, da v nekaterih primerih vplivi močno neregularnih zasnov niso bili pričakovano veliki. Močno so lahko različni pri različnih potresih z istim pospeškom tal in različno prevladujočo frekvenco. Naloga potrjuje tezo, da je regularna zasnova konstrukcij in t. i. "potresno odporna" gradnja po novih evropskih predpisih EC 8 ob ustreznem sodelovanju arhitekta in gradbenika pri zasnovi objektov dobra zaščita pred posledicami močnih potresov.

ključne besede

Zasnova konstrukcij, pravilnost, regularnost, potresno varna gradnja, arhitektura konstrukcij, Eurocode 8.

summary

Various regulations, demands, guidelines and recommendations stipulated in building legislature for construction in earthquake prone areas state the importance of regular building structures, both in layout and heights (which doesn't mean they are necessarily symmetrical). All larger discontinuity of vertical load-bearing elements, just as any significant changes in rigidity of particular floors, is seen as negative. Upon a review of contemporary building structures we can nevertheless establish that creativity in contemporary architectural expression usually refrains from using simple regular forms and likes to take recluse in forms, which are, from the structural attitude, irregular. Use of irregular structures is not strictly prohibited in regulations, but we have to be aware that such structures are in principal more expensive, less safe and consequentially less competitive.

intentions, goals and results

In the presented research we chose two of the most often structural systems used domestically: a) reinforced concrete frame and b) reinforced concrete wall structure and five of the most typical forms of irregularity: 1) irregularity in placement of load-bearing elements in the layout, 2) soft floors, 3) short columns, 4) unequal distribution of fillers and 5) different load-bearing capacities in two perpendicular directions. In the presented phase of the research we limited ourselves to elasticity calculation of time progression of response. The used acceleration graphs are similar in maximum values, while their frequency structures are very different. The maximal horizontal shift at the top of structures, maximal relative shift, and maximal momentum and maximal traverse force in columns, are shown. In comparisons, above all comparison of shifts between different irregularities under the same load and the same structural systems is important, since the obtained differences are consequences of irregular concepts, which is the research issue at hand. Computer simulations showed that irregularities, discontinuance and inconsistent rigidity cause increase in tension and unbeneficial shearing or torsion loads in particular elements of the structure. This is especially dangerous when these tensions emerge in columns of lower floors or when local collapse mechanisms are established. Even if we increase the dimensions and add more reinforcement to elements, in which tensions are excessive, these are still the places in a structure, where a stronger earthquake surge could cause serious damage.

architectural issues, positioning the topic in ongoing debate and its' significance

Irregular structures have to be avoided in early phases of the structural design, since such buildings are more expensive and less earthquake safe. For the benefit of architects-designers we can say that in some cases the effects of irregular concepts weren't as bad as expected. They can be very different under different earthquakes with the same ground acceleration and different prevailing frequency. The research proves the hypothesis that regular structural concepts and so called "earthquake resistant" building, according to the new European regulation EC8, can provide good protection before consequences of strong earthquakes, if the architect and engineer cooperate adequately.

key words

structural concept, correctness, regularity, earthquake-safe construction, construction architecture, Eurocode 8.