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Author:	**Blaž Zoubek**
Supervisor:	**prof. Tatjana Isaković, Ph.D.**
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Abstract

The dissertation describes the results of an extensive experimental and analytical investigation into the effect of connections on the seismic response of precast concrete buildings, which was performed within the framework of the two European projects: SAFECAST and SAFECLADDING. The investigation was concerned with two important groups of connections, i.e. those between columns and beams, and those between the cladding panels and the main structure. Cyclic tests were first performed on specimens from both groups of connections, after which the failure mechanisms, based on the obtained experimental results, and making use of detailed 3D numerical analyses, were explained. A number of robust engineering models were developed, which take into account some of the key characteristics of the cyclic response of connections of the investigated types. In the case of dowel connections, the effect, on the load-carrying capacity of the connection, of stirrups, as well as of the large relative rotations between columns and beams, was investigated. This represents one of the main contributions of the dissertation. In order to evaluate the effect of connections on the seismic response of whole buildings, an extensive parametric study was then performed, which examined the fragility and seismic risk of typical single-storey and three-storey precast buildings located in Ljubljana. It was found that if the load-carrying capacity of the dowel connections was inaccurately assessed, then the safety of such structures could be seriously affected, since the ability of connections of this type to dissipate seismic energy by means of plastic deformation is relatively low. In the case of the connections between the cladding panels and the main structure, it was shown that the probability of failure was, in the case when vertical panels are used, relatively high (between 2.0 and 30% over a period of 50 years), whereas in the case of horizontal panels it was significantly less (between 1.0 and 5.5%, or between 0.1 and 1.3%, depending on the type of connections used). Based on the new findings, guidelines were prepared for the design of beam-column dowel connections, and connections between cladding panels and the main structure. Dowel connections have to be designed according to the capacity design method, for which their load-carrying capacity needs to be accurately estimated. In this part of the dissertation some expressions for the calculation of this capacity are proposed. Methods which can be used to verify the adequacy of connections between facade panels and the main structure are also given. If the performance of such verification methods is infeasible, then second-line back-up devices, i.e. restrainers, need to be installed. The design, testing, and evaluation of the necessary load-carrying capacity of such systems are presented in the final chapter.

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Izvleček

V disertaciji je predstavljena obsežna eksperimentalna in analitična študija vpliva stikov na potresni odziv armiranobetonskih montažnih konstrukcij. Raziskave so bile izvedene v okviru dveh evropskih projektov: SAFECAST in SAFECLADDING. Disertacija obravnavana dve pomembni skupini stikov, in sicer stike med stebri in gredami ter stike med armiranobetonskimi fasadnimi paneli ter konstrukcijo. Za obe skupini stikov so bili najprej opravljeni ciklični preizkusi. Ob podpori eksperimentalnih rezultatov ter podrobnih 3D numeričnih analiz so bili nato pojasnjeni porušni mehanizmi stikov. Na podlagi novih znanj so bili določeni računsko manj zahtevni in robustni inženirski modeli. Ti upoštevajo nekatere ključne karakteristike cikličnega odziva obravnavanih vrst stikov, katerim v okviru preteklih raziskav ni bilo posvečeno dovolj pozornosti. V modelih mozničnih stikov med stebri in gredami sta tako zajeta vpliva stremen ter velikih relativnih rotacij med stebrom in gredo na nosilnost stika, kar je tudi eden izmed bistvenih prispevkov disertacije. Da bi ovrednotili vpliv stikov na potresni odziv celotnih konstrukcij, je bila izvedena tudi obširna parametrična študija ranljivosti in potresnega tveganja enoetažnih in trietažnih armiranobetonskih montažnih stavb situiranih v Ljubljani, pri čimer so bili uporabljeni na novo definirani inženirski modeli stikov. Ugotovljeno je bilo, da lahko napačno ocenjena nosilnost mozničnih stikov med stebri in gredami močno ogrozi varnost obravnanih konstrukcij, saj je njihova sposobnost sipanja potresne energije s plastičnim deformiranjem relativno majhna. Pri stikih med fasadnimi paneli in konstrukcijo se je izkazalo, da je verjetnost porušitve v primeru uporabe vertikalnih panelov relativno visoka (2-30% v petdesetih letih), v primeru horizontalnih panelov pa občutno nižja (1,0-5,5% oziroma 0,1-1,3%, odvisno od tipa uporabljenih stikov). V zadnjem delu disertacije so bili na podlagi novih ugotovitev oblikovani ustrezni napotki za pravilno načrtovanje mozničnih stikov med stebri in gredami ter stikov med fasadnimi paneli in konstrukcijo. Moznični stiki bi morali biti načrtovani po metodi načrtovanja nosilnosti, za to pa je nujno potrebna dovolj natančna ocena nosilnosti, kar omogočajo zaključeni izrazi predlagani v tem delu disertacije. Podane so tudi potrebne kontrole, s katerimi preverimo ustreznost stikov med fasadnimi paneli in konstrukcijo. Če le te ne moremo dokazati, lahko panele varujemo s pomočjo pridrževalcev. Zasnovo, preizkušanje in oceno potrebne nosilnosti tovrstnega sistema smo predstavili v zadnjem poglavju disertacije.