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MITTESTANDARDSETE HOONETE RAJAMISE GEODEETILINE TEENINDAMINE KAASAEGSETE MÕÕDISTUSTEHNOLOOGIATE KAASAMISEGA

GEODETIC SERVICE OF NON-STANDARD STRUCTURES BY INCORPORATING MODERN SURVEYING TECHNOLOGIES

EPT 60 LT

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KOKKUVÕTE

Käesolevas magistritöös uuriti mittestandardsete hoonete ehitusgeodeetilisel teenindamisel esinevate ülesannete lahendamise viise ning saavutatavat teoreetilist täpsust. Selgitati välja projektis ettenähtud ehitusnormatiivid ning neist tulenev geodeetiliste tööde vajalik täpsus ja arvutati sooritatud tööde teoreetiline täpsus. Võrreldi laserskaneerimisel tähistega ja pilv-pilvega registreerimise tulemusena saadud andmete erinevust. Saadud punktipilvedest moodustatud teostusjooniseid võrreldi ettevõtte poolt koostatutega, kusjuures viimane kasutas mõõdistamisel elektrontahhümeetrit. Lisaks sooritati eeltõusuga rajatud vahelael vajumisvaatlused. Uurimustöö käigus sooritati rida mõõtmisi AS Merko Ehitus Eesti poolt rajatav Hilton Hotell Tallinn objektil ja nendega kaasnevaid arvutusi.

Üldistatud andmete põhjal tehti teoreetilised arvutused geodeetiliste tööde eeldatava täpsuse hindamiseks. Arvutuste käigus võeti arvesse tugivõrgu rajamise, montaažihorisondi lähtepunktide ja märkimistööde vead. Saadud tulemustest võis järeldada, et kasutatud meetodid rahuldavad üldjuhul rajatavale hoonele esitatud täpsusnõudeid.

Magistritöö käigus sooritati kontrollmõõdistamine jaotises 6.3 kirjeldatud viisil ning saadud tulemusi võrreldi laserskanneri andmete põhjal leitud vertikaalsustega ning ettevõttelt saadud tulemustega. Selgus, et laserskanneri andmetest saadud tulemused olid küllaltki täpsed (KRV ±2,5 mm), kuid ettevõtte kasutatud meetod ei rahuldanud ehitusnormatiivi EVS-EN 13670:2010 poolt sätestatud tingimusi seinte vertikaalsuse määramisel ja eriti korruste vahelise põkkumise määramisel.

Magistritöö käigus võrreldi laserskanneri abil kogutud mõõdistusandmete töötlust kahel erineval viisil. Esiteks registreerides punktipilved tähiste abil ning teiseks pilv-pilv meetodil. Saadud tulemuste põhjal järeldati, et kasutada võiks kombineeritud meetodit, st et pilv-pilvega registreerimisel tuleks vajadusel kasutusele võtta minimaalsest vajalikust arvust rohkem tähiseid, näiteks antud töös saadi samaväärne tulemus ühel korrusel juba kolme tähise kaasamisega, mis on tunduval vähem, kui tähistega registreerimisel ning annab märkimisväärse ajavõidu välitöödel.

Ettevõtte poolt koostatud plaaniliste hälvete teostusjoonise võrdlemisel laserskanneri andmetest koostatud teostusjoonistega selgus, eeldusel, et ettevõtte poolt sooritatud mõõtmised on täpsemad, et mõõtmiste tulemusel leitud laserskanneri KRV on ±4,3 mm. Arvestades, et ettevõtte poolt sooritatud mõõtmiste teoreetiline KRV on ±4,3 mm, saame mõõdistamise KRV laserskannneriga ±6,1 mm, mis ei rahulda ehitusnormatiivide poolt

sätestatud tingimusi. Laserskanneri kasutamise eelised ilmnevad keerukama kujuga objektide puhul, kus annab eelise elektrontahhümeetriga mõõdistamise ees tänu kogutava andmehulga suurele detailsusele.

Rajatava hoone eeltõusuga valatud vahelagede vajumeid uuriti geomeetrilise nivelleerimisega, kusjuures eesmärgiks oli määrata ainult eeltõusust tingitud vajumeid ning seetõttu ei olnud oluline siduda neid hoone kõrgusliku süsteemiga. Saadud tulemuste põhjal järeldati, et kasutatud meetod on antud mõõtmise jaoks igati sobiv. Taoliste konstruktsiooni elementide uurimine on kindlasti vajalik, sest nagu vaatlustulemustest näha võib vajumine kesta kauem kui arvati ning vajumid võivad olla oodatust suuremad.

Uurimustöö tulemusena anti ülevaade hoonete ehitusgeodeetilisel teenindamisel ette tulevatest probleemidest ning kirjeldati nende võimalikku lahendamist erinevate meetoditega ning anti täpsushinnangud, mille leidmiseks kasutatud arvutusmeetodeid võib rakendada analoogsetel juhtudel. Saadud tulemusi ja järeldusi võiks arvestada sarnaste objektide ehitusgeodeetilistel teenindamisel. Üheks huvitavaks avastuseks oli pilv-pilvega punktipilvede registreerimise oodatavast suurema täpsuse saavutamine, mille oskuslik kasutamine võimaldab säästa märkimisväärselt välitöödeks kuluvat aega.

SUMMARY

In this thesis different ways of solving problems occurring in geodetic engineering servicing and achievable theoretical accuracy during geodetic engineering-servicing of non-standard buildings were investigated. Building regulations have been identified and the resulting effects on geodetic accuracy were stated. In addition theoretical accuracy of the geodetic surveys were calculated. Resulting data from target-to-target registration was compared with data obtained from cloud-to-cloud registration. Acquired point cloud from previously described registration methods an as-built plans were formed. These as-built plans were compared with plans acquired form the surveying company which were surveyed by total station. Subsidence observations were made to investigate deformations of the ceiling, which was constructed with anticipatory ascent. All measurement and calculations which were made during the research were based on an example of a building called Hilton Hotel Tallinn constructed by AS Merko Ehitus Eesti.

As a result of the research, building regulations to which a building must comply were identified and theoretical calculations were made to assess the accuracy of the geodetic surveys. During the calculations the errors that had occurred during the construction of the primary system, secondary system, and in setting out were taken into account. From the results obtained by the theoretical calculations, it can be concluded that the methods used meet the accuracy requirements of the building.

Control surveying in the manner described in section 6.3 was performed as part of this thesis. The results obtained were compared with the verticality found from the collected laser scanner data and with the results obtained from the company. It turned out that the results obtained from the laser scanner data were quite precise (MSE ± 2.5 mm), but the method used by the company did not satisfy the requirements of the building regulations EVS-EN 13670:2010.

Resulting data from target-to-target registration was compared with data obtained from cloud-to-cloud registration. Based on the results that were obtained, it was concluded that, a combined method could be used. That is to say that cloud-to-cloud registration could be used, with more than the minimum number of targets if necessary. For example, the given research gave equivalent results on one floor if only three targets were used, which is considerably less than in target-to-target registration. As a result, significant time saving on fieldwork will be achieved.

The as-built plan, which was created by the company, was compared with the as-built plan, which was constructed from previously registered point cloud. It was expected that the as-built plan created by the company was more accurate. As a result of comparing deviations from both the as-built plans MSE ±4,3 mm was obtained. Whereas, the theoretical MSE of the as-built survey was at the same magnitude, it is a bit much and did not satisfied the conditions laid down by the building regulations. However, in the case of objects with more complex shapes, terrestrial laser scanning is advantageous when compared with surveying with total station due to the increased level of detailed data.

Subsidence observations of the ceiling, which was constructed with anticipatory ascent, were surveyed using geometric leveling, with the only aim to determine subsidence due to the anticipatory ascent of the ceiling. Therefore, it was not necessary to link them to the building elevation system. Based on these results, it was concluded that the method that was used was highly suitable for such measurements. Such surveys are certainly necessary for this type of construction elements, as it can be seen from the results of subsidence observations, sinking of this type of construction elements may last longer and be greater than expected.

As a result of this research an overview of the problems that can occur during geodetic engineering-servicing of a building were given. In addition, different ways to solve those problems using various methods were described. The calculations methods for accuracy assessment can be applied to similar cases. The results obtained can be taken into account during geodetic engineering-servicing for similar construction objects. Another interesting finding was that using cloud-to-cloud registering to merge point clouds resulted in higher accuracy than was expected, which allows for significant time savings if used wisely.