TALLINNA TEHNIKAÜLIKOOL
INSENERITEADUSKOND

Ehituse ja arhitektuuri instituut

PAIGALVALU RAUDBETOONIST HOONE KANDEKONSTRUKTSIOONIDE OPTIMEERIMINE LELLE 22 NÄITEL

OPTIMIZATION OF CAST IN SITU LOAD BEARING REINFORCED CONCRETE STRUCTURES BASED ON THE EXAMPLE OF LELLE 22

MAGISTRITÖÖ

Üliõpilane: Marten Kääp

Üliõpilaskood: 122574

Juhendaja: Dots. Ahti Lääne
Kaasjuhendaja: Andres käes

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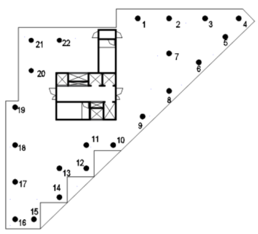
Kokkuvõte

Kõrghoone ehitus tähendab unikaalseid ülesandeid projekteerimises. Projekti keerukuse tõttu tuleb jälgida, et juba projekti algusest oleks tähelepanu pööratud nii strateegilistele küsimustele kui ka detailidele. Käesoleva töös vaadeldakse vastavat teemat konstruktori seisukohalt. Täpsemalt näitamaks eelist, mille annab konstruktori kaasamine hoone planeerimise algstaadiumis.

Käesolevas töös vaadeldi näidishoonena Tallinnas paiknevat kõrghoonet aadressil Lelle 22. Tegemist on 14 korruselise hoonega, millele lisanduvad veel 2 parkimiskorrust. Hoone kolmnurkne kuju, kõrgus ja paigutus (järve poole suurim külg) põhjustasid tüvikusse ja vundamenti suured tõmbejõud. Töö alguses vaadeldi teemasid, mis saavad määravaks tüvikule mõjuvatele koormustele ja võrreldi, kuidas hoones oli lahendatud tüviku paigutus vastavalt teemale. Teemad, mis said tüviku määramisel oluliseks olid (peatükk 2.5):

- Tüviku paigutus hoone raskuskeskme suhtes
- Tüviku suuruse ja kuju mõju saamaks võimalikult suurt vastupanumomenti tüvikult
- Tüviku ja postide paigutus, võimaldamaks võimalikult suure survekoormuse mõjumise tüvikule vahelagedelt
- Tüvikus paiknevate avade mõju vahelagedes ja tüvikus esinevatele pingetele
- Tüviku paigutus võimaldamaks suurt kasutusmugavust ja tulekahju olukorras väljapääsude asetus ohutuks kasutamiseks.
- Tüviku mõju hoone all asetsevale maa-aluse parklale

Uue tüviku paigutus leiti proovimise teel, eesmärgiga saada võimalikult häid lahendusi kõigis eelnevalt nimetatud punktides (peatükk 2.6). Lõplikult valiti välja lahendus, mis on näidatud joonisel 5.1.



Joonis 5.1 Hoone tüviku uus paigutus

Uue tüviku paigutusega vähenes tüvikus kõigis katsetatud koormuskombinatsioonides tõmbekoormus natuke vähem kui 3 korda ja survekoormus vähemalt 2 korda. Kõige suuremat tõmbepinget põhjustavas koormuskombinatsioonis vähenes tõmbepinge 3,7 korda 7732 kN/m-ilt 2107 kN/m -ile. Uue lahendusega kulus samas rohkem poste: eelnevas lahenduses oli 19, siis uues 22. Töö näide tõestab, et inseneri kaasamine projekti alguses tagab lõpuks odavama lahenduse hoonele ja selle vundamendile.

Täiendavalt arvutati töös välja kõikide postide läbimõõt ja osades postides vajaminev armatuur, eesmärgiga omandada oskusi määramaks arvutustarkvaraga postides vajaminevat armatuuri.

Lisaks arvutati töö viimases osas välja 4 korruse vahele armatuur ja tehti valmis vahelae armeerimis joonised. Vahelagede peatükis uuriti põhjalikumalt, mis moodi vahelagi töötab pärast pragunemist. Täiendavalt tehti mudel, mis näitas, et vahelagi jäikusega 1,00 x E näidatud koormuse tippude piirkonnas toimub oluline koormuste ümberjaotus pärast pragunemist.

Magistritöö eesmärk – näidata inseneri olulisust juba projekteerimise algfaasis ning omada paremaid teadmisi betoonkonstruktsioonist, armeerimisest ja arvutustarkvarast – on seega täidetud.

Summary

The building of an high-rise has very many unique problems during design. Due to the sheer complexity of the project, it must be made sure that from the first steps of the project attention is focused on both the strategic questions and the details. This enables specialist from different fields to draw attention to the problems and provide solutions from the beginning. This work will look upon that particular idea from the perspective of a constructor. To be more precise, it will focus on the benefit of having a constructor involved in the project from the very start.

The consequences of including the constructor too late is quite timely and important when looking at today's construction practise. These days the design of a building mostly starts with the architect designing the building and then the constructor provides the necessary construction details. This kind of approach has the problem of the project reaching the hands of a constructor too late in the process. The constructor doesn't have a chance to change the project and in general nobody even expects it from him/her. In the end the client is unknowingly stuck with a project that is not optimal and is either more expensive or less practical than is necessary.

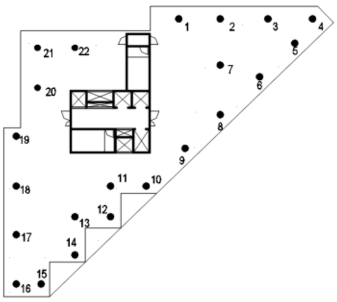
This thesis looks at how the placement of a building core in a building affects the tensions stress in the building core based on the example of the building Lelle 22. It's a 14 storied building with 2 additional stories dedicated to parking. The triangular shape of the building as well as it's height and placement (biggest side is facing the lake) cause quite big tractive forces in the foundation and the building core.

Chapter 2 analyzes the effect of the placement of the building core has to the tensions in the building core. The start of the chapter explains the importance of a stump in a high-rise as well as what the problem was in the initial solution. The chapter 2.5 looks upon the aspects which became decisive for the placement of the building core:

- Placement of building core in relation to the building's center of gravity.
- Layout of building core to ensure the biggest possible moment of resistance.
- Placement of building core from intermediate ceilings to get the biggest vertical load.
- Effect of the openings in a building core to intermediate ceilings and the tensions in a building core.

- Placement in the building to ensure the best usability and also the firesafety.
- Effect the placement of a building core has to the usability of the underground parking floors that are located under the building..

Placement of a new building core was found out using trial and error, while trying to achive the best possible results to all the aforementioned points (chapter 2.6). In the end a best solution was found which is shown on the fixture 1. The reasoning for why this particular solution was above the others was given in chapter 2.7. Then the loads of the building and load combinations were calculated and a brief overview given on the creation of a model. Afterwards measuremeants were made to find the how the columns's distance from the edges of intermediate ceiling affected the functioning of that intermediate ceiling. The optimal distance was measured to be 1.5 meters. Among the measurements was the bending moment of the column as well as the cracking and subsidence of the intermediate ceiling.



Fixture 1. Placement of a the new building core

After the correct placement of the column a model of the building was made. The model was used to test different rigidities of intermediate ceiling in order to get a more correct distribution for the columns located near the building core. Then a comparison was made between the old building and the new building in combinations of load. The outcome was that the combination which produced the greatest pull to the building core caused by wind was reduced almost 4 times. All of the tested situations saw the pulling tensions reduced almost 3 times and compressive stress 2 times. This work based on Lelle 22 proves that including a engineer in the project from the start would allow savings on the material for building core and foundation. The only negative aspect to the new solution was the greater number of columns which saw an increase from 19 to 22.

The thesis also looked into the diameter of the columns and the reinforcing of the columns.

Chapter 4. contains the arming of the 4ft floor intermediate ceiling. A separate modle was constructed for the intermediate ceiling to see how the load distributes in the ceiling after the ceiling itself has cracked. The thesis showed that the ceiling cracking would subsequently cause a big convergence of the loads.

The last part of the thesis contains the reinforcement drawings of the intermediate ceiling which is placed between the 4^{th} floor.

It is concluded that the purpose of this thesis – to show the importance of involving an engineer in the design process from the beginning and therefore having a better knowledge about concrete constructions, reinforcing and modeling software – has been fulfilled.