Aalto University
School of Engineering

Differences in Residential Construction Costs between Helsinki Region Finland and Graz Austria.

Master's Thesis
Department of Built Environment
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Bachelor of Science in Technology
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Tiivistelmä

Tämän diplomityön tutkimuskohteena ovat Helsingin seudun ja Grazin alueen asuntorakentamisen kustannuserot ja niiden keskeiset syyt. Tutkimus toteutettiin kahden itävaltalaisen Grazin alueelle rakennetun asuntokohteen suunnitelma- ja kustannusaineiston pohjalta kahden kohteen case-tutkimuksena.

Tutkimus jaettiin kahteen osatarkasteluun ja tutkimukseen tarvittavat laskelmat toteutettiin Haahtela-yhtiöiden Kustannustieto TAKU®-ohjelmistoilla. Ensimmäisessä tarkastelussa tutkittiin Helsingin ja Grazin välistä rakentamisen hintatasoeroa. Tässä tarkastelussa kohteille laskettiin kustannuarviot ensin ominaisuuksiltaan itävaltalaisen rakentamistavan mukaisina mutta rakennettuna Helsinkiin Helsingin hintatasossa samaan rakennusaikaan, kun ne oli rakennettu Grazissa. Toisessa tarkastelussa kohteiden ominaisuuksia muunnettiin niin, että ne pysyivät mahdollisimman samanlaisina mutta vastasivat paremmin Helsingin alueella tyypillisiä ratkaisuja.

Tutkimuksessa havaittiin merkittäviä kustannuseroja molemmissa tarkasteluissa. Hintatasoeroltaana kohteissa havaittiin Helsingin hintatason olevan keskimäärin 30% Grazia kalliimpi. Merkittävin yksittäinen hintatasoon vaikuttava tekijä, jolle tutkimuksessa löydettiin selkeä syy, olivat työmaakustannukset, jotka nostivat kustannusta keskimäärin 8 %. Rakentamistavassa havaittiin Helsingin rakentamistavan olevan keskimäärin 13 % Grazissa vallitsevaan tapaan verrattuna. Suurimmat erot tyypillisessä rakentamistavassa olivat talotekniikassa, asuntojen viimeistelytasossa sekä rakennuksen vaipan ratkaisuissa.

Tutkimustulokset olivat hyvin linjassa olemassa olevan tiedon ja tilastoaineiston kanssa, joita tutkittiin pohjatietona tutkimuksen yhteydessä. Havaittu hintatasoero oli keskimäärin vähän Eurostatin Itävallan ja Suomen välistä hintatasoeroa korkeampi, mikä johtuu todennäköisesti tutkimusotoksen pienuudella ja maiden sisäisten sijaintien eroilla. Rakentamistavasta ja urakointitavasta johtuvat erot kävivät hyvin yhteen aihetta käsittelevän kirjallisuuden kanssa.

Avainsanat rakennuskustannukset, kustannuserot, case-tutkimus, hintataso

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Abstract

The focus of this thesis was in comparing the differences and main reasons for them in construction costs between the Helsinki region and Graz area. The research was executed as a case study of two Austrian residential projects. The dataset for the study included the designs and financial information of the two projects.

The research was divided in two studies. All the needed estimates were made using the Haahtela’s Kustannustieto TAKU®-software. In the first study the difference in the price level between Helsinki and Graz was studied. In this study the two Austrian projects were estimated in the Helsinki price level of their original construction time and according to the Austrian designs and specifications. In the second study the differences in the typical design and technical solutions used in the projects were studied. The study method was to alter the Austrian projects’ specifications as little as possible in order to make them corresponding to the Helsinki area construction culture and the typical design and technical solutions used.

As a result, significant differences in the costs of construction were observed in both of the studies of the research. The Helsinki price level was observed to be on average 30% more expensive than Graz. The biggest singular reason for which a clear numeric reason was found in the price level comparison was the site tasks cost. The project costs were increased when transferred to Helsinki on average by 8% just for the difference in the site tasks. The typical designs technical solutions study showed that the way of constructing was in average 13% more expensive than the typical way to construct in Graz. Biggest reasons for the difference were found in the service elements, equipment and finishing of the apartments and the typical solutions used in the building envelope.

The research results were convergent with the studied literature on the subject and the statistical data referred to in the research. The observed average price level difference was a bit higher than that found from the Eurostat statistics that is probably due to the differences in the studied locations relative locations in the two countries and the small amount of cases studied. The differences in the way of constructing and contracting are convergent with the literature findings in this thesis.

Keywords Construction costs, cost differences, case study, price level

Preface

This thesis was made as a part of a Finnish Ministry of Environment and ARA's funded RAKLI Clinic –project that was initiated to shed some light to the reasons that lie behind the high construction costs of residential buildings in the Helsinki region. Rakli steered the clinic work in collaboration with Ministry of Environment and ARA. The other Finnish participants in the clinic were SATO Oyj, VVO Oy, VAV Asunnot Oy, Espoon asunnot Oy, Helsinki city executive office, Helsinki housing production department ATT and the contractors YIT Group and NCC Building. From Austria the project was backed up by the Steiermark state governance and the Austrian participants were the Wohn- und Siedlungsgenossenschaft Ennstal and ÖWG Wohnbau. This thesis was made as the part of the clinic that studied the differences in new construction and construction costs. The renovation costs' survey was carried out by CalCon Deutschland GmbH.

For my part I want to thank all the particiants of the project for the possibility to take part in this study and for the collaboration throughout the project. Special thanks I want to direct to my employer, Yrjänä Haahtela and my advisor Erkki Teittinen from Haahtela for the good counsel and advice during the job and to my professor Kauko Viitanen for the advice on finishing this work properly. Ilpo Peltonen and Marika Latvala from RAKLI, thank you for the co-operation.

Espoo 30.08.2016

Johanna Kuusipuska

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Concepts and Abbreviations

Apartment area (AA), sq. : Apartment area is measured as usable area delimited by the inner surfaces of the boundary walls' of the apartment. The horizontal area of the partitions in included in the apartment area. (RT 12-11055)

Gross floor area (GFA), sq.: Gross floor area is a figure that reflects the total scope of the building. It is measured as the sum of the gross floor areas of the building and includes all of the floors not depending on their intended use or on whether or not the spaces are heated or not. Gross floor area is the horizontal area of a floor measured by the exterior walls outer surfaces of their imaginary extensions where there are openings or decorations in the exterior wall. (RT 12-11055)

Floor area (FA), sq.: Floor area is defined in the land use and building to be used in defining the permitted amount of construction on a site. It is defined as meaning the allowable amount of gross floor area that can be built on a site. The gross floor area is measured by the exterior surfaces of the exterior walls. It includes those floors and parts of the basement and attic floors where spaces including in the principal use of the building are or can be located. When considering the inclusion of the basement and attic spaces to the gross floor are the spaces locations, connections, size etc are considered. Should the building's exterior wall's thickness exceed 250 mm the gross floor area can be exceeded accordingly by the additional horizontal area of the exterior walls. (Land use and building act 1999/123 §115)

Room area (RA), sq.: Room area is the area of a room. It is delimited by the walls or their imaginary extensions that delimit the room. (building code of Finland, part G1)

Profitable area (PA), sq.: Profitable area is a term describing the scope of the programmed spaces in a project. It is calculated as a sum of the room areas of the programmed spaces. Exception is made on the apartments that are calculated in the profitable area as apartment area. The profitable area includes all the spaces of the space program but typically not the spaces serving the inner connections on technical systems. Spaces like ventilation and other technical rooms, stairways, aisles, hallways etc are commonly not included in the profitable area. (RT 12-11055)

Room height is measured as the perpendicular distance from a room's floor surface to its ceiling surface. (Building Code of Finland, part G1)

Net area (NA) in this thesis is used to as a term that describes the total amount of apartment and room area. Apartments are included as apartment area and all other spaces in room area.

Floor height is measured as the perpendicular distance from the surface of one floor to the surface of the floor above. (Building Code of Finland, part G1)

Kustannustieto TAKU® (TAKU®) is a software of Haahtela Oy. The software has been used in this thesis in all the studies' calculations.

ÖNORM is an Austrian national standard that is published by the Austrian Standards Institute. (Austrian Standards, 2016)

1. Introduction

1.1. Background

The cost of living is rising in the Helsinki region. The average rent of apartments has been rising on average 3,7% every year between the years 2000 and 2011 (Statistics Finland, 2016). This equals the average rent for an apartment in the Helsinki region has risen during the time span of the statistics, 2000-2011 a whopping 44,5%. The index describing the prices for new apartments was available at a slightly different time span but tells the same tale. In the Helsinki region the index has risen by 16,4% since 2010 (Statistics Finland, 2016). Combined with the statistics of how average earning have at the same time risen by 11% until 2015 (Statistics Finland, 2016) it seems evident that the cost of living is gradually becoming too expensive. As the building stock is renewed and increases through construction activities, the cost of construction plays an important role in these fundamental costs of living. The fact that this development has remained all the time upward at the same time as the gross domestic production of Finland has for the majority of the time remained at much lower figures and fluctuated even in negative figures (Statistics Finland, 2016) raises the question of why this is.

The rising of the cost of living has been noted in the Ministry of Environment as well. There was also an initial reckoning in the ministry that the situation was not quite the same in the Graz area in Austria. Due to the fact that the costs of construction have risen at a notably high level in the Helsinki region, the Ministry of Environment and ARA decided to initiate a RAKLI clinic project to compare the costs of construction of multi-story residential buildings in the Helsinki region with the costs issuing from their construction in Graz Austria with the hope of gaining some mutual benefits in learning from the differences that were expected to be found.

With this background the FIAT –project was initiated as a RAKLI Clinic –workshop in the autumn of the year 2015. This thesis was conducted as a part of this FIAT –project. The FIAT –project included in addition to this thesis the parts of renovations costs comparison conducted by CalCon Deutchland GmbH and the comparison of general practices of the construction field carried out by RAKLI. This thesis' part in the clinic work was to answer for the study of the construction costs of new construction.

1.2. The Aim and Objectives of This Thesis

The main aim of the FIAT-project and this thesis was to find out firstly if the initial hypothesis of construction cost being higher in Helsinki compared to Graz, was correct and secondly to analyse and categorise the reasons for the alleged differences. The objectives of this thesis were the following:

- to find out if the difference in construction costs was real and what were the principal reasons behind the difference
- to find insights to the causes of high construction costs and issues causing them through comparison with the Austrian construction
- to sort out the reasons that come from the Finnish regulations for construction

As in the beginning there was a hypothesis of the costs of construction being lower in Graz compared to Helsinki, the first aim was to verify the validity of this hypothesis. The main aim of this thesis was to find out the reasons for the alleged difference. The aim was to find out to what degree do the costs of construction differ due to the differences in the cost level of the two cities and to what degree are they due to the differences in the products built aka the apartment buildings' technical specifications.

The question of the regulations is an issue somewhat linked with the general practices of the field because the regulations as mandatory legislation can be assumed to affect the general practices of the field. The comparison of the regulations between those in Finland and the regulation concerning the Austrian construction was carried out in collaboration with RAKLI. This thesis' part of the regulations' and general practices comparison was thus smaller and the focus of this thesis was kept in the comparison of construction costs and their direct reasons. The comparison of the differences in the regulations and the general practices prevailing was in the FIAT –project mainly carried out by RAKLI.

1.3. The research questions of this Thesis

For this thesis the principal research questions are:

- Do the costs of residential construction differ between the Helsinki region in Finland and Graz in Austria and to what degree?
- What are the factors that cause the differences? How much is ado with difference in the general price level of construction and how much with differences in the specifications of the buildings built?

Additional question of interest that were studied partly in this thesis but more in the same clinic project by RAKLI was the role of the regulations in the reasons of the cost differences:

- To what degree do the perceived differences originate from differences in regulations of these two countries?

Also reasons for the alleged price level difference were to be considered as much as possible with the available data.

1.4. Scope and limitations of this thesis

The costs compared in this thesis were limited to the contracting costs of construction. The contractee's costs issuing from designing, contractee's tasks, connection fees and plot tasks were excluded from the comparison. The scope of this thesis was limited to the construction costs purely.

What this thesis does not take into consideration are of course also all the other factors outside the costs of construction that inevitably contribute to the rental levels in the Helsinki area. What is to be kept in mind that the rental levels are determined in the rental markets and not in the same markets that price the cost of construction. It was noted in during the work with this thesis that there is a difference in the rental markets between the locations as well. The Austrian participants of the FIAT project were both non-profit organisations providing housing as rental apartments and owner-occupied apartments in the Graz area. They also played an important role in the whole housing branch of the area in Graz meaning there exists a strong non-profit rental apartments' branch in the Graz area. To this there is no comparable equivalent in the Helsinki region where the majority of rental apartments are owned by real-estate investors that are in the business to make profits for their stakeholders. This inevitably has an effect on the rental markets that is not at all related to the costs of construction and the link between the costs of construction and the rental levels is arguably weaker in the Helsinki region housing markets than it is in the Graz housing markets.

Also the much discussed planning related issues are left out of the scope of this thesis and the comparison is made as closely as possible of similar buildings construction costs. The idea of the comparison was to compare the costs of construction. The differences in the quality of the city planning cause of course different costs to the areas. As planning phase was not the topic of this thesis those are not considered here. The topic was to identify if there were differences in the costs of construction and where they arise. This was carried out by comparing as similar building projects in both countries as possible. In that context the planning related differences would cause for too much uncontrollable differentiation.

1.5. Research method

The research method of this thesis is a comparable case study. The comparison was made using the TAKU®-software and the Austrian projects' data. The Finnish projects included in the FIAT-dataset were used as references of the Finnish construction but were not used in the comparison as such. This was done because of the great difference between the projects realised in Graz and in the Helsinki region. To refrain from comparing apples to bananas only the Austrian projects were used as the dataset of the comparison.

The research was right in the beginning divided in two parts with two different types of calculations conducted. The first phase was to study the difference in the two locations' price level by virtually transporting the Austrian projects' into Helsinki. This was done by estimating the two projects with the Austrian designs and specification but in the Helsinki price level of the same time as the projects' had been built in Graz.

The second study was to identify the differences between typical construction solutions in Graz and Helsinki and to identify the costs issuing from the differences in those. The initial assumption was that the projects from Graz reflect the typical way of constructing in the area. To keep them as similar as possible but still make them representative of the Helsinki area construction the projects were altered by utilising the TAKU®-software's default structural and quality level solutions and the Helsinki area's building control departments' guidance on the common spaces of the residential buildings. The apartments amounts and sizes were kept unchanged along with the amount of parking spaces built. The alteration was made with as small changes as possible to make the projects represent the costs of an imaginary similar project built in Helsinki.

After the two studies to compare the costs of construction were made the last phase of the calculations process was to ascertain the price level of the software used to make sure that the results that are conducted using it represent the price level in the Helsinki region. This was carried out by estimating a residential construction project realised in Jätkäsaari, Helsinki at the time of the thesis and comparing the results of the estimation to the realised contracting sums of the project.

1.6. Structure of the Thesis

This thesis is divided into 5 main chapters the first one being this introduction. After the introduction chapter follows the chapter introducing the theoretical framework of the thesis.

In the theoretical framework the theory of the causation of cost in a construction project is described based on existing knowledge from the literature of the field. In the theoretical framework the general cost level of the two studied countries is also studied through statistical point of view. This is done to ascertain the hypothesis about the direction of the difference in the costs of construction.

After the theoretical base study the thesis continues with the research method description and the introduction of the data used in the comparison. This part of the thesis is divided further into the parts describing the comparative case study method used in this study, the research data introduction and the description of the research method and software used in this research.

In the second to last chapter the results of the two studies made in this thesis are introduced. The discovered differences in construction and in the costs of construction are classified according to the types of differences. In the end of the chapter there is a summary of all of the findings of the research.

In the last chapter of this thesis there is the conclusion of the results found in the research and an evaluation of the with regard to the research questions and the theoretical framework and existing knowledge.

2. Theoretical framework

2.1. Factors causing differences in construction costs

Differences in construction costs come from two types of sources, those that concern the building that is being built and those that concern the price factors that contribute to the prices of the resources used to complete the project. The factors causing differences in the building are project related and differ from one project to another as the buildings built are never exactly alike. The differences to the construction costs of a similar scope of spaces programmed issue from differences in the spaces' features, design solutions, conditions of the construction site and the prevailing price level. The price related factors are the matters influencing in the general economy like inflation factors that contribute to the prices of material and labor and other market related factors affecting the contractor's pricing during tendering. (Enkovaara et al. 1998, Haahtela & Kiiras 2015)

When considering the building related factors of the construction costs the parameters affecting to the cost can be divided into the spaces that are needed as a result of the project and the design solutions made when this this need for space is being realized into a building. The need for space usually comes from outside the construction sector and the costs issuing from construction can be seen as resulting from the contractee's decision to acquire more space through a construction project (Haahtela & Kiiras 2015). The spaces with their characteristics are in the very core of construction costs as the differences in spaces built are the biggest reason behind the differences of the costs of construction between projects of similar scope (Haahtela & Kiiras 2015, Vuorela et al. 2001). The space related factors that affect the construction costs of a project arise from the different features and requirements to the spaces that are to be built. The varying requirements that those requirements to the spaces set to the performance levels of the components of construction and their technical specifications cause for varying amounts or resources to be used. This relation between the decisions regarding the spaces' requirements also cause for them to cost different amounts of money to build. The differences can be illustrated by the extremes. It is easy to accept that a demanding laboratory and a warehouse with the same scope come with a different price tag. Initially they are the requirements set to the laboratory space that differ so significantly from those set to the warehouse that cause that the laboratory to cost as much as 10 times the cost of the warehouse although they are of the similar scope. (Haahtela & Kiiras 2015)

Matters that cause construction costs and contribute to the differences in their costs are of course not only space related. Other recognised matters that differ from one project and building to another are the design solution decisions, prevailing conditions on site, price level and differences in the forms of contracting and procurement. (Vuorela et al. 2001) Design solutions play a big role what comes to the cost differences between projects of similar space program and scope. In the construction sector it's commonly acknowledged that even though the costs of a construction project are issued mainly on site during the actual construction but are mainly caused already earlier in the project's designing phase (Vuorela et al. 2001, Lindholm 2009). Design solutions affect in some way all the features of the building. Differences in costs that arise from the site conditions are not straight forwardly issuing from design solution decisions as they come from different amounts of work and elements like stabilisation and piling or solid rock excavation being needed for constructing the project. Site conditions are for the majority out of the project personnel's and the contractee's hands when it comes to making decisions and influencing them but their influence on the construction costs can to some degree be controlled with design solutions (Vuorela et al. 2001). The causation and issuing of costs in a construction project are visualised in the figure 1 below.

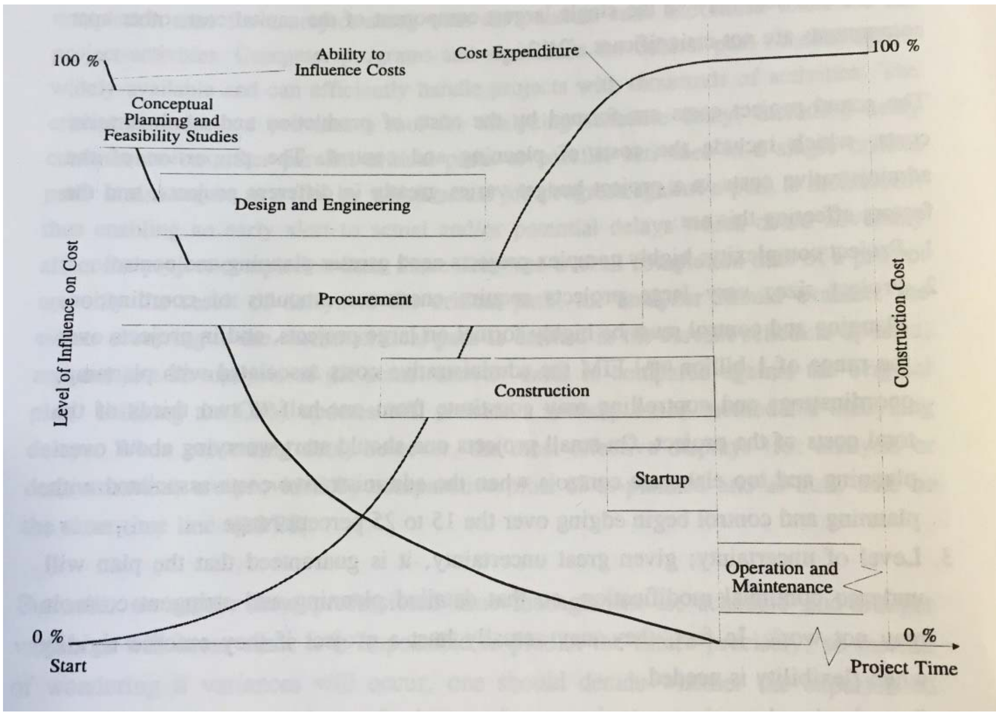

Figure 1: The causing and issuing of costs in a construction project (Martikainen et al. 1994)

What the differences in design solutions also contribute to the projects is effectiveness or ineffectiveness of the use of space. Different design solutions for the same project cause for different amounts of additional space that is not counted in the profitable area of the building needed in addition to the programmed spaces. In other words a less effective solution includes bigger aisles, stairways and technical spaces than a more efficient one. Through causing more additions space to be built less effective designing also causes bigger amounts of building elements and resources to be used during the project. Similar differences in the use of resources between design solutions are also caused through varying solutions in massing of the buildings. More details and variation in the massing causes for more materials and work to be used in building it. Finally the design solutions of course also include the obvious, the differently priced material selections that contribute to the design solutions' cost effects on the total costs of a project (Vuorela et al. 2001). All these are decisions made in the designing phase of the project and can be affected during it in order to steer the costs of the project in the right direction. Design solutions are for their basic characteristic a project scale factor but in a bigger scale they do tend to be linked to the prevailing culture of construction making them somewhat dependent on the time and place of construction through affecting the designing decisions in a given project. (Haahtela & Kiiras 2015).

The cost effect of the price level is issued of price related matters that are related to local, regional and company level issues (Vuorela et al. 2001). The price level of a given place on a regional level is influenced mainly by resource prices' differences and tendering prices fluctuation and in a larger scale by inflation development. The price level differs between locations for all these reasons. The differences in the resource prices within Finland differ mainly due to the differing prices of work because the material production is more stable due to them being transported around the country more easily than the workforce. Due to this the price level is higher in the areas of the country where there is a lot of construction activity going on and lower in the areas where the amount of action in the field is lower. Inflation is a countrywide matter and is more stable in its development. Fluctuation of the prices is on the other hand very local. The construction industry is prone to rapid and big-scale fluctuation that is caused by changes in the supply and demand in the field. The same resources are sold at lower prices when there is little activity and the demand is low and at significantly higher prices when the market is heated and the demand for the work is high. (Haahtela & Kiiras 2015)

The cost effect of the form of contracting is closely related to the questions of who bears the risks related to the construction works and how many margins will be added above one another in the project (Haahtela & Kiiras 2015, Peltonen & Kiiras 1998). The forms of contracting are in many books typically divided into different categories by the scope of the contractors' and the contractee's responsibilities as shown in the figure 2 below.

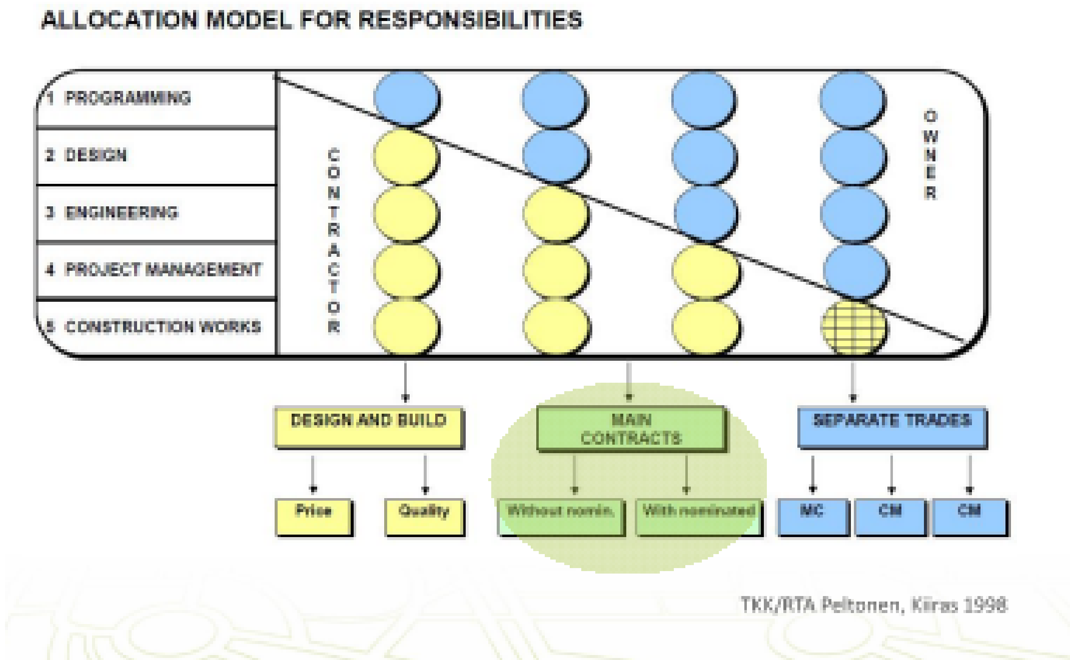

Figure 2: Contracting form divided by the responsibilities allocation (Peltonen & Kiiras 1998)

The prevailing practice of contracting in Finland has remained a form of general contracting described in the middle part of the figure where the contractee first directs the designing phase and then calls for tenders with ready designs and leaves the management of the construction to the contractor. This form of contracting ensures the contractee the possibility to affect the designs and have them drawn to the contractee's will but puts the risks related to the construction, such as the risks of price fluctuation, and flaws in the measurement of amounts to the contractor. The contractee is also not able to get the possible benefit of these possible risks not realising themselves or the fluctuation of prices happening to the negative direction during the project. (Peltonen & Kiiras 2000, Kankainen & Junnonen 2004)

In the Austrian projects the prevailing practice of contracting was a sort of a construction management solution. The construction management as a contracting form is much more divided form of contracting with the project management task kept as the contractee's responsibility either to be done by the contractee or a consultant hired for the task. In the construction management the contractee takes more of the project management responsibilities to take care of by the contractee's personnel or a project management consultant. In these forms of contracting the contractee bears the risks of price fluctuation and gets the final project cost determined only in quite a late time of the project. On the other side, the contractee gets to keep the possibilities to make decisions about solutions and from there also the possibility to affect the costs of the project also during the construction. (Peltonen & Kiiras 2000, Vuorela et al. 2001, Landström 1990) The divided projects with construction management contracting forms have been seen as more cost-effective during an economic boom, when there is a shortage of suitable general contractors presuming a reliable project management consultant or contractor is available for the project (Ashword 2006). The management contracting has been seen as being a flexible form of contracting for the contractee and it has been noticed to be a cost-wise suitable form of contracting when the project is in a hurry and contractee is aiming at reducing costs, is willing to bear the risk related to it and has a professional construction management contractor or consultant available for the task (Landström 1990, Ashword 2006). The risk management in construction projects is a matter that has been discussed in the field quite a lot. The perceived riskiness of a project from the contractor's point of view affects the pricing as added pricing of a potential risk whereas by dividing the contracts the contractee takes parts of the risk from the contractor and consequently only pays for those risks that realise (Ashword 2006). If the risk is seen as too high to be acceptable by the contractor can it result in not tendering as an act of eliminating the risk (Raftery 1994). From risk management literature there are found many points of views for assessing the actions in a project from the risks point of view. The factors that should be considered in the risk division should include things like which party of the project can control the risks and their effect should they realise (Flanagan and Norman 1993, Chapman and Ward 1997). By dividing the works into smaller portions and multiple contracts instead of one big general contract including the whole of the project, the contractee can reduce the risk for each of the contractors and receive cost benefit through a lower price level of the received tenders (Virtanen 1991, Ashword 2006).

Another factor closely related to the existence and division of risks are the use of the bill of quantities and unit based contracts vs lump sum contracts. By giving the bills of quantities as the basis of for tendering in a project the contractee can decrease the risks of the contractor. The risks that can be lifted from the contractor and taken as the contractee's risks are all those related to quantification. In contracting forms where the contractor shoulders all the risks related the price level of the tenders tends to be higher as the contractee then pays the risk marginal for potential risks related to the building project. (Twort & Rees 2004). A ready-made bill of quantities also makes the tendering easier for the contractor and lowers the costs of tendering. When all the tenders are made based on the same amounts the competition is also purely about the price so the contractor who can function the most effectively gets the job.

2.2. Cost Differences between Austria and Finland

2.2.1 The statistical differences in the countries' price levels

The general cost level of the countries is quite commonly considered by looking at their consumer price indices and comparative price levels from statistical sources. The consumer price indices (CPI's) are a generally considered a valid means of considering the changes in price level in any given country or area as it reflects the economical overall situation by quite reliably unveiling periods of inflation and deflation (Eurostat 2013). As the rate of inflation is considered a good measure for analysing an economy's situation in a given area the statistics for that are well cared for. For the EU and Eurozone the European central bank has stated that the average target level of this inflation level in the CPI should be below but close to 2% (European Central Bank 2016). The Eurostat provides harmonised CPIs covering the euro area and the EU that are used to assess the inflation rate in the EU countries and the Euro area. In addition to the CPI and inflation data drawn from it the Eurostat's consumer prices include also the comparative price levels that can be used to compare the different countries' general price level. These Eurostat statistics' publications from both 2014 and 2015 show that both of the studied countries, Finland and Austria were placed above the EU and Euro area averages (Eurostat 2015b and 2016b). In the index the EU-28 area covers the EU member countries and shows the average in them. The Euro area covers the 19 countries included in the monetary union. In the statistics, the EU-28 average has been set to 100 and other countries and the euro area average are being compared to that. In this average price level index both countries in the comparison are being placed above the EU average. The respective index points in the 2014 statistics are for Finland 123 and for Austria 107. (Eurostat 2015b) From these numbers the Finnish general consumer price level seems to be about 15% higher than that of Austria. The figures from the index concerning the year 2015 show the difference having narrowed by an index point as Finland has moved to 120 points and Austria at 105 (Eurostat 2016b).

The Eurostat also lists comparative Price levels for investment prices in the Europe. The investment price level index includes the EU countries, three EFTA countries, Norway, Switzerland and Iceland and EU candidate countries Montenegro, Macedonia, Albania, Serbia and Turkey and yet Bosnia and Hertzegovina which is a potential EU candidate country. The index shows the price differences for investment costs in these areas. The indices for investment prices are being comprised of the components of Machinery and Equipment, Metal products and equipment, Transport equipment and Software. The indices from 2014 and 2015 both show that both of the studied countries, Finland and Austria, are above the euro area average in the general investment price level and that Finland is the more expensive one of the two. The euro area average was in 2014 index figures 102 and in the 2015 figures 101. Between the compared countries there was in 2014 a difference of 18 index points, with Austria being at 108 index points and Finland at 126. The figures for 2015 differ more than those of 2014 with Finland's index points standing at 127 and Austrian at 105 and the difference between the countries has risen to 22 points within the time of one year. The statistics from both years show that Austria is in overall comparison much closer to the euro area average than Finland whereas Finland is closer to the other Nordic countries level than that of Austria. In all the components of the index Finland is the more expensive one with the difference in index points differing between 5 and 22. The difference was in 2014 smallest in electrical and optical equipment investment costs with Finland at 106 index points being only 5 points more expensive than Austria at 101 index points. The difference is highest in the Transport equipment with the countries respective index points being for Finland 136 and for Austria 114. In 2015 statistics the smallest difference was found in software investments. The difference in investment costs in general in the light of this statistics is slightly bigger than the difference in the general price level, with Finland being according to the index approximately 16,5% more expensive than Austria in 2014 and about 21 % in 2015. The figures 3 and 4 below show the price level indices from the years 2014 and 2015. (Eurostat 2015a & 2016a)

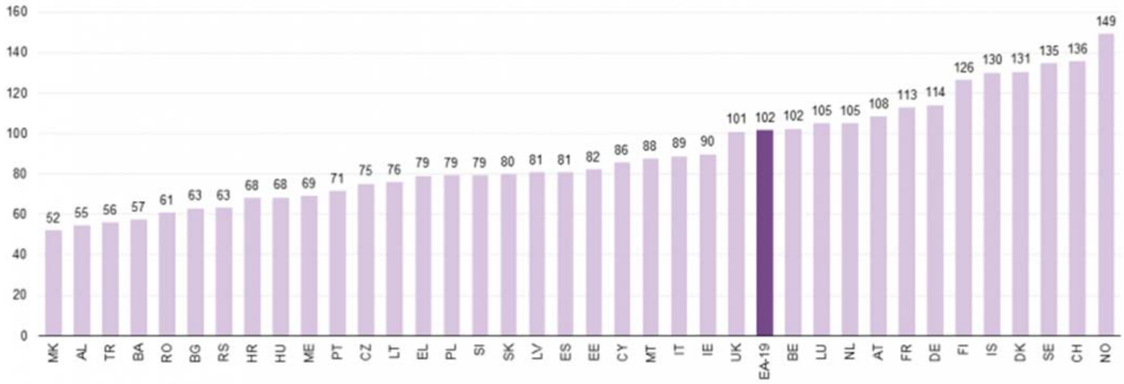

Figure 3:Price Level indices for investment 2014 (Eurostat, 2015a)

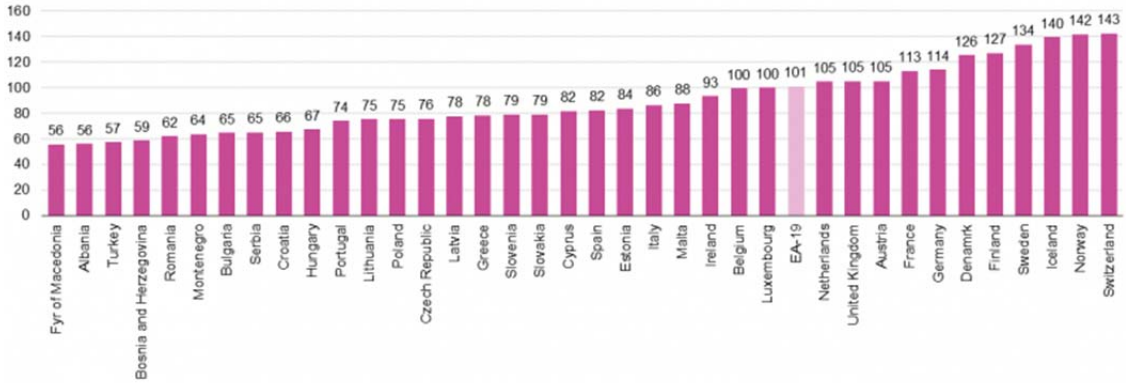

Figure 4:Price Level Indices for investment 2015 (Eurostat, 2016a)

The Eurostat’s more to the point price level indices for this study are those for the field of construction. Those indices show similar differences and placements as the CPI figures. Both Finland and Austria are above the European averages in investment prices and in this field too and Finland in the more expensive one. The European average index level in 2014 was 104 index points with Austria and Finland placing themselves respectively at 115 (Austria) and 135 (Finland) index points (Eurostat 2015d). In the 2015 statistics the Euro average has remained at 104 points but the studied countries have moved, Austria having gone down six points to 109 and Finland having climbed up the same six points to 141 (Eurostat 2016c). In construction as was with the general price level and the price level on investment, Finland is situated closer to the other Nordic countries than Austria. In 2014 the Austrian price level of construction was statistically approximately 85% of that of the Finnish price level but in 2015 the difference had grown and the figure changed to 77%. (Eurostat 2015d & 2016c). This tells the statistical tale about the fluctuation of the field. Both countries have moved 6 index points during just the space of one year although the Euro average has remained in place. The newest comparative price levels for construction from the year 2015 are shown in the figure 5 below.

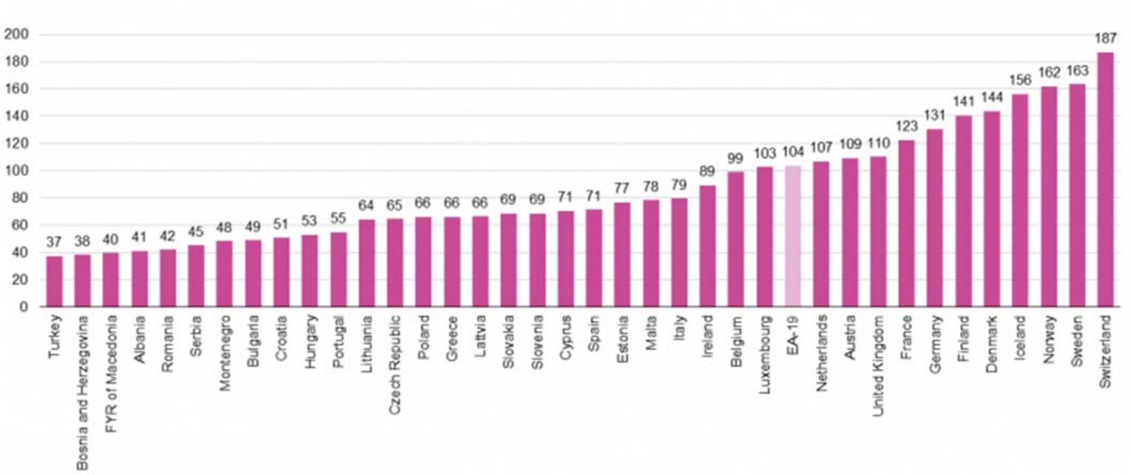

Figure 5: Comparative price level for investment, Construction 2015 (Eurostat 2016c)

2.2.2 The Eurostat statistics' research method

The Eurostat does international cost comparison for their indices on a yearly interval. Their comparisons are carried out using information retrieved from the different countries' collected prices. Eurostat's method of comparing the costs of construction is based on the Eurostat-OECD PPP programmes manual. The aim of the Eurostat-OECD comparison of construction prices is to compare the actual purchaser's prices in the participating countries and to compare them. This is in the field of construction a bit problematic as the products tend to be very country-specific and vary greatly even within a single country. On the other hand the statistics for which the collected purchasers' prices are used sets the demands for the used prices' comparability and representability high. To overcome this problematic nature of the construction fields' products' great variety, from the aspect of statistics at least, the comparisons for Eurostat are made using imaginary standard construction projects' bills of quantities. The use of imaginary projects makes it possible to achieve an acceptable level of both representability and comparability in the prices received form the countries. (Eurostat 2012)

The comparisons made for the EU statistics are formulated based on the data collected from bills of quantities of imaginary projects that have been sent out to the participating countries and that comprise of quantities of imaginary but comparable construction projects. The projects that's bills of quantities are sent out to the countries include in total only 8 projects. The projects are selected from 3 sub-groups that are residential and non-residential building projects and civil engineering works. The residential buildings sub-group is the largest and it consists of 4 bills of quantities; one for a detached house, one for a representative house from Portugal, one for a representative house from the Nordic countries and one for an apartment building. The Non-residential sub-group consists of one office and one factory building and the civil engineering works sub-group from one bridge and one asphalt road project. From the countries Eurostat asks for the filled bills of quantities with the actual prices that the purchasers of these projects pay for the different elements in the bills of quantities. The prices are to include the non-deductible VAT's thus representing the real cost to the purchaser. (Eurostat, 2012).

3. Data and Research Methods of the Comparison

3.1. Comparative case study research

The research method for this study is a comparative case study. The method used is a case study with the intention of comparing the costs and construction styles of the two locations studied. The comparative analysis and case study researching have both been used in social sciences (Miller & Brewer 2003) and much of the literature describing their use is from the social studies field. It has been stated to be a challenging research method due to the problem of analysing the results fairly but has also been recognised as a suitable method of research when the research questions include the questions how and why (Yin 2003). In case studying it is important to make a distinction between cases studied and the object of the research as they are not the same thing (Laine et al. 2007). The cases are the studied cases and the object of the research is the phenomena that shows in the cases studied. It is often the case with case studies that the point of the research is to reveal something concrete about the cases or something theoretical about the object of the research. The case study as a method differs from statistical studies in its emphasis and the level of detail. Whereas statistical studies use vast data in quantitative amounts and only focus in a small amount of characteristics the case study research typically uses only one of a few cases but studies their multiple characteristics in more detail than the statistical studies. Also the data is typically more of the qualitative type in case studying. (Laine et al. 2007)

In this study the cases studied are the Austrian residential projects in Graz, but the object of the research comparison are the costs of construction in the location of the cases and in another location. The aim of the research made is to find out how do the costs and construction differ between Graz and Helsinki and is there are costs differences why are they there.

The research method in this thesis's first study is in a way quite similar to the method that is used by Eurostat in the comparisons regarding the investment price indices for construction. The cases studied were estimated as imaginary projects with the features as they had been built in Graz but in the Helsinki price level. The cases were not originally imaginary as in the Eurostat method but the estimates were made of imaginary projects that did not actually exist in Helsinki with the aim of having comparable figures to compare from Graz and Helsinki.

3.2. Comparison Method

3.2.1. The comparison tool

The comparison was made using Haahtela corporations' Kustannustieto TAKU® -software. TAKU® is a cost estimating software for budgeting, estimating and steering of designs in a construction project. The software is divided in two parts, the Target costing tool and the estimation tool for building elements. The target costing is widely used for budgeting construction projects based on the projects characteristics. The target cost for a construction project can be set based on the user requirements for the spaces to be built. The estimation tool for building elements is used for estimating costs of a project based on designs. The estimating tool for building elements can be used to measure the differences between design solutions and through that in steering the designing process into the right direction to end up with financially viable designs. In the estimation of building elements the amounts for different building elements are drawn from the designs and then the different elements are priced according to the price lists in the program. Using these two methods in different phases if a construction project it is possible to first set the target cost at an acceptable level based on the needed spaces totally without designs being made first and in the following phases of the project to steer the design solutions towards the targeted cost level. (Haahtela & Kiiras 2015)

In this research both parts of the software were utilized in studying the cost differences between Graz and Helsinki and the prevailing price level in the two cities.

The TAKU® software includes a Haahtela –index that describes the price level of the selected location and time of the estimated project. The changes in the price level are followed with an index. The Haahtela-index is the index that index is used to describe the development of the prices of construction. According to the method, the price level variation has three points of view, the resource prices variation, inflation and cyclic change. The resource price level variation consists mainly of differences in the labor costs, average hourly earnings and man-hours and less of differences in the material prices because they are more easily transported and their manufacturing tends to locate itself based on favourable surroundings in places where production costs are lower. Inflation affects construction and construction price levels as it does the rest of the economy. The cyclical changes in price level are in the field of construction relatively high and the cyclical changes are measured by tender price indices, such as Haahtela-index. (Haahtela & Kiiras, 2015)

3.2.2. The comparison methods used

To get results that really tell something about the differences and to make it possible to discern where the differences in costs come from, the comparisons was divided into two main studies, and in total four types of estimates were made. The first estimations were made for the purpose of comparing the price level between Finland, Helsinki and Austria, Graz. The second phase was to compare differences on the resulting product, the multi-story apartment building, and in the issuing costs. Third estimates were made to clarify the factors causing the differences in the price level. In that phase closer comparisons between some of the structural elements were made. The elements to be compared were selected based on the data set available. The costs from which the financial information was comparable between the Austrian prices were selected for the closer comparisons made. When the results were ready the software used as the comparison method was tested for accuracy by estimating a Finnish project from the Helsinki Housing Production Department (ATT) from which the actualized cost data was available.

The estimates were first made using the price level of Helsinki in March 2016 and the resulting prices were then indexed back to the construction times of each of the project using the Haahtela index. In the case of Lassnitzhöhe the time where the estimate was indexed to was February 2013 and for the Badgasse February 2012.

In the Austrian projects' contract-phase cost material the following costs of the project were not included in the figures and hence these costs were excluded from the estimates for the projects in Finland also. The excluded costs include the following tasks of the project classified according to Construction 2000 Classification (Construction 2000 committee and Haahtela-kehitys Oy 2010) are:

- Design tasks
- Project management tasks
- Property management tasks
- User tasks and
- Project provisions

3.2.3. The first study

In the first part of the study the estimates were made to study the price level differences between Helsinki and Graz. For this comparison the two Austrian projects' Badgasse and Lassnitzhöhe projects' data was used. In this first phase the targeted result was to study the difference of the price level between Graz and Helsinki. To do this a cost estimate for constructing a similar residential unit, exactly as it has been built in Austria, was conducted with that distinction that the price level used was that of Helsinki. This estimation was done using the Kustannustieto TAKU® software and the building elements estimation tool of the software. The idea was to estimate the same projects as if they were built in Finland, in Helsinki at the same time as they had been built in Graz Austria and the amounts and building elements priced with the building elements estimation tool were drawn from the Austrian projects' drawings and specifications. All the projects' spaces, scope and amounts of different building elements were the same as they had been built in the two Austrian projects. Only the construction prices used in the estimate were Finnish and drawn from the Finnish price lists of the method. The first study was in a way a virtual transportation of the Austrian projects to Helsinki.

A couple of the elements of construction were such that they are not commonly used in Finnish construction and were not present in the estimating tool's price lists at all. These elements were replaced in the estimate using counterparts for them from that are commonly used in the Finnish construction field. These replaced construction elements and their counterparts were the following:

- Plastic windows (Fenster aus Kunsstoff) were replaced with wooden framed windows.
- The so-called sound-protection-brick masonry (Schallschutzziegel) was calculated as sand-brick-masonry that gives the same dB-insulation as the special masonry product used in Austria.

3.2.4. The second study

Target costing part of the Kustannustieto TAKU® software was used in this research's second part where the Austrian projects differences to the Finnish way of construction were studied. To study the differences between the buildings built in Graz area Austria and buildings built in the Helsinki area Finland, in the second part of the comparison new estimates were calculated for the two Austrian projects of Badgasse and Lassnitzhöhe projects again as if they were built in Helsinki but this time the projects' features were altered in a way that they would more correspond to the typical way of the Finnish construction.

The basic contents of the estimates were kept unchanged. The apartments were kept the same for their amounts, sizes and room counts. Also the amounts of underground parking places and the average size of balconies were kept unchanged. The founding circumstances were assumed to remain unchanged, so no difference would come from costly works like added piling or excavation of solid rock.

Design solutions were altered according to the default settings of the Kustannustieto TAKU® -method. For this reason for example the Badgasse projects' solution of multiple small houses has been replaced with the default designsolution of the method that is to model the residential unit in bigger building masses instead of the many small units solution used in Austria. On the other hand in the case of the Lassnitzhöhe project, the basic solution of balcony entrances is one that is also quite common in the Helsinki region so that was not replaced with a more efficient building mass like in the Badgasse project.

The common and technical spaces and the amount of aisles and stairways in the estimates were altered on the part of their scope according to the dimensioning of the software. The characteristics for the spaces were left according to the default setting of the software in order to end up with an estimate of a typical Finnish solution. The default settings of the program do not of course match any real project totally but they are set in the program in a way that the modelling of the software creates kind of a good guess of what might be the project if a similar set of apartments would be built in Helsinki.

The main features and characteristics of the apartments and the buildings that were altered from the original Austrian specifications to the second study were the following:

- The common spaces, garages, technical spaces and air raid shelters were dimensioned according to the Finnish way of construction
- Ventilation is constructed in the Finnish construction typically as centralized ventilation with heat recovery
- The foundation solution typical in Finland instead of the Austrian massive base floor solution is based on concrete footing and foundation walls when the plot circumstances are favourable to construction
- The structural frame solution was modelled as the typical Finnish solution using pre-fabricated concrete element structural frame instead of the Austrian cast-on site concrete and masonry construction
- The air-raid shelters are added to the estimates with the required scope of 2% of the floor area
- The load-bearing masonry walls were replaced with concrete element walls
- The outer walls were altered to meet the typical solution used Finnish construction that meet the requirements set to the heat-transfer coefficient of the building envelope by the Finnish regulation
- Kitchens and fixtures were added to the apartments
- The electrical connection points and information systems connection points were measured to correspond to the average amount in Finnish construction.

The form of contract is by default in the method the use of a general contractor that is the most common solution in Finland.

The classification of building elements used in categorizing the costs and structures in this comparison is Construction 2000 classification. It divides the elements of construction into the following grouping:

1. Building elements, with sub categories:

11 Site elements
12 Building elements and
13 Internal space elements
2. Service elements, with sub categories
21 Plumbing element
22 Air conditioning elements
23: Electrical elements
24 Data transfer elements and
25 Mechanical elements
3. Project-related tasks, with sub categories
31 Project management tasks
32 Design tasks
33 Construction management tasks
34 Site tasks
4. Property management tasks, with sub categories
41 Site tasks
42 Financing and marketing
5. User tasks
51 Space equipment
52 Maintenance and operation
6. Project provisions
61 Document and price level changes
62 Other provisions. (Construction 2000 committee and Haahtela-kehitys Oy 2010)

3.2.5. Assuring the accuracy of the method used

After actual studies were completed the method of estimating was tested for its accuracy. This was carried out by making an estimate in the similar method using a construction project from which the actualized contracting costs cost data was available for comparison with the test estimate. As the test project a residential project of the Helsinki Housing production department ATT in Jätkäsaari, Helsinki, was used. The estimate was made blinded in the way that the actualized costs of the project were only revealed after the estimates had been drawn. The result of the accuracy test to the method showed a 1 % difference between the estimates made and the actualized contracting costs of the test project giving credibility to the method used.

3.3. Comparison Data

The data used for the comparison included the blueprints and technical and financial data concerning 4 realised Austrian construction projects. The projects selected for the more detailed study and comparison were two typical examples of residential multi-storey buildings. The two selected projects had according to the Austrian FIAT- project participants been realised using typical solutions and structures in Austrian residential construction (Interviews 2016). In the beginning the dataset included four projects for the research but after initial study and classification of the data available the amount of projects studied in more detail was restricted to the selected two projects. The two other projects were used for those parts of the comparison that more data was found useful and available from their datasets. The data from these two additional projects was used for some of the unit prices’ price comparisons.

The projects studied in more detail were the Lassnitzhöhe residential site including 18 apartments and Badgasse residential site including 50 apartments. Both of the selected sites included underground parking facilities. The two other projects used partially were Karlsdorfer Ringbau residential project with 40 apartments and Flossendstrasse project with 44 apartments.

The data available for the study included from Lassnitzhöhe residential project the following data:

- structural, architectural, plumbing, heating and electrical drawings of the project
- financial information on the different contracts and tenders made for constructing the project

Additional information about the costs and the structures was given through email by the project participants in Austria during the calculation process. The financial information available on the project included the contract sums of the contracts of the different construction works of the project.

Badgasse project's data included:

- Architectural and electrical drawings along with additional information on the technical systems of the building.
- Financial information about the contracts and costs of the project

The financial information included the priced bills of quantities from the contracts. The contents and costs of the consultant works and information about the contents of the prices in the financial information of the project were also received by email from the Austrian participants concerning this project as well. As was the case with Lassnitzhöhe, in Badgasse too, not all the costs issued by the project were included in the financial information and the estimate for the comparison project was modified accordingly to match the available information of the data as well as possible. The Badgasse and Lassnitzhöhe projects are introduced in more detail in the following subchapters.

Because not all of the project costs were included in the data received from the Austrian projects the content of the estimates used for the comparison were modified accordingly to get comparable figures. The costs that were left out of the comparison included the project management tasks', designing tasks' and connection fees' costs.

In addition to the Austrian projects, two Finnish projects were also used in the analysing part of the results processing. They were mainly considered as reference and exemplary cases of the Finnish construction projects and how they are constructed. These Finnish projects were the Helsinki Housing Production Department's (ATT) Kangasalantie 13 residential project including 56 rental apartments in Vallila district in Helsinki and SATO Oyj's Kilvoituksentie 1 residential project including 42 apartments in Espoo. Of these projects, the data available for the comparison included the following:

- Architectural drawings and information about the technical systems of the building
- Financial information on the contract sums and cost of the projects

3.3.1. Badgasse Project

The Badgasse residential project consists of five separate apartment buildings and two underground garage facilities that are located in between the apartment buildings on the site. The project was built in the outskirts of Graz, Austria beginning in February 2012. The construction time for the project was 21 months.

The apartment buildings were all constructed quite similarly with a total of four floors. There were three floors above the ground level and a basement floor where the apartments' storage rooms, common drying rooms and the technical rooms were located. The apartments were located on the floors from the ground floor to the 3rd floor. The Garages were located underground in the same level with the apartment buildings' basement floors that had a straight access to the garages from them.

<u>The total scope of the project is:</u>

Gross floor area (GFA), apartment buildings: 6.625 sq.
Gross floor area (GFA), garage facilities: 1.599 sq.
Gross floor area (GFA), in total: 8.224 sq.

Apartment area (AA): 3.770 sq.
Amount of apartments: 50
Average apartment area: 75,4 sq./apartment
The apartments' division by room count:
2r+k, avg. 56 sq./apartment, 14 apartments
3r+k, avg. 75 sq./apartment, 14 apartments
4r+k, avg. 88 sq./apartment, 22 apartments

Apartments' common spaces: 741 sq.
Profitable area (PA): 4.511 sq.
Aisles and stairways: 851 sq.
Technical spaces: 71 sq.
Garage: 1.462 sq.
Amount of parking spaces: 52
Average space needed: 28,1 sq./parking place

Total apartment area , apartments: 5.432 sq.
Net area, total: 6.894 sq.

Efficiency rates are:
Gross floor area/net area, total scope: 1,193
Net area/apartment area, apartments: 1.44
Net area/profitable area, apartments: 1,20
Gross external area/Apartment area, apartments: 1.76
Gross external area/profitable area, apartments: 1,47

Plot area: 7.950 sq.
Plot efficiency, GFA/plot area: 1,03

The form of contracting was divided contracting. The contractee run multiple tendering rounds concerning different works and the different contractors were directly in contractual relationship with the contractee. There was a main contractor whose responsibilities included the site elements and coordination of the works but the main contractor was not responsible for the changes in the other contracts' scope or content. The financial issues were settled directly between each of the contractors and the contractee. The total amount of contractors in the project was according to the project data 18 contractors and the main contractors' share of the total contract sum of the project was approximately 60%.

The structural solutions differed a lot compared to the typical Finnish solution. Most notable differences were the ones concerning the construction technology of the building frame, the foundations and the way the ventilation had been constructed. The principles of the structural solutions used in the project and the site related tasks are explained below categorized by the Construction 2000 building classification (Construction 2000 committee and Haahtela-kehitys Oy 2010).

1 Building elements:
11 Site elements
In the Badgasse project the starting point for the project has been a fairly level plot with easily excavated soil material. No piling or excavation of solid rock has been needed to enable the construction. The amount of excavated material on the site was according to the data in total approximately 15.000 m3. Of this material approximately 1/3 was used for the fillings of the foundations and the site and 2/3 were either levelled on the site or disposed of. The fillings made were for the vast majority done using the excavated material. Of the total roughly 7.000 m3 of fillings only about 1.000 m3 were filled using gravel brought to the site. The site surfaces were for the majority of the site grass areas that used the exciting soil on the site as the growing medium. Only minimal amount of the grass areas were sown on brought humus. In addition to the grass areas, there were planted trees and shrubs among the green areas. The pathways and driveways were covered with asphalt and the parking areas surfaces were covered with lawn stones.

12 Building elements
121/122 Foundations and Ground floors
The foundations when considered keeping in mind those structures typical in Finnish construction, footings and foundation walls were in the case of Badgasse project nearly non-existent. The foundation system was based on a massive ground floor instead. Foundations were found under it only in special places. There was also a separate cleanliness layer included in the foundation system for the sake of simplifying the resulting structure. The constructing of the buildings is begun with levelling the site and casting an even layer of concrete cast at the bottom of the construction site before the actual construction is begun. The layer has no structural importance but its meaning is to serve as a clean base layer for the proceeding construction.

The structure of the ground floors was for the cellars and the garages as follows:
300mm ground floor slab in reinforced concrete
50mm shield layer of non-reinforced concrete
Bitumen layer

50mm layer of insulation
80mm thick cleanliness layer of concrete

The majority of all the structures of the building above were constructed on top of this massive ground floor and only on special places where there were especially hard burdens were additional foundations used.

123 Structural frame
The Structural frame was constructed mainly using cast on-site concrete and masonry wall structures. The load-bearing walls were for the majority of them 250mm thick masonry walls constructed using a local sound-isolation-brick. Parts of the load-bearing walls were also constructed using cast on-site reinforced concrete. The structural system of the apartment buildings was based on load-bearing walls, either in reinforced concrete or brick masonry, and cast on-site reinforced concrete intermediate floors and roofing decks. Columns and beams were used as the structural frame in the garages and they too were cast on-site reinforced concrete. Structural frame stairs and landings were also constructed using reinforced cast on-site concrete.

The structure for the intermediate floors and roofing decks for the apartment buildings was a 200 mm reinforced concrete slab. For the Garages' roofing decks the structure was a thicker, 300 mm reinforced concrete slab.

124 Façade
The Facades' exterior walls of the Badgasse project were constructed using both masonry or cast on-site concrete structural walls and thermal insulation as the exterior surface.

The structure for the exterior walls on the walls above the ground level was:
Inner wall surfaces
250 mm masonry structural wall/ 225mm of cast on-site concrete structural wall
160 mm insulation layer
10 mm plastering

Underground exterior wall structure was:
250 mm reinforced concrete wall
10 mm moisture insulation layer
30/100 mm insulation layer against the earth

The exterior walls' insulation layers were thicker on the apartment buildings' walls and significantly thinner in the garages' exterior walls. The windows were plastic framed double glazed thermal glass elements as the inner glazing and a separate single float glass as the outer glazing. The heat-transfer coefficient for the windows was 1,5 W/sq.K Exterior doors were for the part of the balcony doors the same structure as the windows and for the part of the building exterior doors veneered and lacquered wooden doors were used.

125 External decks

The Badgasse project included balconies for each of the apartment but no other external decks. There were for example no roof terraces. The balconies floor and roofing slabs were 180…240 mm thick concrete slabs suspended from the building’s structural frame. The balcony railings were constructed as crib railings and the balconies were not glazed, but included wooden panes that served as movable sun shades that could be moved around the balconies’ perimeter.

126 Roofs

The roofs were mainly constructed as green roofs with smaller areas constructed using a structure covered with gravel-topped bitumen. The roofing structures above the apartment buildings included the following layers:
100 mm green roof system
Protective layer of moisture block
150 mm Insulation layer
200 mm Insulation layer
Moisture block
(200 mm reinforced concrete roofing deck)

The structure for the roofing structures above the garages are:
Minimum 200 mm of Humus layer and grass seeds
Geosynthetics
50 mm layer of gravel
11 mm drainage composite layer
50 mm Insulation layer
Bitumen moisture block
(300 mm reinforced concrete roofing slab)

The eaves were quite simple structures with covering structures on top of the continuations of the exterior walls. They included the following:
Cover structure and flashings
Wooden under structure
Moisture block
Concrete structure with possible roof drainage pipes from upper roof to the lower

13 Internal space elements

131 Internal dividers

The partitions in Badgasse were mainly constructed as gypsum walls in the apartments and masonry walls in the common spaces. The bathroom walls included a separated installation space for technical installations.

The typical partition structure inside the apartment was:
Surface structures
12,5 mm/ 25 mm gypsum board (two boards in the bathroom/toilet partitions)
75 mm/100 mm metal frame (thinner frame in the bathroom/toilet partitions)

12,5 mm/ 25 mm gypsum boards

The typical bathroom partition structure with the installation room for the service elements was, between the apartment and the stairways:
Surface structure of the bathroom
Moisture block
50 mm mineral wool insulation
65 mm room for service elements' installation and filling
250 mm sound-isolation masonry wall
Plastered wall of the stairway

Internal doors were standard painted apartment doors. The apartment doors were wooden doors and included mail slots. The apartment door sound insulating capacity was 28dB and the door system only included a single door between the apartment and the stairway. In the stairways of the apartments there were light shafts by the elevator shafts. These were equipped with metal railings and horizontal grills between the floors.

132 Space surfaces
In the Badgasse project the most typical floor structures above the intermediate floor slabs were the following.

In the apartment floors the structure included the following:
8 mm parquet layer
60 mm swimming concrete surface slab
PAE-Folio layer
25 mm layer of mineral wool insulation
85 mm layer of EPS granules bound with concrete

The bathrooms'/toilets' floor structure included:
8 mm tiling
60 mm swimming concrete surface slab
PAE-Folio layer
30 mm layer of mineral wool insulation
PAE folio layer
80 mm layer of EPS granules bound with concrete

The stairways' floor structure included:
15 mm stoneware tiling
60 mm swimming concrete surface slab
PAE-Folio layer
30 mm layer of mineral wool insulation
PAE folio layer
95 mm layer of EPS granules bound with concrete (80mm for bathrooms, 95 for stairways)

The main floorings were parquet for the apartment floors, ceramic tiling with moisture block for bathrooms and toilets and stoneware tiling for the stairways. The other common spaces floor surfaces were finished mainly either with concrete or tiling and in smaller amounts with linoleum floorings. The ceilings and walls were for the majority of the spaces levelled and painted. The bathroom and toilet walls were tiled. There were no kitchens, appliances or fixed furniture included in the construction works.

2 Service elements
21 Plumbing elements
The buildings are connected to municipal water, wastewater and district heating networks.

The heating system of the apartment buildings is based on a joint heat exchanger that is located in the heating room located in one of the five buildings. This heat exchanger heats up a large buffer tank using district heating. The heated water is from the buffer tank directed through the garage to the other buildings and onwards to the apartment's radiators. The heat exchanger also pre-heats up water that is connected to the apartments own heat exchangers. The apartments include individual smaller heat exchangers in all the apartments that heat up the pre-heated water distributed from the main heat exchanger. The warm water needed in the apartment is heated to its final temperature with these apartment-based heat exchangers. In the apartments there are no buffer tanks.

22 Air conditioning elements
The air conditioning system in the Badgasse project is based on the apartments being ventilated through the windows. There is no controlled air supply system but there is mechanical air extraction from the toilets and the bathrooms. The air extraction is channelled to the roofs where there are small exhaust air blowers. There are sensors directing the airflow based on the air moisture level. Air supply of the apartments is designed to function based on the inhabitant's activity. There are no air inlets that would direct air in to replace the air that's being extracted. The idea of the system is that the inhabitants should ventilate the apartments by opening the windows as needed.

The garages include ventilation machines for air extraction from them. These exhaust air machines are directed by CO-sensors that control the amount of extracted airflow based on the CO-levels in the garages. The system also includes CO-level warning lights at the garage entrances that light up warning about the high levels of CO in the garage when needed.

23 Electrical elements
The electrical elements were mainly based on similar solutions as in the Finnish construction. The building was connected to the municipal grid and had no own power production. The amount of electrical connection points in the apartments was in average 31,5 connections/apartment.

24 Data transfer elements
The data transfer elements in the Badgasse project included antenna system, telephone system, intercom entry system and internet system. The antenna and telephone systems both include one connection point in each of the apartments, both located in the living room. The internet connection

points are located in all the bedrooms and in the living room. There are in average 4,6 connection points per apartment.

25 Mechanical elements
The mechanical elements in the case of the Badgasse project mean the elevators. There is one elevator in each of the building. The velocity of the elevators is 1m/s and its capacity is designed to accommodate either 8 persons or 630 kg. The elevators serve all the floors going from the underground level to the 3rd floor.

3.3.2. The Lassnitzhöhe project

The second more closely studied case in the research was the Lassnitzhöhe residential project built also in the outskirts of Graz beginning in February 2013. The construction time for the project was 20 months. The Lassnitzhöhe project consists of only one apartment building and one underground garage facility with additional parking space on the roof of the garage facility. The garage was located in a separate location on the site.

The Apartments building is in total 4 stories high building with balcony entrances. In the ground floor in half of the floor was taken up by apartments and the other half included a half floor basement where were located the apartments' storage rooms and the building's technical room. Above the ground floor there were two full floors of apartments and in the top floor was a partial one with a bit less than half of the scope apartments and a large common roof terrace and drying room for the residents use.

<u>The total scope of the project is:</u>

Gross floor area, apartment building: 2.202 sq.
Gross floor area, garage facility: 470 sq.
Gross floor area, total: 2.672 sq.

Apartment area: 1.381 sq.
Amount of apartments: 18
Average apartment area: 76,7 sq./apartment
The apartments' division by room count:
2r+k, avg, 53 sq./apartment, 5 apartments
3r+k, avg. 77 sq./apartment, 8 apartments
4r+k, avg. 100 sq./apartment, 5 apartments

Apartments' common spaces: 242 sq.
Profitable area: 1.623 sq.
Aisles and stairways: 264 sq.
Technical spaces: 19 sq.
Garage: 392 sq.
Amount of parking spaces: 18 (+18 on the roof)
Average space needed: 21,8 sq./parking place

Net area, apartments: 1.906 sq.
Net area, total: 2.298 sq.

Efficiency rates are:
Gross floor area/net area, total scope: 1,16
Net area/apartment area, apartments: 1,38
Net area/profitable area, apartments: 1,17
Gross floor area/Apartment area, apartments: 1,59
Gross floor area/profitable area, apartments: 1,36

Plot area: 2.865 sq.
Plot efficiency, GFA./plot area: 1,07

The form of contracting was also in the Lassnitzhöhe project divided contracting. The total amount of contractors in the project was 19 contractors and the main contractors' share of the total contract sum of the project was approximately 52 %.

As was the case with the Badgasse project the structural solutions differed a lot compared to the typical style of construction in Finland. A notable degree of similarity was to be noticed in comparison with the solutions of the Badgasse project. The structural solutions and the site related tasks are briefly explained below classified according to the Construction 2000 building classification (Construction 2000 committee and Haahtela-kehitys Oy 2010).

1 Building elements:
11 Site elements
In the Lassnitzhöhe project the starting point for the construction of the project has been quite similar as it was with the Badgasse project. No piling or excavation of solid rock was needed to enable the construction and the excavated material has been to some extent usable material for the fillings. The amount of excavated material on the site was in total approximately 3.250 m3. Of this material approximately 650 m3 was used for the fillings of the foundations and the site and the remaining 2.700 m3 was removed from the site. The total filling material brought to the site was in the Lassnitzhöhe project also quite minimal. Only about 15% of the total filling material was brought to the site. The site surfaces were in this project much like those in the Badgasse project. For the majority of the site the grass areas were installed with the existing soil functioning as the growing medium. The pathways, driveways to the garage and the parking area on the garage roof were covered with asphalt.

12 Building elements
121/122 Foundations and Ground floors
The foundations in the Lassnitzhöhe project were constructed on the part of were apartments on a ground floor resting on foundation walls. No footings were used. Where there were only the storage rooms in the ground floor the ground floor slab served also as the foundation just like in the Badgasse project. In the Lassnitzhöhe project as in the Badgasse project the site was levelled with an even cleanliness layer of concrete casting before the actual construction.

The structure of the ground floors was for the basement as follows:
300 mm ground floor slab in reinforced concrete
50 mm layer of insulation

80 mm thick cleanliness layer of concrete

The garage foundation floor structure was uninsulated:
350 mm reinforced concrete slab
80 mm cleanliness layer of concrete

123 Structural frame
The Structural frame was constructed mainly using cast on-site concrete and masonry wall structures. The load-bearing walls were for the majority 250mm thick masonry walls constructed using the local sound-isolation-brick just as in the Badgasse project. Parts of the load-bearing walls were also in the Lassnitzhöhe project constructed using cast on-site reinforced concrete. The structural system of the apartment buildings was based on load-bearing walls, either reinforced concrete or brick masonry, and cast on-site reinforced concrete intermediate floors and roofing decks. Structural frame stairs and landings were constructed using reinforced cast on-site concrete but the balcony entrances' slabs included a cast on-site concrete slab with a prefabricated concrete element slab on top of it. The garage's structural frame was based on a column and beam structure that consisted of cast on-site reinforced concrete.

The structure for the intermediate floors was a 180 mm reinforced concrete slab and the roofing deck's structure was a 200mm reinforced concrete slab. For the Garages' roofing decks the structure was a thicker, 350 mm reinforced concrete slab.

124 Façade
The exterior walls of the Lassnitzhöhe project were constructed using mainly masonry and partially cast on-site concrete structural walls and a thermal insulation exterior surface.

The structure for the exterior walls on the walls above the ground level is:
Inner wall surface
250 mm masonry structural wall/ 215mm of cast on-site concrete structural wall
140 mm insulation layer
7 mm plastering

The garage exterior wall structure, when not against the earth, is:
250 mm reinforced cast on site concrete wall
7 mm plastering

Basement exterior wall structure is for the apartment's part:
14 mm Gypsum boards
Moisture block
250 mm reinforced concrete wall
140 mm insulation layer against the earth

For the part of the storage spaces of the basement and the Garage the structure of the exterior wall against the earth is simpler:
250 mm reinforced concrete wall

50 mm insulation layer against the earth
The garage's exterior walls were when not against the earth, not insulated.

The windows were plastic framed and glazed with double glazed thermal glass elements as inner glazing and a separate single float glass as the outer glazing. Exterior doors were for the part of the balcony doors the same structure as the windows and for the part of the apartments' and other building's exterior doors wooden structured exterior doors.

125 External decks
The Lassnitzhöhe project includes very large balconies for most of the apartments. The apartments in the 3rd floor didn't include balconies but roof terraces that are also large. Average size of the balconies/roof terraces per apartment in the project is 27 sq. In the 3rd floor, on the roof of the 2nd floor there is also a large common roof terrace. The balconies structural slabs are 180…220 mm thick cast on-site concrete slabs suspended from the building's structural frame. Balcony roofs are also constructed from similar suspended concrete slabs. The balcony railings are constructed as crib railings. The balconies are not glazed.

The balcony entrances slabs structure is:
130mm pre-fabricated concrete element slab with a small stone surface
10 mm sound insulation foam layer
180… 200 mm cast on-site reinforced concrete slab
The railings of the balcony entrances were steel crib railings with partial steel structured grilles attached to them.

126 Roofs
The roofs in the Lassnitzhöhe project were constructed mainly as green roofs for the parts where they were not roof terraces. The main roofing structure of the apartment building's green roof is:
100 mm green roof system
Geosynthetics
Protective layer of moisture block
Moisture block layers
240 mm Insulation layer
Bitumen moisture block
(200 mm reinforced concrete roofing deck)

The structure for the roof terrace roofing structure is:
50 mm concrete tiles
10 mm rubber mat layer
Geosynthetics
Moisture block
330 mm Insulation layer
Bitumen moisture block
(200 mm reinforced concrete roofing slab)

The eaves were simple structures. The exterior wall continues higher to cover the roofing structures thickness on top of which there is an eaves structure covering the wall structure.

13 Internal space elements

131 Internal dividers

The partitions in Lassnitzhöhe were mainly 120mm thick plastered masonry walls. Internal doors were standard painted apartment doors. The apartment doors were wooden exterior doors to the balcony entrances.

132 Space surfaces

In the Lassnitzhöhe project the most typical floor structures above the intermediate floor slabs were, for apartment floors' structure:
8 mm parquet layer
60 mm swimming concrete surface slab
25 mm layer of mineral wool sound insulation
85 mm layer of EPS granules bound with concrete

The typical floor surface for bathrooms/toilets on top of the intermediate floor is:
10 mm ceramic tiling
60 mm swimming concrete surface slab
PE-Folio layer
25 mm layer of mineral wool insulation
105 mm layer of EPS granules bound with concrete

The main flooring surfaces were for the apartment parquet, for bathroom/toilets ceramic tiling and for the balcony entrances small stone surfaced concrete. The ceilings and walls were plastered and painted for the majority of them. The bathroom and toilet walls are tiled partially, approximately midway up the walls. There were no kitchens or other fixed furniture included in the construction works.

2 Service elements

21 Plumbing elements

The heating, water and waste water systems, are connected to municipal networks. The heating system of the apartment buildings is based on a joint heat exchanger that is located in the basement technical room in the basement. This heat exchanger heats up a large buffer tank using district heating. The heating water is from there on directed to the apartment's radiators and apartments separate smaller heat exchangers that heat up the warm water for the apartments.

22 Air conditioning elements

In the Lassnitzhöhe project the air conditioning system is also based on the apartments being ventilated through opening the windows. There is no controlled air supply system but there is mechanical air extraction from the kitchens, toilets and the bathrooms. The air extraction is channelled in shafts up to the roofs where the air is blown out. There are sensors that direct the airflow based on the air moisture level. Air supply is designed to function by the inhabitant's activity. There are no air inlets that would direct air in to replace the air that's being extracted by the blowers and the idea of the system is that the inhabitants ventilate the apartments by opening the windows as needed.

The garages include ventilation machines for air extraction from them. These exhaust air machines are directed by CO -sensors that controls the extracted airflow. The system also includes CO-level warning lights at the garage entrances.

23: Electrical elements
The amount of electrical connection points in the apartments was in average 28,5 connections/apartment. There were no electrical connection points in the garage.

24 Data transfer elements
The data transfer elements in the Lassnitzhöhe project included antenna system, telephone system and internet system. The antenna and telephone systems both include one connection point in each of the apartments, both located in the living room. The internet connection points are located in all the bedrooms and in the living room. There are in average 4,8 connection points per apartment. The garage was equipped with the CO2-detector that controlled the ventilation blower and exit signpost lights.

25 Mechanical elements
There is one elevator in the Lassnitzhöhe project. The velocity of the elevator is 1m/s and their capacity is designed to accommodate either 8 persons or 630 kg. The elevator serves all the floors going from the ground level to the 3rd floor. No other mechanical elements were included in the project.

3.3.3. Karlsdorfer Ringbau

The Karlsdorfer Ringbau –project included 2 buildings with an underground basement and 3 stories above the ground level. The buildings included 2 stairways each. In the basement floor were located the apartments' common spaces of the apartments that included the apartments' storage rooms and a drying room and the technical room. The apartments occupied the floors above the ground level.

<u>The total scope of the project is:</u>

Gross area, apartment building: 5.509 sq.
Gross area, garage facility: 1.472 sq.
Gross area, total: 6.981 sq.

Apartment area: 3.136 sq.
Amount of apartments: 40
Average apartment area: 78,4 sq./apartment
The apartments' division by room count:
2r+k, avg, 60 sq./apartment, 1 apartment
3r+k, avg. 74,1 sq./apartment, 27 apertments
4r+k, avg. 89,7 sq./apartment, 12 apartments

Apartments' common spaces: 387 sq.

Profitable area: 3.523 sq.
Aisles and stairways: 802 sq.
Technical spaces: 97 sq.
Garage: 1.472 sq.
Amount of parking spaces: 51
Average space needed: 28,9 sq./parking place

Net area, apartments: 4.422 sq.
Net area, total: 5.894 sq.

Efficiency rates are:
Gross area/net area, total scope: 1,24
Net area/apartment area, apartments: 1,41
Net area/profitable area, apartments: 1,26
Gross area/Apartment area, apartments: 1,76
Gross area/profitable area, apartments: 1,56

The form of contracting was in the Karlsdorfer Ringbau was divided contracting as in the other Austrian projects.

The Karlsdorfer Ring bau project's structures were for the majority similar to the Badgasse and Lassnitzhöhe solutions. The Karlsdorfer Ringbau project was used in the price level comparisons of the singular construction elements.

3.3.4. Flossendstrasse project

The Flossendstrasse –project includes 1 apartments building with an underground basement and 4 stories above the ground level. The building included 3 stairways. In the basement floor were located the apartments' common spaces of the apartments that included the apartments' storage rooms and a drying room and the technical room. The apartments occupied the floors above the ground level. The designs of the Flossendstrasse project were not complete on all accounts and the scope information is missing some points due to this. The project was used for the apartment's and common spaces' comparison. The Flossendstrasse project differs from the other Austrian project in that it is a passive house and includes a controlled ventilation system.

<u>The scope of the project is:</u>

Apartment area: 2.999,5 sq.
Amount of apartments: 44 pc
Average apartment area: 68,2 sq./apartment
The apartments' division by room count:
1r+k, 49,1 sq./apartment, 1 apartment
2r+k, avg, 47,1 sq./apartment, 16 apartments
3r+k, avg. 74,9 sq./apartment, 17 apartments
4r+k, avg. 92,4 sq./apartment, 10 apartments

Apartments' common spaces: 234,5 sq.
Profitable area: 3.234 sq.
Aisles and stairways: 1.074 sq.

Technical spaces: 260 sq.
Garage: 1.366 sq.
Amount of parking spaces: 44
Average space needed: 31 sq./parking place

Net area, apartments: 4.595 nsq.
Net area, total: 5.961 nsq.

Efficiency rates are:
Net area/apartment area, apartments: 1,53
Net area/profitable area, apartments: 1,42

3.3.5. Kangasalantie 13 project

Kangasalantie 13 residential project is one of the two projects selected for the comparison from Finland. The project is a 6 stories high residential building built by the Helsinki Housing Production Department (ATT) and includes 56 rental apartments. The construction was begun in the beginning of the year 2013 and the construction time was in total 21 months. The project includes in addition to the apartments also an underground garage facility adjacent to the building with 66 parking places.

The building has 6 stories above the ground level and an underground basement floor. The building includes 3 stairways. It's equipped with controlled air supply and extraction. In the Kangasalantie project none of the apartments include saunas. The common and technical spaces are located in the basement and in the top floor. The apartments occupy the middle floors. There are also 2 apartments in the top floor. The common spaces included house saunas, apartments' storage rooms, outdoor equipment, personal aid equipment and cycle storage rooms, clubroom, laundry room, drying room, waste disposal room and cleaning closet.

<u>The total scope of the project is:</u>

Gross area, apartment building: 6.145 sq.
Gross area, garage facility: 1.836 sq.
Gross area, total: 7.981 sq.

Apartment area: 3.877 sq.
Amount of apartments: 56
Average apartment area 70,2 sq./apartment
The apartments' division by room count:
1r+k, avg. 39,5 sq./apartment, 4 apartments
2r+k, avg, 57,1 sq./apartment, 21 apartments
3r+k, 76.4 sq./apartment, 18 apartments
4r+k, 90,6 sq./apartment, 12 apartments
5r+k, 110 sq./apartment, 1 apartments

Apartments' common spaces: 492 sq.
Profitable area: 4.369 sq.
Aisles and stairways: 580 sq.
Technical spaces: 149 sq. (inc. garage ventilation, 24,5 sq.)
Garage: 1.702 sq.

Amount of parking spaces: 66
Average space needed: 25,8 sq./parking place

Net area, apartments: 5.073,5 sq.
Net area, total: 6.800 sq.

Efficiency rates are:
Gross area/net area, total scope: 1,17
Net area/apartment area, apartments: 1,31
Net area/profitable area, apartments: 1,16
Gross area/Apartment area, apartments: 1,58
Gross area/profitable area, apartments: 1,83

Plot area: 3.485 sq.
Plot efficiency, sq./plot area: 2,3

The form of contracting was general contracting.

The main structures of the building are in short described below classified according to the Construction 2000 classification (Construction 2000 committee and Haahtela-kehitys Oy 2010).

1. Building elements
11 Site elements
A brown field plot. A small building was demolished before construction. To make the construction possible approximately 3.000 m3 of solid rock was excavated from the site. The site surfaces consist of asphalt, paved and green areas. There are two insulated additional buildings on the site where there are located the ventilation room for the garage and the outdoor equipment storages.

12 Building elements
121 Foundations
The building is founded on cast on-site concrete footings and foundation walls.

122 Base floors:
The base floors are built mainly using the following two structures:

Parts of the basement:
80mm reinforced concrete slab
300…500 mm insulation layer (thickness from the space needed for technical installations)
300 mm thick cast on-site load bearing and watertight reinforced concrete slab
50 mm of insulation
30 mm levelling sand
Minimum of 300 mm gravel
Geosynthetics

Other basement base floors:

15 mm floor material
3…20 mm levelling plaster
370 mm hollow core slab
170 mm insulation
Minimum of 1200 mm air space for a ventilated base floor
Minimum of 300 mm gravel
Geosynthetics

Garage base floors:
300 mm thick cast on-site load bearing and watertight reinforced concrete slab with
100 mm of insulation
30 mm levelling sand
Minimum of 300 mm gravel
Geosynthetics

123 The structural frame
The air-raid shelter is constructed in cast on site concrete structures with 300 mm thick walls and base floors and 400 mm thick intermediate floor above. Intermediate floors are mainly 370mm hollow core slabs in the apartments and 300 mm massive concrete pre-fabricated slabs in the stairways. The roofing decks above the apartments are 320 mm hollow core slabs and above the garage the roofing deck is a cast on-site post stressed reinforced 200 mm thick concrete slab. Columns and beams are cast on-site concrete and the loadbearing walls 200mm and 150 mm thick pre-fabricated concrete elements.

124 Exterior envelope
Building’s exterior envelope’s main structures are:

Basement exterior walls:
300 mm watertight reinforced cast on-site concrete wall
Bitumen moisture block
100/150 mm insulation

Exterior walls for the majority:
180 mm loadbearing prefabricated reinforced concrete element
225 mm insulation
130 mm masonry exterior
20 mm plastering

Apartments’ windows are wooden structured, the common spaces’ metal framed and the exterior door are metal structured.

The balconies are supported with pre-fabricated concrete elements as supporting walls and balcony slabs. All of the balconies are glazed.

The roofing structures above the roofing deck are not very typical solutions in the apartments’ case as the roofs are sloped. The apartments’ roofing structures are for the majority supported by rafters and insulated

with a total of 400 mm of insulation. The roofing of the apartments is a tin roof. The garage roofing solution is the following:
100…150 mm concrete of stone tiling
50 mm installation sand
200 mm expanded clay concrete
0…600 mm expanded clay
100 mm reinforced concrete slab
100 mm insulation
10mm drainage mat
bitumen moisture block
roofing deck

13 Internal space elements
Apartments' internal surfaces include laminate floors, levelled and painted wall and ceiling surfaces with partially suspended gypsum board ceilings where needed for technical installations. The moist spaces' walls and floor structures include moisture blocking and tiled surfaces. The apartments are equipped with kitchens, cupboards and standard additional equipment like towel hooks, toilet paper holder etc.

2 Service elements
The service elements are quite typical Finnish solutions. The building is connected to the district heating and municipal water and waste water systems and the municipal grid. The ventilation system is a controlled air supply and extraction for the whole building, including the common spaces and the garage.

3.3.6. Kilvoituksentie 1 project

Kilvoituksentie 1 residential project is the other one of the two projects selected for the comparison from Finland. The project includes residential buildings built by Sato in Espoo and includes 42 apartments in total. The construction was begun in July 2015 and is scheduled to be finished in January 2017 making the total construction time 18-19 months. There is no underground garage but the car parking is instead located outside and partially in separate shelters.

The buildings are both in total 6 stories high with just 1 stairway in each of the buildings. There are 5 floors above the ground level and one basement floor. It's equipped with controlled air supply and extraction. The common and technical spaces are located in the basement and the top floor and the apartments occupy the middle floors. The common spaces included house saunas for those apartments that don't include a sauna in the apartment, apartments' storage rooms, outdoor equipment, personal aid equipment and cycle storage rooms, drying rooms, waste disposal room and cleaning closet.

<u>The total scope of the project is:</u>

Gross area, apartment building: 3.845 sq.
Gross area, outside car shelters: 106 sq.
Gross area, total: 3.951 sq.

Apartment area: 2.378 sq.
Amount of apartments: 42
Average apartment area: 56,6 sq./apartment
The apartments' division by room count:
1r+k, avg. 32 sq./apartment, 2 apartments
2r+k, avg, 48,4 sq./apartment, 24 apartments
3r+k+s, 66,5/apartment, 12 apartments
4r+k+s, 88,8 sq./apartment, 4 apartments

Gross area/Apartment area, apartments: 1,62
Plot area: 9.740 sq.
Plot efficiency, sq./plot area: 0,4

The form of contracting was divided contracting with a main contractor and a technical contractor.

The main structures of the building are in short described below classified according to the Construction 2000 classification (Construction 2000 committee and Haahtela-kehitys Oy 2010).

1. Building elements
11 Site elements
Solid rock excavation was needed for founding the buildings. The site surfaces consist of asphalt, paved and green areas. There is a non-insulated shelter built on the site where are located the waste disposal room and part of the car parking.

12 Building elements
121 Foundations
The building is founded on cast on-site concrete footings and foundation walls.

122 Base floors:
The base floors are mainly 80mm reinforced concrete slabs cast against the earth with exterior insulation of 150 mm underneath. A small portion of the base floors is built using 370 mm hollow core slabs with 170 mm insulation.

123 The structural frame
The air-raid shelter is constructed in cast on site concrete structures with 300 mm thick walls and base floors and 300 mm thick intermediate floor above. Intermediate floors are mainly 370mm hollow core slabs in the apartments and 300 mm massive concrete pre-fabricated slabs in the stairways. The roofing decks above the apartments are 320 mm hollow core slabs.

124 Exterior envelope
Building's exterior envelope's main structures are the following:

Basement exterior walls:

Prefabricated sandwich-elements: 160mm concrete+240mm insulation+160mm concrete
Exterior moisture block (bitumen layer)

Exterior walls for the majority:
150 mm load-bearing/ non load-bearing pre-cast concrete elements
250 mm insulation
40 mm ventilation gap
135mm brick masonry outer or wooden surface

180 mm loadbearing prefabricated reinforced concrete element
225 mm insulation
130 mm masonry exterior
20 mm plastering

Windows are wooden structured and aluminium coated. The balconies are reinforced prefabricated balcony slabs supported with pre-fabricated concrete elements as supporting walls and columns. The balconies' railing are metal framed glass railings and most of the balconies are glazed.

Roofing structures are mainly of the two following types:
Roofs mainly:
Bitumen surface
40 mm concrete casting
Geosynthetics
600…750 mm expanded clay insulation
130 mm insulation
Bitumen moisture block

And the terraces:
80mm concrete casting
Bitumen moisture block
260 mm insulation
80 mm concrete slab

13 Internal space elements
Apartments' internal surfaces include laminate floors, levelled and painted wall and ceiling surfaces with partially suspended gypsum board ceilings where needed for technical installations. The moist spaces' walls and floor structures include moisture blocking and tiled surfaces. The apartments are equipped with kitchens, cupboards and standard additional equipment like towel hooks, toilet paper holder etc.

2 Service elements
The service elements are apart from the heating system typical Finnish solutions. The building is connected to the municipal water and waste water systems and the municipal grid. The ventilation system is a controlled air supply and extraction for the whole building, including the common spaces and the garage. The heating system is ground heating. The ground heating system is also used for cooling of the supply air in the summer time.

4. Differences of Construction and Construction Costs between Helsinki and Graz

4.1. Price level and total contracting costs

The actualized costs of the two Austrian projects studied when built in Austria and the two different estimates for studying the cost difference to Helsinki are displayed in the Table 1 below. In the same table there are also shown the actualized costs of the Finnish projects presented above. In the table the costs are divided by apartment area to give more comparable figures for different size projects.

Table 1: Actualized and estimated cost of the projects divided by apartment area

	Actualised costs in Graz €/sq. (Apartment area)	Estimated cost in Helsinki €/sq. (Apartment area)	Perceived difference in Price level, %	Estimated cost with modifications to Finnish construction, €/sq. (Apartment area)	Perceived difference in cost issuing from product differences, %
Badgasse	1634	1976	21	2215	12
Lassnitzhöhe	1549	2393	54	2748	15
Kangasalantie				1787	
Kilvoituksentie				1616	

The actualized contract costs of the Badgasse project in Austria, Graz were 6.160.000 €, equaling 1.634 €/sq. The estimated costs of the same project build in Helsinki in the same time and according to the Austrian original specifications, beginning in February 2013 is 7.450.000 €, 1.976 €/sq. and the estimate for the Badgasse project's alteration to Finnish construction 8.350.000 €, 2.215 €/sq. All of the figures excluding VAT.

The corresponding actualized costs of the Lassnitzhöhe project in Austria, Graz were 2.140.000 €, equaling 1.549 €/sq. The estimated costs of the project build in Helsinki in the same time and according to the Austrian original specifications, beginning in February 2012 is 3.305.000 €, 2.393 €/sq. and the estimate for the Badgasse project's alteration to Finnish construction 3.540.000 €, 2.748 €/sq. All of the figures excluding VAT.

It is easy to notice in the tables above that there's a great difference in the cost/apartment square meter actualized in the Austrian projects and that actualized in the Finnish projects. It can also be seen in the table above that the estimated costs of the Austrian projects' modified to the Finnish construction culture are far closer to the same level with the Finnish reference projects included in the comparison. This total difference comes from the difference in the two countries price level and from the differences between the solutions made in the Austrian projects and those used in the Finnish projects and in the estimates of the Austrian projects when modified to the Finnish culture of construction.

The observed total difference between the estimate describing the projects' as they would likely to be if they were built in Helsinki and the actualized cost of building them in Austria was in the Badgasse project 32% and in the Lassnitzhöhe project more than twice that much, 77%. The difference between the studied projects comes mainly from the price level difference and is explained by the resource use per square meter and the lower price of the resources used.

The observed price level difference between the same kind of a project built in Helsinki as has been built in Graz is in the case of Badgasse project, 1.1 M€ which equals

Austrian actualized cost of the project being 21% more expensive when built in Finland at the same time. For the Lassnitzhöhe project the observed difference in the price level is 1 M€, which equals 54% more when built in Finland at the same time making the percentage much more of a difference than in the Badgasse project. The 21% price level difference of the Badgasse project is quite closely in accordance with the Eurostat statistical findings from 2014 and 2015 described earlier in this thesis that showed a price level difference in Finland being from 16% to 23% higher than that of Austria depending on the year of statistics (Eurostat 2015d & 2016c). What is also to be remarked is that of the total difference in the price level change between the actualized costs in Graz and the estimated costs in Helsinki, the site tasks share accounts for a significant amount. The share of the site tasks of the total increase costs is in the Badgasse project 115 €/sq. and in the Lassnitzhöhe project 136 €/sq. If the effect of the site tasks' cost difference is removed from the figures, the pure price level difference was observed to be 14% in the Badgasse project and 46% in the Lassnitzhöhe project. The observed price level differences from the first study are shown in the table 2 below.

Table 2: Observed Price level differences in the studied projects

	Construction cost in Graz	Site tasks' additional cost in Helsinki		Other Price level factors' effect in costs		Estimated cost in Helsinki	Total price level difference
	€/sq. (AA)	%	€/sq. (AA)	%	€/sq. (AA)	€/sq. (AA)	%
Badgasse	1633	7	226	14	226	1976	21
Lassnitzhöhe	1549	9	137	46	707	2393	54

When considering the price level difference between Helsinki and Graz it is good to notice there is significant difference in the prices of construction within Finland as well. The statistics of ARA show that there are great differences in the costs of subsidized housing production within Finland as well. The average cost of construction without the plot acquisition or rental costs during the construction and the connection fees was in 2015 in the whole country 2.883 €/sq. The average for Helsinki region is 3.120 €/sq. and for other growing areas of Finland the average cost was 2.592 €/sq. (Asumisen rahoitus- ja kehittämisekeskus, 2016) The ARA statistics are not comparable to the FIAT project calculations because the ARA figures include the costs of designing and project management that were excluded from this research. The difference between Helsinki region and other growing areas is notable though. The statistics show the difference between the Helsinki region and the other growth centres of Finland to be 20%. Again this difference includes also factors that are not taken into consideration in this thesis, such as differences in the site conditions that are in the Helsinki region typically difficult.

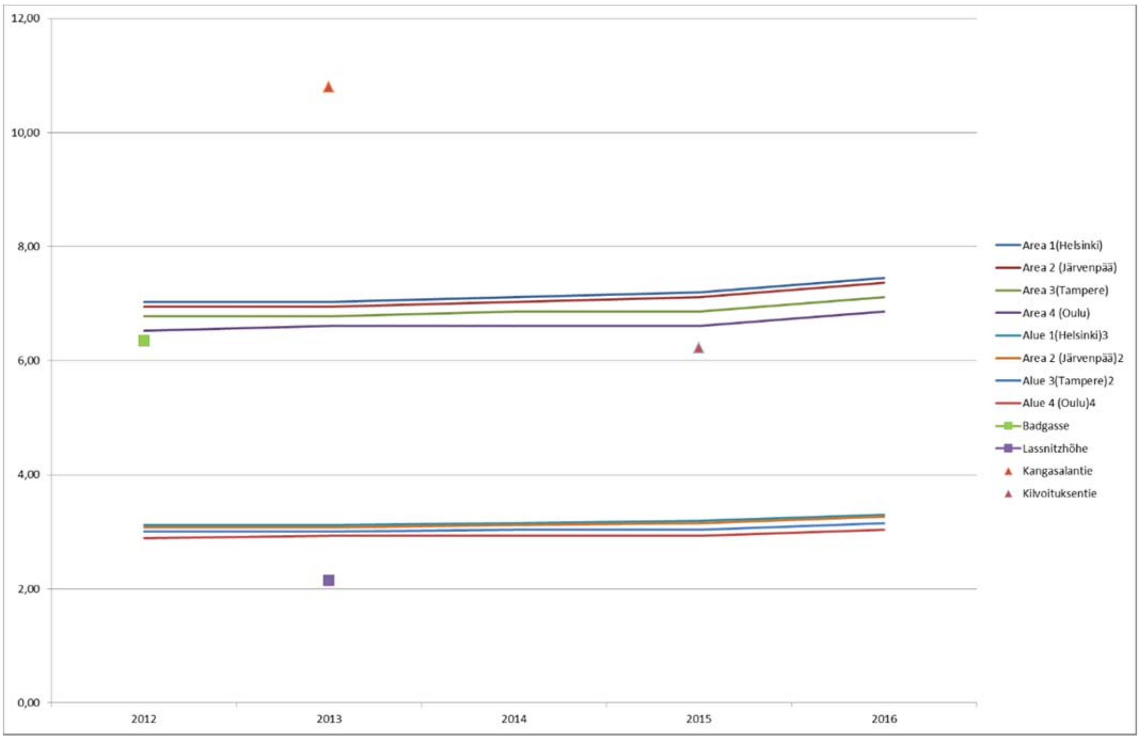

Figure 6: The estimated and actualized cost on different price levels of Finland

The difference in the price level is not that great within Finland but a big portion of the difference in the average costs comes from the differences in the production. The figure 6 above shows the estimates for the Austrian projects in different Finnish price levels which illustrates difference to the price level in Graz when compared across that in Finland in general. The two projects' actualized costs at the times of their construction in Graz are shown in the picture as dots.

Because the car parking is a major issue in the construction costs of the whole project, its construction costs were also separated from the costs of constructing the apartments. The costs divided between the apartments and the garages are shown in the table 3 below.

As can be seen in the table 3 the costs of the garages when divided by the amount of parking spaces built are over double when compared the typical style of constructing them in Finland in the Helsinki price level and the typical solution built in Graz in the Graz price level. Further it is clear that the majority of the difference in the garages' costs comes from the difference in the way they are built. The biggest issues with the garages are the bigger scope and the huge difference in their technical specifications demanded in Finland. These are further explained later on in the statistics but in a nut shell the Finnish cars compared to their Austrian counterparts enjoy a far better indoor air quality and have more room around them in their storage facilities which causes the cost difference to be so big.

Table 3: The costs of the projects divided between the apartments and garages

	Austrian actualized costs	Project estimated in Helsinki	Project modified to Finnish construction
Badgasse			
total, €	6 159 752	7 450 765	8 351 806
€/am2	1 634	1 976	2 215
Garage, €	589 040	812 641	1 212 858
€/parking place	11 328	15 628	23 324
Apartments, €	5 570 712	6 638 124	7 138 948
€/am2	1 478	1 761	1 894
Lassnitzhöhe			
total, €	2 139 370	3 304 273	3 794 591
€/am2	1 549	2 393	2 748
Garage, €	285 795	424 231	632 041
€/parking place	15 878	23 568	35 113
Apartments, €	1 853 575	2 880 042	3 162 550
€/am2	1 342	2 085	2 290

The perceived difference in the price level differed greatly between the two projects studied. The reasons that commonly contribute to the differences in price levels are studied earlier in this thesis. The reasons explaining the difference between the two projects noticed price level was left somewhat unclearned though. There is a difference to be noticed also in the actualized project costs in Graz too. The Lassnitzhöhe project's actualized costs are 85 €/sq. smaller than those of the Badgasse project. The difference is even higher if the costs of only the apartments are being compared. The cost per car parking place has been higher in Lassnitzhöhe than in Badgasse and the cost per apartment square meter without the cost of the garage has been 136 €/sq. less in the Lassnitzhöhe project compared to the Badgasse one. This poses a slight mystery as for its features the Lassnitzhöhe project seems to be posing more expensive solutions such as big balconies that were for their average size 3 times bigger than those in the Badgasse project and the roofing structures that included big roof terraces. In addition to that the project size was less than half of the Badgasse project so synergy benefits in controlling costs should've been smaller. The only numeric reasons that is to be seen as explaining the Badgasse project being the more expensive one of the two are its poorer design efficiency and smaller average apartment size and the massing of the building into 5 separate masses. It was also observed that the studied individual building elements prices the Lassnitzhöhe project were lower than the Badgasse project's prices in four out of the six studied elements. The Austrian project participants explained the difference being due to more strict regulation in the Badgasse project that was a subsidized project unlike the Lassnitzhöhe project. Further clarification for that statement was not discovered from the data. The only explanation found is shown in the table 4 below. The table shows the costs divided by gross square meters of the project and in that inspection the Lassnitzhöhe project's actualized unit price is 52 €/sq. higher than that of the Badgasse project. This gives some explanation to the difference in the price level study also. As there were big differences noticed in the comparison of the individual building elements these are multiplied in the price level study when the projects' realization requires more resources/ apartment square meter compared to the Badgasse project.

Table 4: Costs and cost differences divided by the gross square meters of the projects

	Actual unit cost in Graz €/sq. (GFA)	Estimated cost in Helsinki €/sq. (GFA)	Perceived difference in Price level, %	Estimated cost with modifications to Finnish construction, €/sq. GFA)	Perceived difference in cost issuing from product differences, %
Badgasse	749	906	21	1016	12
Lassnitzhöhe	801	1237	54	1420	14
Karlsdorfer Ringbau	725				
Kangasalantie				1354	
Kilvoituksentie				1574	

The reasons explaining the price level differences for which numeric figures were found from the data and the statistics in this thesis were the price differences of individual building elements and the cost differences in the site tasks price. The other elements affecting the price level and the reasons behind the differences of the prices of individual building elements cannot be numerically stated based on the data of this study but possible reasons were discovered. These include the differences in the organization of the project, risk division between the contractor and the contractee and the utilized form of contracting that are discussed later after the design and structural solutions inspection.

The labor costs differences were studied based on statistical information. According to the Eurostat’s statistics the mean annual earnings’ average in the construction field in their survey on the structure of earning in the year 2010 was in Austria 36.270 € and in Finland 40.608 € (Eurostat, 2010). Based on these statistics the mean earnings on the annual scale have been 12 % higher in Finland than in Austria. The difference is higher if looked at average hourly earnings figures. The average hourly earnings in the year 2010 were for construction in Finland 18,45 €/hour and in Austria 14,16 €/hour, the difference being 4,29 €/hour which equals a difference of 30 % (Eurostat, 2010). The hourly statistics don’t however take into account bonuses etc. that are not paid each pay period that are taken into account in the annual statistics. When the statistics are searched for the labour costs the difference vanishes though. The latest Eurstat statistics show that the hourly labour costs are actually slightly lower in Finland when compared with Austria (Eurostat 2015c) overall it seems that there is probably not a significant difference in the labor costs section that would explain the price level.

What was a explanatory aspect to the price level was the study of the individual building elements prices. There were significant price differences noticed between individual building elements that were studied more closely. The elements chosen for closer inspection were selected based on what data was available in comparable figures from different projects in Austria. For this comparison also the data from the Karlsdorfer Ringbau project was used. The Flossendstrasse project could not be utilized as the more detailed data on the costs of that project was not available. The elements that were found similar from all of the studied projects were the following:

- The ground floor slab, thickness 300 mm reinforced with reinforcement of 33,3 kg/m3.
- Cast on-site concrete wall, thickness 250 mm, reinforcement 13,4 kg/sq..
- Concrete intermediate floor slab, 200 mm cast on-site, reinforcement 16,5 kg/sq.
- Schallschutzziegel, 250 mm.
- Exterior wall thermal plastering, with insulation layer of 140 mm thin plastering on top. This element was found with slightly different thicknesses of the plastering between 7mm and 10 mm. The Finnish counterpart has been estimated with 7 mm of plastering.

- 60 mm thick swimming flooring concrete slab with impact sound insulation of 25/30 mm. The Finnish comparison estimate has been estimated with 30 mm of impact sound insulation.

The resulting price differences are shown in the figure 6 below. In the table the blue and red pieces of the columns are the different components of the works compared and the green part (only visible in the Finnish prices) is the share of the site management costs and contractor's margins in the price. The subcontracting prices meaning prices without the site management costs and the main contractor's margins are not significantly higher in Finland when compared to the Austrian prices. The tasks included in the green column are not unnecessary in the Finnish prices either but the fact that they are included in the Austrian prices suggests that a lighter organization is in place in the Austrian sites compared to the Finnish sites. The recent years have seen the site personnel at least in Finland becoming all the time more burdened with new paper tasks, like controlling CE- certificates, contractors' and sub-contractors' and their workers' different papers and certificates regarding taxes, work permits etc. that all take their time. It may be that for example these obligations are handled in a different way in Austria and a lighter organization is adequate. As more detailed information on the Austrian sites was not available this remains a point of interest for another study.

First comparison was the ground floor slab. The structure was found very similar in all of the studied Austrian projects. The 300 mm ground floor slab was found in all of the projects. There was slight variation to be found in the amount of reinforcement in the slabs but as the tenders where the prices were drawn from were based on bills of quantities the amounts were easily made comparable by adding the reinforcement with the same amount in all of the compared prices. The Finnish estimate for the ground floor slab was estimated with the same features as the Austrian structures but as the Austrian tender prices included in addition to the costs of the concrete, formwork and the reinforcement also the costs of the site management and contractor's profit. These costs were also added to the Finnish estimate in addition to the costs of the concrete works. The components of the different prices in the comparison of the concrete ground slab are the concrete with casting and formwork in blue, reinforcement in red and in the Helsinki figure the costs of site management and contractor's margin in green. The Austrian projects' prices for the ground floor differed between 142 and 199 euros per cubic meter of concrete. The Finnish estimate for the ground slab was 293 €/cubic meter of concrete. The Austrian tenders all informed the price as cubic meters. The corresponding prices per square meter of the 300 mm thick ground slab differ between 40 and 60 €/sq. whereas the corresponding Finnish estimate equals 88 €/sq. of which the site management and contractor's profit account for 13,4 €/sq. The average for the Austrian actualized costs was 48,2 €/sq. which makes the Finnish estimate 82% higher than the Austrian figure.

The comparison for the concrete wall was made in the same fashion as with the concrete floor slab. The thickness found in all of the Austrian project was 250 mm and the amount of reinforcement was set to 13,4 kg/sq. in all of the cases and the resulting price variation of the Austrian projects varied between 79 and 101 €/sq.. The perceived price level difference to the Helsinki estimate was much smaller in the wall than it was in the ground slab. The Finnish estimate for the wall was 109 €/sq. The average price from the Austrian projects was 90 €/sq. which makes the Finnish, estimate 21% more expensive than the average Austrian price.

The intermediate floor slab was compared like the other concrete parts. The amount of reinforcement in the slab was unified to 16,5 kg/sq. and the slab was selected as 200 mm thick because that was the thickness found in all three Austrian projects. What is notable in the horizontal concrete parts is the difference in the reinforcement price. The reinforcement prices when combined the reinforcement material and work is in both slabs over double the cost of the Austrian actualized costs.

The third compared unit price was that of the masonry works. The selected element that was found as similar in all of the Austrian projects was the 250 mm thick masonry product ‘schallschutzziegel’. This article does not exist in the Finnish construction and it was in the estimate replaced with 2x130mm sandbrick masonry wall that gives the same sound insulation level as the original product from Austria. The price for the original product differed in the Austrian projects between 54 and 84 €/sq. the average price for it being 64 €/sq.. The estimated price for the Finnish counterpart was 124 €/sq. which equals 93% more than the Austrian price. Of the Finnish price the site management and the contractor’s profits accounted for 20 €/sq.. Here the comparison is not quite valid as the products as dissimilar as the Austrian product as such does not exist in the Finnish construction. It could also be considered that the more accurate comparison for the Austrian ‘schallschutzziegel’ –wall structure would be the pre-fabriceted concrete element in thickness of 180/200mm. The estimated comparison price for the pre-fabricated concrete element with thickness of 180 mm would be 100,3 €/sq. which equals 56% more than the Austrian product.

The thermal plastering as the exterior wall surface was found to be the prevailing structure in the studied Austrian projects with all of the studied projects constructed with similar structure. There were differences in the thickness of the insulation that varied between 140 and 160 mm. The 140 mm thickness was found in all of the bills of quantities and was selected as the compared structure because of that. There is slight variation in the Austrian prices in the thickness of the plastering on top of the insulation, which was in the Lassnitzhöhe 7 mm and in the Badgasse project 10 mm. The Finnish estimate was estimated with a 7 mm plastering. The prices for the thermal plastering in the Austrian projects varied between 45 and 58 €/sq. the average being 51 €/sq.. The Finnish estimate for the thermal plastering is 71 €/sq. including site management and contractor’s margin costs 13 €/sq.. The estimated Finnish price was 39% higher than the Austrian average.

The last compared element was the swimming concrete floor slab that was found with only small variation in all of the Austrian projects. The Austrian prices’ variation for the swimming surface floor slab varied between 23 and 31 €/sq., the average price being 28 €/sq.. The Finnish estimate for the swimming floor slab was 37 €/sq., including site management and contractor’s margin costs 6 €/sq. This makes the Finnish estimate 32% more expensive than the Austrian actualized prices.

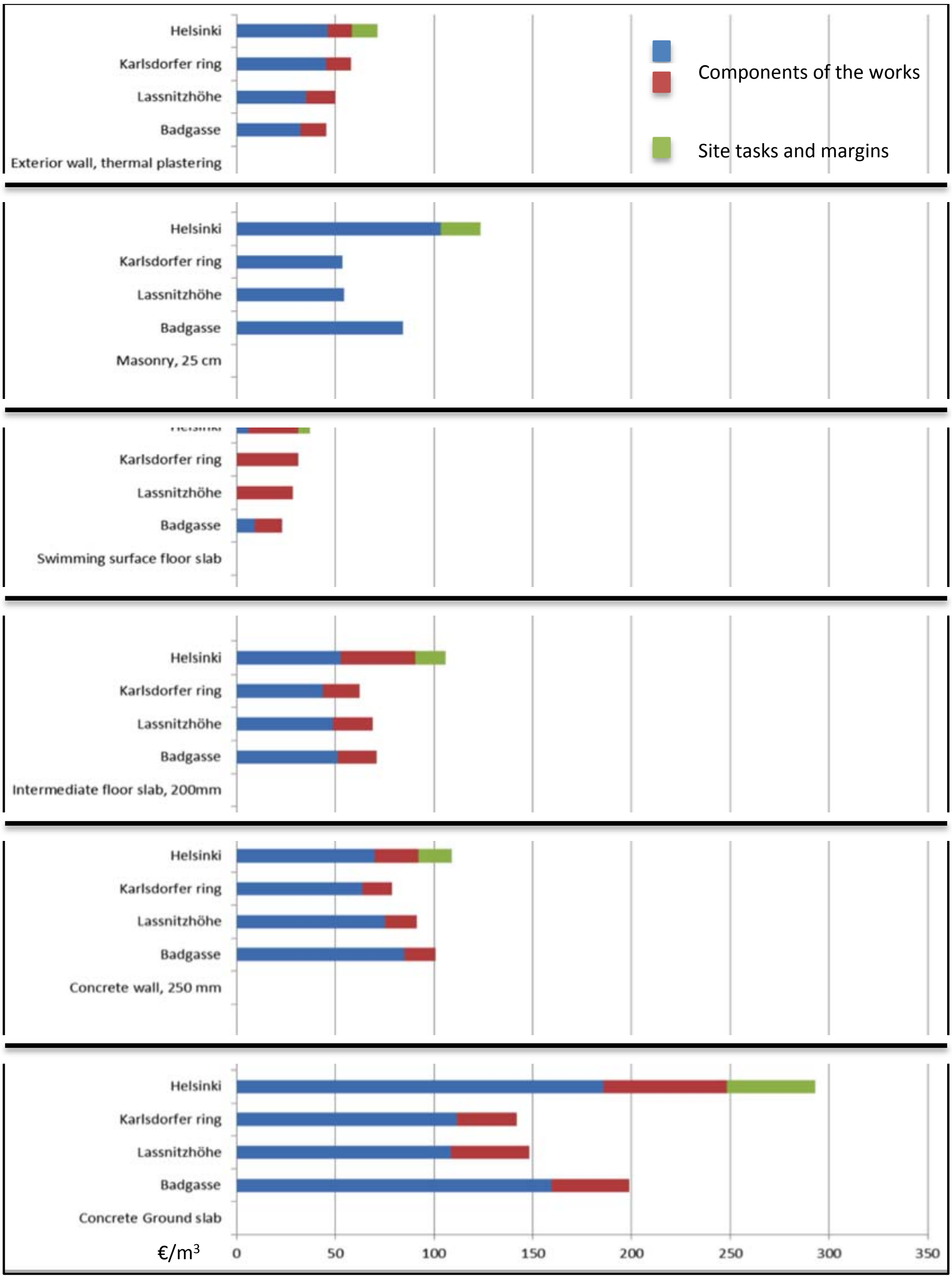

Figure 6: Differences in the individual building elements' costs

If the Ground slab and masonry works are excluded from the comparison the average price level difference between the remaining building elements, concrete walls, swimming surface slab and the exterior wall thermal plastering is still 30% higher in the Finnish estimate.

For the service elements' part the differences went both ways. The cost components of the service elements for different projects are shown below in the Picture 6.

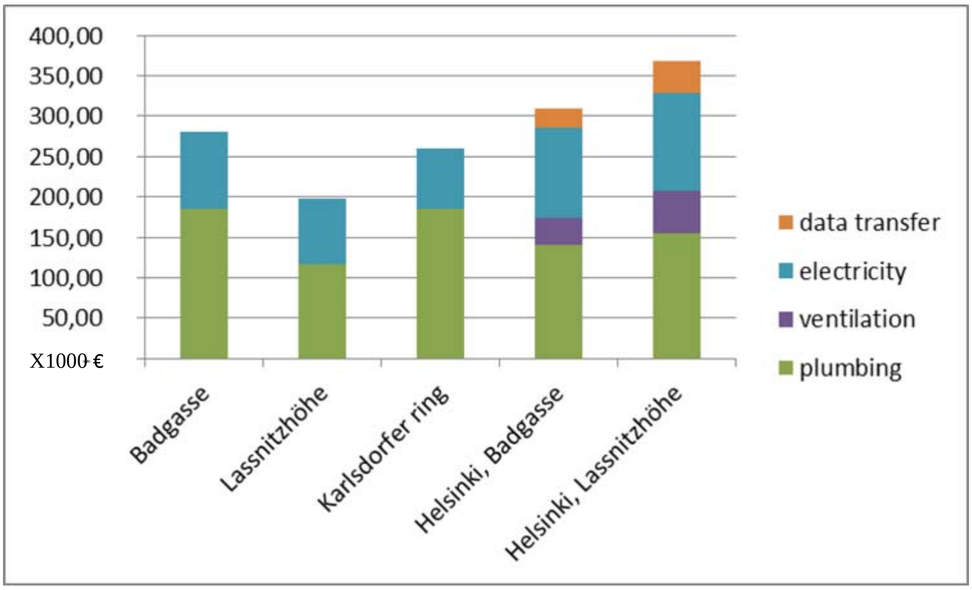

Figure 7: The cost differences of the service elements

In the figure 7 the green plumbing part of the column includes the plumbing and ventilation works and the blue part includes both the electricity and data transfer elements for the Austrian projects as their costs were combined in the data. These are separated for the Finnish estimates for the same projects. It can be seen that the plumbing part was cheaper when estimated in Finland but all the other parts of the service elements were more expensive. This may in part be due to the solutions difference compared to the Finnish construction. The estimate for the double system of the heat-exchangers may include an error and may have been slightly underestimated for its costs in the first estimate in Finland. The system is not used in Finland so the estimate was made based on the bigger heat exchangers' pricing and the more correct price for a small-scale unit might be higher. The electrical systems and data transfer systems were estimated based on the amounts of connection points from the Austrian projects' designs.

4.2. Differences in Scope and Spaces

Both of the Austrian projects, The Badgasse and Lassnitzhöhe residential projects' input data regarding the additional spaces that would be built in addition to the apartments were altered for their second estimates in order to get them to correspond to the Finnish culture of construction. The spaces were altered to mirror the demands set by the Finnish regulations and the municipal building control departments and RT- standard guidance cards' recommendations that are commonly referred to in the Finnish construction field. To modify the Austrian projects into the Finnish culture of construction results in some additional spaces to be built that were not included in the Austrian scope and the alteration of the extents of some of the spaces that exist in both the Austrian projects and the likely Finnish solution. The changes in the projects' scopes go both ways. To one direction as said some spaces required in Finland did not exist at all in the Austrian projects and to the other direction some spaces were required in Finland in extents much less than had been built in the Austrian projects.

The demand for constructing the spaces either totally in addition to the Austrian project's scope or with an altered extent comes mainly from the either the Helsinki area's Building control departments' joint guidance concerning the common spaces of apartment buildings or from the RT-guide cards describing the dimensioning of some of the common spaces for residential buildings. The Helsinki area's Building control departments' guidance includes both obligatory and suggested common spaces to be built with the required/recommended extents for them. For the majority of the common spaces of apartment buildings there is no direct legislation demanding them to be built. Only the air raid shelters are spaces that are built in Finland directly due to the demands of the legislation (Rescue Act 379/2011, Valtioneuvoston asetus väestönsuojista 408/2011). The case of the ventilation room is a borderline case there, the binding regulations do not directly say that it would be obligatory to be built but on the other hand the instructions for the indoor air quality and energy efficiency requirements set for new buildings tend to in the design process lead to the need of a controlled mechanical air supply and extraction which then naturally leads to the need for the space for the ventilation room also (Building Code of Finland, parts D2 and D3).

The apartments' common spaces are programmed and dimensioned in the study as said based on the Helsinki region building control departments' standard for what kind of common spaces are to be built into residential building projects in the area. Not all the spaces in the guidance lists are obligatory. For the recommended spaces the guidance states that if they are not built the designs have to show room for extension where they can be built later on. It is also said in the guide that it is to be adhered to unless otherwise stated in the city plan which leads to the spaces being in most cases built according to the guide. (Helsinki area's building control departments' 2010)

Of the spaces in the guide the ones stated as obligatory in the following extents are:

- Outdoor equipment/Cycle storage, demanded extent 1,5-2 sq./apartment and 1,5-2 Cycle parking places/apartment (may be located in the outdoor equipment storage)
- Baby buggies/Personal aids storage, demanded extent 0,3-0,5 sq./apartment
- Storage room for the apartments, demanded extent 2-3 sq./apartment
- Cleaning room and house maintenance storage, 1 /building

The requirement for the extent of the different storage spaces is required by the guidance so that the smaller amount of space is required for each apartment with 1 to 2 room and the larger extent for each apartment with 3 or more rooms. The cycle storage spaces requirement is given according to the same division but instead of extent of the space as cycle storage places. (Helsinki area's building control departments' 2010) In the second study's estimate the cycle storage is included in the Outdoor equipment storage spaces, so that the outdoor equipment storage is dimensioned by the cycles' amount. The dimensioning of the cycle storage is based on the RT- guide card stating the needed space for parking of a bike to be 0,6m in width and 2 m in length with a minimum distance to the opposing bike storages being 1,75 m in inside storage spaces (Rakennustietosäätiö RTS 2016).

The spaces that are listed in the guidance as recommended to be built with their recommended extents are the following:

- Laundry room, recommended extent between 8 to 26 sq. based on the amount of apartments
- Drying rooms, recommended amount 1/20 apartments with a recommended extent 10sq./drying room
- Club room, to be built in projects with more than 20 apartments, extent 1,5 % of the floor area that has been calculated according to the demands of the city plan
- Common Sauna departments, recommendation 1 department/20 apartments that do not include a sauna. The sauna departments are to include the following spaces: dressing room for 4 persons, bathroom with 2 showers, the sauna for 4 persons and an outdoor cooling area. (Helsinki area's building control departments, 2010)

The dimensioning of the Sauna departments is modelled according to the RT-guide card that gives recommendations for the extents of the spaces included in the sauna department as measurements for the space needed for going to the sauna, washing and changing the clothes. The same card also includes ready design options for different sauna layouts and gives recommended measurements for dimensioning the spaces for the disabled. (Haahtela & Kiiras 2015, Rakennustietosäätiö RTS 1990)

The extent for the air raid shelter is given in the Finnish legislation as 2 % of the total floor area (Rescue Act 379/2011). The total floor area in the estimate is calculated according to a Helsinki city guidance that states that the floor area that is used for dimensioning spaces should be the project's total floor area without the stairways' area (Helsinki, 2014).

The garage dimensioning in the Finnish style estimates is based on the RT-guide cards that state the recommended extents for single car spaces and the distance between them. There are differences to the Austrian projects dimensioning that causes the Finnish garages with the same use to be larger than those built in the Austrian projects. The extent of the Finnish requirements estimate comes from the recommendations in the RT-guide cards that state that the free width of the parking space is to be 2,5 m and the distance between the opposing parking spaces is to be 8 m (Rakennustietosäätiö RTS 2010a). The minimum free height of the garage is stated is stated as 2,5m (Rakennustietosäätiö RTS 2010a). The differences to the Austrian projects' garages' extents come from this Finnish guidance's that are commonly regarded as requirements. In the Austrian projects garages were smaller on all dimensions. The width of the parking space was 2,5m but it was not the free width of the space but the structures were allowed to take their space of that width. The columns were in the projects positioned between the parking spaces in the way that they took some of the space of the parking spaces. In Finland it's considered an acceptable solution if the column are in the opposite end of the parking space from the aisle. The distance between the opposing parking spaces in other words the driveway's width was also significantly smaller in the Austrian projects being only 6 m. The garages were also significantly lower in their free height. In the projects studied the room heights varied commonly between 2,4 to 2,5 meters but the lowest free heights were as low as 2,2 m on some of the driveways' doors and due to the technical installation in the garages' roofs. According to the Austrian participants the minimum requirement for the free height of the garage is 2,1 m (Interviews 2016). In the added costs of the garage shows also the technical difference in them. The Finnish estimate's garages are for example equipped with controlled air supply and extraction just as the apartments. The amount of air to be extracted from the garages is stated already in the building codes, making the good indoor air quality of the garages a legislative factor in construction costs. (National Building code of Finland, part D2)

The extent for the part of the Aisles and stairways in the Finnish requirements estimate comes from the automatic dimensioning of the estimation software used. The amount of these spaces is dimensioned based on the RT -guide cards recommendations (Haahtela & Kiiras, 2015). The differences to the Austrian solutions mainly come from the different massing of the building that is modelled by the estimation tool. The software masses the modelled Finnish style building as bigger building masses, 1-2 buildings instead of the small house like multi building complex constructed in the Austrian project. This results in a more efficient design as the basis of the estimate. There was not a notable difference in the aisles or stairways' widths.

For the Badgasse project the alteration to the spaces accounted in total to an increase of 96 sq. of scope measured in room area, which account for a 1,4% increase in the project's net area. Cost wise the total effect of the differences in the scope and spaces built is in the case of Badgasse 145.000 € which equals 16% of the total difference due to the difference in construction style.

The changes in individual spaces were bigger but as a whole they partly annulled each other in terms of added and subtracted space. The spaces that didn't exist in the Austrian project and were added to the estimate for the Finnish way of construction were:

- The house saunas, 3 pcs with a total scope of 99 sq.
- Laundry room, 23 sq.
- Cleaning closets, 10,6 sq.
- The extra space needed for the air raid Shelter, 19 sq.
- The ventilation room, 228 sq.

The spaces that were altered for their extent were the following:

- Garage, +169,5 sq.
- Cycle and sports equipment storage, +12,7 sq.
- Space for the baby buggies and other aiding equipment, -5,5 sq.
- Apartment's storage rooms, -151,9 sq.
- Waste disposal room, -21,6 sq.
- Drying rooms, -102 sq.
- Common club room spaces, + 9,1 sq.
- Aisles and stairways, -159,2 sq.
- Technical rooms, excluding the ventilation room, -35 sq.

The scopes of common and technical spaces, aisles, stairways and garages in the Badgasse project with the differences in scope and cost between the Austrian Badgasse project and the Finnish modification are shown in the Table 5 below.

Table 5:Badgasse projects scope differences when modified to Finnish construction

Spaces with different scopes	Austrian project, sqm	Finnish culture, sqm	Difference, sqm	Resulting difference in cost, €
Garage	1461,1	1631	169,5	145808
Outdoor equipment/Cycle storage	149,3	162	12,7	19787
Baby buggies/Personal aid storage	33,5	28	-5,5	-6600
Apartments' own storages	299,9	148	-151,9	-167090
Cleaning/House storage	0	10,6	10,6	28090
Waste disposal	71,6	50	-21,6	-52826
Additional space for ARS	0	19	19	22800
Laundry room	0	23	23	49450
Drying rooms	126,9	24,9	-102	-122400
Clubroom facilities	59,9	69	9,1	11375
Sauna departments	0	99	99	210000
Aisles and stairways	828,2	669	-159,2	-312277
Ventilation room	0	228	228	353400
Technical rooms, excl. Ventilation	51,8	16,8	-35	-35000
	3082,2	3178,3	95,7	144517

For the Lassnitzhöhe project the alterations to the spaces accounted in total to an increase of 143,5 sq. of scope measured in room area, which accounts for a somewhat bigger increase in the net area than that in Badgasse, 6,2%. When turned into cost difference the total estimated cost effect of the changes in the scope and spaces in the Lassnitzhöhe case was 175.000 € which equals 36% of the total difference in the construction style. This relatively bigger effect is mainly due to the smaller annulling effect of the Austrian spaces that were built as larger in Austria than would be their scope in Finland, which again is due to the Lassnitzhöhe project's smaller size. The table's sauna department's scope in the Austrian actualized scope is not a sauna department but a toilet that was built adjacent to the drying room on the roof of the Lassnitzhöhe project in Austria.

The spaces that didn't exist in the Austrian project and were added to the estimate for the Finnish way of construction were:

- The house sauna department, 1 pc with a total scope of 32,9 sq.
- Laundry room, 14 sq.
- Cleaning closet, 4,3 sq.
- The extra space needed for the air raid Shelter, 11 sq.
- The ventilation room, 56 sq.

The spaces that were altered for their extent were the following:

- Garage, +105 sq.
- Cycle and sports equipment storage, -10 sq.
- Space for the baby buggies and other aiding equipment, 10 sq.
- Apartment's storage rooms, -41 sq.
- Waste disposal room, -1 sq.
- Drying rooms, -7 sq.
- Aisles and stairways, -4,4 sq.
- Technical rooms, excluding the ventilation room, +3,7 sq.

The scopes of common and technical spaces, aisles, stairways and garages in the Lassnitzhöhe project with the differences in cost and scope between the actualized project and the estimate for Finnish construction are shown in the Table 6 below.

Table 6:Lassnitzhöhe project's scope changes when modified to Finnish construction

Spaces with different scopes	Austrian project, sqm	Finnish culture, sqm	Difference, sqm	Resulting difference in cost, €
Garage	392	497	105	89626
Outdoor equipment/Cycle storage	64	54	-10	-15580
Baby buggies/Personal aid storage	0	10	10	12000
Apartments' own storages	94	53	-41	-45100
Cleaning/House storage	0	4,3	4,3	11395
Waste disposal	23	22	-1	-2446
Additional space for ARS	0	11	11	13200
Laundry room	0	14	14	30100
Drying rooms	17	10	-7	-8400
Clubroom facilities	0	0	0	0
Sauna departments	1,6	34,5	32,9	69788
Aisles and stairways	337	302,6	-34,4	-67477
Ventilation room	0	56	56	86800
Technical rooms, excl. Ventilation	19	22,7	3,7	3700
	947,6	1091,1	143,5	177606

4.3. Differences in Design and Structural Solutions

Differences noticed between the buildings build in Austria and the typical ways to build in Finland were many. Most of them were however related to the same theme, the Austrian way to construct seems to be less complicated than that in Finland. This more simplified culture of construction can be seen in nearly all over the buildings compared. There are fewer structure types in all of the building elements and the basic massing of the buildings is quite simple.

There is also a clear difference in the culture of construction when it comes to constructing on-site or using prefabricated elements. In Finland the percentage of structures in buildings' frame structures has according to the statistics made by the concrete industry been about 1/3 and of the frame structures of the multi-story residential buildings' frame structures even 74 % in the year 2008 (www.betoniteollisuus.fi). In comparison all four of the Austrian projects included in the FIAT project were built with cast on-site concrete slabs and with the loadbearing walls done mainly in masonry and partly using cast on-site concrete. Differences are also to be noted in the ways of managing the projects, division of the tasks between the contractee, designers and the contractors and the resulting risk division between the contractee and the contractor.

The apartments differed between the Finnish and Austrian projects with their average apartment sizes and the apartment divisions. The apartment sizes and their averages are shown in the Table 7 below.

Table 7: Apartments' sizes in the studied projects

	Kangasalantie	Kilvoituksentie	Badgasse	Lassnitzhöhe	Karlsdorfer Ring	Flossendstrasse
Apartment area, sq.	3877	2378	3770	1381	3136	2999
Apartment amount	56	42	50	18	40	44
Average size of an apartment	70,2	56,6	75,4	76,7	78,4	68,2

As can be seen in the table the Austrian projects' apartments were bigger in comparison to the Finnish projects' apartments. In the Finnish projects the average apartment size when both projects are combined is 63,8 square meters/apartment, in the Austrian projects the average size of an apartment is 74,3 square meters/apartment. In the Austrian projects the average apartment sizes were more than 10 square meters larger than in the Finnish projects. There was also a difference in the apartment division in the projects. The division of the apartments in the studied projects is shown in the following tables 8 and 9 below.

Table 8; Apartments division in the projects studied

Apartment division	Kangasalantie apartments	Kilvoituksentie apartments	Badgasse apartments	Lassnitzhöhe apartments	Karlsdorfer Ring apartments	Flossendstrasse apartments
1 room	4	2				1
2 rooms	21	24	14	5	1	16
3 rooms	18	12	14	8	27	17
4 rooms	12	4	22	5	12	10
5 rooms	1					

Table 9:Apartments' division by room count in percenteges

Apartment division	Kangasalantie %	Kilvoituksentie %	Badgasse %	Lassnitzhöhe %	Karlsdorfer Ring %	Flossendstrasse %
1 room	7	5	0	0	0	2
2 rooms	38	57	28	28	3	36
3 rooms	32	29	28	44	68	39
4 rooms	21	10	44	28	30	23
5 rooms	2	0	0	0	0	0

The tables 8 and 9 show the amount of different sized apartments based on their room count and their percentage of the total amount of apartments in the project. When combined by country it can be seen that in Finland the majority of the apartments built in the projects are two-room apartments and in Austria the prevailing room count is three. This may be a fact more related to the location of the projects than the actual division in the countries but in the studied projects the Austrian ones were larger.

The Finnish projects were also higher in comparison to the Austrian ones. The floor counts in the Finnish projects were 5 and 6 floors above the ground level whereas in the Austrian projects were for the majority only 3 floors high. Only the Flosslendstrasse project was 4 stories high above the ground level. It was also the only Austrian project with a controlled ventilation system. What was notable in the Flossendstrasse was the location of the technical spaces. All the technical spaces were located in the Basement. In Finland the fire protection reasons state that the ventilation machines are to be located above the spaces that they serve. The floor heights were also lower in the

Austrian project compared to the Finnish projects. The floor height in Finnish construction is already regulated by the building code as minimum floor height of 3 m (National building code of Finland, part G1).

The classification of the Austrian financial figures in the data received was quite different from that used by the estimation tool used. This is of course resulting of the date received. The Austrian data included the contractors' tenders that were in practice the bills of quantities of the projects with prices included. The division is then naturally done by the works contracted instead of the building elements. The comparison of individual building elements was for this reason done separately from the comparison of the whole costs. In the Tables 10 and 11 below, are however shown the estimated sums for different building elements and the actualized costs of the Austrian projects side by side.

Table 10:Badgasse project's estimated and actualised costs' cost-breakdown

			Study 1: Austrian project in Helsinki, costs €	Study 2: Project altered to Finnish construction costs €	Australian actualised cost and contract division	€
1		**Building elements**	**5.467.029**	**5.970.291**	**Building elements**	**4.944.211**
11		Site elements	499.843	529.642	Site works	322.573
12		Building elements			Clearing	6.087
121		Foundations	54.772	240.197	Drainage	6.428
122		Ground floors	395.419	104.381	Site Structures	135.956
123		Structural frame			Asphalt works	27.849
	1231	Civil defence shelters		79.698	Channels	74.483
	1232	Bearing walls	134.338	204.109	Gardening works	18.549
	1233	Columns	65.486	62.521	Playground works	5.964
	1234	Beams	45.266	58.577	Other	2.721
	1234	Intermediate floors, roofing decks	797.153	585.979	Concrete works	1.686.970
	1237	Structural frame stairs	71.392	86.996	Masonry works	680.914
124		Facades			Exterior walls	223.708
	1241	External walls	953.616	1.256.184	Windows, balcony doors	241.691
	1242	Windows	262.336	274.784	Plastering works	177.756
	1243	External doors	62.529	85.638	Sealing, waterproofing	59.198
125		External decks			Fillerworks	178.996
	1251	Balconies	331.293	394.434	Roofing works	318.252
126		Roofs	389.455	261.804	Tiling works	161.727
13		Internal space elements			Railings, Gratings etc.	137.691
131		Internal dividers			Doors, mailboxes	98.877
	1311	Partitions	623.550	512.519	Carpenter works	23.976
	1315	Internal doors	130.841	189.501	Painting works	56.305
132		Space surfaces			Parquet, floor works	104.155
	1321	Floor surfaces, Floorings	348.073	411.119	Partitions,ceilings,surfaces	190.664
	1323/ 1324	Ceiling surfaces and finishes	122.189	201.357	Fire extinguishers	2.721
	1325	Wall surfaces, finishings	179.478	239.585		
133		Internal fixtures		191.266		
2		**Service elements**	**1.341.508**	**1.727.397**	**Service elements**	**1.197.357**
21		Plumbing elements	527.517	476.094	Plumbing, Ventilation	682.982
22		Air conditioning elements	129.384	390.182	Heatcounter	13.546
23		Electrical elements	421.428	545.157	Electricity works	360.829
24		Data transfer elements	88.020	104.197		
25		Mechanical elements	175.159	211.767	Elevator works	140.000
3		**Project-related task**	**642.228**	**654.117**	**Project-related tasks**	**208.690**
31		Project management tasks	not incl.	not.incl.	Site general costs	185.824
32		Design tasks	not incl.	not.incl.	Cleaning	22.866
33		Construction management tasks	inc.above	inc.above		
34		site tasks	642.228	654.117		
		Total	**7.450.765**	**8.351.805**	**Total excl.VAT**	**6.350.258**
					Discount on all contracts -3%	6.159.750

Table 11: Lassnitzhöhe project's estimated and actualised costs' cost break-down

		Study 1: Austrian project in Helsinki, costs €	Study 2: Project altered to Finnish construction costs €	Australian actualised cost and contract division	€
1	**Building elements**	**2.512.426**	**2.729.269**	**Building elements**	**1.784.763**
11	Site elements	264.894	265.308	Site works	68.396
12	Building elements			Clearing	4.192
				Clearing	12.374
121/122	Foundations, Ground floors	179.876	124.762	Water management works	643
123	Structural frame			Drainage	8.758
1231	Civil defence shelters		38.516	Site Structures	18.635
1232	Bearing walls	43.643	53.603	Asphalt works	48.892
1233	Columns	48.283	52.675	Channels	50.140
1234	Beams	42.791	49.599	Gardening works	5.106
1234	Intermediate floors, roofing decks	320.334	201.783	Sandbox	4.403
1237	Structural frame stairs	35.380	46.877		
124	Facades			Concrete works	591.199
1241	External walls	422.158	565.248	Masonry works	131.411
1242	Windows	144.252	155.912	Exterior walls	88.156
1243	External doors	44.751	50.055	Windows, balcony doors	77.623
125	External decks			Plastering works	54.037
1251	Balconies	258.331	314.567	Sealing, waterproofing	79.365
126	Roofs	178.475	131.073	Fillerworks	49.701
13	Internal space elements			Roofing works	164.926
131	Internal dividers			Tiling works	56.353
1311	Partitions	115.654	92.977	Railings, Gratings etc.	147.787
1315	Internal doors	85.680	111.398	Doors, mailboxes	41.620
132	Space surfaces			Carpenter works	30.711
1321	Floor surfaces, Floorings	193.682	216.471	Painting works	14.402
1323/ 1324	Ceiling surfaces and finishes	50.290	62.637	Parquet, floor works	34.881
1325	Wall surfaces, finishings	83.952	99.325		
133	Internal fixtures		96.483	Fire extinguishers	1.052
2	**Service elements**	**559.549**	**782.542**	**Service elements**	**309.632**
21	Plumbing elements	212.780	177.738	Plumbing, Ventilation	91.302
22	Air conditioning elements	74.173	232.148	Heating	69.485
23	Electrical elements	166.161	210.896	Electricity works	113.285
24	Data transfer elements	56.498	91.061		
25	Mechanical elements	49.937	70.699	Elevator works	35.560
3	**Project-related task**	**232.300**	**282.779**	**Project-related tasks**	**44.978**
31	Project management tasks	not incl.	not incl.	Site general costs	21.471
32	Design tasks	not incl.	not incl.	Cleaning	5.042
33	Construction management tasks	inc. Above	inc. Above	Other	9.505
34	site tasks	232.300	282.779	Weather Shelter	8.960
	Total	**3.304.275**	**3.794.590**	**Total excl.VAT**	**2.139.373**

In the Building elements differences can be seen in all of the categories, the building elements, service elements and proportionally most prominently in the project-related tasks. The difference of the site tasks is great between the Austrian actualized costs and the estimate for constructing it the same way in Finland but only small increase can be seen between the two estimates estimated in Finland. This is because the estimating tool models the site task in the Finnish way already in the first estimate for Finland and the difference between the two estimates is only small due to the added scope of the project.

The differences between the estimates and the modifications made to them on the two Austrian projects, Badgasse and Lassnitzhöhe are explained below with the discovered effects in the construction costs. For the sake of clarity the differences are categorized by the construction 2000 classification the same way as the main features of the projects were before. The features are mainly the default values from the estimation tool and the changes made to them are explained under each element. The differences in structures and their amounts between the two estimates are described below using the categorisation of Construction 2000 classification (Construction 2000 committee and Haahtela-kehitys 2010).

1 Building elements:

11 Site elements

The most visible difference when it comes to the site elements is the use of the excavated material on site. On the Austrian sites the use of delivered chisel was not nearly as common as it is in Finland and the use of the excavated material for the foundation fillings was much more common. This suggests that there are differences in the characteristics of the construction sites available. The Finnish comparison sites are all located in the Helsinki metropolitan area where many of the sites nowadays constructed are in the middle of the existing city structure, on brownfield plots or in parts of the area that have been left unconstructed by the previous generations due to difficult site characteristics and availability of easier plots at the time. The regulations in Finland do not categorically counter the use of excavated material as long as the filling material used for the fillings meets the demands set for the fillings of the foundations. These demands set by in the legislation take a stand to the strength and solidity and the amount of impurities in the filling material (Rakennustietosäätiö 2010b). The general quality standards for the soil works also only sets demands to the validity of the filling material based on its loadbearing capacity or the evenness of the resulting surface (RT 14-11005 2010). The site elements include mainly excavation and filling elements, soil stabilization and reinforcement elements, paved and green areas and the site equipment and constructions (Building 2000 Committee and Haahtela-kehitys 2010). For the stabilization, reinforcement, paved and green areas and the site constructions differ much between each individual plot and project even within the same country, they were kept unchanged in the estimate for the Finnish construction style as well. The differences in amounts excavated, disposed and filling materials brought to the site differed in the studied projects as follows:

For Badgasse project the difference in the massing of the buildings decreased the total needed excavation amount by 1/3 and the needed filling material by approximately 40%. The excavated material amount to be disposed of however roughly doubled because none of it was used for the fillings.

For the Lassnitzhöhe the changes were smaller in comparison to Badgasse. This was because in the Lassnitzhöhe project the majority of the excavated material was also originally disposed of and the changes in the amounts of the excavated material and needed fillings were for the Lassnitzhöhe project quite small. The amount of excavated material decreased roughly by 30% due to the difference in the massing of the garage. The Finnish typical solution is to build the garage in adjunction to the building or under it which compared to the Austrian solution decreased the needed excavated amount. The filling material amount in total remained approximately the same but the amount of filling material brought to the site was in the Lassnitzhöhe project also nearly doubled. The cost difference was not very significant in either of the projects as the effects go both ways.

12 Building elements

121/122 Foundations and Ground floors

The foundations in the Finnish estimates are modelled based on typical solutions used in Finland when site conditions are favorable. The buildings are when it's possible typically founded on cast on-site concrete foundations that include footings on top of which stand the foundation walls. The Base floor structures in the Finnish estimates are the following:

Main base floor structure:
80mm cast on-site reinforced concrete base floor slab
150 mm insulation underneath
Air raid shelter base floor structure:
150 mm cast on-site reinforced concrete base floor slab
150mm insulation underneath

The heat-transfer coefficients for base floors are 0,16 W/sq.K.

The differences in the total amount of concrete used for the foundations and ground floors are significantly smaller in the Finnish construction style compared to the Austrian solution of construction. In the Badgasse project the total amount of concrete calculated from the bill of quantity in the foundations and ground floors was roughly 1.600 m3 where as in the Finnish estimate the total amount was approximately only 650 sq.. As a result the foundations and ground floor slabs combined were estimated at approximately 20-25% more expensive constructed in the Austrian way compared to the Finnish way when both solutions were estimated to be built in Helsinki.

123 Structural frame

The Structural frame in the Finnish style estimates is modelled very similarly to both of the projects studied. The structural frame is constructed mainly using prefabricated concrete elements.

The load-bearing walls are modelled as prefabricated concrete element walls. The thickness of the walls is mainly 180 mm and partially 200 mm. The Air-raid shelters' walls are 300mm thick cast on-site reinforced concrete walls.

The structure for the intermediate floors and roofing decks is mainly the hollow core slab with a thickness of 320mm in the apartments' intermediate floors, and 500 mm in the garage roofing deck and the intermediate floor between the apartment floors and the garage. The roofing decks above the apartments are thinner, 200 and 265 mm thick hollow core slabs. The stairways intermediate floors are 260 mm thick prefabricated reinforced massive concrete slabs which are a common structural solution in Finland. The use of on-site cast concrete slabs is minimal compared to the Austrian projects' structures. Only small amounts of cast on-site concrete slabs are modelled into the Finnish style estimate.

The differences on structural elements amounts were in the Badgasse notable especially on the account of the roofing decks. The amount of roofing decks was decreased nearly by half and replaced by the intermediate floor decks due to the massing alterations in the project. Other than that the modelling of the Finnish solution added to the amount of column and decreased the extent of the ground floor by 1/3.

The differences in amounts were in the Lassnitzhöhe project for the majority not very significant. The added space has added the amount of intermediate floor slabs accordingly and the slightly different massing with the garage decreased the amount of ground floor slightly.

In total the cost difference of the whole structural frame was not a very significant. The difference in the cost of the whole structural frame is bigger in the Lassnitzhöhe project than in the Badgasse project due to the effect of the garage's structures. In the Lassnitzhöhe the differences in the amounts of the different part so As a whole, in the estimates the other parts of the frame that are common in both countries were a little more expensive in the Finnish solution but the intermediate floors and roofing decks were a lot cheaper in comparison to the Austrian solution. This is due to the software modelling the frame slabs mainly as hollow core slabs that are widely used in Finland and that are quite inexpensive compared to the cast on-site concrete floor slabs. The estimated price for the hollow core intermediate floor slab is 59 €/sq. and for a 200 mm cast on-site concrete intermediate floor slab 96 €/sq.. In the structural parts a matter that adds costs to the Finnish style estimate in both projects is the construction of the air-raid-shelter. The construction of the air-raid shelter made the structures of the spaces built approximately 60 % more expensive than they would've been if the spaces were built with the same structures as the surrounding spaces.

124 Façade
The exterior walls are modelled by default in the estimate using typical structures in Finnish construction projects. The exterior wall structures in the estimate are thus again similar in both cases. The biggest differences to the Austrian typical solution with the facades are the structure of the exterior wall and the windows. The exterior walls typical structure in the Finnish estimate is constructed with pre-fabricated concrete elements as the structural part instead of masonry walls and an added masonry layer underneath the plastering.

The structure for the exterior walls on the walls above the ground level is:
Inner wall surfaces
200 mm pre-fabricated reinforced concrete element
275 mm insulation layer
50 mm wind blocking insulation layer

85 mm masonry exterior
20 mm plastering

The garage and basement exterior wall structure against the earth is:
Inner wall surfaces
250 mm cast on-site reinforced concrete wall
moisture block
150 mm insulation layer

The windows and exterior doors in the modelled estimate are aluminium structured windows and exterior doors. The modelled structures fulfil the demands of the Building Code of Finland for their energy efficiency. The heat-transfer coefficients for the modelled structures windows and exterior doors is 1,0 W/sq.K and for the exterior walls 0,17 W/sq.K. Replacing the wooden framed windows with aluminium structured windows was a 5% more expensive solution in the estimates.

For the facades amounts differed somewhat in the two studied projects' estimates in the Lassnitzhöhe project the amount of the building's envelope decreased by 9% when modified to the Finnish construction culture. The amount of exterior walls and windows combined in the Badgasse project was 16% smaller in the Finnish version.

The average price of exterior walls were in the Finnish culture estimate estimated at 299 €/sq. in the Badgasse project and 310 €/sq. in the Lassnitzhöhe project. The corresponding average prices for the exterior walls were in the Austrian style estimates were in Badgasse 189 €/sq. and in Lassnitzhöhe 186 €/sq.. The average estimated prices for the exterior walls were in other words roughly 60% more expensive in the estimates for the Finnish culture of construction. The difference is the result of the heavier structures of the exterior walls. The Finnish culture estimate includes in addition to the Austrian solution moisture block all over the basement walls, thicker insulation layers, a basic exterior wall structure with an additional masonry layer underneath the plastering and a thicker plastering layer. Also the garage walls are insulated and include a moisture block in the Finnish style estimate.

125 External decks
The balconies in the Finnish construction style estimate differ mainly for their structure and the glazing. The balcony slabs are pre-fabricated concrete element slabs with mainly supporting balcony walls and columns and partly suspended supports as their supporting structures. The railings of the balconies are steel crib railings and the balconies are glazed. The average sizes of the balconies were kept unchanged from the first estimates because the size of the balcony is considered to be more a matter that is a choice in the apartment quality and it differs as such much more from project to project than between different countries. The balconies were in the Badgasse estimate approximately 20% more expensive in the Finnish solution due to the added glazing. In the Lassnitzhöhe estimates the big size of the balconies caused additional cost from the glazing but as the Austrian solution for cast on-site concrete suspended balcony slabs

was in the estimate more expensive and the amount of the slabs was so big the Finnish solution was in the end estimated as roughly the same as the Austrian solution. The modelled balcony structure with pre-fabricated elements as balcony slabs and the supporting structure as concrete walls is in the estimates cheaper than the Austrian solution. The balcony structural solution is linked to the structural solution of the building's structural frame as the suspended balcony slabs require additional cast on-site concrete parts to the intermediate floor slabs as well.

126 Roofs
The typical roofing structures differ from the Austrian typical solutions somewhat. In the Austrian projects, green roofs were used in both of the compared projects and also in one of the two other projects included in the FIAT project. Based on the project sampling they seem to be a common solution for Austria. Green roofs are at least for now however still quite uncommon in Finland's residential construction. The reason for this is apparently their relatively high price, although they may be on the way to becoming more mainstream in Finland too. Austria is just ahead of Finland in this development and the prices of the green roofs are probably much lower there too. There are however many benefits to be found from installing green roofs and if the demand for them would grow their price would likely decrease to a more affordable level in Finland too as has happened in the German speaking parts on Europe (Nurmi et. al 2013).

The roofing structures are modelled as a typical solution in that could be expected in Finland nowadays and the modelled structures in the estimate include a bitumen exterior and in total 250 mm of insulation and a steam block. The eaves are modelled as typical wooden structures producing quite simple eaves not that different from those built in Austria. The heat-transfer coefficients for the roof structure is 0,09 W/sq.K.

The amounts of the roof structures were smaller by almost a half in the Finnish version estimate in the case of the Badgasse project. This came from the different massing as a more compact solution. The same was not seen in the Lassnitzhöhe project's case where the overall amount of roof structures was roughly the same in both versions of the project but the Austrian green roof solution is in the Finnish price level more expensive than the Finnish solution. As a result from the differences in the amounts and the solution the roofs were in the studied projects 25-30% less expensive constructed in the Finnish style compared to the Austrian style.

13 Internal space elements
Internal space elements as a whole don't differ very much from the Austrian projects' solutions. The biggest differences are in the loadbearing walls and those separating the apartments from each other and in the internal fixtures. The space surfaces are not that different from Austria and as a whole the apartments are with a few differences quite similar as in the Finnish construction. The amounts of the internal space elements were almost on all account roughly the same as in the Austrian solutions. The overall estimated difference in the internal space elements was 20-30%

with the partitions being less expensive because of the different solutions and other part being somewhat more expensive due to bigger amounts.

131 Internal dividers

The partitions in the estimate are modelled as a combination of 200 mm sand brick masonry walls and steel framed gypsum walls. The walls separating apartments from each other are mainly the load bearing concrete element walls included in the structural frame. The partitions in the apartments are mainly steel framed gypsum walls and the partitions of the bathrooms are sand brick masonry walls. The partitions in the common spaces are mainly also sand brick masonry walls. Internal doors in the apartments are standard painted apartment doors and the apartment doors are wooden doors with 30 min fire resistance requirement. The Finnish solution with the apartment doors is typically and in the estimate of the kind that there is the actual apartment door and a second door right after it. That is typically the solution that fulfills the requirement se in the Building code part C1, stating that the apartment door or combination of doors must be structures with minimum of 30 dB sound insulation value (Building code part C1). It is typical that only the apartment door would not fill this requirement because of the mail slots that are usually integrated into the apartment door. The doors of the common spaces are mainly wooden structured doors. The door to the air raid shelter is a steel structured special door and the saunas' doors are modelled as tempered glass doors.

132 Space surfaces

In the Finnish culture estimates the main space surfaces for the apartments were the following: The flooring surfaces are parquet floors with impact sound insulation and for the bathrooms and toilets ceramic tiling. The apartments' walls are plastered and painted in all the dry spaces and in the bathrooms and toilets tiled with water insulation. The apartments' ceilings' are plastered and painted with partial suspended ceilings where the technical installations are located. The common spaces space surfaces are the following:

The stairways: floors mosaic concrete tiling, walls, plastered and painted, suspended ceilings.

The storage rooms: vinyl flooring, plastered and painted walls and ceilings

The garage: dust sealing painting on all surfaces

The aisles: vinyl flooring, plastered and painted walls and ceilings.

133 Internal fixtures

In the Finnish construction the apartments are during the construction project fitted with standard internal fixtures. The kitchens are ready to use kitchens when the construction works are ready and include the standard appliances, like refrigerators, ovens etc. The standard in Finland is to equip the apartments also with fittings like towel hooks in the apartments and cycle racks, laundry machines etc. in the common areas of the apartment building. This is a major difference to the Austrian construction culture where the tenants and residents are responsible for the procurement and assembling the kitchen and other fixtures.

2 Service elements

21 Plumbing elements

The heating, water and waste water systems, are typically connected to municipal networks in Finland too. The heating system of the apartment buildings is based on a joint heat exchanger in the Finnish system as well. In Finland however the big buffer tank and small heat exchangers in the apartments are not used. The hot water for the apartments is produced with the same heat exchanger as the heating system water is heated. There is one pipe circuit more in the Finnish system compared to the Austrian system where the water for the apartments is delivered to the apartments as cold and preheated and the water is then heated up for the part of the hot water in the apartments heat exchangers. In the Finnish system there is a separate water circuit for cold water, hot water heated centrally with the heat exchanger and a circulation circuit for the hot water to stay in movement to not cool too much when the water is not used. There are no buffer tanks or additional heat exchangers like in the Austrian projects. There were also small differences in the sanitary equipment between the Austrian and Finnish construction. In Finnish version there were some connection points more in total due to the differences in the spaces (house sauna's and laundry rooms) and the kitchens being ready. On the other hand in the Austrian projects the apartments with at least 3 rooms included a separate toilet where as in the Finnish estimate there are separate toilets only in the apartments with at least 4 rooms. The Austrian projects also included bathrooms in at least half of the apartments. In the Badgasse project, there were bathtubs in 90 % of the apartments and in the Lassnitzhöhe project in 55% of the apartments. In the Finnish estimate version there are no bathtubs at all. All in all the plumbing elements were estimated 10-15% less expensive in the studied projects when constructed in the Finnish way than the Austrian way the main reason to this being the absence of the buffer tank and double heat-exchangers and the smaller amounts of water points and sanitary fixtures.

22 Air conditioning elements

The air conditioning system is one of the biggest differences that was observed based on the studied projects between the Austrian and Finnish construction. The Finnish system is equipped with a controlled air supply and extraction system not only in the apartments but also in the garages and the common spaces. The same kind of a ventilation system is used in Austria used when constructing passive houses, in order to reach the energy requirements for them (Interviews 2016). In standard construction though, the ventilation system is typically as it was in the Badgasse and Lassnitzhöhe projects (Interviews 2016). The addition of the controlled air supply and extraction system roughly triples the cost of the air conditioning elements in the projects' estimates. It is also a major factor in causing for the garages to cost over doubly as much in Finnish construction compared to the Austrian standards.

23: Electrical elements

The electrical elements did not differ very much for their basic solution much from the Austrian projects. The amount of electrical connection points however was bigger in the Finnish construction style. The average amount of connection points per apartment was for the Badgasse project's equivalent in Finland 46,4 connections/apartment and for the equivalent of Lassnitzhöhe 45 connection points/apartment. The amount of electrical installations is much higher than it was in Austria where the respective amounts of connection points were in Badgasse 31,5 and in Lassnitzhöhe 28,5 connection points per apartment. The cost effect of the added electrical installations was 30-40% in the studied projects.

24 Data transfer elements
The data transfer elements in the Finnish requirements estimates included the same systems as in the Austrian projects, the antenna, the telephone and internet systems. The amounts of connection points per apartment were in these systems also quite a lot higher in the Finnish requirements estimates than in the projects they modelled from Austria. The antenna systems included on average 4 connections/apartment in the estimate for Badgasse and 4,4 connections for the estimate of Lassnitzhöhe. For the part of the telephone system the amount of connection points was for both of the project's estimates 4,9 connections/apartment. This is a significant addition in comparison to the Austrian amounts of 1 of each connection points per apartment. The internet connection points were in comparison closer to the averages being for Badgasse 5,1 and for Lassnitzhöhe 5,3 connection points per apartment when the Austrian amounts for these connection points were 4,6 and 4,8 connections per apartment. The garage is in the Finnish construction estimate also equipped with fire alarm system. The cost difference if the data transfer elements in the estimates was in the Badgasse project 20% and in the Lassnitzhöhe project 60%. The huge difference in the increase comes from the projects' sizes' difference and the bigger effect of the garage's additional systems.

25 Mechanical elements
In the case of Badgasse project the method modelled the elevators as two big and fastelevators instead of multiple smaller ones. The elevators are dimensioned for 13 people and run at the speed of 1,6 m/s. For the Lassnitzhöhe there was no difference to the elevators' features and also in the Finnish estimate only one elevator was modelled. In the mechanical elements an addition to the Austrian projects' scopes form the air-raid shelters' equipment and the machinery of the laundry and drying rooms. The resulting increase in the mechanical elements' cost comes to 20-30% higher cost depending on the project.

4.4. Differences in the contracting form and the site tasks

The project-related tasks included in the comparison included the construction site management tasks and the site tasks. In addition to costs also the forms of contracting were compared as they were seen as being a likely factor in the causation of the price level differences. The site tasks include the site services that serve the entire construction site (Construction 2000 committee 2010). These include the temporary infrastructure of the site, site accommodation, assisting works, site consumables, maintenance, equipment and lifting tasks. The site management tasks include the site responsible management and general site management works.

In both of the Austrian projects the construction management tasks were included in the main contractor's contract. The main contractor in Badgasse was the contractor, whose responsibilities in the project included the site works, clearing, drainage works, site structures, asphalt works, channels, concrete and reinforced concrete works, masonry works, exterior walls, plastering works, screed works, sealing and waterproofing works. In the Lassnitzhöhe project the construction management tasks were included in the main contractor's contract the same way as they were in the Badgasse project. The main contractor in Lassnitzhöhe was the contractor whose responsibilities in the project included the site works, clearing, water management works, drainage works, site structures, asphalt works, channels, concrete and reinforced concrete works, masonry works, exterior walls, plastering works, sealing and waterproofing works.

The main contractor's responsibilities also include the responsible site management and general site management tasks. These costs along with the costs occurring from the contractor's margins were for this reason divided back to the costs of the different building elements in the projects estimates in Helsinki also. In both of the projects the site tasks were included in the main contractor's responsibilities. The site tasks costs displayed in the two projects bills of quantities only accounted for 20-30% of the site tasks' costs in the projects' estimates if they were built in Helsinki.

The difference in how the site tasks are handled in Austria compared to how they are estimated in the Finnish construction was not totally clarified. When asked, all the Austrian project managers said that all the same site tasks were included in the contractor's responsibilities. Interviews made during the research revealed some reasons for the costs reasons. Apparently in Austria the main contractor doesn't need to arrange similar social facilities for the workers on site as in Finland, but only a portable toilet facility is required on site (Interviews 2016). It is also not a typical solution in Austrian to construct a large weather covering and the exterior scaffolding is typically done in a less costly way (Interviews 2016). These are only a couple of examples of the differences on how the site tasks are managed in general in a lighter fashion in Graz compared to Helsinki. The differences concerning the studied projects were not clarified very well as the information on how the site is organized was not available from Graz. There was one element of the site tasks that's cost difference was clear in the studied projects and that was the site cleaning. In the Badgasse project the site cleaning costs were reported as being 23.000 € where as they accounted for a total of 52.000 € in the Finnish estimate for the same project built in Helsinki. Similar figures were observed in the Lassnitzhöhe project, with Austrian actualized cleaning costs being 5.000 € and the corresponding estimate for site cleaning in the estimate for the same project built in Helsinki being 19.000 €. This is most likely not a case of site cleaning being from 2 to 4 times as expensive in Helsinki as it has been in Graz but also a matter of how frequently and at what extent the cleaning is carried out in the projects.

The way of contracting differed greatly between the typical Finnish way and the way it was carried out in the projects in Graz. The prevailing practice used in the Austrian projects was a form of construction management where the contractees themselves managed the project during the construction works and called for tenders separately for the different construction works carried out during the project. The risk to the contractors was further diminished by giving the contractors bills of quantities to be priced in the tendering phase. In Austria the contents of the bills of quantities was partly regulated by the national Ö-norm that included requirements for the contents of the designers' specifications, tendering documentation, contents of contracts and even requirements for invoicing in an electrical form. The financial procedures related to the contracting and organizing of the projects were also stated in the Ö-norm. (Interviews 2016)

The bid for tendering documentation was from the Finnish perspective quite different. The same documentation included the specifications for the structures to be constructed and the financial terms of the contract.

4.5. Summary of the perceived cost differences

The perceived differences between the Finnish and the Austrian construction and construction cost were in the light of the studied projects many and quite notable.

As a summary of how the costs rised from the actualized cost in Graz to the likely solution estimate in Helsinki, the differences and the reasons found for them are collected in the Tables 12 and 13 below. All the costs have been divided to the apartments square meters and gross square meters of the projects.

Table 12: Summary of the discovered cost differences between Graz and Helsinki in the Badgasse project

	Actualised and estimated costs €/sq. (AA)	Influence in costs €/sq. (AA)	Actualised and estimated costs €/sq. (GFA)	Influence in costs €/sq. (GFA)
Actualised contracting costs in Graz	1633		749	
Difference in site tasks		+117		+52
Other price level factors		+226		+104
Estimated contracting cost in Helsinki	1976		906	
Difference in Building elements		+35		+16
Difference in Internal space elements		+90		+41
Difference in Service elements		+102		+47
Difference in site elements and site tasks		+12		+5
Estimated contracting cost modified to Finnish construction	2215		1015	

Table 13: Summary of the discovered cost differences between Graz and Helsinki in the Lassnitzhöhe project

	Actualised and estimated costs €/sq. (AA)	Influence in costs €/sq. (AA)	Actualised and estimated costs €/sq. (GFA)	Influence in costs €/sq. (GFA)
Actualised contracting costs in Graz	1549		801	
Difference in site tasks		+137		+70
Other price level factors		+707		+365
Estimated contracting cost in Helsinki	2393		1236	
Difference in Building elements		+48		+25
Difference in Internal space elements		+109		+56
Difference in Service elements		+161		+83
Difference in site elements and site tasks		+37		+19
Estimated contracting cost modified to Helsinki construction	2748		1419	

As was noticed earlier the different building elements' costs varied greatly in many ways. In the study comparing the differences in the construction culture there were differences noticed in both directions, some elements being more expensive and some less expensive in the Finnish construction culture compared to the Austrian way of construction when the price level was similar. Significant differences were also noticed between the two projects. When the costs are summed up in all of the estimates made and in all of the categories the costs of construction are at least somewhat more expensive when estimated in Helsinki compared to Graz.

Because the difference between the two projects is so great a clearer picture comes from the averages of the two. The averages of the projects studied divided by the classification headers into building, service and project related elements are shown below in the Table 14 below.

Table 14: Averages of the two Austrian projects costs

	Actualised costs in Graz, €	Austrian projects estimated in Helsinki cost level, €	Austrian projects modified to the Finnish construction, €
1 Building elements	3364487	3989727	4349780
2 Service elements	753494	950528	1254970
3 Project related tasks	126834	437264	468448

Looking at the averages from the two projects studied in the table 14 a few summarized notes can be made. In the first study comparing the price level differences the average observed difference in the price level is 30 % more expensive in Helsinki compared to the price level of Graz.

The most striking difference in the price level comes from the site tasks costs, visible back in the tables 10 and 11. They are in both projects multiplied by at least three. The average figures smooth the differences in the site tasks but even in the averages they remain 2,5 times as expensive in Helsinki as they had cost in Graz. Although the contents and organisation of the site tasks was not clarified in the Austrian projects the great difference in their cost gives a reason to assume that the sites are probably managed in a much lighter fashion and with a significantly smaller organization compared to the Finnish standards. This assumption was further strengthened in the light of the interviews made. During the research it became evident that the Finnish standard for the site services is notably higher (Interviews 2016). The few notes that came up in the interviews, the toilet, dressing and washing room facilities and the ladders of the scaffoldings can be in Finland linked back to the legislation concerning contractees' obligations concerning working environments and work safety regulations. This note raises the question of how much does the legislation differ between the countries on those parts. This same assumedly much lighter organization is probably part of the reason behind the significant difference in the price level of the individual building elements prices described earlier in this thesis. Through greater need for site management resources and supervision of the works the unit prices of the works grows higher.

In the second study, where the point of interest was in the differences in the construction and the typical solutions chosen, the vast majority of the cost difference arising from the differences issued from the service elements and internal space elements. The average addition to the project costs when they were altered to match the construction culture of Helsinki was 13% but the costs issuing from the service elements increased in average by 30%. The biggest single reasons for the higher costs in the service elements and at the same time the biggest regulation-related issue noticed in this study was the ventilation system used. Other significant differences in the service elements part in the projects' specifications were the amounts of the different electrical and data transfer connection points. As an example where in Austria there was only 1 antenna connection per apartment in both of the project in the Finnish default solution there were 4. Similar difference was noticed in the amount of electrical connection points. The average amount of connection points in Graz was 30 per apartment. In the estimate for Helsinki there were on average 45 electrical connections per apartment. This shows in the respective costs also. Another big difference in the construction culture is seen in the finishing level of the apartments. In Finland the apartments include all standard fixtures and full and ready to use kitchens when the construction works are ready. In Austria the tenants and residents begin their living in their new flat by first assembling the kitchen and other fixtures in place.

Other common to all solutions reason that raise the costs of Finnish construction are the construction of the air-raid shelter and the scope and features of the garages. The air-raid shelter counted for 29-32 € per apartment square meter additional cost in the studied projects. For the underground garages the Finnish solution was estimated approximately twice as expensive as the actualized costs of the solution in Austria. The difference comes from the conditions that are required in the garage. In the Austrian garages there is no ventilation, they are smaller in all directions, dimmer and cold if the air outside is cold.

5. Conclusion and Evaluation of the Results

There are differences between Graz and Helsinki when it comes to construction. Those differences concern the whole culture of construction and are as a result also seen in the costs of construction. In this study the cost differences issuing from the price level factors and the product related differences were found out but a lot about the reasons behind them was still left in the shadows or was only partially explained. It is of course easier to see the differences in costs than to find numerical exact reasons for their occurrence.

The biggest differences that were found out were in the price level of the two cities and in some of the typical design solutions used. The structural reasons were more clearly explained but for the reasons for the differences in the price level only likely solutions were found. The design solution related factors are by their nature already the easier ones to discern and explain. They are in the end always the result of direct decisions during the project's designing phase. It is a choice to have a layer of masonry under the plastering in the exterior wall or to construct an air-raid shelter and the machine operated ventilation. That whose decisions these are is another matter. There are times when all these are already decided by the regulations and the city planning authorities when the designers are selected.

The price level figures were the other group of the differences notices in this thesis. The average difference in the price level between Graz and Helsinki in the Austrian projects was 30%. It should be noted that the contents of the prices is not totally similar. The differences in the site tasks and the division of the Finnish costs in the individual building elements costs shows differences in how the sites are managed and handled so there is a difference in the contents and the amount of resources used in Austria and Finland. The difference to the price level consists of the whole of the construction culture in the Helsinki region and its difference to that of the Graz area. The competition environment, the lighter site management, lower material and possibly labor prices and a contracting style that diminishes the risks of the contractor all contribute to the lower price level in Austria.

When considering the results found, it must also be kept in mind that the research is a case study of the two Austrian projects from Graz and estimates based on them located in Helsinki. The reliability of the study is only as good as the studied cases' representativeness of the bigger mass of the construction in Graz. The translation to Finnish construction is also only the likely solution that could be the solution in the Helsinki region from where all of the project's Finnish cases were from. The original title for the research was to compare the construction costs between the two countries, Helsinki and Finland, but as the data from Austria was all from Graz and the reference projects' list from Finland included only projects from the Helsinki region, the study was by the data set already turned into a comparison between the two locations in Finland and Austria, Helsinki region and Graz. The way of construction and typical solutions differ much within Finland as can be seen in the statistics of ARA (ARA 2016) also so further generalization of the results is not advisable.

The accuracy of the estimates of the projects in the Helsinki price level can be considered quite reliable. The calibration study testing the accuracy of the method used showed only 1% difference in the total contracting costs and the estimated total costs which suggests that the Finnish estimates are reliable in describing the price level in the Helsinki region. Where there may be error in the estimates are the estimated costs of the projects built in Helsinki as they had been built in Graz. The data was not detailed enough to clarify all the points and there was in addition a language barrier between the data and myself so some error may exists especially in the service elements part. For the service elements part not quite all the designs were available from the projects and the technical solutions differed on parts very significantly from those used in Finland so a few solutions' prices were not as such available and needed to be assessed based on slightly different basic solutions used in Finland.

When drawing conclusions based on this study it is also important to remember that the comparison was made between Helsinki and Graz. Helsinki is the capitol areas in Finland where as Graz is the second largest city in Austria. The comparison data to start with was not of nationally similar places in the studied countries that should be taken into account when considering the results. There is probably a difference between Graz and Vienna areas within Austria just as there is between Helsinki and Tampere in Finland. All in all, the differences between the construction and in the price level are real. There are many more topics that could be studied further to clarify more issues and to fine down the differences and the reasons there, like the differences in the site management and the site tasks.

The aim the Ministry of Environment set for the FIAT clinic to finding the reasons to the construction cost was in this thesis covered thus far. The task of lowering the costs of construction to promote more affordable housing in the Helsinki region is a tough one. Finnish regulations are being renewed and re-formulated all the time (Ministry of environment, 2016). There is a risk of further issuing the increase of construction costs if the regulations are tightened. At the same time there is a growing concern about the all the time rising costs of the apartments and through them of living in the Helsinki region. The ways to promote more affordable housing are not easy.

The research questions set for this thesis were:

- Do the costs of residential construction differ between the Helsinki region in Finland and Graz in Austria and if so to what degree?
- What are the factors that cause the differences? How much is ado with difference in the general price level of construction and how much with differences in the specifications of the buildings built?

In addition to these two basic research questions there was also an additional question of interest of to what degree do the perceived differences originate from differences in regulations of these two countries?

The main questions about the existence of the difference of construction costs, the amount of the difference and where they come from were all answered in this thesis. In that respect the results were found. Their accuracy is to be considered with respect to the amount and representativity of the data. As the Austrian cases studied should be representative of the Austrian way of constructing multi-storey residential building in the Graz area (Interviews 2016) the results can be considered correct. The additional research question about the effect of the regulations was a more complex one. There were a few clear regulation based reasons for the higher costs of construction in Finland such as the ventilation system used, the specifications of the garages and the construction of the civil defence shelters. The rest of the differences were not so much straightforwardly ado with the regulations but more linked to them through the culture of construction that they in part are creating. There is a vast amount of different regulations, standards and guidance across the field of construction and their implementation and interpretations vary between the different doers in the construction field. As a whole the question of construction costs seems to be a factor caused by the whole of the construction culture and not only the fault of the regulations.

When the results of this research are considered against the existing literature studied from the topic they are convergent with the existing knowledge. There was much evidence in the literature about the risk division the effect of the way of contracting to the project's costs. Also the basics of the causation of costs from the literature are convergent with the findings of this research. The results can based on the existing knowledge be considered to be consistent with the literature when it comes to the difference in the typical solutions

It seems that the regulations could take on a different role from the current one though. In the Austrian regulation system there were notable few regulations and those that existed were clear and simple, only stating the most important aim of the regulating. Also the planning was initially only roughly guiding the construction and the quality level of the projects was ascertained in a separate process during the designing of the project. On the other hand there are regulation level demands set to the form and information level of contracting documentation that causes for a certain kind of similarity in the process of calling for tenders and tendering. This whole system gives the construction branch a whole more freedom and more responsibility concerning the outcome of the products produced. As a result the culture of construction has developed into an effective and highly competed field where the markets have set the demands for the quality level of construction.

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