OPINNÄYTETYÖ - **AMMATTIKORKEAKOULUTUTKINTO**
TEKNIIKAN JA LIIKENTEEN ALA

CLARIFICATION AND COMPARISON OF CAST IN PLACE AND PRECAST CONSTRUCTION COSTS AND SCHEDULES IN THAILAND USING THE BIM MODELING

Authors: Mari Kuronen
Emilia Turunen

SAVONIA-AMMATTIKORKEAKOULU

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Tiivistelmä

Tämän opinnäytetyön tavoitteena oli selvittää elementtirakentamisen mahdollisuuksia Thaimaassa ja vertailla paikallavalurakentamisen aikataulua ja kustannuksia elementtirakentamisen aikatauluun ja kustannuksiin. Lisäksi vertailtiin Suomen ja Thaimaan rakentamista keskenään. Tarkoituksena oli selvittää onko elementtirakentaminen kustannustehokkaampaa ja nopeampaa perinteiseen paikallavalurakentamis menetelmään verrattuna. Opinnäytetyön toimeksiantajana toimi Scanditech Co., Ltd, joka on rakennusliike Thaimaan Pattayalla.

Opinnäytetyö kohdistui Scanditechin tulevaan Tropical Garden -asuinkerrostaloprojektin A-talon runkoon. A-talon paikallavalurunko mallinnettiin Tekla Structures -ohjelmalla olemassa olevia CAD- kuvia apuna käyttäen. Vertailuksi sama runko mallinnettiin myös elementteinä, kantavat seinät-laattarunkoratkaisulla. Lisäksi vierailtiin valmisbetoni tehtaalla sekä elementtitehtaalla. Myös aikataulu ja kustannusarvio tehtiin elementtirakenteiselle rungolle, ja näitä vertailtiin Scanditechin Tropical Garden A-talon rungon kustannusarvioon ja aikatauluun.

Tuloksena saatiin A-talon elementtirungon kustannusarvio sekä aikataulu rungon pystytykseen elementtitehtaalta saatujen tietojen perusteella. Tätä tulosta voidaan hyödyntää vertailtaessa paikallavalu- ja elementtirakentamisen kustannustehokkuutta.

Avainsanat
Tekla, paikallavalurakentaminen, elementtirakentaminen, määrä- ja kustannuslaskenta, Thaimaa

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THESIS
Abstract

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Abstract

The aim of this thesis was to clarify possibilities of precast construction in Thailand and to compare precast schedule and costs to cast in place schedule and costs. In addition, Finnish and Thai constructing were compared. The purpose was to find out if precast constructing is profitable and erection time is faster compared to the traditional cast in place method. This thesis was commissioned by Scanditech Co., Ltd construction company in Pattaya, Thailand and the upcoming residential building project of Scanditech was used when comparing the two frame structures.

This thesis focused on the frame of the Tropical Garden building A. The cast in place frame was modeled by using Tekla Structures utilizing the existing CAD pictures of the Tropical Garden. By comparison the same frame was modeled by using load bearing walls with slab as a precast frame structure. In addition, a concrete factory in Pattaya and a precast factory in Bangkok were visited. Schedule and the bill of quantity of the precast frame was generated which were compaired to Scanditech's bill of quantities and the schedule of the Tropical Garden cast in place frame.

As a result, the bill of quantities and schedule of the precast frame was generated according to the data from the precast factory. This result can be utilized when the cast in place and precast constructing are compared.

Keywords
Tekla, cast in place, precast, quantity and cost calculation, Thailand

FOREWORD

The idea of clarifying precast constructing in Thailand came up when we noticed many problems in the traditional cast in place constructing method. During our internship in Scanditech Co., Ltd we developed the idea with Finnish project manager of Scanditech. The aim of our thesis was to present an optional constructing method and also decrease biggest problems in constructing.

We did the whole thesis together and we lived six months in Thailand so that we could learn the Thai constructing and culture better. This thesis project was challenging from the very beginning because of the huge differencies between Finnish and Thai constructing and culture. The theory of this thesis is based on Finnish constructing regulations and gathered information from Thai concrete factories and our own observations. Knowledge from the staff of Scanditech made our work easier when we researched Thai constructing and its theory.

For making all this possible, we would like to give our special thank you to Samphan Kham Un, the directing manager of Scanditech and Kimmo Manninen, the project manager of Scanditech. We would also like to thank Mr. Viljo Kuusela for his patience during this project. Last but not the least we would like to thank both of our families for the support and our children Aada, Hugo and Wäinö for being so brave despite all the big changes during this process.

Kuopio 11 May 2015
Mari Kuronen and Emilia Turunen

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1 INTRODUCTION

Precast concrete technique was already researched in the beginning of the twentieth century and it is one of the most remarkable developments in the construction of concrete structures. The use of prefabricated elements has developed and increased since then. In Western countries this system has been widely used in constructing bridges, office buildings, and residential buildings. Prefabrication technique provides many advantages compared for example to the cast in place system. (Precast concrete applications & general overview, Elematic Group)

With prefabrication technology construction effectiveness and consistent high quality can be achieved. Factory made products mean reduced manpower requirements on site, shorter construction time, cost-effective solutions and an environmentally friendly way of building. (Precast concrete applications & general overview, Elematic Group)

Precast constructing is not as well known in Thailand as it is in Finland. The cast in place method has been in use for centuries and it is still the most common way to build in Thailand. When the aim is to build fast and achieve high quality, it would be profitable to clarify other options instead of using only the traditional cast in place method.

1.1 Goals and background of this thesis

While doing the internship for a construction company called Scanditech Co., Ltd. in Thailand in 2013 we were offered an opportunity to write our thesis about how to improve effectiveness of constructing. In Thailand precast is not a common method and therefore Kimmo Manninen, the project manager, suggested a research on costs and possibilities to use precast products instead of the traditional cast in place method. After returning to Finland, it turned out that it was possible to get financing from Savonia University and the suggested thesis subject was approved. At first we got to know CAD pictures of the project and started 3D modeling with TEKLA based on the pictures. In the beginning of the thesis process Ville Kuusela, the supervising teacher was contacted and the subject of the thesis was narrowed down together. Before arriving to Thailand, Kimmo Manninen was also contacted several times. The aim is to clarify precast construction possibilities in Thailand and to compare precast costs and schedule to cast in place costs and schedule. In addition to this, Finnish constructing is compared to Thai constructing.

The cast in place system is a traditional construction method that is the most used one in Thailand. The frame system used in residential buildings is mainly the column-post tensioned slab. Partition and exterior walls are masonry walls. All of the Siam Oriental's and Scanditech's projects have been built by using this method. As the company develops and larger projects are under construction it has raised a question, is it more profitable to use the precast system. The time consumed on the construction has a direct impact on the certain construction costs and technical costs of the construction site. The profit gets better when the construction time gets shorter and more buildings can be built in the same time. Time used in construction can be reduced by choosing the most suitable construction method.

The purpose of this thesis is to clarify if cast in place is the most cost effective and fastest way to construct residential buildings for this company, or is it possible to significantly reduce costs and construction time by using the precast components.The aim is to find out what are the possibilities to use the precast system in Thailand and are there any other solutions. Existing CAD pictures from the project will be utilized when doing the 3D model with TEKLA. Also schedules and bids from previous projects will be used. Information obtained from interviews, visits to concrete and precast factories will be used in this thesis. The main sources of information will be the Finnish RATU and BY201. Because Thailand is located in an earthquake area, seismic activity has to be considered when planning structures for residential buildings.

Only the subjects mentioned above will be covered in this thesis. The whole Tropical Garden project will be modeled with the cast in place frame, but when comparing and modeling the precast frame only building A will be used.

1.2 Scanditech Co., Ltd and Siam Oriental Trading Co., Ltd

This thesis was comissioned by a construction company Scanditech Co., Ltd and a Finnish developer Siam Oriental Trading Co., Ltd. Scanditech was founded in 2009. Siam Oriental Trading was founded in 2004 and it has completed six 8-storey buildings and three are under construction. Scanditech has constructed four of them. The Scanditech`s upcoming project is Tropical Garden which contains 427 apartments in three separate buildings. The apartments are from 25 square metres studios to 85 square metres 2- bedroom apartments. There is going to be a 1,000 sqm tropical garden with a large pool in the inner ward. The construction works will begin in 2014 and the apartments will be ready to move in at the end of 2015. This study focuses on the Tropical Garden project (Image 1). (Siam Oriental Condos, Pratamnak, Pattaya)

IMAGE 1. Modeled version of Tropical Garden project (Siam Oriental Condos, Pratamnak, Pattaya)

1.3 Chonburi province, Thailand

The Tropical Garden project site is located in Pattaya, Chonburi province, 147 km from Bangkok, the capital of the Kindom of Thailand. Pattaya is one of the most popular tourist destinations in Thailand.The number of inhabitants is 117 000 (2000), although the actual population is much more due to the fact that people who move to Pattaya do not make the change of address notification.

According to Juha Timonen, the managing director of Siam Oriental Trading Co.,Ltd, during the nearest 5 to 6 years approximately 200 000 housing units will be built in Pattaya, which means 40 000-50 000 units per one year. Constructioning is seen everywhere in big cities (Image 2).The biggest challenge in the near future is infrastructure in addition to distribution of water and electricity and sewerage.

IMAGE 2. Cranes are familiar scene in big cities. Street scene from Bangkok in June 2014 (Kuronen and Turunen 2014-06-06).

1.4 Abbreviations and definitions

CAD = Computer- Aided Design

3D = Three-Dimensional

RATU = Rakennuksen tuotannonsuunnittelu (Production design of the building)

BY = Betoni yhdistys (concrete association)

GPS = Global Positioning System

KSC = Kilograms per Square Centimetres

IISEE = International Institute of Seismology and Earthquake Engineering

BIM = Building Information Modeling

IFC = Industry Foundation Classes

1.5 Cooperation partners and copyright holders and other parties

Scanditech Co., Ltd and Siam Oriental Trading Co., Ltd

1.6 Background material

Tropical Garden CAD-pictures

2 GENERAL ABOUT CONCRETE CONSTRUCTION

There are three phases in the cast in place construction, form work, reinforcement work and casting work. The same phases are used when using the precast frame, except that the work is done inside a factory, and prefabricated elements are transported in to the construction site and installed in place. (Betonitekniikan oppikirja BY 201 2004, 191-192.)

The success of the final product requires that design, quality, technique, planning and actual constructing are coordinated together. Also conditions during construction and when the final product is in use must be considered. (Betonitekniikan oppikirja BY 201 2004, 191-192.)

Concrete constructions are usually reinforced. Reinforced structures are made using the drawings planned by the structural engineer. These drawings are based on the measurement calculations, the measures and shapes of the structure that are described in the calculations.Own weight of the reinforced structures are massive for which reason quality of strength, tense, fire resistance and sound insulation are good. In addition to these, flexible planning, manufacture technique and versatile formability are also good. Reinforced concrete is used in various sectors of building. (Betonitekniikan oppikirja BY 201 2004, 191-192.)

The annual production volume of concrete is approximately 4.2 milliard cubic meters world wide. Structures of buildings are a large area of use. Choosing the frame system is a complex process, where owners of the building, users and all participants of the construction process have to be taken into account. In addition to these, the environment and location of the building set requirements when choosing the most appropriate frame system. The cast in place concrete structure differs in particular because of its production technique but also because there are determinative differences when comparing technical properties to other competitive concrete systems. (Betoniteollisuus Ry, betoni.com)

Quality requirements are determined by the purpose of the use in Finland. It has to be insured that the cast object enables the function planned in the target space. Therefore the different ways of use set different requirements. Examples of these are strength classes, requirements related to retention and functional and appearance requirements of the concrete surface. In addition to this, concrete structures are divided into three structural classes. Class 1 which is used in demanding structures, class 2 which is for conventional constructions and class 3, which is for simple work. The structural class is marked after the strength class, for example K30-2. (Figure 1) (Betonitekniikan oppikirja BY 201 2004, 192.)

TAULUKKO 7-(FI)
Normaalipainoisen betonin ja raskasbetonin puristuslujuusluokat. Suunnittelussa suositellaan käytettäväksi toistaiseksi lihavoituja RakMK osan B4 mukaisia lujuusluokkia.

Lujuusluokka	Lujuusluokka SFS-EN	Alin 150 x 300 lieriöillä määrätty ominaislujuus $f_{ck,cyl}$ (MN/m²)	Alin 150 mm:n kuutioilla määrätty ominaislujuus $f_{ck,cube}$ (MN/m²)
K10	C8/10	8	10
K15	C12/15	12	15
K20	C16/20	16	20
K25	C20/25	20	25
K30	C25/30	25	30
K35	C28/35*	28	35
K37	C30/37	30	37
K40	C32/40*	32	40
K45	C35/45	35	45
K50	C40/50	40	50
K55	C45/55	45	55
K60	C50/60	50	60
K67	C55/67	55	67
K70	C57/70*	57	70
K75	C60/75	60	75
K80	C65/80*	65	80
K85	C70/85	70	85
K90	C75/90*	75	90
K95	C80/95	80	95
K100	C85/100*	85	100
K105	C90/105	90	105
K115	C100/115	100	115

*) Nämä lujuusluokat eivät ole SFS-EN 206-1 mukaisia eivätkä ne sisälly tulevaan Eurocode suunnittelustandardiin EN 1992-1-1. Ne ovat RakMK osan B4 mukaisia lujuusluokkia, joita voidaan käyttää SFS-EN 206-1 huomautuksen mukaisina ns. välilujuustasoina.

FIGURE 1. Finnish strength classes (Rakentamismääräyskokoelma B4 2005, 78.)

The next section gives general information about cast in place and precast construction in Finland and in Thailand. The purpose is to present advantages and disadvantages, theory and also give information about Thai construction methods.

2.1 Cast in place construction

Advantages of the cast in place frame system are easy transportation and its flexibility when it comes to geometric shapes. It is also relatively easy to do late changes to the structure. On the other hand the cast in place system requires various temporary works. It is produced in an unprotected environment and needs additional time for the drying out process. Material and equipement have to be transported to and on the site and tasks have to be performed in a certain sequence. Climate, congestion, out-of-sequence work, multiple starts and stops, obstruction and interruptions have to be taken into account while constructing which makes the cast in place system quite complex process. (Betoniteollisuus Ry, betoni.com)

Cast in place frames can be divided by load bearing vertical structures like load bearing walls, load-bearing columns (column-slab) and load bearing walls with complement columns. Equally strong slab and slab which is reinforced are suitable for horizontal structures with one way beams and lightweight slab, although they are rarely used nowdays. Horizontal structures mentioned above, can be implemented as unstressed or stressed reinforced concrete structures. By using stressed structures, long spans and slim structures can be achieved. (Betonieteollisuus Ry, betoni.com)

Different building types require different basic solutions. Almost all frame systems are suitable for apartment buildings. Wide open space is needed in office and commercial buildings as well as parking halls. When using the column-slab system, wide open and undivided space can be implemented because of the variety of the system. (Betoniteollisuus Ry, betoni.com)

The cast in place process consists of the casting plan, concrete transportation from the factory to the construction site, forms and reinforcement, casting and curing.

The casting plan is an important part of the cast in place production process, because it is used as a check list in different phases of casting work. The casting plan is made on the construction site before starting the casting work. (BY 201 2004, 210.) A technically successful result, which is high quality and a long-lasting concrete structure, is ensured when the casting plan is done with care. Unnecessary work and additional costs are avoided with a preliminary casting plan. It also guarantees that the work is fluent and it is made in minimum time.

Concrete is brought to the construction site in fresh workable form usually with a concrete mixer truck. There are different sizes of concrete mixer trucks up to 10 cubicmetres. Concrete is received at the construction site either to the transfer station or trasfered straight to the target by pumping or by a concrete transfer container. (Koski, Koskenvesa, Mäki and Kivimäki 2010, 61-84.)

Forms and reinforcement have been arranged for the fresh concrete. The purpose of the reinforcement is that it receives tensile stresses and the concrete compressive stresses.

The construction frame can be devided into blocks when the aim is rapid frame erection. Block division enables an effective form rotation and block division settles naturally to expansion joints. Block division ought to be set in the early stage of the planning phase either by the architecht or by the structural engineer at the latest.

A form construction is temporary and it supports, bears and protects the concrete during casting and curing. Form systems are devided into forms for vertical structures which are used in foundations, walls and columns and into forms for horizontal structures which are used in ceilings, bridge decks and into special forms which are used in both when needed (kivitalo.fi). In addition to the concrete quality and proper work performance, used form material, strength and tightness of the form structure, have an influence on exterior surface and the quality of the concrete. When the form and the reinforcements are ready, casting can be performed.

It requires careful curing and monitoring process to achieve good results. The cast concrete has to be cured, i.e. cast concrete has to be kept moist and protected. Curing has to start directly after casting to minimize cracking. The curing time is usually from 3 to 7 days, depending on the conditions. (Betoniteollisuus Ry, betoni.com) (Appendices 1 and 2)

2.1.1 Cast in place construction in Thailand

Cast in place is the most in common and traditional construction system in Thailand (Images 3 and 4). Cheap labor is one of the reasons why the cast in place technique is mainly used. At the moment building in Thailand is skyrocketing, and building is busiest in big cities. In the Pattaya area 40 000-50 000 units are completed per year. Even though construction projects are massive, manpower is still used instead of machinery work and precast products. In Thailand a project starts when purchasing a property. The architect designs preliminary drawings and structural plans and after that permits are applied for.The factory which delivers concrete to the construction site, will plan the reinforcement of the post tension slab. The width of the road determs the maximum height of the eaves.

IMAGE 3. Foundation work of cast in place residential building. Picture is taken from Scanditech's project in Pattaya (Kuronen and Turunen 2013-07-24).

IMAGE 4. Piling work from the Tropical Garden project (Kuronen and Turunen 2014-07-24).

It was possible to visit a local concrete factory and get familiar with the ready-mixed concrete production. Local production did not differ much from the European way. The visit was to the CPAC factory from which Scanditech orders all the concrete to its projects (Image 5). CPAC has two factories in Pattaya and 500-600 cubic meters of concrete are delivered daily. The maximum amount of allowed transported concrete is 7 cubic meters and concrete is delivered in a radius of 15 km.

IMAGE 5. CPAC factory (Kuronen and Turunen 2014-05-28).

Because one of the biggest problems in the cast in place construction in Thailand is poor quality control, extra attention was paid to it while visiting the factory. The factory does not test every concrete set automatically, only when requested by client (Images 6 and 7). CPAC makes its concrete by machinery and in semiautomatic production lines. There was also a concrete mixer with an ingredient silo. When making concrete, natural ingredients like aggregate, water and cement are mixed together. In Thailand concrete production includes receiving and storaging ingredients, measuring the ingredients, concrete mixing, adjusting the plasticizer together with quality control. After that the concrete is delivered to the construction sites with concrete mixer trucks. Trasportation is supervised with the GPS system which is installed in every truck to avoid illegal resale.

IMAGE 6. Cylinder concrete test samples in CPAC concrete factory (Kuronen and Turunen 2014-05-28).

IMAGE 7. Cubic concrete test samples and compressive strength testing in the CPAC concrete factory (Kuronen and Turunen 2014-05-28).

2.1.2 Cast in place process in Thailand

The contractor delivers the casting plan, which informs what target is cast and when and the quality of the concrete. Reinforcement and forms are made on site following the plan. According to Kimmo Manninen, the Scanditech's project manager, special attention is needed in form supporting to avoid unnecessary repairs. Casting is done after reinforcement and forms are ready and approved by the supervisor. The contractor's responsibilities are to take care of the form demolition, curing and to deliver concrete quality test results when asked. Supervised curing is concentrated on columns which are covered in wrapper after form demolition.

The strength class of concrete is expressed as kg/cm2 = kilograms per square centimetres = KSC in Thailand. For example concrete used in walls is 280 KSC, which is equivalent to 27.5 megapascals = MPa. As an example, C25/30 concrete used in Finland tells the compressive strength of concrete as in sylinder strength/cubic strength. Meaning that the minimum compressive strength of concrete is 25 N/mm2 and it is equal to 25 MPa when defined with the cylinder test sample. When defined with the cubic test sample, the minimum compressive strength of concrete is 30 N/mm2 which is equal to 30 MPa. The most common concrete strengths used in Thailand are 280 KSC and 380 KCS (Table 1.)

TABLE 1. Concrete strengths used in different building blocks

BUILDING BLOCK	KSC Kg/cm²	Mpa
Wall	280	27.46
Slab	380	37.27
Column	280	27.46
Beam	280	27.46

2.1.3 Seismic activity

A concrete structure has to resist various loads, which have an impact on the building. Dead loads, live loads and dynamic loads. Dynamic loads occur mostly in infrastructures. It is important to notice that both wind loads and earthquake loads cause horizontal stresses instead of normal vertical stresses. Earthquake loads have to be considered when building in seismic area. Earthquakes shake building strongly both vertically and horizontally which may cause the building to collapse.The heavier the structure the bigger the strength. (International Institute of Seismology and Earthquake Engineering 2000-2003)

Thailand is located in the tropical zone, which means that floods, storms, landslides, wildfires and drought may occure. There are three seasons; cold season from November to January, hot season from March to May and rain season from June to November. Earthquakes are usually not observed in Thailand, but earthquakes in the neighboring countries may cause slight damage to buildings in regions along the western border. (International Institute of Seismology and Earthquake Engineering 2000-2003)

IISEE (International Institute of Seismology and Earthquake Engineering) has conducted a research project entitled “Information Network on Earthquake Disaster prevention Technologies” in 4/2000 – 3/2003. This project aimed at accumulating and diffusing valuable technical information in order to contribute to disaster prevention efforts in earthquake – vulnerable countries. (IISEE) Thailand is divided in to three seismic zoning factors; 0, 1 and 2. In zone 1 and 2 seismic activity has to be considered when planning structures. The research shows that in Pattaya area seismic factor is 0, which means that no need to take seismic factor in to account when planning structures (Figure 2). (International Institute of Seismology and Earthquake Engineering 2000-2003)

FIGURE 2. The map shows where seismic activity has to be taken into account when planning the structures (International Institute of Seismology and Earthquake Engineering 2000-2003)

2.2 Precast construction

In the precast constructing system the primary aim is fast and economic total implementation. This leads into more intensive finishing products in the factory and reduces work done at the construction site. (Betonitekniikan oppikirja BY 201 2004, 441.)

The whole construction frame can be implemented by precast technique. The rapid erection of the frame of the building is the main advantage compared to the cast in place construction. It is less than half of the conventional cast in place construction. Precast elements are manufactured in the factory and only erection of the frame takes place on the construction site. When the whole frame is implemented by precast technique, work schedule is clear and overlap work can be avoided. Other advantages are independece of weather and an environmentally friendly way of building. Because the elements are produced in factory, quality is easier to control and an equally high quality is secured. When using the precast technique noise and dust are easier to control. On the other hand, precast building requires a detailed design and connection details are complicated. (Betoniteollisuus Ry, elementtisuunnittelu.fi)

2.2.1 Precast production

The precast process consists of designing, manufacturing, transportation and erection. When manufacturing elements, planning is important and it is a multistage process. The products of precast concrete industry are mainly planned by the customer or constant products which are modified to customers needs. Precast drawings and other planning documents work as a productions work instruction and determinative factor. The completion of the drawings will be agreed with the element designer by making a planning schedule. More detailed capacity and schedule planning is done in the concrete factory. It includes what element products are made on which day. The order of manufacturing is planned according to the installation plan, material situation, form plan and capacity situation, though manufacturing has to be more or less synchronized to the installation order.

The manufacturing process in the factory starts when the drawings have been checked and the need of raw material and required special products have been evaluated. Forms and reinforcement are made according to plans. Fresh concrete is transported to the work station and it is compressed carefully. The quality of the element is assured by good and careful curing so that the element is ready to be transported to the construction site after the disassembly of the form. (Appendices 3 and 4)

In transportation, finished factory made products are brought to the construction site and will be directly installed or stored. During transportation careful protection is important to avoid damage of the products. Also infrastructure has to be taken into account.

Installation is one of the most important work phases in the precast construction because it defines the final quality of the precast frame. Erection of the precast concrete frame means installing products to their places and casting joints. (Appendix 5)

To be sure that the installation will succeed, measuring work has to be done properly. Erection of the frame starts according to installation plan of the elements. The plan includes temporary storage of the elements, cranes and other lifting accessories, joint material, welding information, protection of joint casting, the support during installation and the order of installation. Elements have to be lifted and installed following the installation plan and directive given by precast manufacturer. Used lifting equipment is determined by the size and weight of the element. Structural engineer have to give needed information of the installation order, temporary supports and final attachment so that the structural stability will remain in every phase of the installation. Measuring work has to be done carefully to be sure installation will succeed. (Betonitekniikan oppikirja BY 201 2004, 484-492.)

2.2.2 Column beam slab frame

The cross-section of a column is rectangular or circular. The recommeded minimum thickness of a column is generally 280 millimetres. Normally columns are located centrally to module grid of the frame. In case of widening the building it does not affect the size of the module grid. The measures of the cross-section of the column are chosen so that the capacity of the column is enough compared to stresses affecting the column. The production measure of the column is n x M (accession measure) – 20 millimetres 380 for example 380 x 380. The standard bevel, 15 x 15 square millimetres, is primarily used on the corners of the columns. Figure 3 presents generally recommended column sizes.

When choosing the size of columns these factors should be taken into account:

- Architectural, functional and economic requirements
- Primarily rectangular columns shoud be used
- Usage of rectangular columns is considered when horizontally loaded, like tower columns, for example wind columns of hall buildings.
- Circular columns are recommended to be one storey high
- Same cross-sections ought to be used in the same construction
- Load capacity is controlled by changing the concrete strenght and reinforcement not by changing the size of the column. Most profitable way is to increase the strength of the concrete and then add reinforcement
- Smaller cross-section saves space costs but on the other hand it is more difficult to support beam on a smaller column. (Betoniteollisuus Ry, elementtisuunnittelu.fi)

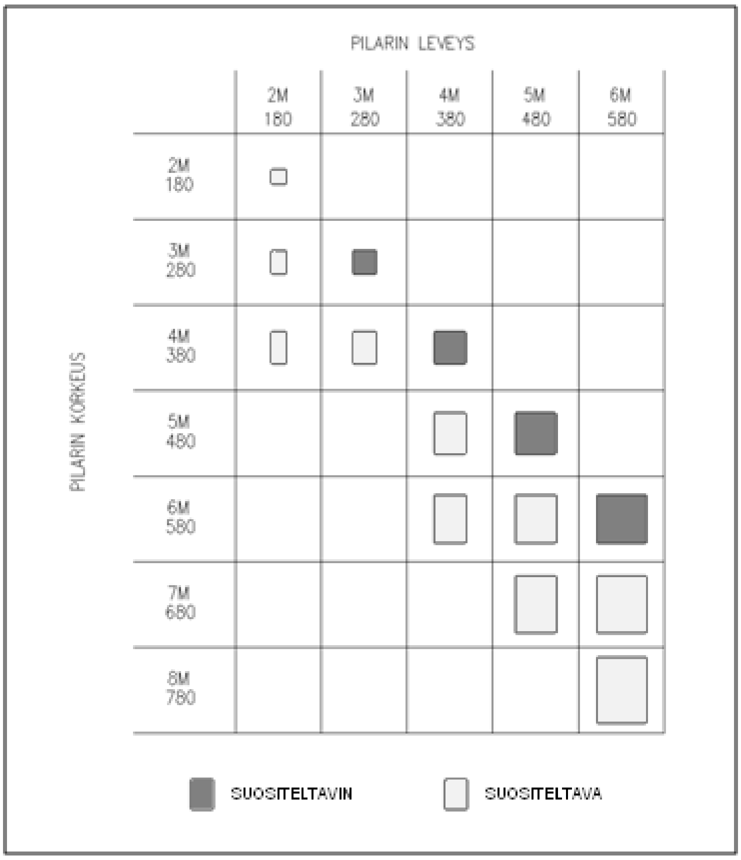

FIGURE 3. Recommended column sizes. Width of the column is marked vertically and hight horizontally (Betoniteollisuus Ry, elementtisuunnittelu.fi)

Precast beams can be normal reinforced beams or prestressed beams. Figure 4 presentes different beam types.

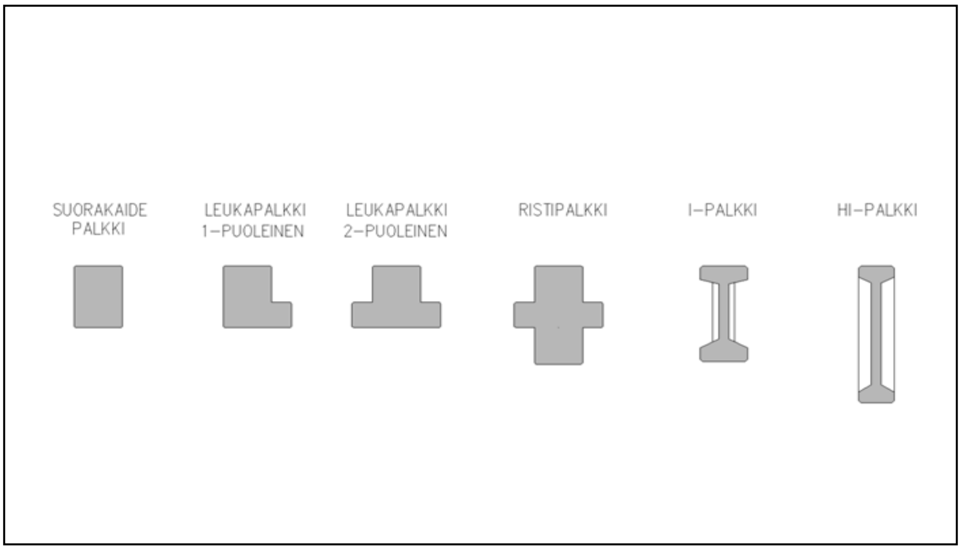

FIGURE 4. Beam types listed from left to right: Rectangular beam (Reinforced or prestressed), L-Beam (Reinforced or prestressed), Two-side L-Beam (Reinforced or prestressed), Cross- Beam (Re-inforced or prestressed), I-Beam (Prestressed) and H-Beam (Prestressed)

Span, loads and usage affects when choosing the beam type. Rectangular beams, L-Beams and crossbeams are mainly used in ground and intermediate floors. I- beams are mainly used as roof girders.

When choosing the size of beams these factors should be taken into account:

• Production size of the beam is n x M (accession measure) – 20 millimetres (for example 680x480)
• Same cross-sections ought to be used
• Rectangular beam is usually the most cost effective solution in reasonable spans
• If space is needed under slabs, L-Beam is used instead of rectangular beam
• Crossbeam should be used only exceptionally (height >1000 millimetres or large production serie)
• Notch measure of the notched beam on its ends is 300 millimetres. Standard bevel 15 x 15 square millimeters is used in visible

Functional requirements and loads affect when choosing the slab type. Functional requirements vary with different building types. Common slab types are presented in figure 5.

When choosing the slab type these factors should be taken into account:

• Span of slabs and liveload capacity
• Architectural requirements, for example underside surface
• LVIS-installation placement and other structures joining to slabs
• Sound insulation especially in residential buildings
• Fire resistance varies by slab types
• The shape of the building and openings of the slabs affects when choosing the slab type
• Own weight of the slab can affect when looking at the element’s treatment and other structures from loadbearing point of view.

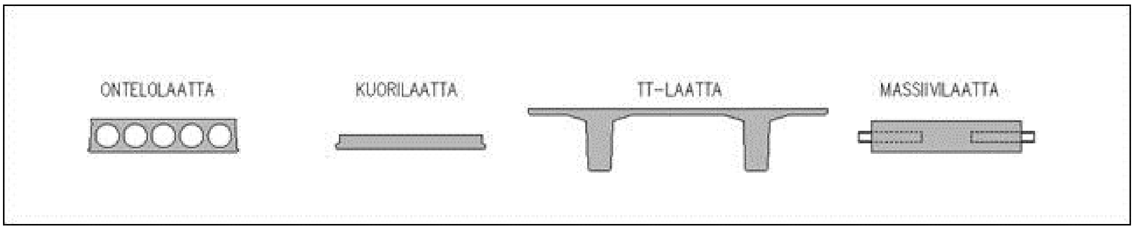

Figure 5. Common slab types are listed from left to right: Hollow-core-slab, core slab, Double Tee-slab, massive slab

The hollow core slab is the most common element type, which is used in concrete frame buildings. They are used in residential, commercial, industrial buildings' ground, indermediate and upfloors. Hollow core slabs are prestressed slab types, which are streamlined with longitudinal hollow cores. C40 – C70 strenght concrete is used when producing the hollow core slabs. Slabs are casted by slidecasting on long steelbeds. The mass used in casting is so stiff that without separate form sides the slab will keep its form shape is formulated and compressed by casting. Height, amount and shape of the hollow cores vary with the height of the slab. Production thicknesses are 150, 200, 265, 320, 370, 400 and 500 millimetres (Table 2.) and standard width is 1,200 millimetres. By using the hollow core slabs it is possible to have 20 meter span. (Appendix 6)

TABLE 2. Width and maximum spans of the hollow core slabs (Betoniteollisuus Ry, elementtisuunnittelu.fi)

SLAB TYPE	SLAB HEIGHT [mm]	WEIGHT [kg/m²]	WEIGHT WHEN SEALS [kg/m²]	MINIMUM SUPPORT SURFACE [mm]	MAXIMUM SPAN [m]
O15	150	205	215	60	7,0
O20	200	245	260	60	11,0
O27	265	360	380	60	13,5
O32	320	380	400	60	16,0
O37	370	485	510	60	14,0
O40	400	435	465	100	18,5
O50	500	560	600	100	20,0

The used slabtype is chosen mainly by its load bearing capacity. Big openings are recommended to be done in the factory. The maximum size of openings varies with the slab type, the span measure and the location of the loads and the openings. The openings are recommended to locate so that they will cut as few strands as possible between hollow cores. The concrete cover of the cables has to be taken into account when locating openings.

For example O37 slab type is generally used in the ground and idermediate floors of residential buildings. This slab type meets the requirements of sound insulation when using the normal intermediate structure where the filler, the flexible underlay and the surface material come on top of the hollow core slab. The benefit of using the hollow core slabs is that pipes can be installed inside the hollow core. (Betoniteollisuus Ry, elementtisuunnittelu.fi)

2.2.3 Load bearing walls with slab frame

The maximum recommended height of the wall element is 3.6 metres. 5 meters is the maximum lenght of the wall element without reinforcement. The maximum length of the reinforced wall element is 8 to 9 metres. The lifting machinery has to be taken into account when planning the element division so that the elements are not too heavy. Usage, loads, demands of the upper element's support surface as well as fire and sound technical issues. These all factors affect when choosing the thickness of the walls. Minimum thickness of partition wall without reinforcement is 120 millimetres. Other thicknesses in use are 160, 180, 200 and 240 millimetres. The minimum thickness of the solid wall is 180 millimetres (Image 8).

IMAGE 8. Wall elements (Elematic Group)

Using the partition walls is the most common frame solution in Finland where the floor slabs are supported to loadbearing walls and to exterior walls. In this case exterior walls that are parallel to floor elements are normally not load bearing and forms not loadbearing frontage where the balcanys are usually located. This solution is commonly used when building a lamell houses. Walls between apartments are concrete walls (thickness 180 or 200 millimetres), when the required sound insulation and fire compartment are easy to achieve.

Planning recommendations:

- Slab system is based on modul measures 12 M
- Floor slab spans are chosen by slab producer's diagrams
- Slab elements have to be supported to concrete walls from it's both ends.
- Chimneys and openings ought to be parrallel to slabs
- Load bearing wall lines on top of each other

- Wet areas on top of each other
- Window- and door beams and side columns of openings are sufficient on exterior side

The frame is stiffened with transverse load bearing concrete walls, bearing exterior walls and stair-well and elevator shaft walls. If the combination frontage is used and inner surface is not in the load bearing side, 150 millimetres longitudinal exterior walls can be used as a load bearing and stiffening structure. Balcany frontages usually have lots of openings which make a stiffening effect small and at the same time stiffening calculations will be more complicated which may cause problems.

2.2.4 Load bearing exterior walls with slab

Exterior walls can be loadbearing on balcany frontages mainly in diverse residential buildings. In lamell houses the cost effectiveness of the load bearing exterior walls should be examined separately. The walls between apartments are often made of concrete because of sound and fire technical reasons. So the amount of the concrete walls is bigger than in the partition walls with slab alternative. In addition, openings of the load bearing frontage requires special carefulness. (Betoniteollisuus Ry, elementtisuunnittelu.fi) (Image 9.)

IMAGE 9. Load bearing exterior walls with slab frame (Betoniteollisuus Ry, elementtisuunnittelu.fi)

2.2.5 Combining different frame types

Under residential buildings there is normally a parking space when the building is located in the center of the city. Usually storages and office spaces are located in the first floor therefore three different frame types have to be combined. When planning, apartment partitioning and parking space have to be coordinated because the location of the load bearing structures of the apartments affects the parking space. The stiffening plan of the building requires special attension. (Betoniteollisuus Ry, elementtisuunnittelu.fi)

2.3 Using the precast structure in residential buildings in Thailand

The precast frame is rarely used in Thailand. Hollow core slabs are more common but they are only used in townhouses. When researching Pattaya area, all the buildings that were constructed or were under construction that were using only precast method, could not be found. A construction site where precast exterior walls are used with cast in place frame was found (Image 10).

The visit to the construction site, where over a 20 storey building is under construction, the frame was built by using the cast in place system and exterior walls were precast on site. The company called Pre Built has used this method in all its projects, which are mainly in Bangkok. Pre Built Public Company Limited is a contractor that has completed a number of large residential buildings, commercial buildings, shopping centers, schools and government centers in the country. Exterior walls are produced on the construction site and they are designed project-specific. Adoon Panyasen, the general superintendent from the Pre Built Company speaks with 30 years` experience that using precast exterior walls makes the constructing faster and more effective. According to Panyasen it takes 7 to 10 days to build one floor in this project. A Pre-Built site completes 13 precast components per day. For example they have 14 different precast products for this project, which include exterior walls which are 10 cm thick and also staircase components. When using this technique, it is possible to monitor the quality easily. It also reduces labor and material costs. If components were ordered from a concrete factory, logistics would increase costs and the precast technique would lose its effectiveness, says Panyasen. Even if the elements which are made on the construction site makes erection faster, the outside factory is still exposed to weather conditions. (Panyasen 2014-05-14.)

IMAGE 10. Exterior walls precasted on Pre-Built Public Company Limited’s construction site

One of the biggest precast factories is located in Bangkok. Despite multiple contact attempts, it was not possible to visit the factory because of their strict policy of not letting outsiders see their production process. Instead it was possible to visit Pro-build precast factory in Bangkok. In order to obtain rough square metre price of precast products to the A- building of the Tropical Garden the model was checked together with the personel of the precast factory. Pro-build offers load-bearing wall-slab frame including product transportation and installation. All the precast costs and schedules that are compared in this thesis are from Pro-build precast factory. Pro-build also offered a chance to get to know the production process (Images 11 and 12).

IMAGE 11. Precast wall elements in the Pro-Build precast concrete factory

IMAGE 12. The reinforcements of loadbearing wall in the Pro-Buid factory

Information about precast production was also received from a presentation of a precast factory under construction, which is located in the Chonburi province. This factory offers 3D modelling, precast planning and reinforcement planning, as well as production and storage, transportation, installation and installation training. Elements are delivered to the site in the installation order and storage if needed. This fully automatic factory uses a new technique in Thailand by using flexible magnet forms, and still provides its products at competitive prices.

The theory of frame structures in this study is based on the Finnish way of constructioning because of the difficulties to find information about constructing in Thailand. This theory is used as a source of information when modeling the Tropical Garden. Preliminary research on different frame structures showed that the column beam slab frame is a rarely used frame structure also in Thailand as well as in Finland. Accoring to Scanditech's architect Rachan Chaimongkol the loadbearing walls – slab frame structure would be easy and cost effective way to build. Because of the expensive land, parking is located below the ground floor and it would cause massive loads to the beams, which might cause problems when planning and implementing the frame.

Constructing in Thailand differs a lot from constructioning in Finland. For example the climate differencies between Finland and Thailand have to be taken into account when applying the theory of precast constructing. For example isolations are not needed in exterior walls and the amount of reinforcement is considerably higher because of the strength of the steel.

3 BIM MODELLING

BIM, building information modelling offers new kind of tool to help planning, constructing and to control building information. In planning phase, information modeling intensifies construction solutions and analyzing systems as well makes decisions faster. In construction phase total productivity can be improved by using the BIM in accuisition and in task planning. (Sustainable engineering and design 2013)

3.1 Modeling in design process

Information modelling based design is that building's information model works as a virtual model which helps analyzing the design solutions and their workability with different options. With the help of information model, information of the building is fast to control in demonstrative form. Costs of construction are determined mainly in design phase. Information model offers significant advantage by creating opportunity to optimize costs as well designer's, developer's, contractor's as user's point of view. (Rakennusteollisuus RT RY, Finmap consulting oy 2004)

BIM designing is more expensive than traditional 2D modeling, but information model often saves total costs by preventing design errors and advantages that BIM offeres on site.

3.2 Using the 3D model in production

BIM demonstrates progress of construction site's production with different visual ways and this allows that production can be also planned forward for example by using model when planning rotation of the form. Fast and reliable amount information from BIM helps when planning schedule and its control. Clarity of the model makes problem solving easier or planning the rules of procedure understood by all, for example information can be shown to workers from laptop on the construction site. Opportunities offered by information model appear best when making complicated structure components or combining work of different spaces. (Mäki, Rajala and Penttilä 2009)

The key benefit of the information model to contractor is to get construction components, technical components and their features automatically from model plans list-like amount information. With assistance of the model, implementation process of the building can also be simulated before starting constructioning and this way analyze design solutions and their workability beforehand. (Penttilä, Nissinen and Niemioja 2006, 18.)

The contractor can use data from the BIM daily and weekly for example workplanning realization monitoring, simulating installation order as well option- and offer comparison. Built components can easily be compaired to visual plans of the model. Picking different kind of list-like information, as measure, amount, and cost information for production planning needs can be done with BIM. Location- and measurement information of BIM can be used as well on the construction site as in making precast components inside the factory. Schedule sets the phase to all these functions (4D), which can be used in comprehensive scheduling, monitoring work progress as well in leading in production and the construction site. (Penttilä ect. 2006, 15-16.)

3.3 Modeling the Tropical Garden cast in place frame by TEKLA

CAD pictures from the Tropical Garden project were received while still in Finland. After becoming familiar with the CAD drawings and data, modeling the frame of the project started according to the original plans of the Tropical Garden project to a 3D form with TEKLA. At an early stage of the modeling differencies were noticed in reinforcement plans. TEKLA did not offer right kind of components, so appropriate reinforcement had to be created to columns and piles one by one. Because it is not possible to model post tensioned slab by TEKLA, the slab was modeled without reinforcement in order that the amount of concrete could be calculated. The elevator shaft and staircases are also modeled without reinforcements. All three buildings were modeled according to CAD drawings and the object browser was used when creating the list of amounts. List of amounts were used in the bid comparison of Tropical Garden. (Image 13) (Appendix 7)

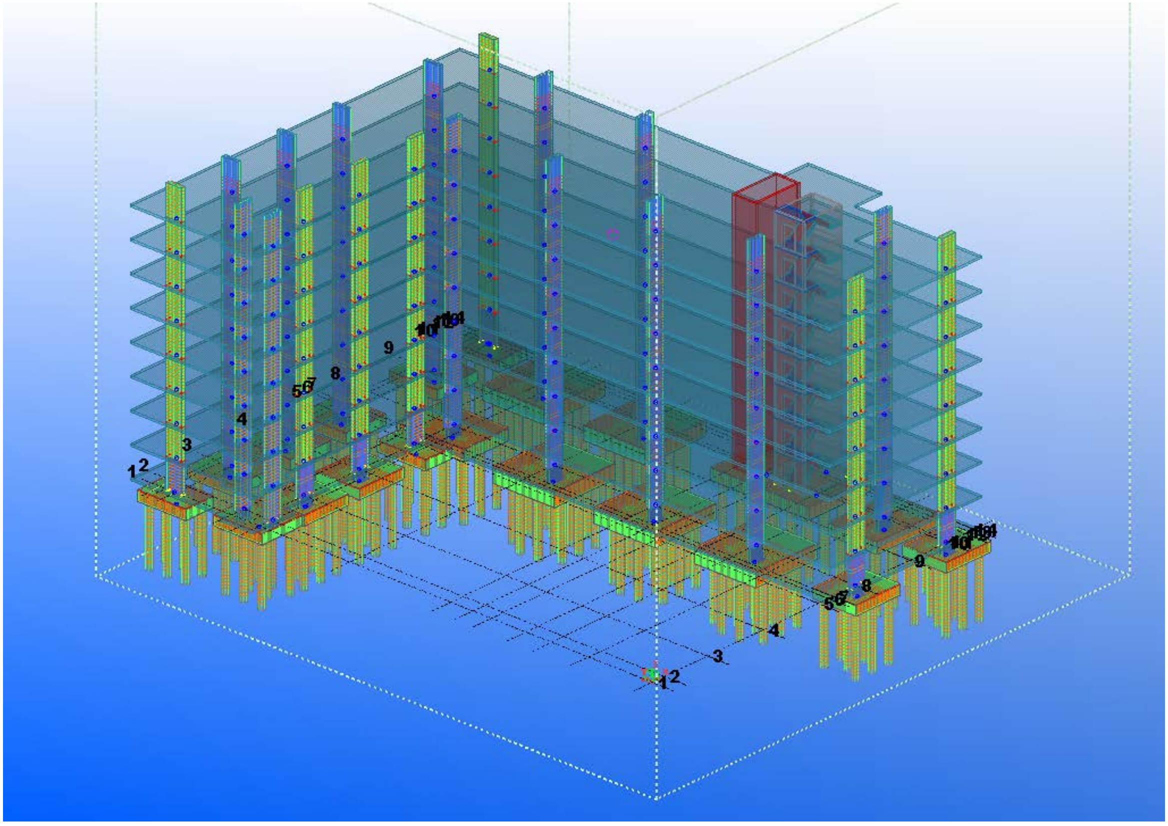

IMAGE 13. Tropical Garden building A cast in place frame

3.4 Modeling the Tropical Garden precast frames by TEKLA

The purpose is to model both of the precast frame alternatives, column, beam- slab frame and load bearing walls with slab frame. 3D models are used when comparing properties between cast in place and precast constructing and use the models as help when inquiring the prices of the precast products. Modeling with TEKLA is going to begin by planning the modul grid and the sizes of the elements.

3.4.1 Modeling the column beam slab frame

At the beginning of modelling the Tropical Garden building A, the column division and module grid was planned. The column division was planned to the same shape as in the original drawing. The stairwell and elevator shaft were stiffening structure and their places were not changed. When planning column, beam and slab sizes, elementtisuunnittelu.fi was used as help. Module grid was planned 12M multiple. There are seven columns on the sides and five columns in the middle. The beams on the sides are 84M and the beams in the middle are 126M. The chosen beam is a rectangular 480 mm width beam. The height of the beam is 680mm and it was chosen on the basis of the thickness and the length of the hollow core slab. Hollow core slabs are 12M wide, the length is 7 or 9 metres and thickness is 320 mm (Figure 6). The span of the beam is 8.4 and all the beams used in this model are of the same size.The building is devided into two blocks and on one block the column division is 60M and on another the block column division is 126M. The original elevator shaft, size 2200mm, is modified to 2400mm to fit module grid. The original measures of the building are also modified to fit the module grid. The volume of the building A is approximately the same as the original one. Joints are not taken into account.

Taulukko 10

JB-suorakaidepalkki, B=480 mm, C50
Ontelolaatta
Kuormaluokka E
Kuormitus g_k=2.5 kN/m²
q_k=10.0 kN/m²

Laatan jänneväli	Laatan paksuus	Palkin jänneväli					
		6 000	7 200	8 400	9 000	9 600	10 800
6 000	400	580	580	680	780	780	880
7 000	400	580	680	780	880	880	980
8 000	400	580	680	780	880	980	1080
10000	400	680	780	880	980	1080	
12 000	400	680	880	980	1080		
14 000	500	780	980	980			
16 000	500	880	980	1080			
17 000	500	880	1080				

Suositusalue likimäärin

FIGURE 6. Betoniteollisuus Ry, elementtisuunnittelu.fi

3.4.2 Modeling the load bearing walls with slab frame

The modelled walls are 200 millimetres thick and 3,000 millimetres high. The building is devided into two blocks. The walls between two apartments are loadbearing and the thickness of the hollowcore-slabs are 200 millimetres and the length is 5 metres in block one. The corridor is 2,400 millimetres. Delta beams are placed in every 5,000 millimetres to cross the corridor. The hollow core slabs on the corridor are 5 metres long so that there will be no deflection differences. Exterior walls in block two are load bearing and delta beam is used to cross over balcony. The hollow core slabs used in this block are 12,000 millimetres long. The elevator shaft and the stairwell are the main stiffening structures. There should also be load-bearing walls to increase stiffening because the elevator shaft is not stiffening enough. Hollow core slab cannot go over load bearing wall because there will be difficult detail on the intermediate support and the reinforcement amount would increase in top surface. It could be possible to examine is it profitable to use 10 metre hollow core slabs and masonry wall in every five metres instead of cutting the hollow core slabs into 5 metres. (Image 14.)

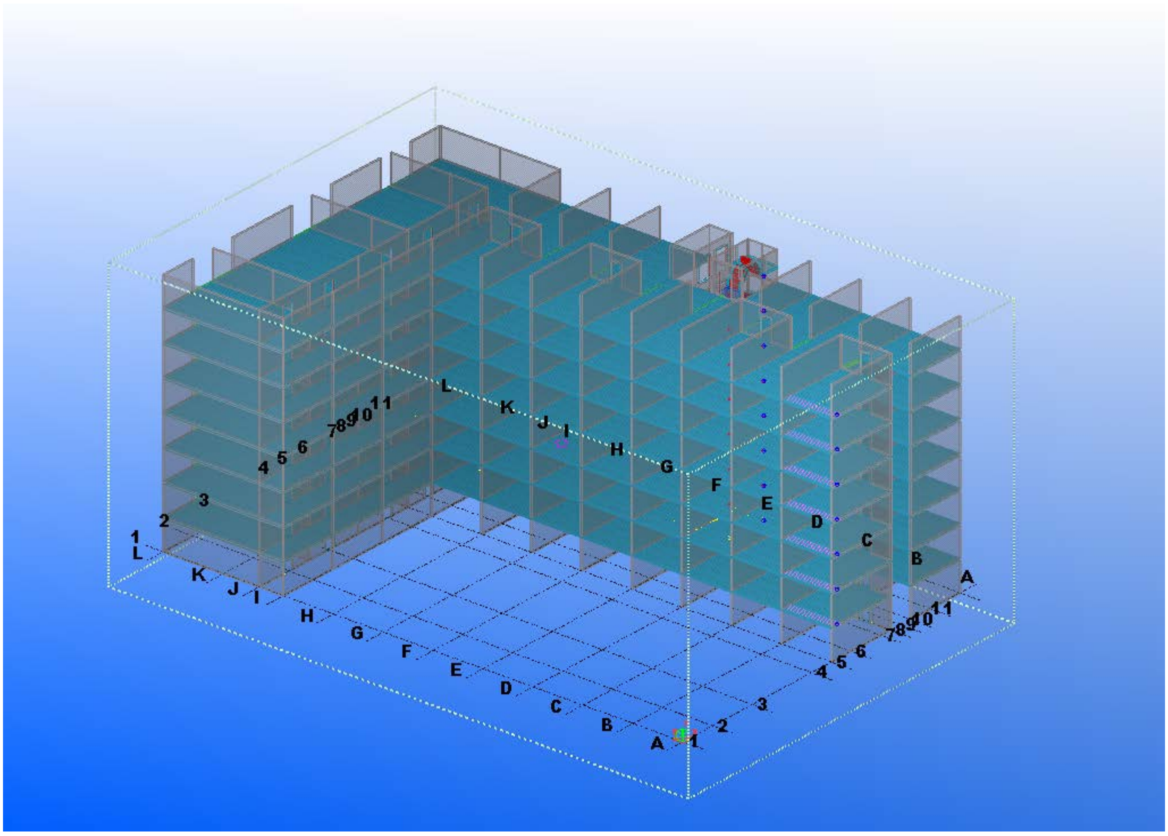

IMAGE 14. The precast frame of the Trpical Garden building A

4 QUANTITY AND COST CALCULATION

Construction costs are mainly determined in the design phase. Costs caused by construction can be divided in to investment as in establishing costs and maintenance costs. Investment costs consist of building, machinery used in work and costs of land. Maintenance costs include usage costs.

Total costs of construction are determined by made decisions and following effect. Selected way to build, schedule, building conditions and designing solutions are the most significant factors creating the costs and affect their volume.

4.1 Utilization of the building information modeling (BIM) in quantity calculations

The common goal to all is to get reliable quantity data directly from the model. Based on this information it is easier to start to build automatic data transfer to production control systems and production.

Through the utilization of the building information models (BIM) it is possible to make quantity take-off considerably more effective, and to increase the utilization of quantity data in different decision-making situations. Measuring the quantities manually from the drawings is replaced by computer-assisted measurement from a BIM. Quantities can be measured from architectural, structural and building services technology data models and their integrations. It is possible for the building owners and clients, designers, contractors and product fabricators to utilize quantity take-off in completely new ways and from new perspectives. (COBIM 2012, 5.)

With regard to quantity take-off, model information content can be divided into building and building services elements, nomenclature items and product and product-structure quantities. When taking off building and building services elements, the elements reported on the basis of BIM contain the information defined for example by the designer, organized by element types. The quantity report is produced as a bill of quantities using the basic reporting tools of design software or, for example by exporting data from an IFC file into Excel. (COBIM 2012, 11.)

4.2 Keynote systems used in Finland

Costs and schedule goes hand in hand in Finland. Using the keynote systems is in big value. This chapter tells the keynote system shortly and the meaning of the system to schedule and costs. Nomenclature system building 2000 is used in this thesis. There are no keynote systems used in Thailand so the schedule is processed separately. Nomenclature system Building 80 is most used among construction companies. The benefit of the nomenclature is its construction site centricity. The cost monitoring of the construction project is focused on the construction site in which case the construction site centricity is the most important feature of the nomenclature system. Some companies use Building 90 in cost calculation but cost estimates are translated into Building 80 system in the construction phase.

“Building 90 is not only a series of classification tables, but a comprehensive tool supporting design procedures as well as new methods of production planning and control. The element classification is used in design, especially in specifications. The clients and contractors use the methodology in cost estimates of different accuracy by spaces, elements of construction or work sections as well as for detailed bills of quantities. The classification tables are also used in planning, scheduling and controlling the construction resources: labour, subcontracts, site equipment and purchases of building materials” (The Finnish building classification system, Building 90 Group and the Finnish building centre)

Building 2000 nomenclature is national nomenclature system formed in cooperation of construction business. It is the base of data transfer of constructioning to all parties. Building 2000 nomenclature improves and unifies the data transfer of constructioning process between parties.Building 2000 nomenclature is used to standardize plan norms, quality requirements, cost- and sale files together with quantity calculation and contract documents. Building is described in nomenclature as product structure and construction- and technique part. Production is described as input structure in other words as products, work and stock. This nomenclature can also be used in international projects.

4.3 Cost calculation evaluations and procedures

Differences of design solutions that cause standard deviation of costs can be even 10% depending on the project type and design solutions. In addition to common design solutions, system and building block solutions and production technique cause differences in costs. Different construction technique can not be compared only by the cost of structure components, all the total costs and schedule costs have to be taken into account. Quality, durability of structures and usage with its affect to lifespan costs have to be considered when comparing different construction techniques. Costs have to be viewed project case basis. Different frame solutions should be compared already in the beginning of the project to find an optimal way to build. (Betoniteollisuus Ry, elementtisuunnittelu.fi)

Cost estimation of building blocks is a system where building is divided into building blocks based on the nomenclature. The building blocks are measured based on the directions of the quantity measuring and are priced based on the unit prices of the building block catalogue. The cost calculation of the contractor means that when the contractor calculates the quantities of the contract and prices them following the bid comparison documents. Space based cost estimation means that the developer makes a space program. Normally the cost estimation is made based on the scetches of the arcitecht.

4.4 Quantity and cost calculation in Thailand

The nomenclature systems cannot be applied in Thailand because the so called project targeted keynote system is in use. The project targeted keynote system means that construction parts and the keynotes of the tasks are not continuous from one project to another. Construction costs in Thailand vary as they do anywhere in the world and according to a multitude of factors for example the type of the project, what is being built, the architect's drawings, the professionalism and quality of the contractor, what is included in the construction price, the quality of materials and the construction site conditions. Prices have increased in the most parts of the world, also in Thailand due to increase of the material costs and more recently the minimum wage increase of 2013. Also land prices have increased dramatically in recent years. Construction costs in Thailand are still lower than in many countries. The land price affects frame solutions when building residentialt buildings. The more expensive the land, the more efficiently squaremeters are usually used. An example of this is green areas and gardens. They are required in regulations and it is not profitable to build in an expensive land, so they are placed in upper floors with swimming pools. (Image 15)

IMAGE 15. One of the completed projects of Scanditech (siamoriental.net)

4.5 Quantity and cost calculation of cast in place construction

Well pre-planning creates prerequisite to cost effective cast in place feasibility. Successfull plan makes use of best quality, plasticity and structure's diversity of cast concrete. Production cost is not dependent on building's architecture or difficulty, its production cost is linked to feasibility. Here are few design factors that affect costs of formwork, which have been noticed to have a great impact on formwork itself or finished component. Frequency, structure solutions, meaning of the details, quality of the concrete surface and cooperation are few to mention. Cast in place frame costs comes from form work and materials, labor costs, concrete and reinforcement. The biggest factor in form work costs is number of usage as well in material and in labor costs. Despite the difficulty or the surface of the structure the price is determined by the number of usage. This shows especially in formwork of vertical structures.

Usually when the structure is optimal concrete and reinforcement sales can be minimized, but at the same time measures of the structure varies which means that the formwork gets slower and form material and form labor costs multiplies.

When using cast in place technique usually reinforcement is designed to be made with bulk bars when the main attention is focused on minimizing the reinforcement amount. I.e. calculated amount of reinforcement is aimed to implement as accurate as possible. Serielenght affects mostly to industrial reinforcement costs. Recommendable amount of each reinforcement type is at least few dozen. Different reinforcement types should be minimized instead of minimizing weight of the reinforcement. About half of finished reinforcement costs are material costs and other half variable work phase costs, including supervision. The reinforcement sales are dependent on the structure solutions and loads therefore it forms quite firm expenditure. (Talonrakennusteollisuus RT ry and Rakennustietosäätiö RTS)

4.6 Quantity and cost calculation of precast construction

Cost effectiveness of the precast building is based on better productivity in factory and smaller workload on the construction site. The construction time will shorten so the total costs will decrease. When frame, frontage, supplementary structures and constructing technique are prefabricated as far as possible, then the industrial constructing will benefit the most. Costs of the precast products are divided as follows: production, planning transportation, installation and cast joints. When using the precast alternative, the total costs of the construction site will decrease. When precast products are measure exact, surfaces are as prepaired as possible and prefabrication level is high, suplementary work can be decreased. A shorter construction time will save the interest costs and the investment yield can be achieved earlier than in the cast in place alternative. The major part of the costs of the precast constructing are focused on the factory, only transportation and istallation remains on the construction site. (Betoniteollisuus Ry, elementtisuunnittelu.fi)

4.7 Bill of quantities of the cast in place frame and the precast frame

The quantity and costs of the frame of the Tropical Garden project building A was researched in this thesis. Only the frame of the building is taken into account in this research. The parking space below ground and foundations are left out i.e. floors above ground are calculated. The Scanditech`s bill of quantity of Tropical Garden is used when researched the quantity and costs of cast in place frame. Only the costs of the frame phase are specified from the bill of quantity. There are none keynote systems used in Thailand however the construction phases are numbered. Numbers 1-5 are used in this project and for example number 2 means construction frame phase.This project`s number 2 is comparable to the finnish Building 2000 keynote 123. This thesis concentrates on numbers 1-2. Finnish Building 2000 keynotes are added to tables below (Table 3). (Appendix 8)

TABLE 3. The bill of quantities of the cast in place frame

PROJECT	TROPICAL GARDEN BUILDING A (8 516 M2)						
Nomenclature building 2000	NO.	DESCRIPTION	UNIT	QUANTITY	MATERIAL BHT/UNIT	LABOR BHT/UNIT	TOTAL
	1	**ARRANGEMENTS**					
41 751	1.3	MOBILE CRANE & HARD MACHINE					
123 41	2	**STRUCTURE WORK**					
123 41 03	2.5	STRUCTURE CONCRETE 240 KSC.(cube)	m3				
1235 41 03	2.6	CONCRETE 380 KSC.(Cube) POST TENSION SYSTEM	m3				
123 41 01	2.7	FORMWORK	m2				
	2.8	POST TENSION SYSTEM	m2				
1235 41 02	2.8.1	POST TENSION SYSTEM REINFORCEMENT	KG				
123 41 02	2.9	**REINFORCEMENT**					
	2.9.1-2	RB	KG				
	2.9.3-6	DB	KG				
	2.10	TIE BAR	KG				

The cast in place frame is compaired to the costs of the precast frame. The bill of quantities of the precast products is from the precast factory in Bangkok. The precast factory estimated the square metre price of precast frame, transportation- and installation of elements. According to the Probuild precast factory the cost of the crane is approximately 1 500 000 BHT. It is assumed that the crane is continuously on the construction site the whole erction time of the frame. The installation of the precast frame is approximately 74 days. Square metre price of the labor is 400-500 per / m2 (includes labor and joints) according to the precast factory. Average 450 BHT per square metre is used. The Probuild precast factory estimated two different prices. The first estimated price includes production, transportation and installation. In the other offer, these three phases are separately. The second price, which includes all phases, is clearly cheaper and this price is used in comparison.

Precast installation labor cost is 450 BHT/ m2 and cast in place labor cost is 440 BHT/m2 (calculated from the cast in place bill of quantities). Labor costs are almost the same even though erection time differs significantly. Erection time of the cast in place frame is 120 days and the erection time of the precast frame is 74 days. This shows that the traditional cast in place labor costs is half from precast labor costs. This is one of the reasons why the cast in place method is still the most used one in Thailand. The bill of quantities of the precast frame is shown more precicely in the table 4 and 5. Table 6 shows the quantity of the elements from the Tekla model.

TABLES 4 and 5. The bill of quantities of the precast frame

PROJECT	TROPICAL GARDEN BUILDING A (8 516 M2)						
Nomenclature building 2000	NO.	DESCRIPTION	UNIT	QUANTITY	MATERIAL BHT/UNIT	LABOR BHT/UNIT	TOTAL
1232 42, 1235 42	1	PRECAST ELEMENTS	m2				
1232 42, 1235 42	2	TRASPORTATION	m2				
1232 42, 1235 42	3	INSTALLATION	m2				
42 751	4	CRANE		1			

PROJECT	TROPICAL GARDEN BUILDING A (8 516 M2)						
Nomenclature building 2000	NO.	DESCRIPTION	UNIT	QUANTITY	MATERIAL BHT/UNIT	LABOR BHT/UNIT	TOTAL
123 42	1	PRECAST ELEMENTS, TRANSPORTATION, INSTALLATION	m2				
	2						
	3						
42 751	4	CRANE		1			

TABLE 6. Quantity of precast elements from the modeled frame

bearing walls with slab 1 floor 1027,2m2				**precast sqm**
hollow core slab 1200x200	5000	mm	109	654,0
	9500	mm	28	319,2
	2500	mm	28	84,0
	total 1 floor		165	
wall 7200x200x3000			10	216,0
wall 6000x200x3000			21	378,0
wall 3600x200x3000			3	32,4
wall 3500x200x3000			4	42,0
wall 5000x200x3000			4	60,0
			1 floor	1 785,6
			total	14 284,8

5 SCHEDULE

Schedule sets goals to the whole project, singel work tasks and labor usage. Goal of the project is to follow the schedule in starting and in finishing tasks. Monitoring the schedule requires continuous knowledge of the updated overall and situation of single tasks, as well compairing to planned situation and catch up the schedule when needed. (Kankainen and Sandvik 2002, 14.)

The process of schedule planning begins in planning phase of the project by making preliminary schedule and by orientating planning- and contract documents and estimated goal. When the project proceeds schedule gets more accurate, exactly defined and task-spesific. With the management of the site, the whole construction time and milestones will be cleared up as well as technical requirements, manufacturing conditions, manufacturing solutions, principals of labor usage and work done by subcontractors. General schedule makes the frame, but more accurate schedule- and task-planning makes sure that the project will meet the goals. (Aikatauluteoriaa, Kankainen and Sandvik 2002, 16.)

5.1 General schedule

The meaning of the general schedule is to show planned work of the project. The schedule should show a realistic view of the timing and duration of the project phase i.e. general schedule is example of implementation of the site and timing control. It measures also the main resource which means that the general schedule works as an outputdata for resource plans, as labor, acquisition and stockplans, as well more detailed plans as construction phase-, weekly schedule and task plans. General schedule is the main information tool between parties in the construction site and basis to supervision during construction. In addition to mentioned above, designing and estimating plan schedule during construction are made based on the general schedule.The succesfull implementation of the project requires functional connection between plan schedule, acquisition schedule and general schedule of construction site. The general schedule is made right after signing the contract agreement before starting the construction or when the decision about starting construction have been made. Operation manager, designer or construction engineer as well construction manager participate in making of the general schedule. (Talonrakennusteollisuus RT ry and Rakennustietosäätiö RTS)

The most important output data when making general schedule are:

- technique plans, for example drawings and work commentary
- contract documents, especially fixed dates
- holidays and days off
- titles of general schedule
- condition information of the construction site
- calculation and estimated costs
- premilinary general schedule
- most important choices of work methods

- production files (ratu and company based calculations)
- availability and limitations of resources (Betoniteollisuus Ry, elementtisuunnittelu.fi)

The titles of work tasks are chosen by the technical plans of the project. An average 20-30 important tasks will be chosen to general schedule depending on the project's complexity and stage of difficulty and its normally presented in segment schedule or position-time diagram form. Accuracy requirement of the task duration is 0.5 weeks and time of the task is 1 week.

5.2 Construction phase schedule

The construction phase schedule is made for a certain construction phase or period. The purpose of the construction phase schedule is to make sure to keep the general schedule. The most important resources of the work phases will be measured with effective work inputs, task interlacing and alternative calculations. The construction phase schedule gets its frame from the general schedule and correspondingly gives frames for making weekly schedules.

The construction phase schedule is made either for a 2 to 6 month period or for a construction phase as earthworks and foundation, frame, interior works as well handover phase.

The construction site is always responsible for making the construction phase schedule. Bacause of its prevalency and accuracy the construction phase schedule is the main control tool on the construction site.

The output data of making the construction phase schedule are:

- technical plans
- checked amount of calculation
- contract documents, especially fixed dates
- general schedule and previous construction phase schedule
- more accurate production plans e.g. form plan
- work method and machinery choices
- available resources as capacity of machinery and labor as well resource limits and realized acquisition and machinery reservation
- production data: company specific files and realized data

(Talonrakennusteollisuus RT ry and Rakennustietosäätiö RTS)

10 to 40 titles according to the resource groups will be taken into the construction phase schedule which is based on general schedule. There has to be the most important side contractor and subcontractor tasks measured and synchronized and also matched dependencies with construction techniqual works in the phase schedule. Work order will be planned according to the frame of the general schedule, which means that the titles will be devided by the type of work or set of work. The construction phase schedule is presented in the segment schedule or position-time diagram

form. Accuracy requirement of the task duration is 1 week and time of the task is 0.5 week. (Talonrakennusteollisuus RT ry and Rakennustietosäätiö RTS)

In the construction phase schedule there are presented:

- title
- title code
- performance amount and unit
- work input, work achievement
- group chosen to work
- duration of task
- timing and dependencies

(Talonrakennusteollisuus RT ry and Rakennustietosäätiö RTS)

5.3 Schedules of the cast in place and the precast frame phases

This thesis is focused on the frame phase of Tropical Garden building A and the general schedule of this project is used in comparison. Only the frame phase of the general schedule is taken into account which is devided into construction phase schedule (Figure 7) for the comparison. Erection time of one floor takes 15 days when using the cast in place method. (Appendix 9)

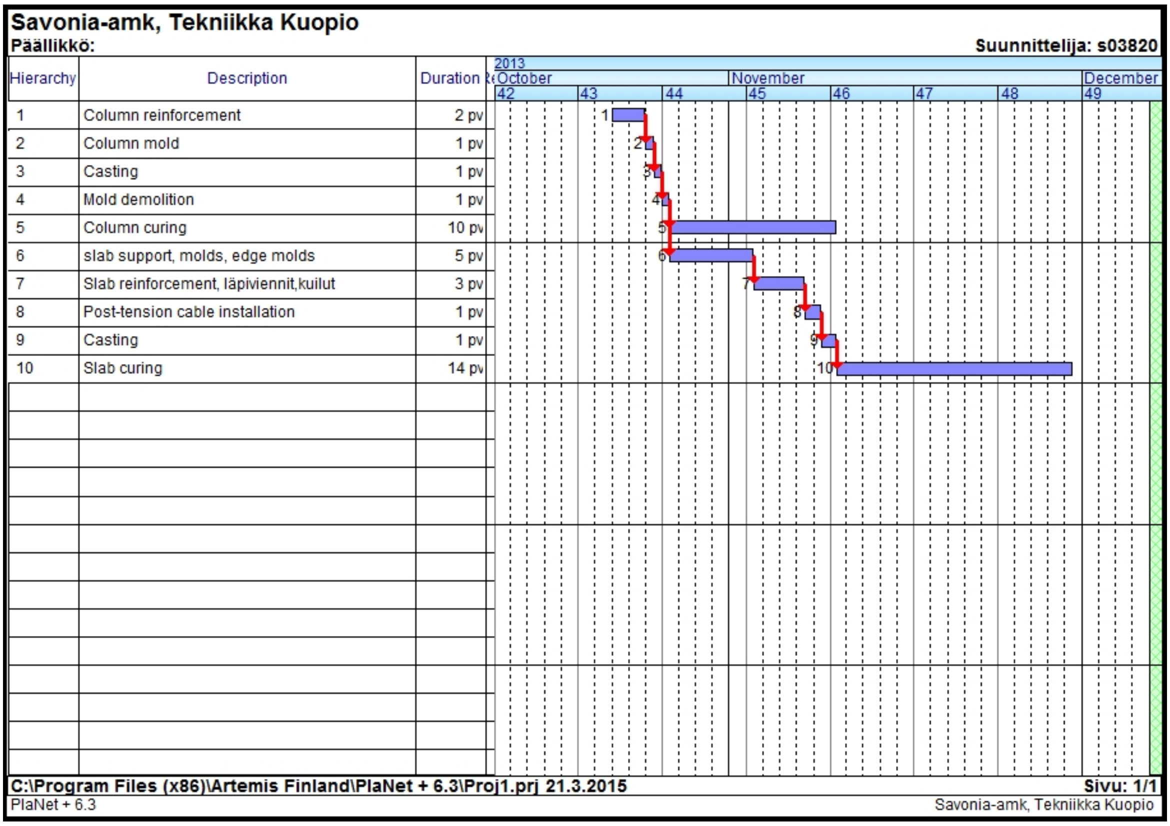

Figure 7. Cast in place construction phase schedule

Making the precast schedule, 3D model and estimated installation schedules from the precast factory are used as a source because the given precast prices are in square metres. The estimated installation schedule is to install 20-25 elements in one day with ten workmen. The average 22.5 installed elements in one day are used in this thesis. The elements are transported to the construction site in installation order. Erection time of one floor takes little less than 10 days when using the precast method. (Figure 8)

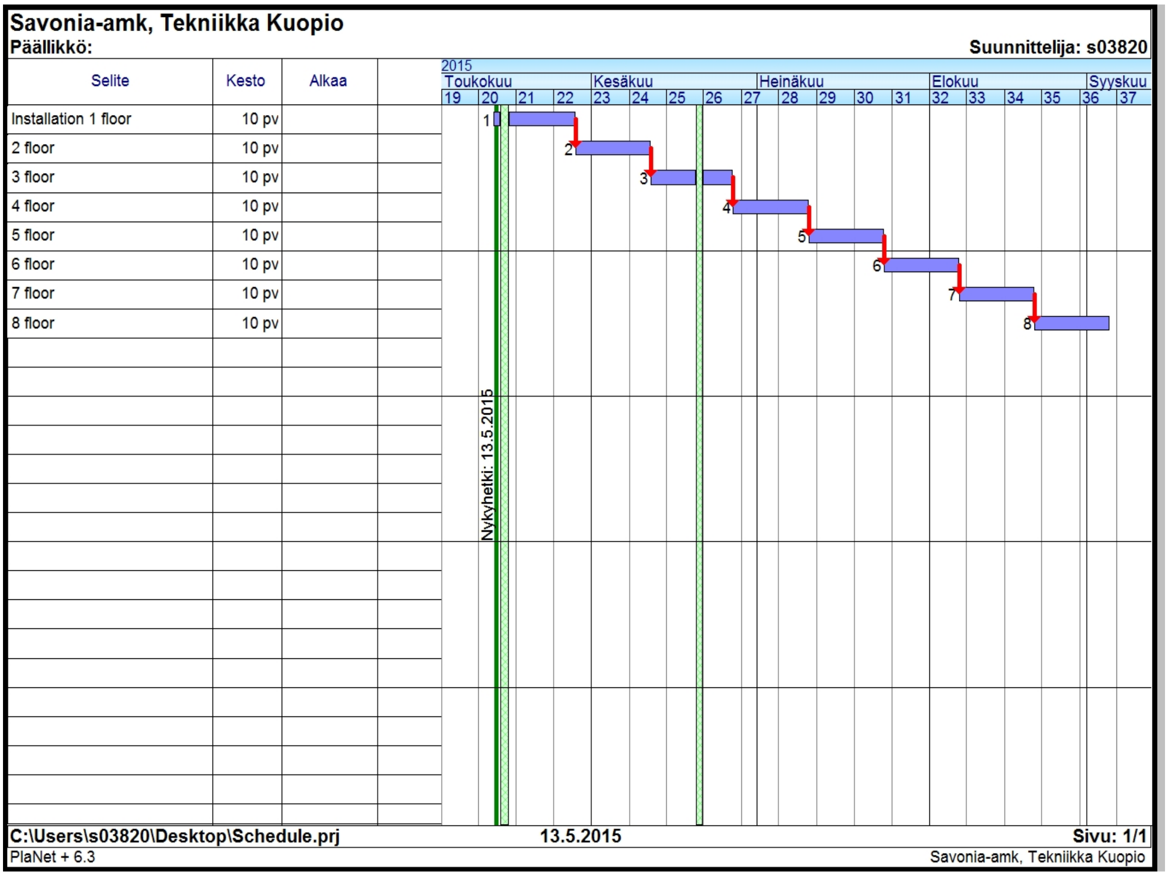

Figure 8. The precast construction phase schedule

6 CONCLUSIONS AND COMPARISON OF THE CAST IN PLACE AND THE PRECAST CONSTRUCTIONING

The goal of the thesis was to clarify possibilities to use precast constructing in Thailand and would it be more profitable to use it instead of the cast in place frame. There were two different precast frame types, load bearing wall-slab frame and column-beam-slab frame. The purpose was to compare alternative frames to the traditionally used cast in place frame. All three frame alternatives were modeled to 3D with TEKLA. Schedules were made and costs were calculated. First task was to get to know CAD pictures of the project and make a 3D model of the cast in place frame. The purpose of the the 3D modelling was to indentify the project and to use amount lists from TEKLA in cost calculation and planning schedules. In addition logistic and seismic activity of the area was taken into account because these factors have to be noticed when constructing a building and planning transportation for example. The early stages of this clarification it became clear that the column-beam-slab frame is not profitable in any way. Because of the under ground parking hall the load of the beams would be enormous and therefore the beam sizes would not be reasonable or profitable.

6.1 Cast in place and precast construction in Thailand

When compairing precast construction to cast in place construction, there is a clear difference between cost results as well as in schedule results. The cast in place frame structure is clearly profitable than the precast frame structure. But it is also slower and it is more difficult to manage the comlplex e.g. the costs and quality. Extra costs and dealys caused by fails of quality control and communication problems in cast in place constructioning are not seen in this thesis because the information is based only on output data and do not show the big picture. Neither precast shows the whole time spent with the project. The big difference in erection times between cast in place and precast method is because the elements are produced before installation i.e the precast process has already started weeks before the schedule shows. Although precast is more expensive, time would be saved and continous repairs that poor quality control causes could be avoided. If precast were used, the quality would be more consistent and it would be easier to control. Less labor would be needed when using the precast construction and the erection time would be twice as fast. The costs would be more comparable and accurate when there are more pids. Even the precast method would be a much faster way to build, most of the precast production and usage is located near Bangkok and knowledge of precast building is poor. Transportations are expensive and installation requires professional skills as well as planing. In summary, the traditional cast in place construction method is more cost profitable than the precast construction method. On the other hand, precast construction method is twice as fast and the quality is more consistant.

6.2 Cast in place construction in Finland and in Thailand

The cast in place construction technique is the most used technique in the world. This construction technique was used commonly before the beginning of the 1970s in Finland when there was a strong breakthrough in precast construction industry. (valmisbetoni.fi) Cast in place constructing is well planned and professional builders are used. Purpose is to follow the before made plans and make good results at once so there would be nothing to fix afterwards.The modern form technique and specific form rotation plans ables effective cast in place constructing. Cranes and machinery are used in cast in place constructing in Finland.When using the cast in place method in Finland the climate and the seasons have to be taken into account. In Thailand cast in place is the most in common construction method because of it is the cheapest way. The erection time when using the cast in place frame is considerably longer than in Finland because of the fails in planning and the lack of professional skills of workmen. For example there was no form rotation plan in the studied project. Quality control and communication problems are causing delays and makes constructing more difficult in Thailand. When comparing to the Finnish cast in place technique and quality control,Thailand is far behind.

6.3 Precast construction in Finland and in Thailand

In Finland precast constructioning is based on knowledge of industrial precast constructing. (elementtisuunnittelu.fi). Precast elements are widely used in Finland in residential constructioning. Production methods and planing are advanced and high quality. Construction regulation collection of Finland is followed. Precast construction is very effective and profitable in Finland. Precast constructing in Thailand is focused on Bangkok in the capital area. There are large precast factories in Bangkok but the traditional cast in place is still more widely in use. Hollow core slabs are more used but mainly in smaller townhouses. Though the used hollow core slab differes a lot from what hollow core slab means in Finland. It is only 5 centimetres thick and 5 centimetres thick concrete with iron mesh is casted on the slab. Elements produced on construction site and used with cast in place frame is a one method that is used in Thailand. Precast elements used in Thailand and in Finland differ considerably mainly because of the climate. For example bearing wall thicknesses produced in Probuilt precast concrete factory were 120 millimetres when in Finland typical bearing wall thicknesses are 160, 180, 200 and 240 millimetres. In Finland, the recommended minimum thickness of solid walls is 180 millimetres. Differencies in thicknesses of wall elements are mainly because there are no isolations used in Thailand. Because there is neither isolation nor sound isolation regulations in Thailand the hollow core slabs can be less thick.

7 DISCUSSION

When modeling the cast in place frame the most challenging task were the differencies in reinforcement to the ones used in Finland. TEKLA did not offer components to certain types of reinforcement, therefore the needed components had to be created manually which slowed modeling significantly, neither post tensioned slabs were available. Post tensioned slabs are typically used in Thailand as well as in the Tropical Garden project. The Savonia UAS curriculum does not offer post tensioned slab studies which means that we did not have enough information or time to study about post tension slab before leaving Finland.

When planning the precast elements we had to use Finnish regulations and standards which caused problems. Due to the climate in Thailand regulations are different from ours. For example isolations are not in use. The used elements in the model have been chosen using Finnish precast recommandations, but costs are estimated by precast availability in Thailand. Because of these reasons, walls and slabs are thicker, which basically makes our TEKLA precast models useless. Only square metres and amounts of the precast elements are taken from the TEKLA model.

When contemplating the precast schedule instead of the main schedule, it does not give an overall picture. If precast were used in these projects which were examined, it would erase quality problems of structure phase, which are mainly caused by poor supervising. Compared to cast in place, quality control is considerably easier in precast production. The cast in place is already slower and continuous and repeated repairs are delaying the construction even more. Because of these common problems many construction sites are behind schedule. In cast in place constructing quality control is the biggest issue. Poor control on site and poor communication between workmen and foremen led repeatedly new repairs and the same problem continued despite the notices. In addition, prepairing and planning the work tasks more effort should be used to make work clearer and easier to control.

There are no precast factories nearby the Chonburi area and the largest factory in Bangkok declined our request to visit. In our opinion knowledge about precasting was surprisingly poor as well as English skills. It was challenging to ask information from local engineers let alone workmen.

We came to a conclusion that there is not enough knowledge and skills to start to use precast in our research area. Information about logistic costs varied. The factory in Bangkok, where we visited, showed that they transport stairwell elements to the Pattaya area which was a discrepancy to information that transportation from Bangkok is too expensive.

There are problems in many sections in constructing development from cultural factors to education. Communication between parties is very inadequate and develop skills is not important among Thai construction business. But the upcoming modern precast factory would be able to help to increase the precast constructing in wider scale than only in the Bangkok area. Thai construction style is based on old traditional ways and they have difficulties to adapt in any new construction method. Most of the biggest contractors are international and this upcoming factory will provide huge advantage if they can utilize the opportunity. In our opinion the best solution would be to use precast elements made in construction site with the cast in place frame. This method would make constructing little faster without bringing too much new. Other considerable progress idea would be to research how to improve traditional cast in place method and eliminate most problems. By improving supervising and quality control cast in place constructing would be more effective and would reduce constant repair work that delays schedule.

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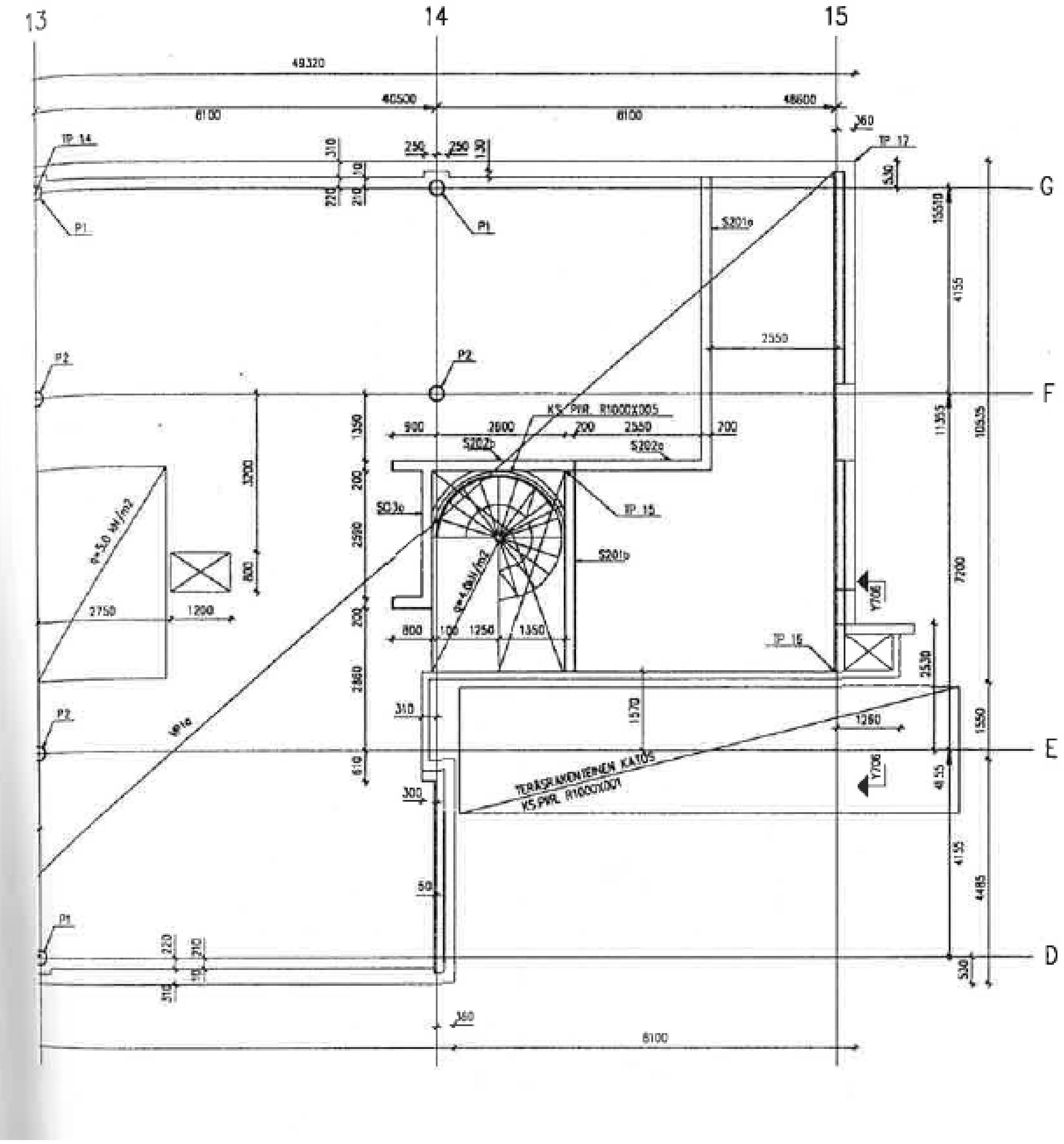
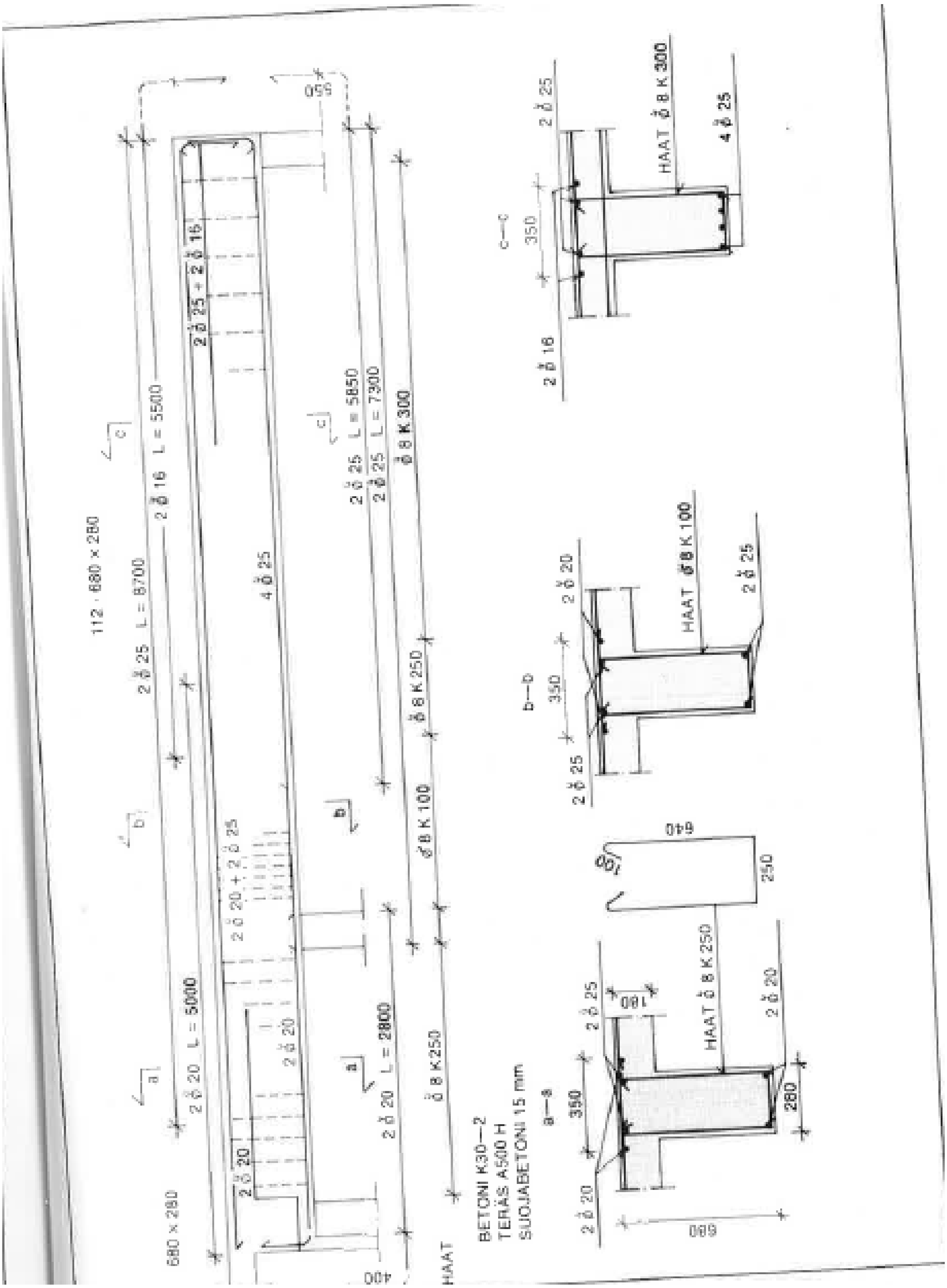
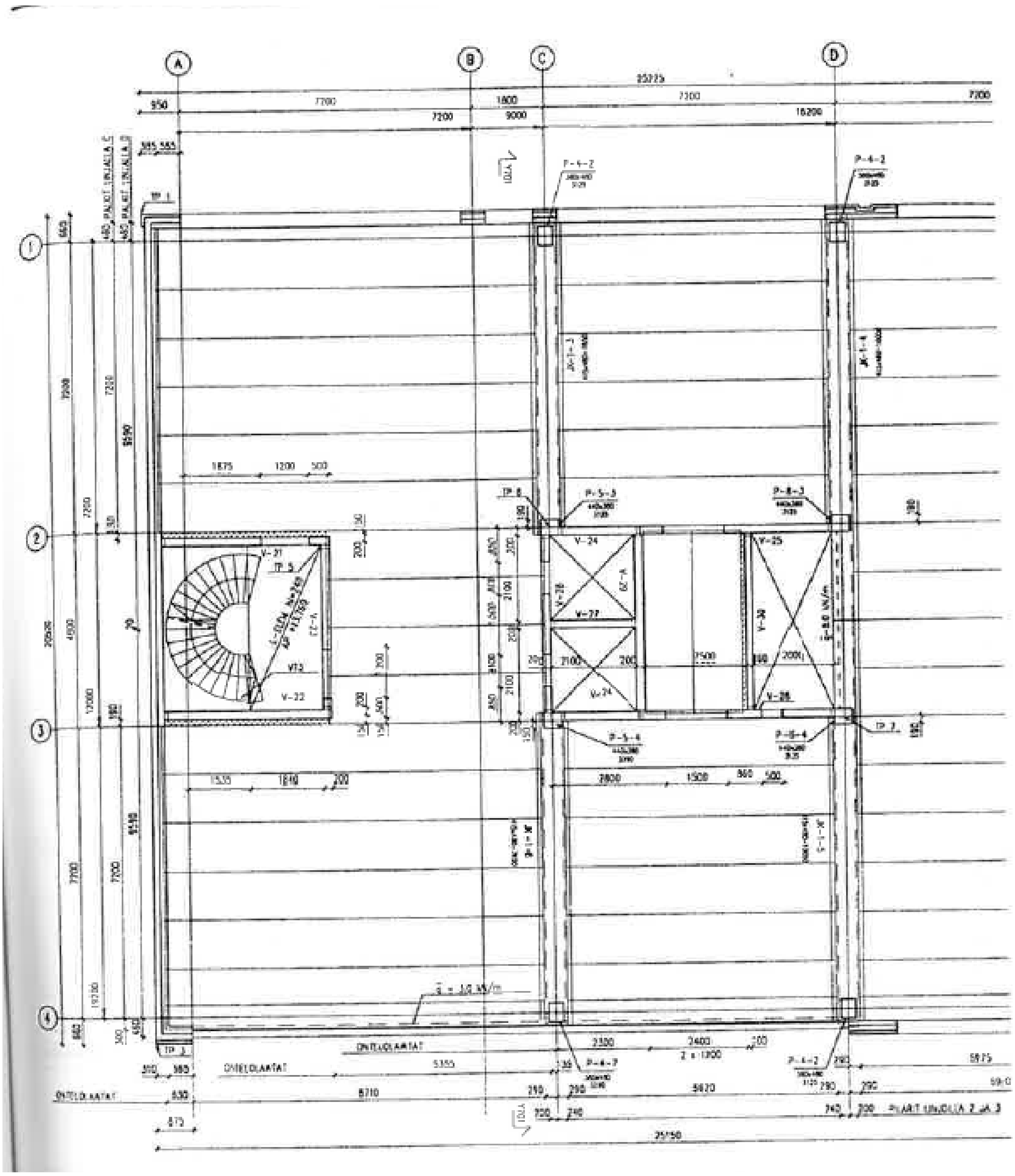
APPENDIX 1: CAST IN PLACE MEASUREMENT DRAWING



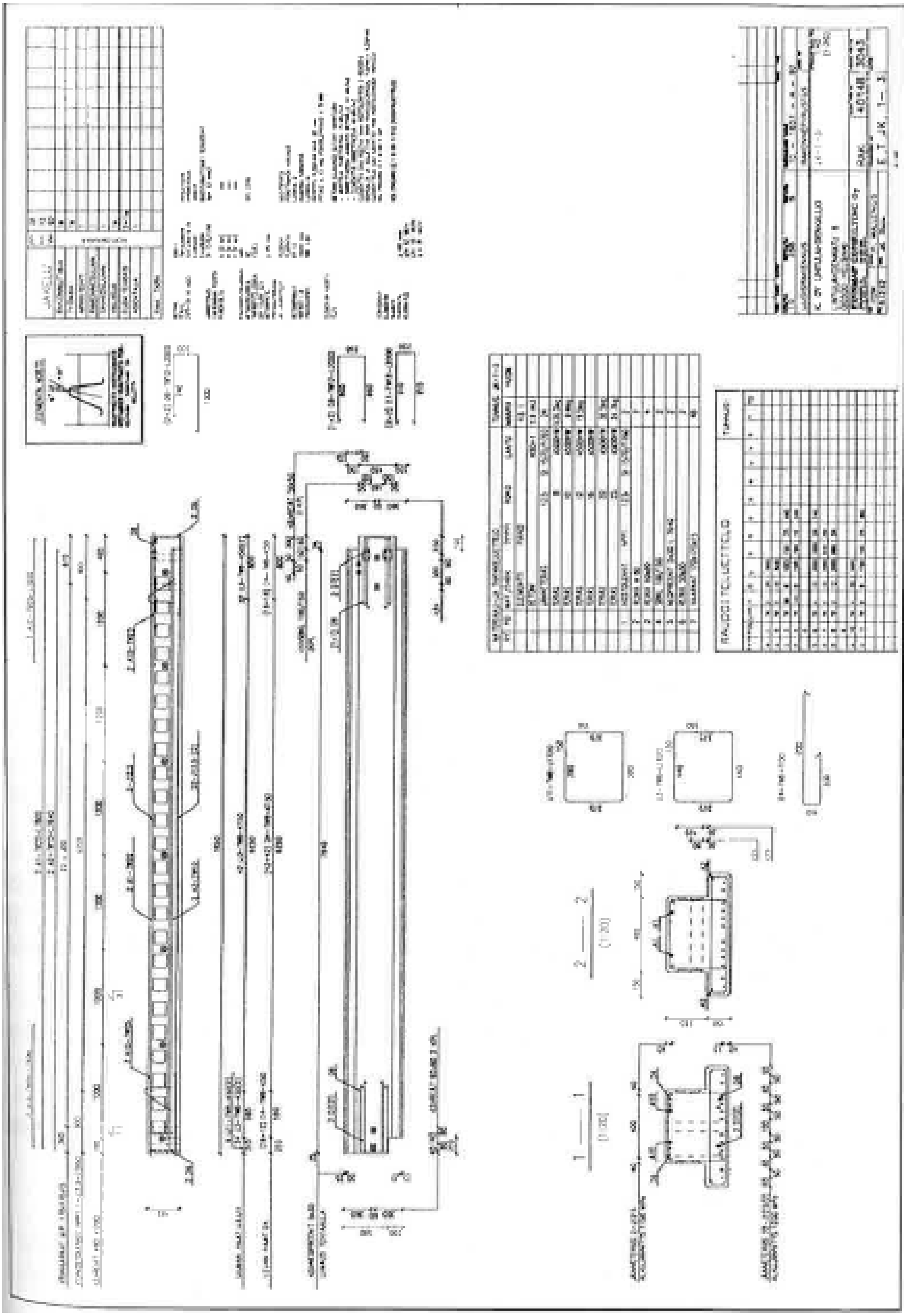
APPENDIX 2: BEAM REINFORCEMENT DRAWING



APPENDIX 3: PRECAST MEASUREMENT DRAWING



APPENDIX 4: PRECAST DRAWING



APPENDIX 5: INSTALLATION PLAN

ELEMENTTIEN ASENNUSSUUNNITELMA

Sivu 1

1. Kohdetiedot työmaasta

Työmaa

		pvm	19.06.2013
		muu-tos	
Rakennuskohde	**Koy Sipoon PT-logistiikkakeskus,kellarielementtiurakka/vaihe 1**		
Työmaa n:o		Osoite	Keuksuontie 3 Sipoo
Rakennuslupa n:o			

Henkilöstö

Päätoteuttaja		Puhelin	Gsm
		e-mail	
Vastaava työnjohtaja		Puhelin	Gsm
		e-mail	
3.osapuolen rakennetarkastaja		Puhelin	Gsm
		e-mail	
Työmaan valvoja		Puhelin	Gsm
		e-mail	
Pääsuunnittelija		Puhelin	Gsm
		e-mail	
Vastaava rakennesuunnittelija		Puhelin	Gsm
		e-mail	
Vastaava elementtisuunnittelija		Puhelin	Gsm
		e-mail	
Rakennuttajan turvallisuuskoordinaattori		Puhelin	Gsm
		e-mail	
Elementtitoimittaja A -projektin hoitaja		Puhelin	Gsm
		e-mail	
Tuotannon vast.henk.		Puhelin	Gsm
		e-mail	
Kuljetuksen vast.henk.	-erillinen liite (liite 5)	Puhelin	Gsm
Elementtitoimittaja B -projektin hoitaja	Lujabetoni Oy	Puhelin	Gsm
		e-mail	
Tuotannon vast.henk.		Puhelin	Gsm
		e-mail	
Kuljetuksen vast.henk.	-erillinen liite (liite 5)	Puhelin	Gsm
Elementtien asennusliike		Puhelin	
		e-mail	
Asennustyönjohtaja		Puhelin	Gsm
		e-mail	

Nosturit

Nosturityyppi 1	Autoalustainen hydraulipuominosturi Liebherr LTM1130 (130t)	Nosto-teho 16,8 tn Max.tukijalkakuorma n.65tn	Ulot-tuma 20 m
Nosturityyppi 2	Tela-alustainen ristikkopuominosturi Kobelco CKE1800 (180t)	Nosto-teho 21,6 tn Max.tukijalkakuorma	Ulot-tuma 26 m
Nosturityyppi 3		Nosto-teho tn Max.tukijalkakuorma	Ulot-tuma m

Suunnitelman laatija

Suunnitelman laatija	Puhe-lin e-mail	Gsm

2. Elementit,nostoapuvälineet ja erityistoimenpiteet

Sivu 2

Huom! Max.mitat ovat raskaimman elementin/-tyypin mittoja

Tyyppi	Max.pituuს	Max.leveys	Max.korkeus	Max.paino	Määrät
Perustuselementit				Nostoapuvälineet	Kaksihaara-raksit
	m	m	m	kN	kpl
Sokkelit				Nostoapuvälineet	Kaksihaara-raksit
AN	m	m	m	kN	kpl
Pilarit				Nostoapuvälineet	Nostoakseli d = 100mm
P	4,03 m	1,08 m	1,08 m	118 kN	56 kpl
Palkit Tb				Nostoapuvälineet	Kaksihaara-raksit
K	m	m	m	kN	kpl
Palkit Jb				Nostoapuvälineet	Kaksihaara-raksit
JK	5,6 m	0,48 m	0,68 m	45 kN	4 kpl
Ontelolaatat				Nostoapuvälineet	Puomi ja sakset
O/BM50	10,8 m	1,2 m	0,5 m	73 kN	98 kpl
TT-laatat				Nostoapuvälineet	Nelihaararaksit/-vaijerit
	m	m	m	kN	kpl
Jännelaatta				Nostoapuvälineet	Nelihaararaksit/-vaijerit
JL	8,32 m	1,2 m	0,5 m	118 kN	kpl
Sokkelikuorielementit				Nostoapuvälineet	Nelihaara-raksit
KE	m	m	m	kN	54 kpl
Väliseinät				Nostoapuvälineet	Kaksihaara-

					raksit
Tyyppi **V**	Max.pituus 5,14 m	Max.leveys 0,3 m	Max.korkeus 4,17 m	Max.paino 160 kN	Määrät 103 kpl
Parvekkeet				Nostoapuvälineet	Nelihaara-raksit
Tyyppi	Max.pituus m	Max.leveys m	Max.korkeus m	Max.paino kN	Määrät kpl
Tb-laatat				Nostoapuvälineet	Nelihaara-raksit
Tyyppi **L**	Max.pituus m	Max.leveys m	Max.korkeus m	Max.paino kN	Määrät 12 kpl
Ulkoseinät,sw-elem.				Nostoapuvälineet	Kaksihaara-raksit
Tyyppi **S**	Max.pituus m	Max.leveys m	Max.korkeus m	Max.paino kN	Määrät 15 kpl
Ulkoseinät,kuorielem.				Nostoapuvälineet	Kaksihaara-raksit
Tyyppi	Max.pituus m	Max.leveys m	Max.korkeus m	Max.paino kN	Määrät kpl
Porraselementit				Nostoapuvälineet	
Tyyppi	Max.pituus m	Max.leveys m	Max.korkeus m	Max.paino kN	Määrät 17 kpl

Erikoisnostovälineet,elementtien kääntäminen,yhteisnostot yms. Elementtien mahdollisista kääntämisistä ja/tai yhteisnostoista laaditaan erillinen suunnitelma ja toteutuksen kuvaus,mikäli em. toimintoja joudutaan tekemään.	Liitteet	kpl
Elementtitoimittajan ohjeet erikoiselementtien käsittelystä ja elementtikuormien purkamisesta liitteenä		

3. Työmaatiet,kuormien purku,vastaanotto ja työmaavarastointi

Sivu 3

Nostopaikat Jokaisen kellarin ulkopuolella seinälinjojen vieressä.	Työmaatiet Rakennuksen sisä- ja ulkopuolella työmaalueen käyttösuunnitelman mukaan.

Varastointipaikat Elementtien varastointipaikat sijaitsevat nostopaikkojen välittömässä läheisyydessä asennuksen etenemisen mukaan vaihdellen,varastointipaikoilla elementtejä yleensä yhden työvuoron tarve. Kuljetuspukeille varastoiduille elementeille on erillinen alue.		
Elementtien vastaanottotarkastus Elementit tarkastetaan silmämääräisesti ennen kuorman purkua ja sen aikana,mahdolliset lohkeamat ja muut virheet dokumentoidaan (kuormakirja ja/tai muu selvitys)		
Laatupoikkeamien käsittely Elementtiasennuksen aloituskokouksessa sovitulla tavalla.	Vastuuhenkilöt Toimittaja Asennustyönjohtaja Tilaaja	
Varastointikalusto Seinäelementit varastoidaan kampafakkiin ja/tai A-pukkiin sekä kuljetuskalustosta riippuen myös maahan laskettavassa kuljetusalustassa.		
Purkamisjärjestys elementtitoimittajan ja kuljetusliikkeen antamien ohjeiden mukaan (liite)		
Erikoiselementtien varastointitapa		

4. Asennusjärjestys (yksityiskohtainen asennusjärjestys liitteenä)

Asennusjärjestys rakennuksittain

Asennusjärjestys lohkoittain

Q3	Q4	Q1	Q2	P1	P2	S1,S2 (8-linjan puoli)	R1,R 2

Yksittäisten elementtien asennusjärjestys,saumaamattomien tasojen kuormittaminen

Pilarit,väliseinä- ja sw-elementit,juuri- ja alusvalut heti perään
Palkit ja ontelolaatat sekä jännelaatat (seinien pystysaumavalut ja ontelolaattojen saumavalut)
Tb-laatat ja porraselementit
Sokkelikuorielementit
Saumaamattomia ontelotasoja ei kuormiteta,saumateräkset tms. voidaan nostaa laatastolle

Juotosjärjestys Asennuksen etenemisen mukaan ennen ko. elementille tulevaa kuormitusta.	Hitsausjärjes-tys Asennuksen etenemisen mukaan.

Yksityiskohtainen asennusjärjestys liitteenä	X	Rungon jäykistystapa liitteenä	

5. Toleranssit ja seurantamittaukset

Toleranssiluokka	Betonielementtien toleranssit 2003 Normaaliluokka	X	Kohdekohtaiset erikoistoleranssit	
	Erikoisluokka		ohje liitteenä	

Lähtö-mittaus	Mitattavat kohteet	Mittausperiaate	Tekijä	Vastuuhenkilö
	-pilarit,seinät	- keskilinjat,nurkkapisteet	- päätoteuttaja	

Tarkastusmittaukset

Mitattavat kohteet	Mittausperiaate	Tekijä	Vastuuhenkilö	Suoritusajankohta
- pilarit	-pystysuoruus,sijainti	- asennus-ryhmä	- as.työnjohtaja	- jat-kuva
- seinät	-pystysuoruus,sijainti	- asennus-ryhmä	- as.työnjohtaja	- jat-kuva
- palkit	-tukipinnat,sijainti,pystys.	- asennus-ryhmä	- as.työnjohtaja	- jat-kuva
-ontelolaatat	-tukipinnat,sijainti.,kork.as.	- asennus-ryhmä	- as.työnjohtaja	- jat-kuva

6. Asennuksenaikainen tuenta ja vähimmäistukipinnat

Sivu 4

Tarvittavat väliaikaistuennat	
Seinät	Väliseinät asennetaan vinotukien varaan (2 kpl/elem.),vinotukien alapään kiinnitystä varten
	erillinen betoniantura (tai valmis pohjalaatta)
	Sw-elementeissä lisäksi myös asennusaikaiset hitsauskiinnitykset nurkissa.
Palkit	Palkit tuetaan tarvittaessa alapuolisin pystytuin toispuoleista kuormitusta vastaan erillisen

	tuentasuunnitelman mukaan.				
Tukien purku	Palkkien mahd. tuennat voidaan poistaa,kun ontelolaatasto on saumattu ja betoni kovettunut				
	ja/tai kun ontelolaatat on asennettu palkin molemmin puolin.				
	Vinotuet voidaan poistaa,kun seinäelementtien pystysaumajuotokset on tehty ja betoni				
	riittävästi kovettunut.				
Vähimmäis-tukipinnat	Seinäelementit	as.palat 100*100 mm2	Betonipalkit	väh.neopren in ala	mm
	Ontelolaatat	80 mm	Teräspalkit		mm
	MTT-laatat	mm	Massiivilaatat		mm
	Pilarit	as.palat 150*150 mm2	Kuorilaatat		mm
Elementtitoimittajan asennusohjeet liitteenä			Lisäohjeet,ks.asennuspiirustukset		

7. Elementtien lopulliset kiinnitykset

Hitsaus

Hitsausmenetelmät	Hitsausluokat	Koot
-puikkohitsaus	C	-detaljien mukaan

Hitsausmenetelmien materiaalit					
Menetelmä	-puikkohitsaus	Perusaine	S235/S355	Lisäaine	OK48.00 tai vast.
Menetelmä	-puikkohitsaus	Perusaine	AiSi 304	Lisäaine	OK63.20
Menetelmä	-puikkohitsaus	Perusaine	S235/Aisi304	Lisäaine	OK67.70
Menetelmä		Perusaine		Lisäaine	
Hitsaussaumojen tarkastus	Silmämääräisesti,asennustyönjohtaja tarkastaa.				
Elementtityyppikohtaiset ohjeet hitsauksista liitteenä					

Betonointi

Lujuusluokat	Kovettumisajat	Betonilaadut
-pilarien juurivalut väh. K50 -ontelosaumabetoni K30 -seinien saumabetoni K30	-toimittajien lujuudenkehitystaulukoiden mukaan	-juotosbetoni 600/3 -saumabetoni K30 -pystysaumabetoni K30 Tarvittaessa käytetään talvijuotos-/pakkasbetoneita
Lämmitysohjeet -talviolosuhteissa juotosvalujen lämmitys esim. lankalämmityksin		
Lujuudenkehityksen seuranta -lämpötilamittauksin	Muu laadunvarmistus	
Koekuutiosuunnitelma		
Elementtityyppikohtaiset ohjeet betonoinnista liitteenä		

Pulttiliitokset

Peruspultit	Muut pultit
Detaljien mukaan -pilarit M45	Detaljien mukaan -pilari/palkkiliitos M24,M30
Elementtityyppikohtaiset ohjeet pulttiliitoksista liitteenä	

8. Työturvallisuus			Sivu 5
Työmaan työsuojelupäällikkö		Puh	
Asennusliikkeen työsuojelusta vastaava		Puh	
Asennustyön turvallisuusriskit kartoitettu	X		

Työtasot -siirreltävät telineet -henkilönostimet	Kenen vastuulla -asennustyönjohtaja/-ryhmä	Asennus- ja purka-misajankohdat -tarpeen mukaan
Nousutiejärjestelyt -erilliset porrastelineet,porrashuoneet	Kenen vastuulla -päätoteuttaja	Asennus- ja purka-misajankohdat -asennuksen etenemisen mukaan
Kerrosten putoamissuojaus -kaiteet ja aukkosuojaus holvien ja aukkojen ympäri heti asenn. perään	Kenen vastuulla -asennustyönjohtaja/-ryhmä -päätoteuttaja (materiaalit)	Asennus- ja purka-misajankohdat -asennuksen etenemisen mukaan
Vesikattokaiteet ja katolle kulku -ei tässä urakassa	Kenen vastuulla	Asennus- ja purka-misajankohdat
Turvavaljaat -laatta- ja kaideasennuksissa sekä henkilönostokoreissa	Kenen vastuulla -asennusryhmä -asennustyönjohtaja	Turvavaljaita käytetään aina silloin, kun putoamissuojausta ei ole voitu muutoin järjestää.
Erityistoimenpiteet	Kenen vastuulla	Asennus- ja purka-misajankohdat

9. Pätevyydet ja valvonta	
Henkilöpätevyydet,tarkastukset	
Asennustyönjohtaja	Betonielementtien asennustyönjohtajan pätevyys (Fise ylläpitää)
Asentajat	Elementtiasentajan pätevyys/riittävä kokemus
Betonointityöt	
Hitsaukset (pätevyydet)	Voimassa olevat pätevyystodistukset
Vastaavan rakennesuunnittelijan tarkastukset	
Asennustyön valvonta	
Työturvallisuuskortit	Kaikilla
Tulityökortit	Kaikilla

10. poikkeamien ja muutosten käsittely

11. Asennussuunnitelman liitteet				
Liite 1	Sisältö	Yksityiskohtainen asennusjärjestys- ja aika (alustava,täydentyy suunnitelmien valmistumisen mukaan)	Sivuja	2
Liite 2	Sisältö	Asennustyön turvallisuusriskien kartoitus	Sivuja	1
Liite 3	Sisältö	Kuivabetonien käyttöturvatiedotteet ja tuoteselosteet	Sivuja	6+6 3+2
Liite 4	Sisältö	Ontelolaattojen varastointi- ja asennusohjeet	Sivuja	7+8
Liite 5	Sisältö	Elementtitoimittajien yhteystiedot	Sivuja	

Allekirjoitukset	
Vastaava rakenne-suunnittelija	Päi-väys
Asennustyönjohtaja	Päi-väys
Vastaava työnjohtaja	Päi-väys

ELEMENTTIASENNUKSEN TURVALLISUUSRISKIEN LUOKITTELU JA TOIMENPITEET

Liite 2

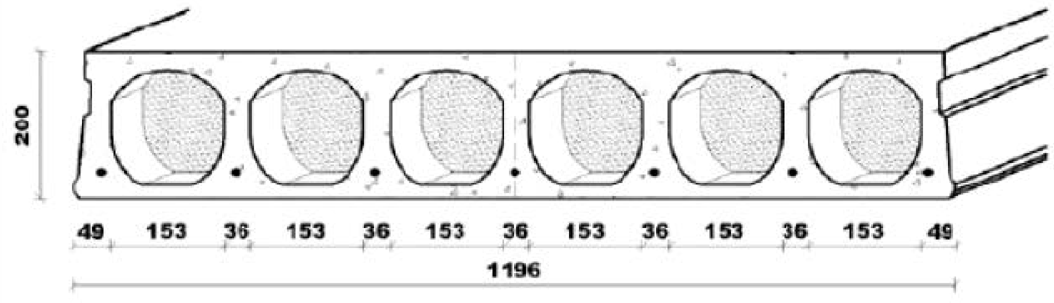
Yritys:	
Kohde:	
Pvm:	19.06.2013
Laatija:	

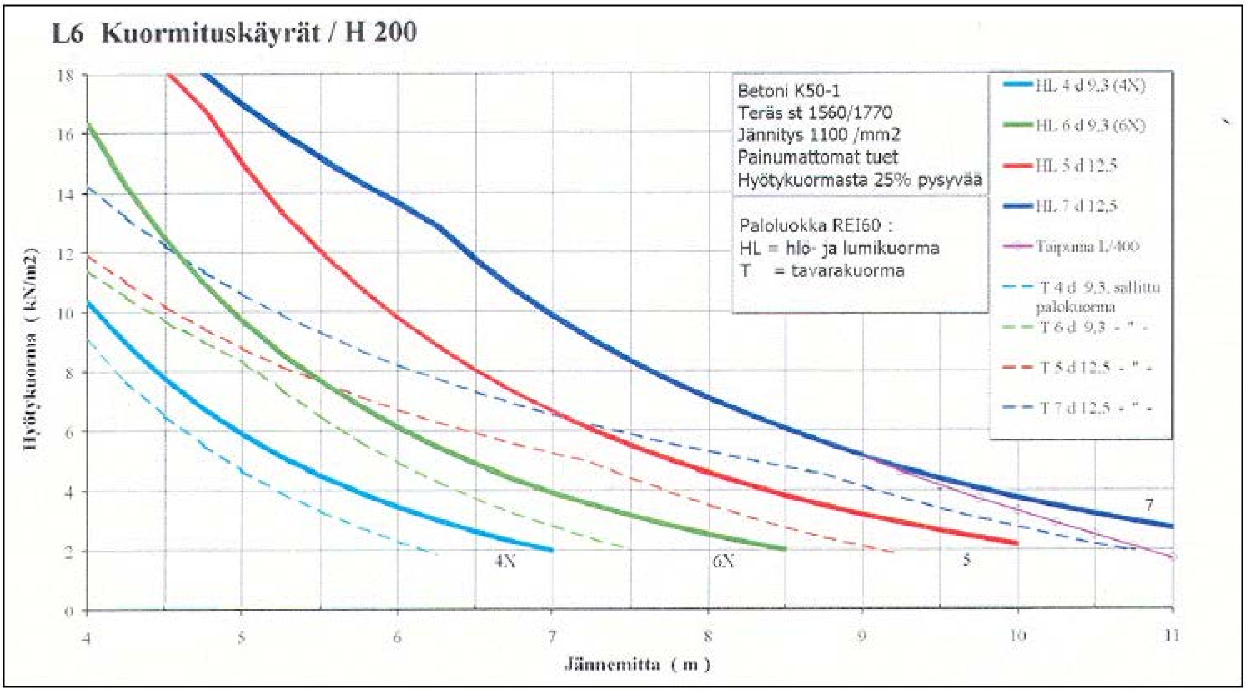
Vaaratilanteen kuvaus	Riski	Toimenpiteet
Kuormien purku ja välivarastointi -putoaminen kuorman päältä	Va 4	Kuorman purkuohjeet,perehdytys
-liinan luistaminen/katkeaminen	Va 4	Tarkastukset,ohjeistus,valvonta
-käden/jalan väliin jääminen	Va 4	Huolellisuus,ohjeistus,valvonta
-nipun/taakan hajoaminen	Va 3	Huolellisuus,ohjeistus,valvonta
-liukastuminen	Ha 3	Liukkauden esto,sopivat jalkineet
-kommunikointi nosturiin	Va 3	Ohjeistus ja opastus,sovittu käytäntö
-välivarastointi	Va 3	Huolellisuus,ohjeistus,valvonta
-maapohjan kantavuus	Va 3	Työmaatiet käytettävien koneiden mukaan
Asennus -putoaminen/liukastuminen	Va 4	Putoamissuojaussuunn.,valvonta,valjaat
-käden/jalan väliin jääminen	Va 4	Huolellisuus,ohjeistus,valvonta
-aukot	Va 4	Putoamissuojaussuunn.,valvonta,valjaat
-eri tasoissa työskentely	Ha 3	Asennusalueen eristäminen,valvonta
-muut urakoitsijat	Ha 2	Töiden yhteensovitus,urak.palaverit
Nostot -kommunikointi	Va 3	Ohjeistus ja opastus,sovittu käytäntö
-kahden nosturin nostot	Va 3	Ei tässä ura-kassa
-nostoapuvälineet	Va 3	Jatkuva seuranta,vuositarkastukset
-kappaleiden putoaminen	Va 4	Huolellisuus,ohjeistus,valvonta
-kova tuuli	Ha 4	Tuulirajat,taakan ohjaus köydellä,työt seis
-nosturien törmäykset	Va 4	Ei tässä ura-kassa
Telineet,henkilönostimet -kaatuminen	Va 4	(Työnantajalta lupa käyttää henk.nostimia) Ohjeistus,opastus,tarkastukset
-putoaminen	Va 4	Henkilönostimissa turvavaljaiden käyttö
Työkoneet -hiomakoneet	Ha 3	Ohjeet,opastus,laitetarkastukset
-piikkauskoneet	Ha 2	Ohjeet,opastus,laitetarkastukset
-porakoneet	Ha 2	Ohjeet,opastus,laitetarkastukset
-naulaimet		Ei käytetä tässä kohteessa (urakassa)
Muut vaaratekijät -melu	Vä 3	Kuulonsuojainten käyttö
-pöly	Vä 3	Työmaan siisteys,suojainten käyttö
-tärinä	Vä 1	Satunnaisia tapauksia (piikkaus tms.)

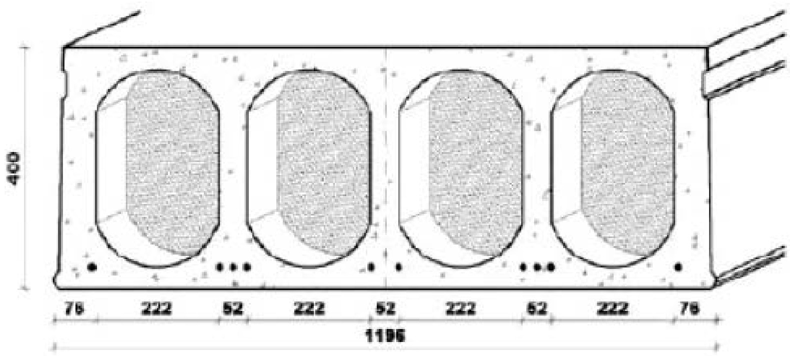
-roiskeet silmille ja iholle	Ha 3	Ohjeistus,suojaimien käyttö
-kylmyys	Ha 4	Asianmukaiset varusteet ja suojaimet

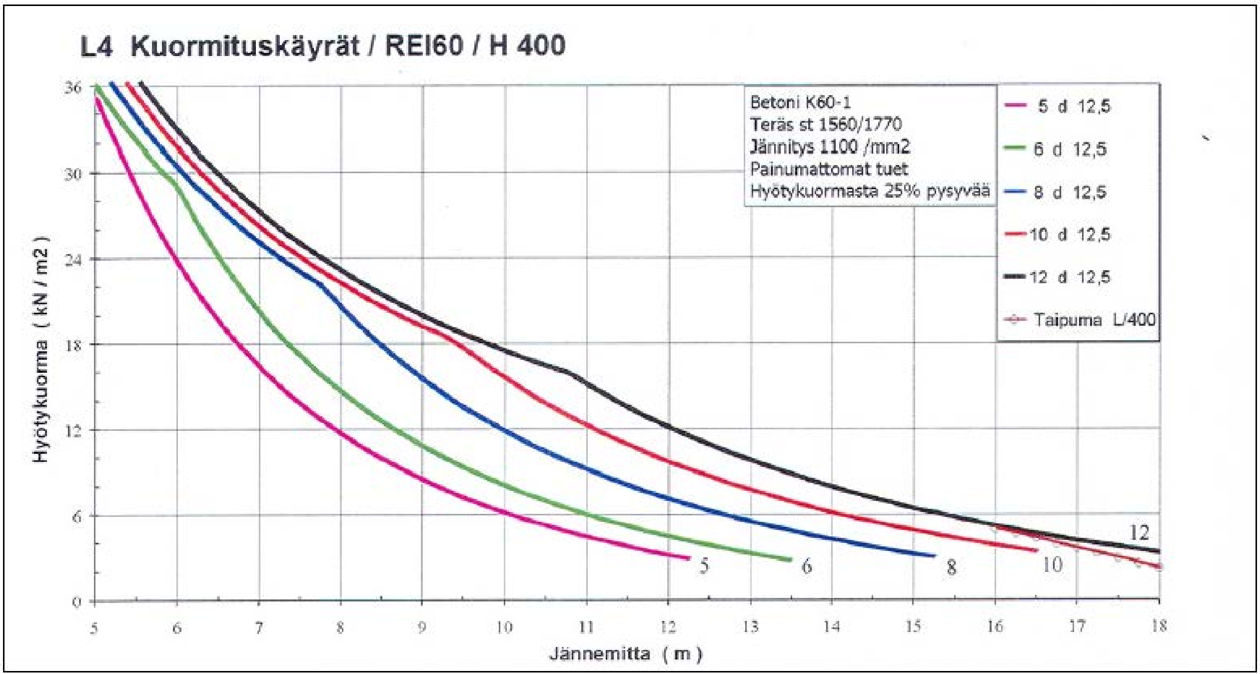
Tapahtuman todennäköisyys	Seurausten vakavuus		
	Vähäiset	Haitalliset	Vakavat
Epätodennäköinen	1.Merkityksetön riski	2.Vähäinen riski	3.Kohtalainen riski
Mahdollinen	2.Vähäinen riski	3.Kohtalainen riski	4.Merkittävä riski
Todennäköinen	3.Kohtalainen riski	4.Merkittävä riski	5.Sietämätön riski

APPENDIX 6: LOAD GRAPH






400
76
222
52
222
52
222
52
222
76
1196


L4 Kuormituskäyrät / REI60 / H 400
Betoni K60-1
Teräs st 1560/1770
Jännitys 1100 /mm2
Painumattomat tuet
Hyötykuormasta 25% pysyvää
5 d 12,5
6 d 12,5
8 d 12,5
10 d 12,5
12 d 12,5
Taipuma L/400
Hyötykuorma (kN / m2)
Jännemitta (m)
36
30
24
18
12
6
0
5
6
7
8
9
10
11
12
13
14
15
16
17
18
5
6
8
10
12

APPENDIX 7: TEKLA AMOUNT LISTS

Name	Content type	Material type	Material	Position number	Profile	Top level / mm	Height / mm	Length / mm	Width / mm	Volume / m3	Weight / t
COLUMN	PART	CONCRETE	Concrete_Undefined	Concrete_C-1/0(?)	400*1500	27 000	400	3 000	1 500	1,8	4,32
COLUMN	PART	CONCRETE	Concrete_Undefined	Concrete_C-1/0(?)	400*1500	24 000	400	3 000	1 500	1,8	4,32
COLUMN	PART	CONCRETE	Concrete_Undefined	Concrete_C-1/0(?)	400*1500	21 000	400	3 000	1 500	1,8	4,32
COLUMN	PART	CONCRETE	Concrete_Undefined	Concrete_C-1/0(?)	400*1500	18 000	400	3 000	1 500	1,8	4,32
COLUMN	PART	CONCRETE	Concrete_Undefined	Concrete_C-1/0(?)	400*1500	15 000	400	3 000	1 500	1,8	4,32
COLUMN	PART	CONCRETE	Concrete_Undefined	Concrete_C-1/0(?)	400*1500	12 000	400	3 000	1 500	1,8	4,32
COLUMN	PART	CONCRETE	Concrete_Undefined	Concrete_C-1/0(?)	400*1500	9 000	400	3 000	1 500	1,8	4,32
COLUMN	PART	CONCRETE	Concrete_Undefined	Concrete_C-1/0(?)	400*1500	6 000	400	3 000	1 500	1,8	4,32
COLUMN	PART	CONCRETE	Concrete_Undefined	Concrete_C-1/0(?)	400*1500	3 000	400	3 000	1 500	1,8	4,32
										16,2	
										32,4	2
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			3 000			0,081
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			3 000			0,081
REBAR	REBAR	CONCRE-	Undefined	C/0(?)	400*150			2 970			0,08

		TE			0						
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			3 000			0,081
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			3 000			0,081
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			3 000			0,081
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRETE	Undefined	C/0(?)	400*1500			2 970			0,011

REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 000			0,081
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 000			0,081
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 000			0,081
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 000			0,081
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,08
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			2 970			0,011
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			1 060			0,029
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			1 120			0,03
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REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			1 120			0,004

REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			900			0,003
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			900			0,003
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			900			0,003
REBAR	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			900			0,003
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,006
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,006
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,006
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,006
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,006
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,006
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,006
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,006
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,006
STIR-RUP	REBAR	CONCRE-TE	Undefined	C/0(?)	400*1500			3 620			0,002
											2,946
											5,892

Name	Content type	Material type	Material	Position number	Profile	Top level / mm	Height / mm	Length / mm	Width / mm	Volume / m3	Weight / t
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	27 000	39 251	51 809	250	277,3	665,486
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	24 000	39 251	51 809	250	277,3	665,486
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	21 000	39 251	51 809	250	277,3	665,486
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	18 000	39 251	51 809	250	277,3	665,486
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	15 000	39 251	51 809	250	277,3	665,486
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	12 000	39 251	51 809	250	277,3	665,486
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	9 000	39 251	51 809	250	277,3	665,486
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	6 000	39 251	51 809	250	277,3	665,486
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	3 000	39 251	51 809	250	277,3	665,486
SLAB	PART	CONCRETE	C25/30	Concrete_S-1/0(?)	250*39251	0	39 251	51 809	250	277,3	665,486
										2773	

APPENDIX 8: ORIGINAL BILL OF QUANTITIES OF TROPICAL GARDEN BUILDING A

This appendix contains private information

This appendix contains private infomation

APPENDIX 9: ORIGINAL CAST IN PLACE SCHEDULE

This appendix contains private information