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BACHELOR`S THESIS

TASK PLANNING OF CAST-IN-SITU FRAME`S CONCRETE WORKS IN ST. PETERSBURG HOUSING.

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PREFACE

This graduate study was commissioned by NCC Real Estate LLC. I want to thank Metropolia's supervisor Mika Lindholm and NCC's advisor Pekka Eskola for strict guidance during the project. I want to thank my family and my friends and all the others involved for support and encouragement to finish the study. Especially I want to thank my girlfriend who has given me the best support and motivation during this project.

Helsinki 22 April 2009

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ABSTRACT

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This study was done about the task planning of cast in situ frame for housing construction in St. Petersburg. The goal was to present matters associated with task planning and also to examine working phases of cast in situ construction such as form work, reinforcement work, pouring of concrete and dismantling and cleaning of forms. Also the basics of concrete as a building material are presented in the study. The study contains information about the Russian construction markets and chances of Finnish construction companies in these markets are evaluated in the beginning of the study. The effect of the global liquidity crisis on the Russian construction markets is also analysed.

NCC has established a subsidiary company in St. Petersburg, Russia, which started housing construction in the beginning of the year 2009. The case project is called Hakkapeliitta Village and it contains 300 apartments. The project's load bearing frame is going to be implemented as cast in situ structure and a task plan for cast in situ works is going to be made as a result of this study and the finished task plan is attached to the study. Solutions and choices made in this task plan are presented in the end of the study.

This study was made in the English language on the request of the client and it was mainly done as literature research.

Keywords: Concrete, Cast-in-situ, Task planning, Task plan

INSINÖÖRITYÖN TIIVISTELMÄ

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Tämä insinöörityö tehtiin asuinkerrostalojen paikallavalurungon tehtäväsuunnittelusta. Tavoitteena oli selvittää tehtäväsuunnitteluun liittyviä asioita ja tutkia itse paikallavalurungon rakennusvaiheeseen liittyviä tehtäviä, kuten muotitus, raudoitus, betonointi ja betonin jälkihoito. Myös betonirakentamisen perusteet on esitetty työssä. Työssä tutustutaan Venäjän rakennusmarkkinoiden nykytilanteeseen ja tulevaisuuteen, sekä arvioidaan Suomalaisten yritysten mahdollisuuksia kyseisellä markkina-alueella. Nykyisen taantuman vaikutusta Venäjän rakennusmarkkinoille on myös arvioitu.

NCC Rakennus Oy on perustanut tytäryhtiön Pietariin Venäjälle, mikä on aloittanut asuinrakennustuotannon vuoden 2009 alussa. Ensimmäinen kohde on nimeltään Hakkapeliitta Village ja siihen kuuluu 300 asuntoa. Kohteen runko tullaan tekemään paikallavalurakenteisena. Työn tuloksena syntyy tehtäväsuunnitelma kyseisestä kohteesta ja sen tekemiseen liittyvät valinnat ja ratkaisut on esitelty työn lopussa. Tämä kyseinen tehtäväsuunnitelma on työn liitteenä.

Työ tehtiin englanninkielellä tilaajan pyynnöstä ja se toteutettiin pääasiassa teoriatutkimuksena.

Avainsanat: Betoni, Paikallavalu, Tehtäväsuunnittelu, Tehtäväsuunnitelma

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1 INTRODUCTION

1.1 NCC and its operations in St. Petersburg

This graduate study was commissioned by NCC Real Estate LLC. Most of it was written in NCC`s offices in St. Petersburg, Russia and in Helsinki, Finland.

NCC

NCC is one of the leading construction and property development companies in the Nordic region. The turnover of NCC construction group in 2008 was 810 million Euros, increasing by 6,8 million Euros from the year before. The share of NCC Tähtikoti homes decreased from previous years 284 million to 218 million. NCC had 785 apartments under construction in the end of the year 2008. 295 apartments were unsold in Finland and 133 in the Baltic countries. New projects were delayed to a later moment because of the decelerated demand in the housing markets. The starting projects in 2009 are mainly housing-partnering. [1]

NCC has purchased plots of land from St. Petersburg for building of approximately 3900 apartments, but in this cyclical depression the construction work is not going to be started.

NCC is active throughout the value chain in its efforts to create environments for working, living and communication. NCC develops and builds residential and commercial properties, industrial facilities and public buildings, roads, civil-engineering structures and other types of infrastructure. NCC also offers input materials used in construction, such as aggregates and asphalt, and conducts paving, operation and maintenance operations in the roads sector. [1]

NCC mainly conducts operations in the Nordic region. In the Baltic region, NCC builds housing on a proprietary basis and in Germany NCC mainly engages in the construction of single-family housing. NCC's vision is to be the leading company in the development of tomorrow's environments for working, living and communication. [1]

NCC Tähtikoti (Star Homes) are high-quality homes for consumer customers. They are produced in compliance with the principles of the homes-for-consumer's business process. The process begins with general market values and customer segmentations, and on the basis of these, decisions are made on acquiring the necessary tract of land and plot. A housing property, which in all cases also fulfils the special requirements set for NCC TähtiKoti properties and is tailored to the chosen target group, is designed for the acquired tract. The homes-for-consumers process ends with the annual inspection required by the Housing Transactions act and with the systematic repair of defects found. This act can also be extended to embrace services during the occupation period. Sub-concepts and service products are being developed under the heading of NCC Tähtikoti, an example of which is the Active Home designed for older occupants. [1, p. 6]

The efficient throughput of the project sales process leads to the production of housing projects of the right quality for non-profit-making clients and for property investors making placements in housing. Projects can also be built for individual clients – as homes for a corporate customer's personnel, for example. The suitable plot and subject are found and mutual agreement is reached on financial and quality targets and a letter of intent is made with the customer. On the basis of the letter of the intent, NCC initiates planning and starts preparations for production. The project sales process ends with the handover of the property specified in the agreement and its commissioning on the agreed date. The process continues in part, in respect of guarantees, pledges and after-sales action. When a separate agreement is reached, NCC also produces operating and maintenance services for these projects. [1, p. 6]

NCC's goals in St. Petersburg

NCC is launching a housing production programme in St Petersburg, Russia. NCC's goal is to ensure that the case project (Hakkapeliitta village) succeeds in order for the company to get a good start in the St. Petersburg building markets.

Most of the frames in Russia are implemented as cast in situ structures. This is mainly because precast concrete techniques are not as developed as in Europe. Precast technique was used in 1958-1970 to build apartment houses in St. Petersburg suburbs. Most of these houses were built from the same plans and they were of poor quality in many ways. The biggest problem was bad sound proofing and also exterior features (figure 1). This has made Russian people very sceptical towards precast construction and forced construction industry to respond to people's need.

Figure 1 Photo of prefabricated housing block in St Petersburg

Hakkapeliitta village's load bearing frame, both walls and slabs are going to be implemented as cast in situ structures. Construction time is going to be short and many workers are going to be involved with the frame building phase. NCC wants to make sure that good cast in situ techniques, which are used in Finland, would also be in use in their Russian sites in order to assure good quality and fluent progress of construction.

Quality assurance is important in all the construction projects in order to achieve ideal final product. Construction of cast in situ frame includes many different tasks which have to be perfectly synchronized and guided for the best possible quality. Task plan is extremely important and a good way to assure the success of a task. It helps project personnel in task's quality control and guidance during a task entity and it is highly recommended to formulate at least one of the critical tasks such as construction of cast in situ frame. [3, p. 1]

1.2 Goals of the study

The purpose of this study was to examine working phases of cast in situ building and to create an example of a task plan for the use of NCC's Russian site management personnel. How, where and by whom should the task plan be used, is presented in the end of the study.

The study also includes theory about the Russian building markets and also St. Petersburg's building history is briefly presented.

This study does not include any theory about other components of apartment house's frame than load bearing cast in situ structures. The example task plan covers only cast in situ tasks. Production methods for non-bearing structures, such as gas concrete brickwork, which is also part of the frame of Hakkapeliitta Village, are defined in the study. Also, logistical solutions for building elements which should be hoisted up as the frame climbs are not covered in this study.

The study is mainly done as a literature research. It includes theory about the Russian construction markets, cast in situ construction and task planning. It also includes an example of cast in situ frame's task plan for NCC's project called Hakkapeliitta Village. How the task plan is prepared, is then presented in the last chapter of the study.

1.3 St Petersburg's and Russian construction markets

St. Petersburg is a city with a population of 4.6 million. It is the second biggest city in Russia after Moscow and fourth biggest in Europe. It is Russian's most important harbour city next to the Baltic Sea. In addition, St. Petersburg is known as the world's most northern city with the population of over one million. It is located in the eastern end of the Gulf of Finland, the bayou of Neva River and in the islands of the bayou. It is one of the biggest centrals of culture and education in the whole of Russia. [19]

The city was called Petrograd during the years 1914-1924, although this name was never used outside Russia. In the year 1924 the name was changed to Leningrad, which was the official name until year 1991. The city was founded by Peter the great in the year 1703 and it was Russian's capital from year 1712 all the way until the year 1918. St. Petersburg is the Russian federations Commonwealth subject, which is surrounded by Leningrad region, which is also a commonwealth subject of the Russian federation. The same kind of management system in Russia is only found in Moscow, where both the city and Oblast which surrounds it are both different commonwealth subjects. In other parts of Russia, metropolis is a part of Oblast which surrounds it or a part of autonomous republic. [19]

The height of buildings in St. Petersburg, when moving away from the city centre, is almost like an opposite comparing to western cities. This is because cost of plots did not control building projects during the time of planned economy. The same effect can be noticed almost in every soviet city. Buildings are quite low in the centre city and they get higher when moving away from the city. Suburbs close to the central consist of building complexes which are about five stories high and further away from the city buildings are normally from ten to twenty stories high. [19]

In St. Petersburg a lot of effort has been made in order to maintain and repair the city's historic monumental centre. During the past years also apartment house suburbs have been renovated and rebuilt more and more. These suburbs which are called hruštšovks were mainly built during the years 1958-1970 and they are normally five stories high. Their life cycle expectancy during the construction work was only about 30 years. About 600 000, people which is 11 % of the city's population live in these kind of houses only in the city centre of St. Petersburg. Only a couple of one hundred neighbourhoods are renovated and the action has been too small-scale considering the need of the city. Average residential density rate is about 15 square metres for each person, which is for example only half of the rate in Helsinki. [19]

Construction markets

Construction markets in the Russian federation have been growing constantly by about 10,5% every year since 2000 and this has made building one of the fastest growing fields in Russian economy. This has also been a historic opportunity for foreign companies to improve their business activities and to increase benefit. In order to develop competitiveness, companies have to lean on local presence and Finnish know-how has to be combined with competitiveness of Russian companies, labour force and construction materials. [20, p. 17]

The need for new apartments for the growing middle class is huge. President Putin has ordered that 80 million new apartment square metres have to be built in year 2010 when the number was 45 million in 2005. Finnish builders are especially interested to build new houses for the fast growing middle class, because they can make the buying decision by themselves and they are also interested in buying apartments with high quality finishing. At the moment, about 90% of new apartments in Russia are handed over to the customer partially or completely unfinished. Increasing of finishing, which is an essential part of a building project in Finland would improve competitiveness and profit of Finnish builders. At the same time, different companies which are becoming established in Russia such as builders, material industry, hardware dealers etc., should increase their cooperation for more fluent business operations. [21, p. 22]

There are about 130 000 active construction companies and about 4.5 billion employees working in the Russian markets. About one million from all the employees are from foreign countries. More than 95% of the companies are in private ownership. The biggest construction companies are holding companies, which mean that they carry out everything in their projects, also including material production. These kinds of companies are rare in Finland. The turnover of the biggest Russian construction companies is almost one billion euros. Most of them operate only locally, only few infrastructure builders operate nationwide. Russian companies dominate the markets. Their market share is about 95%. From foreign companies, the Turkish have the biggest share, which is about 2-3%. Finnish companies hold the second place with a share of about 1%. [21, p. 12]

Competition in the Russian markets is not fully open. Local monopolies rule the construction markets in many places. Markets are developing to be more open in the Moscow area and in North West Russia, but the further from these areas, the less open the markets are. Big local companies get the needed licenses faster and easier than other companies. It is also easier for them to benefit from governments loans. Assets of foreign companies are new techniques and effective operation. [21, p. 12]

Established operation varies with the markets. It has been forecast that Russian markets will grow by about 10% in a year, which means that Finnish construction companies with good constructional skills and strong Russian knowledge will grow at least with the same speed as the markets do. Prerequisites for even faster growth are strong, because Finnish builders have good know-how from the whole chain of housing construction. Russian government has also approved a program which aims to double housing construction by the year 2010. [21, p. 13]

Finnish builders have been operating in Russia for more than 45 years and during this time some thousands projects have been carried out. In the soviet time, construction was mainly project export. Establishing of construction companies started in 1990 and has since increased as Russian circumstances have become more stable. [21, p. 12]

At the moment, the construction volume of Finnish companies in Russia is about 1.3 billion Euros, but it can be increased to 4-5 billion by the year 2011. The growth mainly comes from subsidiary activity between construction companies and product manufacturers. Also more traditional exportation is going to grow in the future. Real estate investors and many other service providers also bring new growth to the construction markets. [21, p. 7]

The main part of the growth will, how-ever come by courageous establishing in the Russian markets and by operating with local personnel. This is a distinct possibility for Finnish construction companies to multiply their business operations. St. Petersburg is a big enough market for most of the Finnish companies to set foothold in the markets and after that the business can be diversified to other parts of Russia. In addition to north-west Russia, the central Russia and Ural regions are also areas where economical growth is happening really fast. [21, p. 7]

Finnish companies have enough technological know-how and experience from leadership of big construction projects in different operating environments. A Finnish construction cluster also has a really good reputation in Russia, which means that prerequisites for success are very good. [21, p. 8]

The most important areas of growth in the construction markets are self-financed housing construction, office building (including production plants, office blocks and buildings for logistic services) and infrastructure, where projects and requirements are really huge. Finnish companies can offer special know-how in all of these fields, which has competitive edge in the Russian markets. [21, p. 9]

The primary market area for Finnish construction cluster is how ever formed by the need of new apartments, which requires aggressive marketing and co-operation between the whole value chain. This means that Finnish companies also have to develop their co-operation with Russian companies. Also Russian personnel should be used in business activities for fastest possible growth. This however requires Finnish experts and managers to work in Russia to get the business rolling. [21, p. 9]

The more the income level grows, the better quality is expected. Russian customers have a positive image of Finnish construction quality, which gives possibilities to fulfill their expectations. Good reputation is based on the conception that Finnish companies and brands represent advanced construction culture, good control of the techniques and materials, punctuality and high level designing. Finnish construction industry has established itself in the Russian markets much slower than other Europeans. [21, p. 15]

41 million square meters of new apartments were built in the year 2004 and 43.5 millions in 2005. 515 000 new residential apartments were built in the year 2005. Apartments are handed over to customers almost without any finishing, which is then carried out by the buyer, individual skilled worker, working group or specialized contractor. [21, p. 21]

There are two definite developmental trends: the average size of new apartments is increasing and the number of one room apartments is increasing when the number of three room apartments is decreasing (table 1). However the most common apartments in new housing production are still 2-3 room flats with the average area of 84.7 square meters (2005). The demand for bigger and more luxurious apartments has increased at the same with the income level of potential customers. Demand is bigger than supply with big 4-5 room apartments with all the comforts such as security systems and underground parking. [21, p. 21]

Table 1 key figures of housing production [21, p. 21]

	1992	1995	2000	2003	2005
Number of apartments (in thousands)	682	602	373	427	515
Average area of the apartments (sqm)	60,8	68,2	81,1	85,4	84,7
Apartments by the number of rooms, % of all:					
One room	18	18	20	23	n/a
Two rooms	32	32	29	31	n/a
Three rooms	40	38	34	31	n/a
Four or more rooms	10	12	17	15	n/a

Over a year after the global financial turmoil began, the Russian construction industry is still developing with construction output growing by 20% year on year. However, markets have been severely affected in terms of residential construction. Background to the current situation is summarized below:

- Early 2000s in the United States: beginning of housing bubble – interest rates lowered, mortgages become easily available.
- Banks simplify loan procedures, and demand for housing increases, as do prices.
- Subprime mortgage industry emerges.
- Total value of mortgage loans up, to more than 60% of GDP *
- 2005-2006: housing market slows down, and the Fed raises interest rates.
- Beginning of 2007: subprime industry collapses.
- August 2007: worldwide credit crunch, subprime mortgage backed securities found in portfolios of many financial institutions in the world.

- Banks and hedge funds report losses, and the cost of money increases worldwide.

  *(**GDP**) is one of the measures of national income and output for a given country’s economy.

[10, p. 1]

The mortgage market meltdown seen in the US is unlikely to be repeated in Russia. Housing requirements in Russia are enormous and remain unsatisfied. [10, p. 3]

Russia has been able to maintain growth in the construction industry, however, even in Russia the rate of growth has been declining gradually since the beginning of the year 2008 (figure 2). [10, p. 3]

Figure 2 Year-on-year changes in Russian residential construction [10, p. 6]

In residential construction a considerable slowdown has been seen in Russia. At the beginning of 2007, construction of residential space increased by more than 60% year on year in Russia and the rate of growth is now less than 10%. Housing construction indicators began to fall few months before the liquidity squeeze which indicates that the problems on the Russian residential markets began earlier and that the financial turmoil merely contributed to the slowdown. Liquidity problems are expected to continue in 2008 and 2009, and banks to remain reluctant to provide financing for development projects. [10, p. 6]

2 TECHNOLOGY AND PRODUCTION OF CAST IN SITU FRAME

2.1 Technology

2.1.1 Concrete as a building material

Concrete is one of the most important construction materials. It is used in almost every building project because of its many good properties. It is used to build frames for big apartment houses mainly because of its excellent compressive strength. [9, p. 8]

Concrete is an artificial stone which is produced by gluing gravel or crushed stone aggregates of different size to each other (figure 3). The glue is manufactured by mixing cement with water. Different kinds of additional substances, such as accelerators or plasticizers can be used in order to alter concretes properties. [7, p. 31]

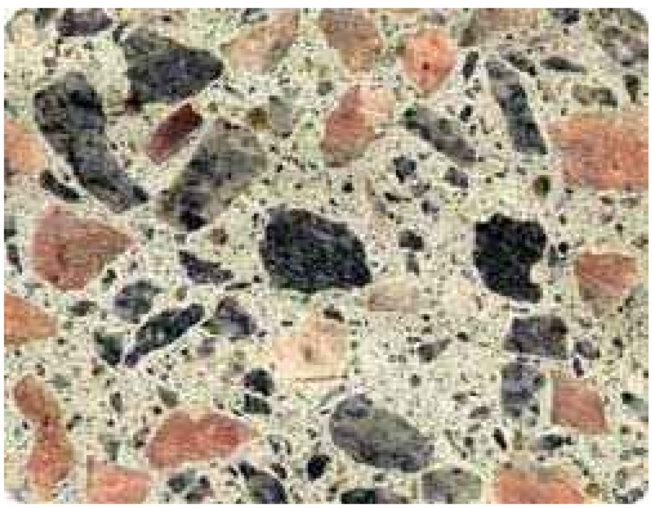

Figure 3 Concrete's cross section

Aggregates percentage in concrete is from 65 to 80% and this is why it is obvious that the properties of an aggregate effect a lot to concretes properties (figure 4). The aggregate has to be appropriate for the particular purpose. It cannot include harmful amounts of substances which debilitates freshly mixed concrete's, hardened concrete's or reinforcement's properties. Aggregates cannot be weathered and it cannot contain any waste, clay lumps, oil, snow, ice or frozen stone lumps. [9, p. 18]

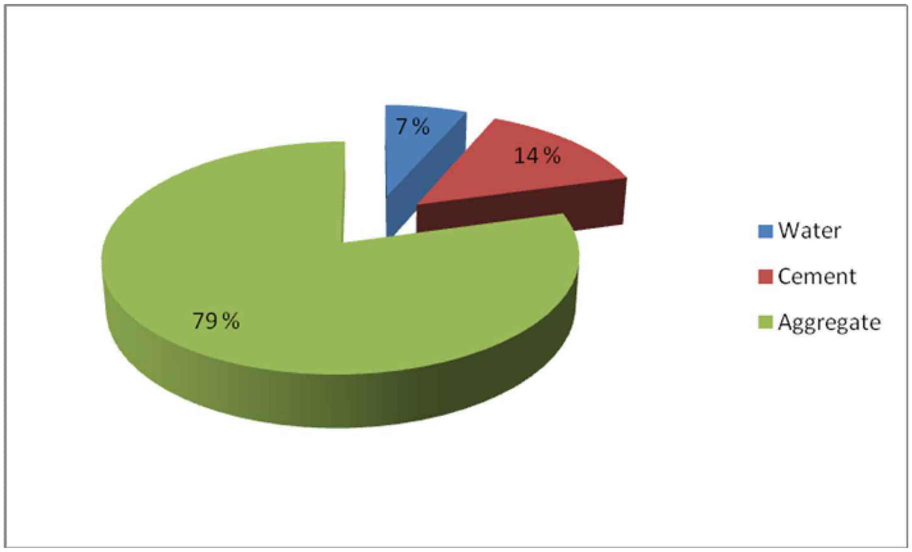

Figure 4 Eaxmple of simple concrete mix [7, p. 31]

Cement is a hydraulic adhesive, which forms hard and resistant final product when it reacts with water. Cement has a crucial effect to many of concrete's properties. It's chemical composition effect for example to fresh concretes workability and to hardened concretes durability. Also strength, heat release, and chemical durability of concrete can be affected by the choice of cement. [7, p. 39]

Properties of concrete can be regulated by the choice of components. Also additives can be used to regulate the properties of hardened concrete as well as fresh concrete's. Additives effect to concrete in a physical or chemical way and their amounts in concrete are really small comparing to other components. Some grades of concrete such as frost resistant concrete and high-strength concrete are really hard to prepare without the use of additives. Commonly used additives are retarders, accelerators, plasticizers and water-reducing agents. [7, p. 63]

Properties of hardened concrete are normally evaluated by its compression strength and by its durability against different kinds of stresses. The importance of durability has increased after the builders have started to construct concrete structures in to more and more demanding conditions. The most important properties, considering northern hemispheres weather conditions, are frost and salt resistance. Concrete's good properties can easily be lost by very small failures even though concrete by itself is quite preservable material. [7, p. 69]

Concrete holds compression stress very well but not much of tension. Tensile strength of concrete structures has to be improved to get the structure working in a proper way. This improvement is done by placing reinforcement bars in to structure's tensile parts (figure 5). The grip between concrete and the bars moves tensile stress from concrete to reinforcements. [7, p. 79]

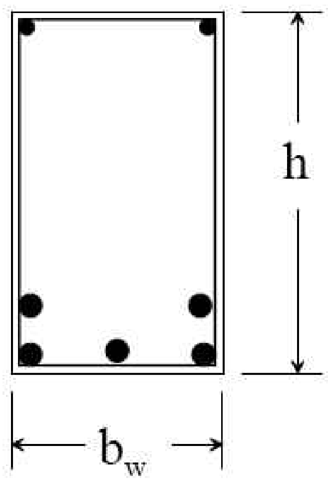

Figure 5 Cross section of reinforced concrete beam

Reinforced concrete is a construction material which is combined from two materials with quite different properties. The basic idea of combining is that strength properties of these materials complete each others in a good way. Concrete grips to reinforcement bars and tensions start moving from concrete to bars and from bars to concrete (figure 6). The grip is formed by the effects of molecular grip and friction. [7, p. 250]

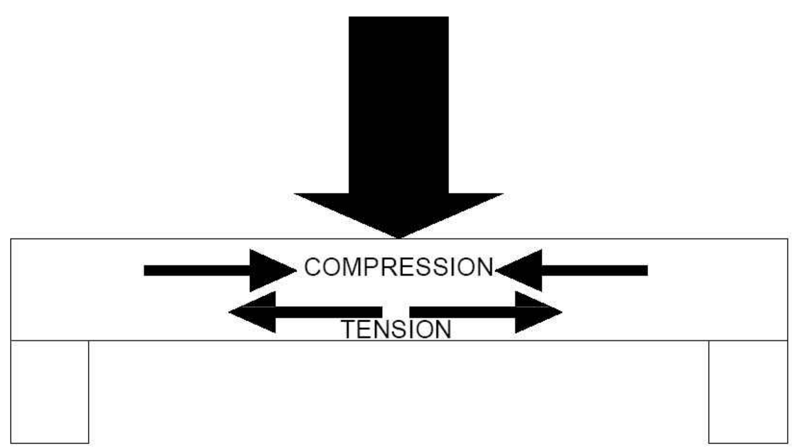

Figure 6 Compression and tensions stresses in concrete structure [9, p. 33]

Concrete protects reinforcement from corrosion. Concrete cover of the bars has to be thick enough also to ensure good grip between the concrete and the bars. It also protects reinforcement in a case of fire because of concretes good fire endurance. The thickness of concrete cover is always presented in the structural drawings. The durability of well chosen reinforced concrete structure is excellent and it holds external stresses very well such as weather conditions, moisture, erosion and chemical effects without any particular protection procedures. [7, p. 252]

Concrete is classified by its compression strength (MN/m2) in to different grades. These grades are K10, K15, K20 and so on. Marking means that for example K15 concrete’s compression strength after 28 days from pouring is 15 MN/m2. Concrete structure also has to withstand stresses caused by ambient conditions, loads and other factors in a way that required qualitative and operational properties lasts through the whole life span of the structure. [9, p. 33]

2.1.2 Cast in situ frame systems

Cast in situ frame is suitable for all kinds of construction projects. Housing blocks with many floors as well as commercial buildings with varying loads are typical to be constructed with cast in situ technique. Cast in situ frame offers alternative architecture, which takes resident’s needs about the apartment into better account. It also offers better comfort for residents, for example because of frame’s better sound insulation properties. Cast in situ frame can be constructed with fair costs and it has long life cycle expectancy. [8,1,p. 4]

Cast in situ frame has a lot of competitive advantages. The biggest benefit is the freedom in designing. This concerns both single apartments and the building as a whole. For example possible brackets, arcs and intermediate slabs openings can be easily made in to cast in situ frame. Amount of work in cast in situ frame’s production planning is significantly smaller than in pre cast one and plans can also be changed even when the production has already started. Construction of cast in situ frame also offers added value in to contractor’s business operations if it’s done by company’s own personnel. [8,1,p. 8]

The amount of cast in situ framing systems is almost unlimited. Normally it is recommended that the frame is made as simple as possible in order to ease the actual production phase. Building of the cast in situ frame requires a lot of work force compared to pre cast system. This matter must be recognized while designing production. [6, p. 77]

Column slab structure is suitable to all housing production. Only columns and equal strengthen slab is needed when the spans are reasonable (figure 7). The frame is then stiffed with staircases or trusses. In low buildings the stiffening can also be done with stiff mounting of column ends. [6, p. 77]

Figure 7 Column slab frame under construction in St. Petersburg

Load bearing wall and slab structures are mainly used in apartment buildings (figure 8). Massive intermediate walls between apartments are needed anyway to ensure required sound insulation level. Load bearing vertical structures are placed paralleled, normally cross directionally because of form technical reasons. Also different way structures are needed to ensure overall stiffness of the frame. These kinds of frame systems are normally built by flying-form systems. Maximum building speed is achieved with flying form and table form combination. In these cases the slabs are normally two way systems. [6, p. 77]

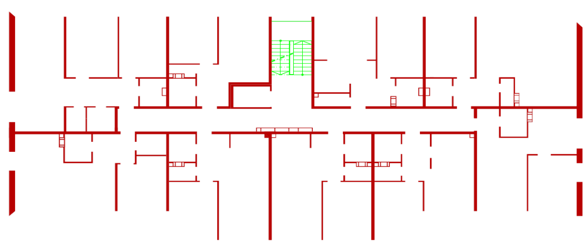

Figure 8 Load bearing walls system (Hakkapeliitta Village)

Few other possible cast in situ framing systems are presented in the picture below (figure 9):

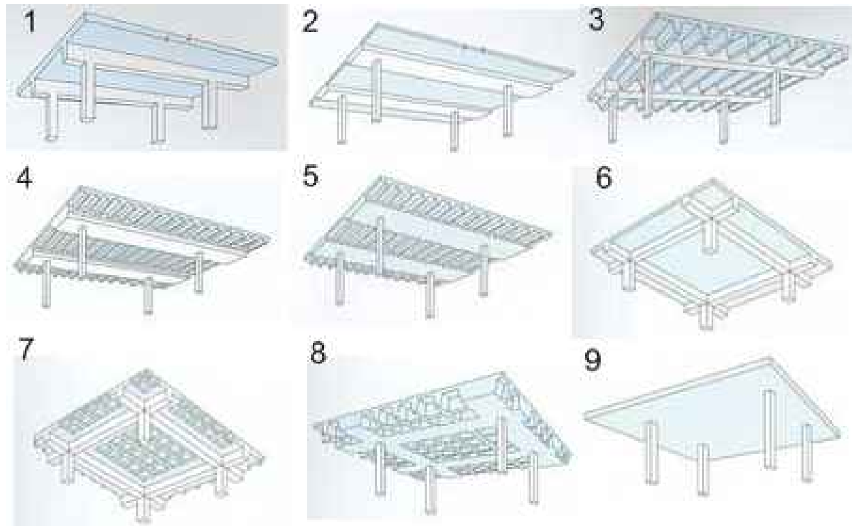

Figure 9 Few cast in situ frame options. [12]

1. One-way solid slabs.

2. One-way slabs with band beams.

3. Ribbed slabs.

4. Ribbed slabs with band beams.

5. Troughed slabs.

6. Two-way solid slabs.

7. Waffle slabs.

8. Waffle slabs with integral beams.

9. Flat slabs. rchitectural finish can be applied directly to the underside of the slab.

[12]

Building's frame system is normally chosen in sketch design phase. Loads, fire resistance class, structural layers, main geometry and the most important details are defined in this stage. After this the cost estimations for different frame systems can be prepared. Architectural, structural and hepac designing are also matched in sketch design phase. Designers have to remember that about 80% of frames becoming costs are bond after the selection and these costs cannot be easily reduced afterwards. Frame system is chosen by structural safety, operating targets and life cycle expectancy of the building and the structures. Combining load bearing structures with non bearing ones and hepac systems also effect the selection of a frame system. [6, p. 77]

2.2 Production of cast in situ frame

Production of cast in situ frame can be started very quickly. Construction work can be started immediately when plans for the foundations are finished. Production does not have to wait planning of pre cast blocks, which takes typically very long period of time and also the progress of frame building is not dependent about precast concrete manufacturing plant. Cast in situ frame can be built just as fast as pre cast one if the frame building phase is differentiated in to own independent working phase. [6, p. 76]

It is essential that the demands of frame's production are taken into account already in design phase of the project. Efficient form cycle is the most important part of the actual production. Production phase can be intensified by exploiting technical possibilities of the chosen form work, reinforcement and concrete pouring techniques. Logistical chain of cast in situ production is well defined and it is easily controllable by contractor's site management. Form equipments and ready mixed concrete must be available through the whole frame construction phase. Prefabricated reinforcements should be used in order to intensify the construction phase. [8,1,p. 15]

The production of cast in situ frame includes following tasks (figure 10):

- Form work
- Reinforcement
- Concrete pouring
- Dismantling and cleaning of forms

Construction of cast in situ frame starts from form work. Forms can be divided in different types and groups by many bases. Grouping principles are for example form unit's size, number of times the form can be used, building project, structural part or the direction of form's supports. [11, p.43]

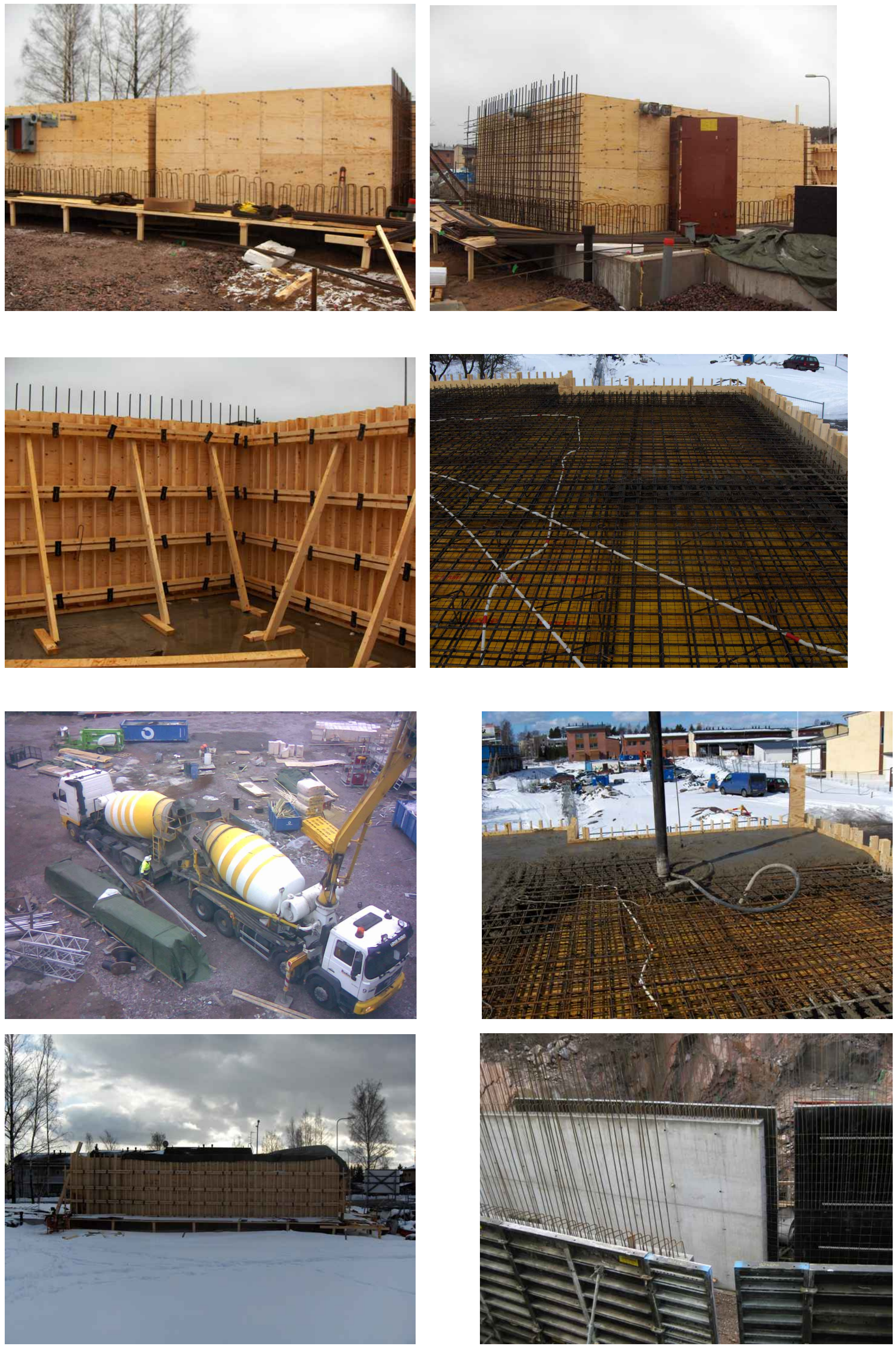

Figure 10 Progress of cast in situ construction from form work to dismantling of forms

2.2.1 Form systems

Form systems are divided in vertical, horizontal and special forms. Vertical forms are used to build for example load bearing walls, columns and foundations when horizontal ones are used to build for example concrete slabs. Special forms are used both in horizontal and in vertical structures in a way the form technique requires. [11, p.43]

Form surface material plays a major role in achievement of a good qualitative concrete surface. The material which has been used and the carefulness can always be seen in the finished surface. Quality requirements and usage times of form materials have to be always observed when choosing the best form material for each construction project and for each structure. The most in common form materials are:

- Plywood
- sawn wood
- fibreglass and plastic
- form fabrics

Plywood with other kind of wood panels are the most used materials from these. They are normally coated in order to achieve as hard concrete surface as possible and for more durability for form equipments. Uncoated, un oiled wood sucks so much moisture out of concrete that the hydration of cement can also stop, causing the surface to be fluffy and week. Extension of wood panels can always be seen in finished concrete surface. Strip of wood can be used to fade out the extension if this is not acceptable for example for architectural reasons. [7, p.212]

Sawn timber and plywood forms can be used to all kinds of structures (figure 11). This system can be used to architecturally challenging buildings and otherwise hard structures because of its good versatility. These kinds of forms can only be used couple of times. In addition this system requires a lot of professional carpentry skills and many workers. [7, p.216]

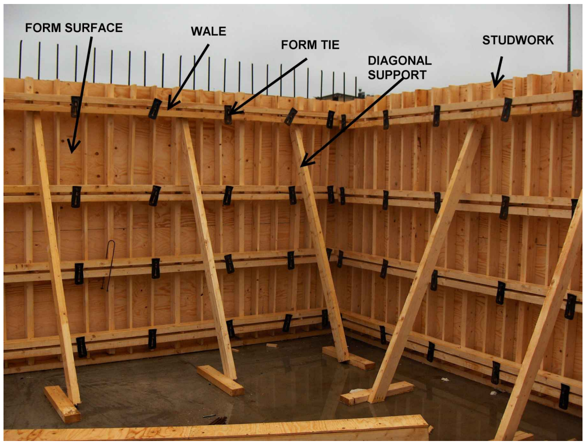

Figure 11 Sawn timber wall form

Steel forms can be used to make large, continuous and smooth concrete surfaces. Steel forms can be used very many times, but still they need a lot of maintenance and repair. Typical damages in steel forms are rust and different kinds of handling damages such as grinding mistakes, holes, depressions and welding marks. [7, p.213]

Flying forms are normally used to build straight wall structures with a lot of repetitive. It is a suitable system for example for construction of cast in situ frame with load bearing walls and a slab. They are steel-framed and standard sized and a crane is needed to move them (figure 12). Plywood is normally used as a form surface. Halves of forms are attached together with form ties with sparse and regular spacing. Flying form is typically insulated and equipped with heating system, which allows form cycle to be faster. The amount of work force is quite small comparing to other form systems. [7, p.216]

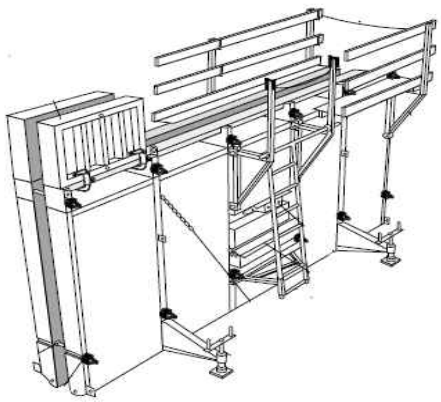

Figure 12 Flying form unit [7, p.216]

Sheeting-panel form work system is the most commonly used system to build vertical concrete structures. It can be used to build all the vertical structures of construction project such as walls, elevator shafts, stair enclosures and columns. This system can be used in polymorphic as well as in clear straight structures. Single panels can be used as well as large units can be composed which allows this system to work in a same way as flying forms (figure 13). Panels include plywood or steel sheets which are attached to wooden-, steel- or aluminum frame. Also the needed fastening equipments, supports and fittings are included to this system. Crane is needed in assembling, installation and dismantling work. [7, p.217]

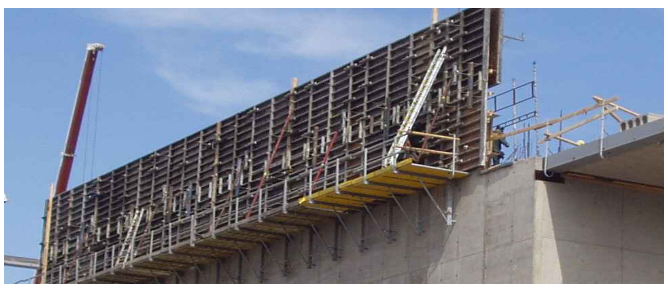

Figure 13 Large unit of sheeting panel form system

Standard beam form is a project specific form system which is assembled from standard components (figure 14). It is used in projects which has special requirements for the forms. First assembly takes a lot of time and it requires a lot of professional skills and careful pre-planning. [7, p.219]

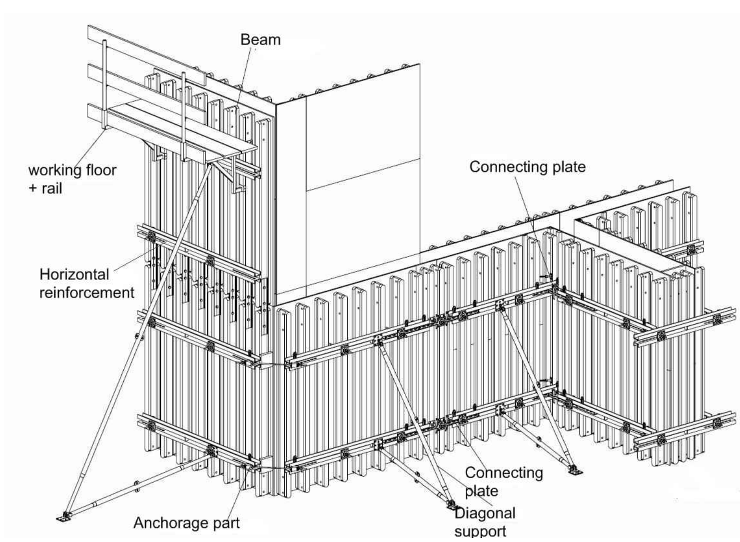

Figure 14 Standard beam form system [7, p.219]

Column forms are normally manufactured from steel, reinforced plastic, plywood or sawn timber (figure 15). Sawn timber form is normally disposable and it can also be used to build circular columns. [11, p. 45]

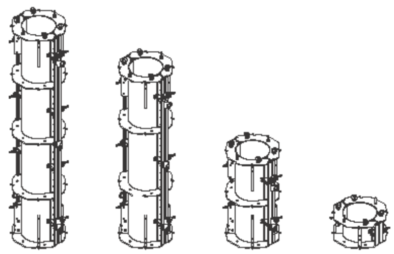

Figure 15 Column forms [7, p. 22]

Table forms are used to build intermediate floors which dimensions are chosen project-specific. This system's main parts are form surface, studs and head beams, vertical- and diagonal supports, rails, insulation- and heating systems and travelling wheels (figure 16). Steel or thick and stiff plywood are used as surface materials. Sawn timber, standard wooden or aluminium beams are used as studs. Head beams are steel or wooden and their purpose is to move loads to the supports. Normally table form is stiffened with diagonal and horizontal ties which limit working space under the form system. The size and shape of a table can be chosen by the demands of the project. The need of working force is small when using this system. It is suitable for the projects where fast form cycle is important and where the structures are repetitive. First assembly takes a lot of time but still this is the most profitable system if the project specific table can be used at least in seven form cycles. Good and careful form cycling plan is highly important and it should be prepared early enough in order to get the best benefit from this system. [7, p.223]

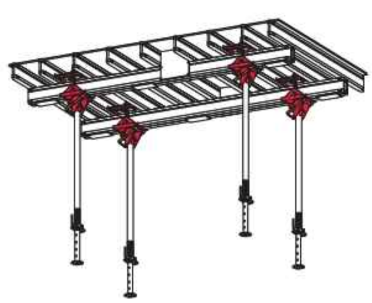

Figure 16 Peri Table form

Sheeting panel form system can be used to build straight slabs which have no through holes such as columns or air chimneys. It can be altered easily but it is desirable that building’s dimensions follow modular system if this system is used. Slab panels are aluminium framed and plywood is normally used as surface material. The need of work force is small and a crane is not necessarily needed. [7, p.224]

Standard beams and form panels system consists of lowering heads which are attached to vertical supports and aluminium or wooden standard beams which are installed on top of them (figure 17). System is suitable for rather small and polymorphic slabs and when there is only few form cycles in the project. [7, p.226]

Figure 17 Installation of standard beam form system

2.2.2 Reinforcement

Basic components of industrial reinforcement are reinforcement bars, wire mesh reinforcements, column and beam reinforcements and corner reinforcements (figure 18). Costs can be decreased by using as much prefabricated elements as possible. Prerequisite for this is that also other tasks advance quickly. Otherwise any benefit is not achieved. Reinforcement bars are needed for example in joints between different structures also while using prefabricated elements. [8,4,p. 4]

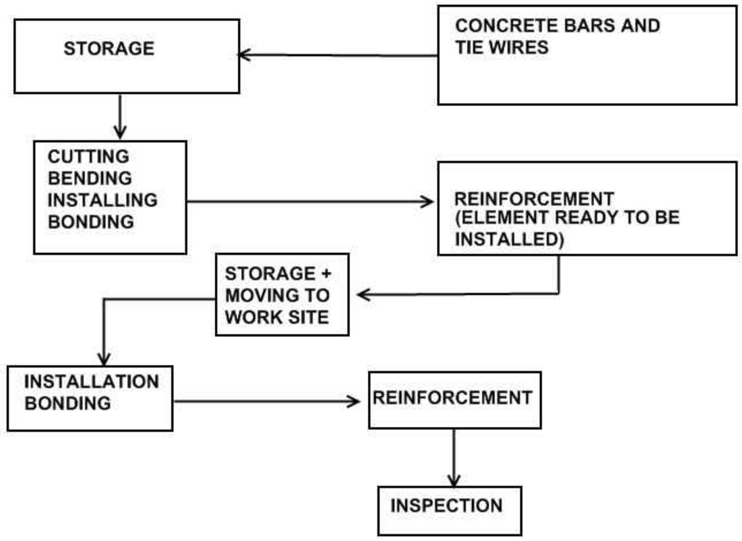

Figure 18 Procedure of reinforcement work. [7, p. 276]

Simple and clear reinforcement solutions are normally best in cast in situ structures. Plastic properties of concrete and structure's ability to move internal forces are taken into account while planning reinforcement systems. [8,4,p. 4]

Reinforcement work is started after the first half of vertical structure's form is installed. Reinforcements are tied in to forms with spacers and bar supports in a way that they do not move during the pouring of concrete or other working phase. Bar supports are not normally shown in the structural drawings and simple rules about how they should be used are impossible to give. Experience and testing helps to install right amount of supports to right places. [7, p. 279]

Repairing of reinforcement is really hard or even impossible after concrete is poured and hardened. This is why it is a must that reinforcements are inspected before pouring of concrete starts. Supervision during the work performance is also really important. [7, p. 284]

2.2.3 Pouring of concrete

Demands of concrete structures are shown in structural drawings which are determined by structural designer. Concrete, to be used, is decided by task's foreman in the site. Choice of right concrete is really important because the concrete needs to fulfil all the demands determined by structural designer and also the demands set by working technique and conditions of the site. These days ready-mixed concrete is used in almost every concrete pouring. [7, p. 301]

Most in common ways to move concrete inside construction site from concrete truck to structure are concrete bucket and concrete pumping (figure 19).

Figure 19 Concrete bucket and concrete pump used to pour a wall structures

Concrete should be poured in to form evenly and the concrete layers should be thin enough. It needs to be compacted steadily and placed directly to its final destination. In addition it has to be joined to pre-poured fresh concrete without joints before it has hardened. When filling a wall form the height of one concrete layer should not be more than 0,5m. Concrete is compacted straight away after the pouring for the following reasons:

- To fill the whole form with concrete
- To surround the reinforcements
- To remove extra air from concrete
- To get the particles of aggregate to seek their way closer to each other

[7, p. 317]

Concrete is poured in a layers of about 300mm. Compaction comes about 2 meters behind the pouring and it is done in the squares of about 500mm (figure 20). Surface of the concrete is float-finished after concreting and needed heating and protection tasks are carried out. [9, p. 79]

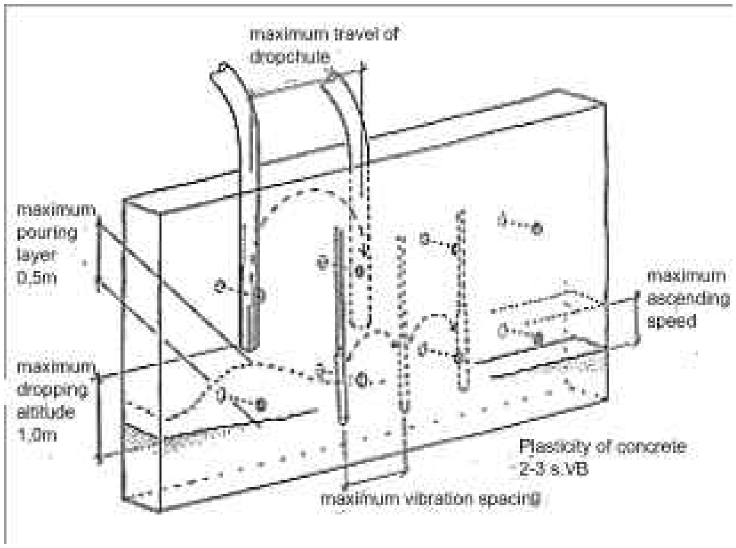

Figure 20 Instructions for concrete pouring to vertical structures [7, p. 322]

Dropping altitude of the concrete cannot be more than 1.5 meters while concreting walls, which means that flexible dropchute should always be used in wall structures. Dropping altitude has to be supervised by the site foremen, because it is typical that the workers do not follow this rule for better work achievement. [7, p. 327]

Normally the compaction is done by vibrating. When the concrete is forced in to vibrating movement, the internal friction reduces which causes concrete to be more fluid and it compacts with the help of gravitational force. If this phase is skipped it may for example cause the concrete's porosity to be too big or strength and density to be decreased. Compaction is done by dropping spud vibrator in vertical position in to concrete. Compacting effect reaches from 300mm to 1000mm in vertical direction and 200mm to 600 mm in horizontal depending on vibrator's size. Vibrator's size is chosen by the thickness of the structure and the amount of reinforcements. Right compacting time depends especially on concrete's plasticity but also on shape of the structure and reinforcements. The stiffer the concrete is the longer compacting time is needed. Generally good compacting time is about 10 to 20 seconds. When cement glue rises to surface and air bubbles stop appearing the vibrator is slowly pulled up to make sure that the hole caused by it closes properly. [9, p. 74]

Slab is also poured in layers if it is thicker than 300...400mm. Pouring of a new layer is started when the pouring is advanced from 5 to 10 meters.

Slab’s surface can normally be left as construction joint surface because its final topping layer is poured later. [7, p. 330]

Concrete pouring to footings and foundation walls is relatively easy in normal housing construction because of their looseness. Wall footings can either be poured at one time or alternatively by first pouring concrete to footings and after that build forms for the wall and do the pouring later. This leaves a construction joint between footing and the wall. Base for foundations can be rock, levelled foundation soil or compacted gravel or crushed aggregate layer. Before concrete pouring the cleanliness of forms needs to be checked. It is typical that forms get filled with all kinds of loose materials such as mud, garbage or snow which needs to be removed before the actual concrete pouring can be started. In the winter time it is normal that the forms need to be heated before the pouring of concrete can be started. [7, p. 326]

2.2.4 Dismantling of forms

The forms can be dismantled after hardened concrete has reached sufficient strength. Loads coming for the structure (load bearing/non bearing), quality of concrete and the temperature of hardening time are main things which effect to the point of time the dismantling can be started. Forms are dismantled carefully to achieve required quality for hardened concrete surface. Carelessness use of dismantling tools can cause unrepairable harm for the surface. Poorly compacted parts are plastered over after the forms are dismantled. [14]

Form surfaces are cleaned and oiled with form oil right away after they are dismantled. This is really important in order to achieve longest possible life cycle for the forms. Broken plywood and other parts are replaced with new ones. Cleaned and repaired forms are then stocked in a good order to wait for their next cycle. [14]

Dismantling time of load bearing structure’s forms is agreed together with construction site’s supervisor and structural designer. Typically the forms can be dismantled when the concrete has reached 60% of its compression strength. Thumb rule for right timing is that non bearing structure’s forms can be dismantled earlier than load bearing ones. Reliable information can be consulted from the experts of concrete supplier in unclear cases. [14]

2.3 Scheduling and production planning

2.3.1 Construction planning principles

In general, the main objectives of planning are analysis, anticipation, scheduling resources, co-ordination and control and production of data. Good production planning ensures achievement of objects and demands which are set in the beginning of the project. Production planning is a chain which sharpens and systematically goes forward. The projects manager’s power to influence the course of the project diminishes as the project progresses. As decisions are made, actions taken, designs made and the contract entered into, the project takes a more definite shape and the opportunities to make changes decrease. It is clear that the early decisions have far reaching effects and so must be made in a well planned and objective way. [2, p. 4]

Production planning procedure consists from five straight phases:

- Quantity surveying of the project and preparation of a task list.
- Dimensioning and synchronization of the tasks.
- Preparation of schedule for the frame phase and selection of recurring task entity.
- Task planning for the recurring task entity.
- Choosing the amount of forms needed for the project.

[8,7 p. 5]

Production planning is started from quantity surveying of the whole project and preparation of a task list. Amounts are calculated from technical plans and they are specified separately to horizontal and vertical structures. After this the amounts are divided in different tasks based on work force’s professional skills. [8,7 p.6]

The success of construction requires production planning guidance and production management in order to achieve goals set for the project. Schedule is a model of projects implementation where targets are set for the project and for individual tasks. Targets concern implementation and finishing of the tasks and also the usage of manpower and machinery during the building project. These targets have to be realistic and measurable and they need to be bond with time and output. [8,7, p 7/

2.3.2 Phases of scheduling

Scheduling requires a lot of familiarising with the project before the actual time planning can start. Construction schedules are supposed to describe production and one of the main things is to help designers to notice deviations. Following steps are to be done in order for schedule to be operative:

- Right tasks are chosen to be presented in the schedule.
- Scheduled tasks need to be designed as complexes which are big enough so that the guidance is possible.
- All the tasks have to be designed based on labour input and earlier achievements.
- Enough time has to be reserved for each task.
- Only one task can be performed at the time in one work site.
- Dependences between different tasks have to be manageable.
- Schedule has to be presented in a way that it makes guidance of production possible.

[23, p. 12]

Phases of scheduling:

1. Timing of project
2. Checking tightness of construction schedule
3. Calculating efficient construction period
4. Dividing project in sections
5. Choosing sequence for sections and parts
6. Preparing of task list
7. Dimensioning tasks
8. Synchronising, pacing
9. Preparing time-and-place chart
10. Placing the remaining tasks on line chart
11. Setting intermediate targets for the project

Preparation of schedule is contractor’s responsibility. It needs to be carefully prepared because its realism, target-orientation and connection with project’s other plans creates a base for all the other time planning. Scheduling program Graphisoft control is an excellent tool to help schedule designer to make more cost efficient and reliable timetables. Planning in time-place view is very fast because execution order of partial targets, task order and dependences can all be seen in one print. In addition it is easier for the designer to detect and stop discontinuities which harm effective time management and deviations from synchronised production speed. [23, p. 14]

Duration and solid costs can be reduced without any risks by comparing efficiency of different execution orders and by synchronising productions speeds of different tasks (figure 21). In synchronised schedule there are fewer conflicts between different working groups and this way the duration of the project can be shortened. [8,7 p.8]

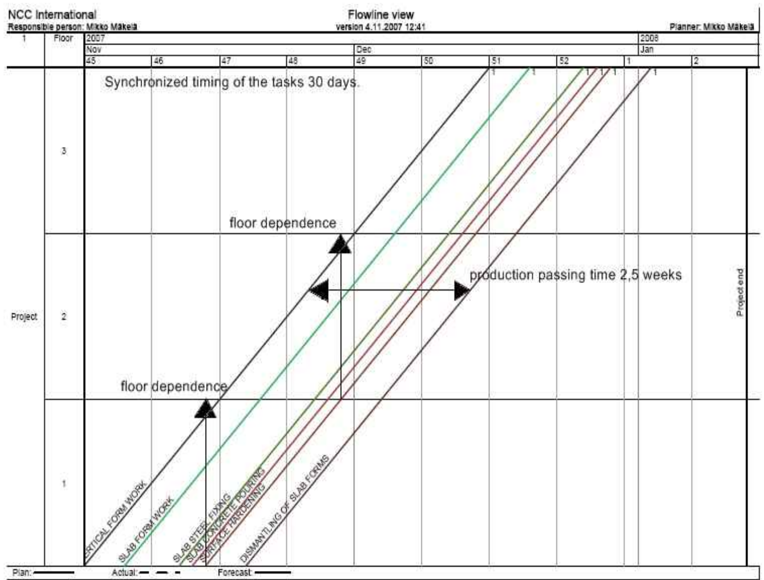

Figure 21 Synchronization of cast in situ frame's tasks by the slab's form work [8,7 p.8]

Schedule is more extensive and reliable to execute if the duration of tasks is planned based on project's bill of quantities. This way the actual amount of work and need for resources are known task-wise. In addition information about task's amount of work and designed working group is given for site's management. For one part the full employment and even strength are ensured in resource chart. [23, p. 15]

Schedule presents:

- Scheduled tasks by construction phase
- Quantities and units to be completed
- Total labour demand for task

- Work group
- Duration in shifts
- Calendar scheduling of tasks
- Intermediate targets
- Dates planned for suspension
- Resource calculation

[3, p. 8]

Dimensioning and synchronization is done after preparation of quantity surveying and task list. Detailed task entity and consistence of the working group are determined in this phase in a way that task's duration concurs with synchronized duration. Synchronized duration for tasks in frame production is defined based on form work's duration and all the tasks are synchronized to take as much time as it does. Synchronization is done by changing the size of working groups in different tasks and by altering task entities. [3, p. 8]

2.3.3 Weekly planning

The purpose of weekly planning is to ensure implementation of targets, efficient use and adequacy of resources. Required resources can be estimated based on time and amount targets and then compared to available ones. Weekly schedule is also an instruction for subcontractors and information source for site's foremen. The main concentrate in weekly planning is in sites activities in the following two weeks. Weekly schedule is excellent tool for site management's daily planning and control of the activities. Its key targets are to ensure preconditions for starting works, eliminate disruption in advance, enable efficient use of resources and to co-ordinate subcontracts with own work. Weekly schedules are shown in the site office and in the workers social premises. [23, p. 25]

Foreman of each task prepares individual weekly schedules which are then matched together with site super intendment's guidance. Successful planned production demands that preconditions for implementing of tasks are okay. Cleared working place, plans, machines, equipment, materials, workers and enough time are needed to complete the work that needs to be done. Implementation of a task is possible when these preconditions are okay. Level of schedule and production planning can easily be evaluated by comparing designed and realized tasks from weekly schedules. [23, p. 26]

3 TASK PLANNING

3.1 The idea of task planning

Task is an aggregate which is normally executed by one work group and it consists of either one particular working phase, such as sheet metal cladding, or from more than one phase like bathroom tiling which includes water proofing and the actual tiling. Task planning is a way for contractor to design and control single tasks during the construction phase of the project. Task plan is prepared before subcontract negotiations, purchase of materials and at least before the particular task is started and it contains information about scheduling, quality, work safety and potential problems of the particular task. The meaning of a task plan is to make sure that all the parties have similar understanding about the content and the targets set for particular task. It offers tools for monitoring and for quality assurance during the task which makes it easy for the project management to notice deviations in quality and schedule. [3, p. 1]

Planning lays the foundation for the control of each task of the project (figure 22). Determined planning is essential for contractors in order to reach certain quality level. Site management's power to influence attainable quality level with planning diminishes as the project progresses. It is important to prepare all the needed plans early enough to get the best benefit out of them. [2, p. 3]

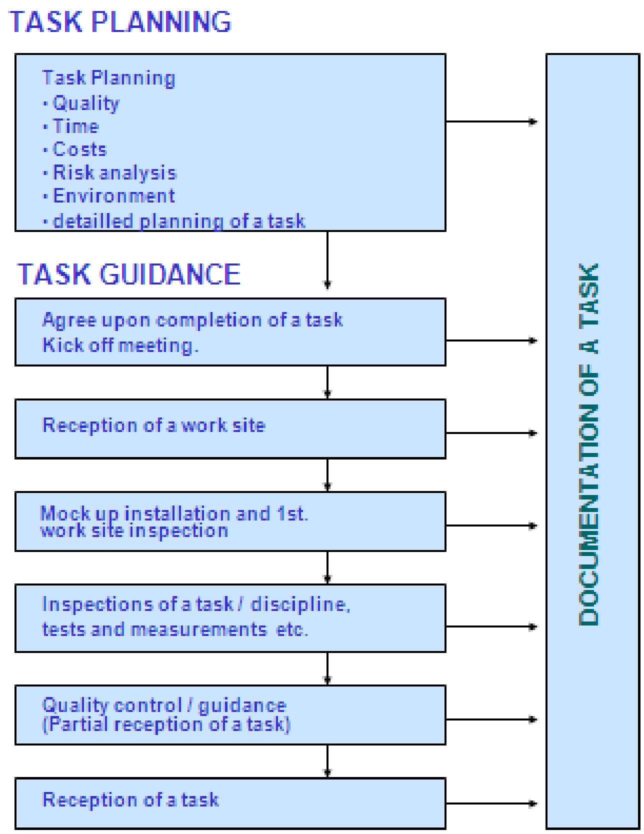

Figure 22 Tasks quality control starts by preparation of a task plan [5, p. 3]

Task plan is normally prepared for 5-10 tasks which are found to be the most important for sites economy and schedule. In normal housing construction task plan should be prepared at least for frame building, brick laying work, bathroom floor works, tiling and partition wall building. Task plan is also prepared if a task is new for working group or if it is founded to be critical in guarantee inspections in earlier sites. [4, p. 15]

Preparing of a task plan starts by specifying the content, scale and parts of a task. The content is presented by specifying:

- Initial condition, such as the work group receives a task.
- Scale and list of parts of the task, which includes or eliminates auxiliary construction such as cleaning and protection of surroundings.
- Final condition, such as the task or a room is handed over for the next work group.

[3, p. 3]

A task can be formed either straight from one task of sites master schedule or it can be composed from several different tasks in a way that the complex includes parts from one or more sections of the schedule. Exact description of task entity and limits is highly important when dealing with subcontractor because task has to be ready and finished exactly at the right time so that the next work group can start their work on time without any obstacles. [3, p. 3]

Project-specific and general documents are collected as an initial data for a task plan (figure 23). Project specific documents are for example site's quality plan, drawings, building specification made by architect, contract and master schedule. Economical and schedule targets, content of a task, project specific conditional requirements, safety and quality requirements and references to common sources of information are gathered from these documents. General documents contain for example code of building regulations of the country where construction takes place. [3, p. 4]

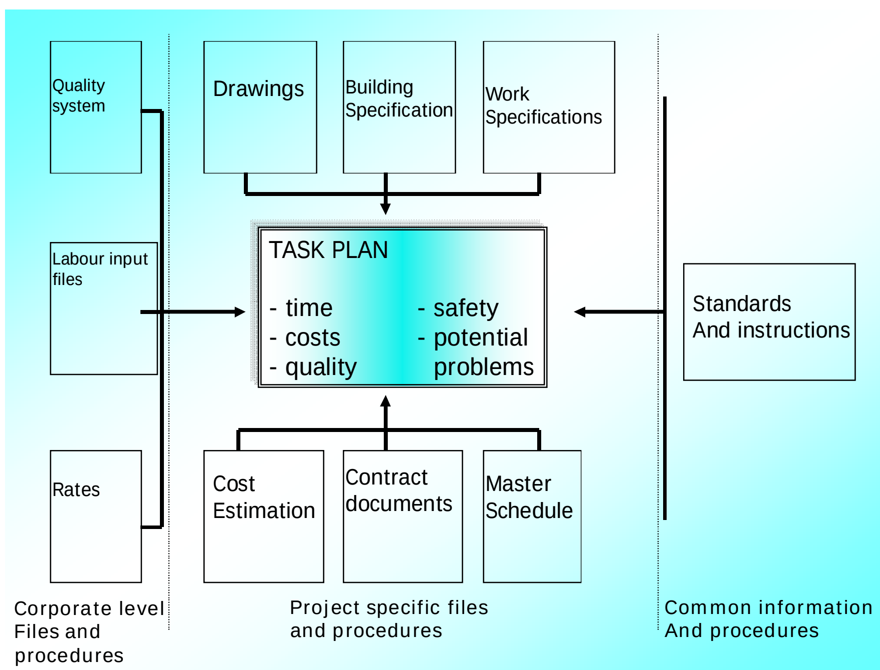

Figure 23 Formation of a task plan [16, p. 15]

Task plans prepared for previous projects can be used as an example. This makes it easier and faster to finish new task plan. It has to be remembered that intended benefit won't be achieved with straight copying of old task plans. Task plan needs to always be prepared so that special characteristics of the project are taken into account. [3, p. 4-5]

Identification marks of a good task plan and for goals set for it are the following:

- Clearness
- Results are measurable
- Task is tied in to schedule
- Goals are set for a task and they are realistic

[4, p. 15]

Parts of a task plan are economical and schedule planning, quality requirements, kick-off prerequisites, risk analysis, work safety, working methods and guidance during the task. [4, p. 16-17]

3.1.1 Scheduling

If a task does not stay in its schedule it usually means that targeted costs won't be enough. This is why scheduling is also part of a task plan. Feasibility of master schedule is checked and corrections are done if there are some deviations. The amount of workers in working group can be added if it seems that there is not enough time to finish the task before next one starts. Working order can also be changed in order to achieve better production speed. Planner needs to consider task's overall duration, starting time, intermediate goals and production speed. Schedule part of a task plan is presented as a flow line view where intermediate goals are shown (figure 24). [5, p. 7]

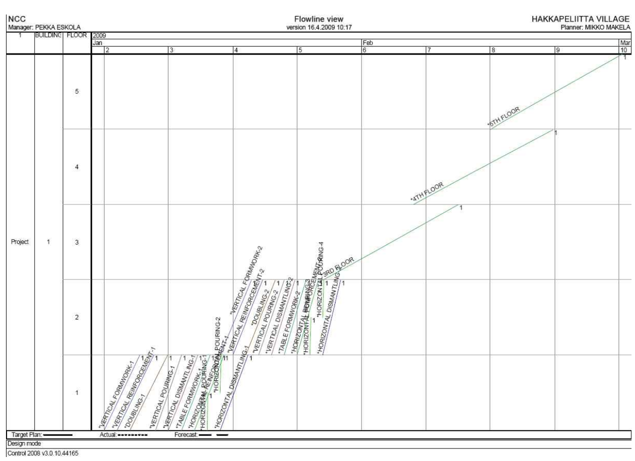

Figure 24 Example of a cast in situ frame's schedule

Cast in situ frame's schedule is prepared in two phases. In the first stage the frame's production is planned as wholeness for the project and in the second stage a detailed schedule for one floor is prepared. Dependence of the floors is assured in the first schedule and even use of resources is assured in the detailed one. [8,7 p. 8]

Building of the frame can be made even faster when project is divided in separate sections. Decrease in section's size shortens production's passing through time, which decreases needed amount of form equipments, even though the production time stays constant. If the frame can be made faster, the whole project can be completed in a smaller time and less costs. Time is money especially in construction field. The benefit of block technique is a lot bigger in big projects and it should be used in Russian sites also. [8,7 p. 13]

A section can be for example one building in bigger construction projects (figure 25). All the blocks can be started at the same time which saves a lot of time. Much more workers are needed and also a crane for each building. [8,7 p. 14]

Figure 25 Example of sectioning (Hakkapeliitta Village)

Form work group normally consist from company's own carpenters, whose professional skills and work achievement are well known. This is why form work's dimensioning contains fewer risks than the other tasks do. Form work constitutes the foundations for the whole production planning of cast in situ frame. This is why continuity and even use of resources of form group synchronizes all the other tasks in production of cast in situ frame. [8,7 p. 6]

Size of a form working group stays even and usage of resources is continuous as a result of good production planning of task entity. Variation in total resources is caused by changes in the need of labour work which is caused by alternation in task's work content in one task and in different points of time. Although the overall need of labour force stays almost the same in recurring period of time. Small changes in the labour resources are allowed, because they do not have any effect in synchronisation of the whole production and to schedule. The overall need of labour force in construction project is always bigger than in frame phase's tasks. [8,7 p. 10]

Plan for form work's advance is prepared after the form system has been selected for the project. Form work's synchronization has to be observed with the following tasks:

- Measurement and installation of the forms
- Steel fixing and HEPAC installations
- Concrete pouring and hardening time
- Dismantling, cleaning and movement of forms
- Installations of prefabricated concrete units and masonry.

It is typical that 2/3 of the whole time used to build house's frame is used to build vertical structures when cast in situ technique is being used. This means that vertical form work's influence to costs and schedule is much bigger than horizontal form work's ones. [7, p. 238]

Form work cycle in horizontal structures is 2.5 days in ideal conditions. To make the cycle to be continuous there need to be 1.5 times the amount of vertical form and 2 times the horizontal equipments comparing to the area which is poured at one time. Sometimes the amount of horizontal forms can be as big as 3-4 times the amount which is needed for one pouring area. [7, p. 239]

Increase in frame's production speed adds the need of form work equipments if production's passing through time stays constant (figure 26). With faster production speed there are more equipments in use than there are dismantled from previous places. Passing through time of production speed and gaps between different tasks must be shortened and the sizes of work sites must be reduced in order to keep the amount of form equipments constant. [8,7 p. 12]

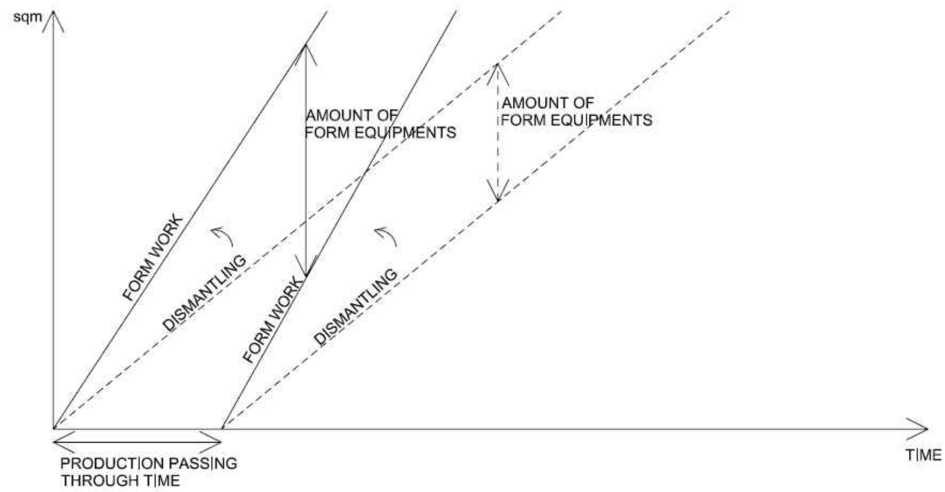

Figure 26 Effect of the amount of form work equipments to production passing through time [8,7 p. 12]

Reinforcement work is normally contracted out to subcontractor, which means that the resources of steel fixers can vary in different phases of production. This is why task's duration in dimensioning calculations does not have to be same as synchronized duration though steel fixing still needs to go forward at the same production speed as all the other tasks. Reinforcement work's resources in production of cast in situ frame are normally very variable. This is why resource need from synchronisation calculation does not always match with the actual occasional need of steel fixers. Resource need from synchronisation calculation describes production where task goes on without any interruptions and a usage of resources stays even through task. In a reality, need of steel fixers varies depending from form work's schedule and demands in a way that synchronisation of form work and concrete pouring is suitable with the length of work shift and that it meets the needs of own work's production schedule. Steel fixing is normally done by subcontractor because that way it is easier to synchronise with the rest of a production. [8,7 p. 6]

Concrete pouring is continuous phase of production which has to be completed during one shift. This is why synchronized timing of the tasks has to be planned in a way that it matches as well as possible with the length of one working shift. Other tasks in production of cast in situ frame are not as bound to shift's length, because other tasks can be stopped for a night time and then continued again in the following morning. [8,7 p. 6]

Concrete pump is the fastest way to pour concrete with pumping power from 20-160 m3/hour. Pumping distances and heights cause almost without exceptions that the actual pumping power is smaller than the theoretical one. Pipe-elements are used to build lines for long distance movements of the concrete. This method has been used to move concrete more than 700m in horizontal and 400m in vertical directions. [7, p. 315]

The rate of placing concrete is used to describe how much concreting ascends vertically during one hour. It shouldn't be more than 1 m/hour and in massive structures 0.3 m/hour. These rules can be applied if the concrete which is used is fine granular, coherent and the rate of placing concrete is sufficient to make sure that the concrete stuck to form panels and to reinforcements does not have time to harden. In every case it has to be checked that the earlier concrete layer hasn't hardened before the next one is poured.

Concrete bucket may be used if there is a crane at the site and if the pouring speed does not have to be that fast. Cubic capacity of a normal concrete bucket is from 250-1000 litres. While choosing the most suitable bucket the capacity must be compared with crane's hoisting capacity. [9, s. 66]

Dismantling of forms is done by form working group. Dismantling time of load bearing structure's forms is agreed together with construction site's supervisor and structural designer. Non bearing structure's forms can be dismantled earlier. [14]

3.1.2 Quality

Quality is a multidimensional concept which varies depending of time, place and many other things. For example quality stands for achieving of cost and schedule targets, fulfilling requirements of quality, work safety, smooth progress and good co-operation with different parties involved with the project. Quality is important for all the parties involved in construction project such as builder, designers, material producers and contractor. In brief quality means fulfilling of requirements which are set for the project. Consistent quality assurance protocol is necessary in order to achieve these goals. Preparation of a task plan is a kick off for a task's quality assurance. [4, p. 5]

Quality is a part of a task plan because qualitative requirements are typically written as references to common quality requirements and that's why they need to be rationalized. Quality requirements are gathered into work performance guide, measurable quality properties and operation objectives. Quality part contains quality requirements, self control forms and agreed quality insuring methods and responsibilities. [5, p. 8]

3.1.3 Quality guidance during a task

Kick-off meeting is held before implementation of a cast in situ frame. Requirements and goals are specified between site management and persons (contractors) who are going to perform a task. Quality is expected from workers and it can only be measured if demands are explained in a well-defined way. Risks of a task, economy, payments, scheduling, quality control, safety and working methods are discussed and agreed in this meeting. All the agreed matters are written in to memo which is then saved to NCC`s project bank and to site's quality map. Memo is sent to all the participants of the meeting. It is really important that the actual workers also receive a memo if they didn't participate to the l meeting. Participants of a task kick off meeting are at least sites general manager, foreman, contractor's manager and site engineer. [15]

Task plan is introduced to all the participants and required corrections are made. At this point work performers engage themselves to carry out their work in a way described in a task plan.

The purpose of worksite reception is to ensure the preconditions for commencing works in relation to the preceding work phases, working conditions and other site arrangements. At the inspection the completion of preceding works, dimensional accuracy and other factors of earlier work phases with a direct effect on the work to be commenced are verified. The worksite reception procedure is carried out observing the principles of internal customer ship in which the preceding work phase is the customer of each subsequent work phase. [15]

At the worksite reception occasion an agreement is always made on the remedies for discovered defects and on the starting date and location of the commencing work phase. Any defects discovered at the worksite reception inspection can be marked directly at the worksite and the defects are established at the work phase kick-off meeting, or a memorandum of worksite reception can be prepared. [15]

The purpose of mock-up installations and reviews is to ensure the feasibility of designs of a given work entity, to assess the working group’s ability to fulfil the quality requirements set; to evaluate the validity of a technical solution for its purpose; to give an appraisal of the visual factors of the solution and to produce an object of comparison to be used during execution of the work phase. Fulfilments of qualitative demands which are defined in a task plan are checked at this stage. Generally the aim of mock-up installation activity is to achieve a common view of the correct, agreed quality between the parties. Site mock-up installations are planned in a quality assurance matrix of a work entity, and in some cases a separate mock-up installation plan is prepared. [15]

Mock up installation activity includes the following phases:

- The location, scope, completion date and approval criteria (technical quality requirements) of mock up are defined.
- Mock up installation work is executed.
- Mock up installation review is held.
- Defects in the mock up installation are recorded / mock up is accepted.

Persons who should participate the inspection of mock up installation are at least foreman of the particular work phase, general foreman, person performing the installation and supervisor hired by builder. Memo is filed in to sites quality folder and also to NCC`s project bank. This task is normally performed by site engineer or particular task’s foreman. [15]

Contractor meetings are arranged at least every second week during construction work. The main purpose of these meetings is to give a clear view of site’s situation for all the persons who are somehow involved in it. All the contractors whose works are carried out at the meeting date are obliged to join the contractor meetings. Site engineer prepares a memo from the meeting which is then sent at least to all the attendees and saved to NCC:s project bank. Original memo is filed in to site’s quality folder. Things that should be under discussion during the meetings are at least plans related to ongoing tasks, safety documents, working situation of the sub contractors, tasks that are going to be started soon, schedule situation of the site and other things that come up during the discussion. [15]

At the final acceptance of a work phase the completion of reviews of parts and sections is established and any defects established at the reviews are established having been remedied for. In addition, an inspection walk of general nature is carried on the work performance to discover any new defects or shortcomings and to agree on their correction. After this the work phase is technically accepted, in which case the remaining installments can be paid / the final financial settlement of a subcontract can be made. An acceptance inspection does not release the subcontractor from liability for defects related to the product. [15]

3.1.4 Costs

It is highly important for a site to stay in targeted costs. That's why economical part is also included into a task plan. Targeted costs of a single task are gathered from project's cost estimation and they are formed from production and logistical solutions and from consumption of material. Project budget is prepared well before task planning phase begins and it needs to be in planner's use while the task plan's economical part is under preparation. Optional solutions are searched if costs of a task exceed targeted costs. The planner needs to check the amounts, material and labour input (unit cost x € / square meter) and prices when preparing economical part of a task plan. When this phase is finished the designer can compare estimated costs with targeted ones. Check calculations and comparison between estimated and targeted costs are presented in the final written task plan. [5, p. 6]

3.1.5 Safety

Safety at the site is really important no matter which task is under production. Safety is assured individually in each task by preparing needed plans and by defining work safety procedures. Safety of the workers is secured for example by inspecting machines which are used for the task. It is also important that personal safety equipments are available when the actual working starts. Responsibilities are named and safety plans are prepared in task planning phase. Task plan includes at least safety plans, safety instructions, inspection records and list of personal safety equipment which needs to be used. [5, p. 9]

Working methods and phases of a task needs to be designed well before working actually starts in order to ensure efficient and faultless implementation. Equipment, tools and safety devices are defined in advance. This phase of task plan contains detailed planning of work performance, timing of delivery sets, movement and storage of materials, waste management and check lists from machines, equipment, devices, materials, accessories and bulk supplies. Working order and used equipments are shown in a task plan. [5, p. 10]

3.1.6 Risk analysis

Most potential problems can be prevented by recognizing the main risks of a task. The potential problems are always analyzed based on projects special qualities and requirements. This way there is at least enough time to prepare for becoming problems even though they may not be avoidable. Problems can be technical, operational or purchase problems. Good example of purchase problem is a delay in concrete blocks delivery. Operational problem can be for example injury as a result from careless crane lift and a technical problem can be exceeding of installation tolerances. All of these problems can be prevented with accurate planning while preparing a task plan and by determined supervision during the task. Site management’s and employees` professional knowledge is used to identify potential risks. It is really important for the one who prepares a task plan to interview employees who have done similar kind of work earlier. This gives the designer much better vision of how the task is really going to be carried out and what kind of risks the task contains. Recognized risks and solutions for their avoidance are written in to task plan. Task plan also contains analyze for consequences if potential problems occurs. Risks are represented in a task-specific risk table (figure 27). [5, p. 5]

Problem	Alarm	Preparing to the problems
Bad shape of foundations	- Delivery inspection of foundations is not done - A lot of shortages are noticed in work site`s reception inspection. - Foundations are finished too early.	- Work site's reception installation is carried out early enough to make sure that there is enough time to do all the repairs before form work of the frame starts. - Dimensions are checked and required repairs are done.
Bad weather conditions	- Work is carried out in winter, fall or in some other time when weather can cause problems.	- Heaters and covering materials are reserved in to site. - Equipment for measuring structural strength and heat are reserved to site. - Frost resisting concrete to be used when needed. - Weather forecasts to be followed.
Problems with machinery.	- Many stops in the work. - Rented equipment is used and its maintenance is not agreed. - Equipments are old and maintenance has not carried out properly.	- Condition of equipments is always checked before the start of concrete pouring. - Equipments are maintained always after use and also when the work is in stop. - Equipments are protected against mechanical damages and rain. - Back up equipments to be reserved in to site.
Forms are damaged in site	- Long term stocking of forms and insufficient protection. - Wrong kind of lifting equipment is being used. - Site area is very small.	- There must be big enough storage for forms in the site and also an area where they can be treated. -

Figure 27 Example of cast in situ frame's potential problem analysis table

4 CASE HAKKAPELIITTA VILLAGE

4.1 Background of the project

Because of the new investments of Nokian Tires to nVesovolozhski they are forced to increase amount of employees from 400 to 1000. This year Nokian Tires plans to produce three million tires in Russia. By 2011 production will increase to 10 million tires a year, requiring additional personnel. The company will invest $294 million in production in addition to the $220.5 million which has already been invested. [22]

It is getting harder and harder to secure skilled labourers because of the tightened competition. Nokian tires responds by building finished low-cost apartments for their employees, which are sold at cost-price of 41,000 rubles ($1,677) per square meter. This way the employees are tried to be bond to company. Nokian Tyres currently organizes regular bus shuttles between St. Petersburg and the plant. [22]

Employees will be able to take a loan with a discounted interest rate of 7.3 percent a year from the Leningrad region Mortgage Agency. When buying the apartment, employees engage themselves to work at the factory for seven years. At present, 75 employees have signed agreements to buy apartments in Hakkapeliitta Village. Loans can be taken for up to 20 years. If the employee wants to leave before that he or she is forced to pay the difference between cost price and market price of the purchasing time to Nokian tires. [22]

Hakkapeliitta village consists from seven five stories high apartment houses with technical basement and it is going to be built in to a plot of 4.5 hectares, which is located only 10 kilometres from Nokian tires factory (figure 28). Hakkapeliitta village is going to be built in two stages and it is going to be finished by the year 2010. It will include 300 apartments and the average size of an apartment is about 60 square meters. [22]

Figure 28 Architect's sketch of Hakkapeliitta Village.

4.2 Production

The first stage of the construction started in the beginning of the year 2009 and it should be finished by the end of August 2009. Construction work is going to be carried out in two 10 hours working shifts and a lot of workers are needed to finish the project in schedule. According to preliminary estimates, construction of the complex will cost over $22 million.

The project is going to be carried out in two phases. Four houses are going to be built in the first phase and the rest three in the second one (figure 29). The idea is to build the first phase in only one year. This means that the construction work has to be carried out in two shifts and all the four houses need their own working team and a crane. Also the working shifts are at least 10 hours per day in Russia so the construction speed is much faster than in Finnish sites.

Figure 29 Site layout of the first stage of construction

Load bearing frame and intermediate slabs are going to be made from cast in situ concrete and non bearing exterior walls are made from gas concrete (figure 30).

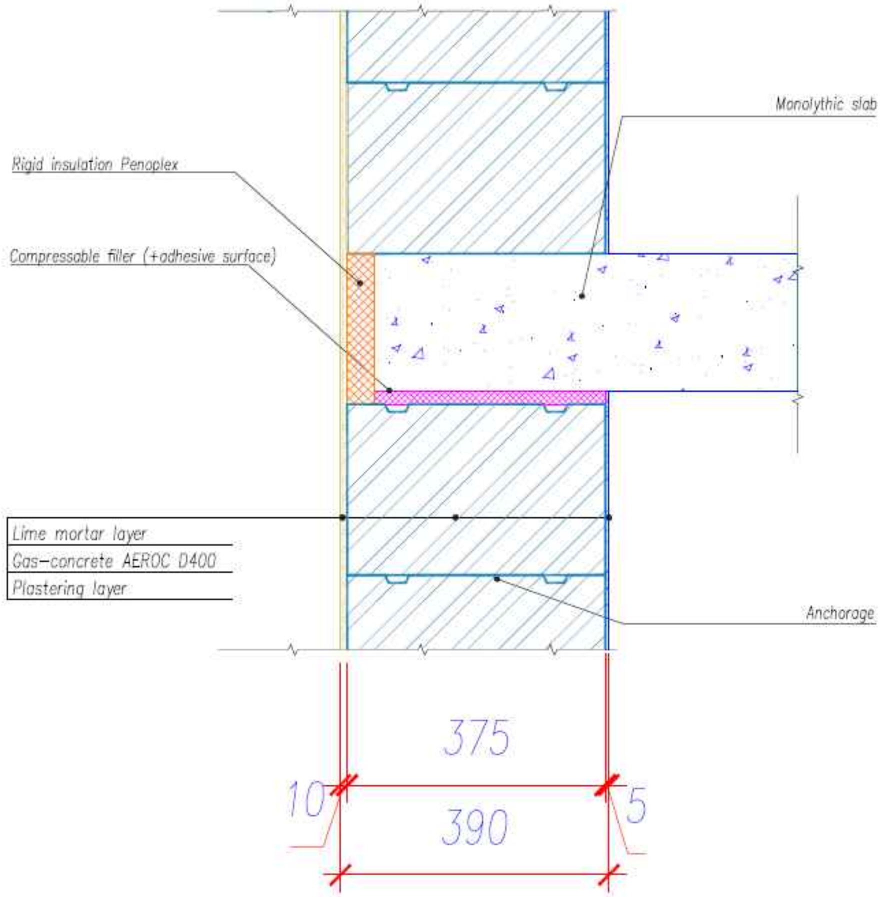

Figure 30 Hakkapeliitta village's non bearing exterior wall.

Building of the load bearing frame starts from foundation slabs which are supposed to be built in 27 working days. The actual frame building starts straight after that and it is supposed to take 99 days for four houses according to site's master schedule.

4.3 Task plan of Hakkapeliitta Village's cast in situ frame

Task plan for the project's cast in situ frame is prepared early enough so that it can be used already while preparing tender documents in order to make good contracts. It is easy for a contractor to get a clear vision about how work performance is supposed to be carried out in this particular project after reading a task plan made for it. See appendix 1 for task plan of Hakkapeliitta villgae's cast in situ frame.

4.3.1 Scheduling and work groups

Schedule was made with scheduling program called Graphisoft Control and it is based on quantities of cast in situ works. Task's schedule is presented in LOB. chart which gives viewer the clearest vision of how the actual construction advances from form installation to dismantling and cleaning of forms.

The site was divided in to four same size sections to make the production even faster (figure 31). Every building of the project is a section and it has its own tower crane, which means that in the first stage of the construction there are four cranes in the construction site. Cast in situ works start at the same time in each section and proceeds with the same speed.

Figure 31 Sectioning of first stage of construction

Schedule was prepared based on labour inputs and amounts of cast in situ works which were found from projects cost estimation chart.

Cast in situ tasks are going to be performed in the following order (figure 32):

- Vertical formwork (first face) 2 work shifts.
- Wall reinforcements. 2 work shifts.
- Vertical formwork (second face) 2 work shifts.
- Pouring of concrete to vertical structures. 1 work shift

- Dismantling of vertical formwork. 2 work shifts
- Horizontal formwork. 2 work shifts
- Slab reinforcement. 3 work shifts
- Dismantling of slab’s forms. 2 work shifts

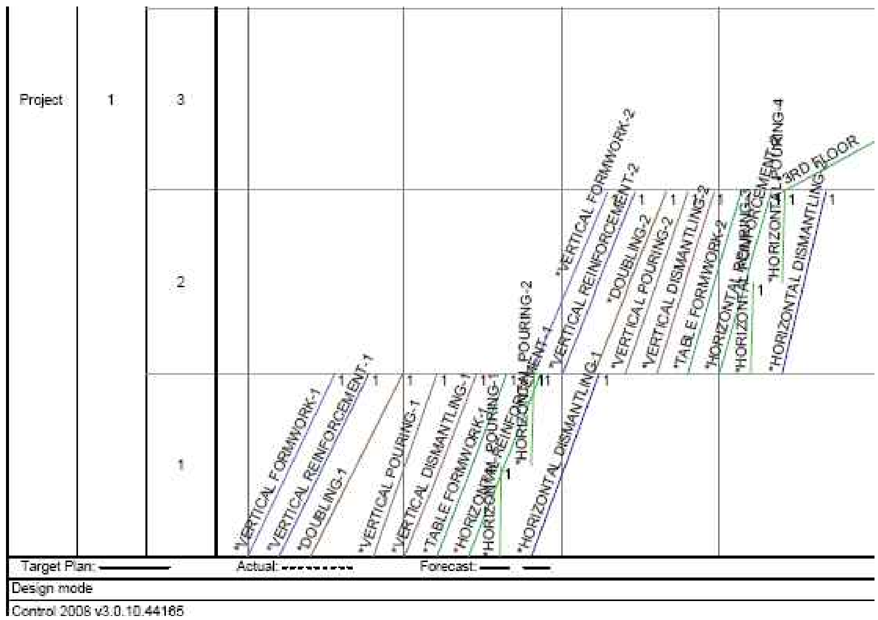

Figure 32 Snapshot of cast in situ frame's schedule

Following work groups were chosen for cast in situ works. Groups were chosen based on labour inputs and interviews made for specialists of cast in situ construction. Only reinforcement work is done by subcontractor, all the other tasks are done by NCC’s own workers. This means that resources of steel fixers can vary in different phases of production depending on the need.

- Vertical form work group 3+1.
    - Vertical form work, pouring of concrete to walls and dismantling and cleaning of forms.
- Horizontal form work group 3+1.
    - Horizontal form work, slab’s pouring of concrete and dismantling and cleaning of forms.
- Steel fixers 2-4.

- o Reinforcements to vertical and horizontal structures.

4.3.2 Quality assurance and control

Quality requirements for task plan were gathered from structural drawings, RATU etc. Forms and other elements were chosen in a way that all the quality requirements will be fulfilled. Quality assurance protocols for each working phase were introduced in the task plan and all these matters need to be considered during construction for achievement of required quality. These protocols are kick off meeting, reception inspections of work site, mock up installation and reception inspections. Memo is made from each inspection and filed to site's quality control folder.

4.3.3 Costs

Targeted costs of cast in situ tasks were gathered from Hakkapeliitta Village's cost estimation which is also attached to cast in situ frames task plan. All the costs are presented in Rubles and the estimation was established in the beginning of the year 2009. Correctness of amounts was checked by calculations made from structural and architectural drawings. Economical part of task plan is defined from the version which is given for subcontractors. In this case the only subcontractors are steel fixers.

4.3.4 Equipments and materials

Selection of the most suitable form systems started by defining the qualitative demands to be filled in the structure. Other facts that were considered in the selection process were production speed, dimension accuracy and other facts which are specified for the concrete structure. These factors are specified by structural engineer and demands are shown in construction drawings. If there are a lot of almost identical structures it is normally justified to use big form units in order to achieve the fastest production speed possible. Many different options must be considered before the best form system can be found for each project.

In Hakkapeliitta Village the vertical structures are built with Ramirent Manto sheeting-panel form system. It is an innovative, high capacity, large panel concrete forming system that redefines productivity. It has fewer components, less weight and faster assembly times than systems that require walers and other hardware. All panels in this system can be assembled either in an upright or horizontal position. Footings and low walls can be formed quickly and economically with just one row of ties in the concrete. Because connections are not dependent on fixed-bolt spacing like most modular systems, panels are fully stoppable in either orientation. [18, p. 5]

Horizontal structures are built with Doka 1-2-4 system. Dokaflex 1-2-4 is the fast, versatile floor formwork for floorplans of any shape, for beams, slab overhangs and semi finished floor elements – and the ready reckoner is ideal for calculating the quantities of materials, so there's no need for formwork planning. The free choice of formwork sheets leaves nothing to be desired when it comes to the finished structure of the fair-face concrete. [17]

A detailed plan is prepared on how the forms are going to be used. At this stage also the amount of form equipments is optimized. This plan includes dimensioning of forms, calculations and instructions about the speed of concreting. Stiffening and binding of forms are presented in installing instructions and in form drawings. Prints from form work planning are lists of form equipments and products in addition with the drawings. Working groups, storing, lifts and movements, installation order, heating and protection methods and the need of the post supports have to be taken into consideration when the plan is made.

The amount of form work equipments needed in cast in situ frame's production can be calculated with the following equation.

$$M = k \times t \times T_1$$

Where M = the amount of form equipments (m2).

k = extra factor of the equipment.

t = production speed (m2/work shift)

T_1 = passing through time (working shifts)

Form work bonds equipments and dismantling of forms releases them. Amount of form equipment which is loose at the certain moment can be calculated by taking off the amount which is bonded in to production from the overall amount of form equipments. Extra coefficient in the equation above is used to describe extra equipments which are not bonded in to production.

These equipments are used to even out variation in different phases of production and to replace damaged equipments if needed. Form equipment storage must be planned to be big enough, even though production of the frame is carried out with minimum amount of form work in order to make it as cost efficient as possible. [8,7 p. 12]

Demands for concrete structures are shown in structural drawings which are determined by structural designer. Concrete to be used is decided by the foreman in the site. Ready-mixed concrete needs to be ordered normally 1-2 days before the pouring day. The order should still be verified a little bit before the concrete pouring should start. The following things need to be informed while ordering the concrete:

- Name, address and the phone number of the orderer
- Address of the pouring site, phone number and the name of contact person
- Invoicing address
- Destination structure of the ready-mixed concrete
- Over all need of the concrete, m3
- Qualitative requirements
- Structural class
- Strength class
- Biggest grain size
- Consistency class
- Type of cement to be used
- Special demands and properties
- waterproofness
- Additional substances
- Temperature of the concrete
- Possible need of frost resistance
- Porosity
- Other possible special needs
- Date of delivery, starting time and possible brakes in pouring
- Pouring method
- Pouring speed (how many loads/hour or how many m3/hour)
- Wanted size of the loads
- Pouring schedule

- The type of wanted concrete delivery truck

[9, s. 57]

Reception place of concrete should be planned already while preparing site’s general plan. This way the access roads can be prepared to last heavy loads and they can be placed in to right places. Concrete can be received to concrete bucket, concrete pump, straight in to structure or for example on top of plastic. There is waybill with in every concrete truck from which has to be checked that the delivery is equivalent with the order. Waybills are then filed in to site’s concrete folder. [7, p. 305]

4.3.5 Safety

Safety of the workers has to be assured at all times during cast in situ works. Frame building is generally the most dangerous phase of building project and this is why safety matters needs to be taken into account really carefully while making task plan. Safety planning was made against falling and needed personal safety equipments are presented as well as safety inspections which need to be made during work progress. Safety harness has to be used at all times when falling is not fully inhibited by safety rails. This rule is not generally obeyed in St. Petersburg but in NCC’s construction sites it is a must.

There is no such work accidents which can be tolerated under any circumstances. Every accident can be prevented.

4.3.6 Potential problem analysis

Potential problems are charted in the end of the task plan. Analysis contains the most in common problems, matters which should alarm site’s management of becoming problems and means how the problems can be avoided. Earlier experience or interviews made for cast in situ experts can be used to recognize these risks. Most in common problems can also be found from cast in situ quality books. [3, p. 12]

4.4 Conclusions

Hakkapeliitta Village’s task plan was prepared using project’s structural drawings, building specification, cost estimation and general quality requirements were considered. The feasibility of the plan is good and it is clear and well defined. Sectioning of one building is made clearly and work groups are chosen in a way that production advances fluently. Schedule is shown in LOB. chart which gives reader a good and clear picture of how the actual production is going to be carried out. Quality requirements are written in to task plan which makes it easier and faster to use comparing to a plan where only page numbers of a quality book is shown. Forms are chosen for fastest possible form cycle and their amount is optimized based on theory about form work. Safety at the site as well as potential problem analysis is shown in the end of the plan.

Accurate form plan was not included to this task plan for schedule reasons. It should be prepared in order to make cast in situ frame's schedule even more functional. Also check calculations of costs are missing because of the lack of information about St. Petersburg's material prices. More detailed planning for HEPAC installations should also be included in following projects.

This task plan was made for the production of Hakkapeliitta Villages cast in situ frame, but it can also be applied to other construction projects where the frame is going to be carried out as cast in situ structure even though project specific information has to be always considered. It should only be used if building's structures are similar to Hakkapeliitta village's ones.

5 SUMMARY

This study was made for the use of NCC's St. Petersburg office. The study includes theory about St. Petersburg's construction history as well as information about Russian and St. Petersburg construction markets. The effect of global liquidity crisis is also presented in the beginning of the study.

Most of the new buildings in St. Petersburg have cast in situ frame. Cast in situ construction includes much more working phases than for example construction with prefabricated units and it requires a lot of special know-how from actual workers as well as from project management. Careful production planning and accurate schedules as well as right kind of working methods and equipments are vital to succeed in cast in situ frame's construction phase.

Concrete is used in nearly every new construction project. Enough expertise of its properties and production technology is required from construction project's site management in order to complete construction phase successfully. This study presents basic information about concrete as a construction material as well as introduces production methods of cast in situ frame. There are a lot of different structural solutions for cast in situ frame. The most in common frame systems are presented in this study and load bearing walls and a slab system which is used in case project called Hakkepeliitta Village is introduced in more detailed way.

Task planning is key element for achievement of required quality-, schedule-, economical- and work safety requirements. This study presents basic theory about task planning and more accurately the content of cast in situ frame's task plan. Scheduling is really important part of task plan. Phases of construction project's scheduling are introduced and theory of cast in situ frame's scheduling, sectioning and synchronizing of different tasks is part of this study.

An example of a task plan for NCC's project called Hakkapeliitta Village was prepared based on the theory of this study. This task plan is attached to the end of the study and it is also sent to all the engineers in NCC's St. Petersburg office to be used in later projects with project specific changes. Choices which are made to this particular task plan are explained in the end of this study. Chapter 4.3 presents preparation of cast in situ frame’s task plan phase by phase and it is written to be used by project management as an instruction for preparation of task plan.

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APPENDIX 1

TASK PLAN FOR HAKKAPELIITTA VILLAGE'S CAST IN SITU FRAME

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TASK PLAN: CAST IN SITU FRAME

PROJECT: HAKKAPELIITTA VILLAGE

The first stage of Hakkapeliitta Village project consists from four five stories high housing blocks. The construction of each building's frame is started at the same time, which means that each building has its own tower crane and own working groups for completion of cast in situ works.

1 TASK'S CONTENT

This task plan is made for production of Hakkapeliitta Village's load bearing cast in situ concrete frame. It presents how the frame of one building should be constructed and it can be applied to each building of the project as well.

The frame consists of load bearing intermediate walls and massive slab as an intermediate floor (figure 1). Construction of the frame includes the following work phases in the following order:

- Form work
- Reinforcement
- Pouring of concrete
- Dismantling and cleaning of forms

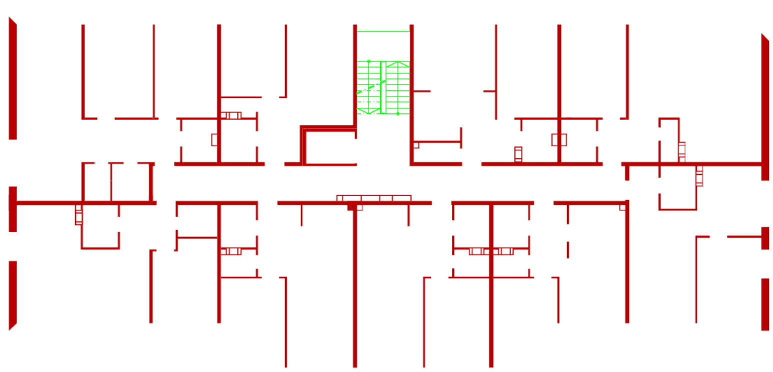


Figure 1 Hakkapeliitta village's load bearing concrete frame

2 SCHEDULE

Planned starting date of cast in situ frame:	05.01.2009
Deadline for completion:	06.03.2009
Planned work achievement:	1floor/week.
Intermediate goals:	2nd floor ready 29.1.2009
	4th floor ready 20.2.2009

2.1 Sectioning

The site was divided in to four same size sections to make the production even faster (figure 2). Every building of the project is a section and it has its own tower crane, which means that in the first stage of the construction there are four cranes in the construction site. Cast in situ works start at the same time in each section and proceeds with the same speed.

Figure 2 Sectioning of the project

2.2 LOB

Schedule is prepared based on labour inputs and amounts of the task. Schedule is presented in LOB. chart shown below.

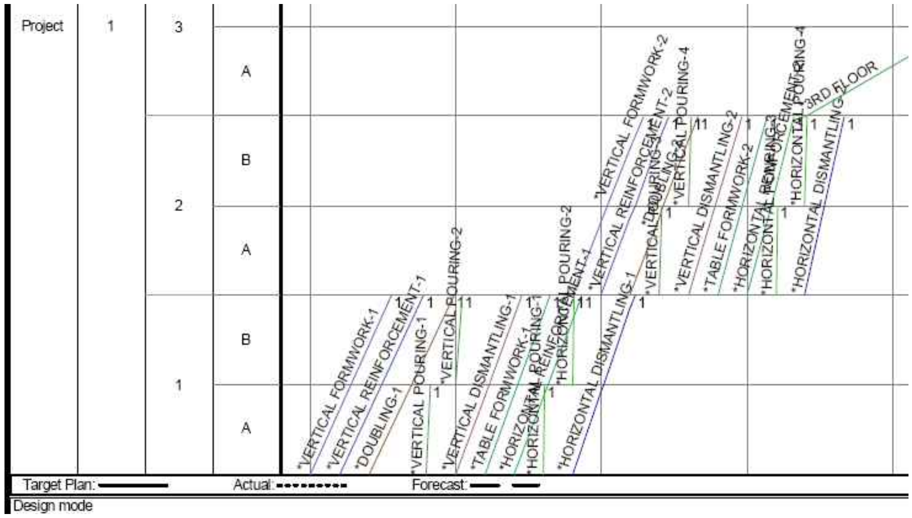


Figure 3 SCHEDULE OF CAST IN SITU WORKS

For full schedule see attachment 1.

2.3 Labour inputs

In form work the numbers present how many hours it takes to make 1sqm of finished work from one worker.

Form work	Board form	Panel form-work	Sheeting panel Form work	Flying form Table form
Walls				
Installation	0,30	0,30	0,32	0,05
Dismantling	0,32	0,22	0,15	0,04
Slabs				
Installation	-	0,32	0,16	0,08
Dismantling	-	0,18	0,16	0,07

In reinforcement the numbers present how many hours it takes to install or handle 1000kg of reinforcement by one worker.

Reinforcement	Steel bar	Labour input
Cutting and bending by machine		2,4…3,3
Material moving		
By hand		0,5…3,0
By crane		0,1…0,2
Slab, reinforcing mesh (10m2)	4mm, 150mm	16,5
	6mm, 150mm	7,5
	8mm, 150mm	5,0

Slab	8mm	12,0
	10mm	8,0
	12mm	5,5
	16mm	4,5
	20mm	4,2
Walls	8mm	13,0
	10mm	7,3

Pouring of concrete	Average pouring	Hours/m3	Hours/pouring
Preliminary works			
Slabs	25m3	0,02	0,50
Pumped concrete			
Walls		0,26	
Slabs		0,20	
Concrete bucket pouring			
Walls		0,26	
Slabs		0,19	
Finishing works			
Walls	30m3	0,02	0,60
Slabs	25m3	0,03	0,75

2.4 Chosen work groups

Work groups are chosen based on labour inputs and interviews made for specialists of cast in situ construction.

Vertical form work

- **3+1**. (Vertical form work, pouring of concrete and dismantling and cleaning of forms)

Horizontal form work

- **3+1**. (Horizontal form work, pouring of concrete and dismantling and cleaning of forms)

Reinforcement work

- **2-4** Steel fixers. (Reinforcements to vertical and horizontal structures)

Work site, working methods and used equipments are presented to workers before the work is started. Qualitative requirements and quality control tools are also presented as well as project-specific safety procedures. Newest, approved plans have to be at work groups' use at all times.

Welders have to be qualified enough and all the workers who carry out hot work operations need hot work cards and –permits granted by person responsible of site's hot works.

2.5 Schedule's monitoring and guidance tools:

- Schedule task control chart (Graphisoft control)
- Weekly meetings
- Contractor meetings

Correction methods for deviations in schedule:

- More work force

3 INITIAL CONDITIONS OF THE TASK

3.1 Plans

Inspection needs to be done for the following plans:

- Dimensional drawings of the frame, profile- and detail drawings
- Building- and work specifications
- Form work and pouring of concrete plans
- Reinforcement drawings
- Site's general plan
- Master- and building stage schedules
- Targeted cost estimation
- Instructions of material producers.

3.2 Materials and equipments

Form materials:

- Form timber materials (boards, squared timber, sheets), Sheeting panel forms, form ties (10mm round steel bars, aluminum bars), sleeves, form clamps, form spacers, steel clamps, form dismantling materials, nails

Reinforcement materials:

- Ribbed- and round steel bars, mesh reinforcement, binding wires, space-rs and supports

Pouring of concrete materials:

- Ready mixed concrete, dry mix, aggregate, cement, additions, water, heat insulation

Protection materials:

- Tarpaulins, support structures
- Sealing off lines, temporary fences

Machines and equipments:

- Electronic or optical measuring equipments, water hose, builder's level, alignment wire and long tape measure
- Lifting and moving equipments, working floors
- Circular saw, nail gun, impulse gun, oil gun, carpenter's tools
- Reinforcement bending equipments, clippers, hook, jaws, welding equipments
- Receiving container for ready mixed concrete, concrete bucket, drop chute, concrete pump, shovel, concrete barrows, vibrator, floating rules, curb tools, protection- and heating equipments
- Brushes, pressure washer, water hose, protecting covers, garbage bins

3.3 Site's readiness before the work is started

Site needs to be preserved for frame building phase. Site needs to be clean and lighted enough. Safe passages and water + electricity have to be organised to work site. Garbage bins for construction waste, wood, stone and for scrap are arranged to the site.

Site access roads from site's gate to material reception spots needs to withstand the loads of transport equipments. Big enough area is reserved for material stocking. This area needs to be properly lighted and it has to be chosen in a way that materials can be safely lifted from there to work site.

Site's foundations needs to be built according to plans.

Effects of weather conditions to frame work are clarified before the work is started. Appropriate heating system is arranged to construction site during the winter time to prevent frost damages. Also frost resistant concrete is used while pouring concrete in really cold conditions. Tarpaulins and needed supports are used to protect structures and formwork against rain.

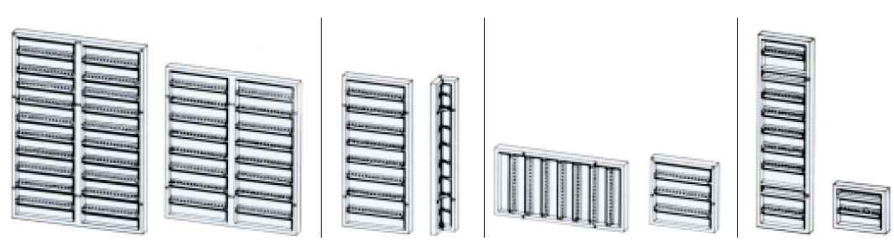
4 EQUIPMENTS

4.1 Form systems

4.1.1 Vertical structures

Chosen form system is called Manto and it is a sheeting panel form system. The amount of vertical forms needed is 1,5 times the amount for one floor which is **520m2**. The amount is calculated from structural drawings.

Optimal sized form complexes are assembled in the beginning which can be used in each block of the project to build similar walls from 1st floor to 5th floor. A crane can lift 40sqm of Manto forms at the same time which makes form work really fast with this system. Manto form system contains different sized sheeting panel forms shown below.



4.1.2 Horizontal structures

Horizontal structures are built with Dokaflex 1-2-4 floor form work system. The amount needed is 2 times horizontal equipments comparing to the area which is poured at one time. Calculated amount from structural drawings is **680sqm**.

1-2-4 – the numbers represent the maximum spacing for setting up Dokaflex 1-2-4. Triangular marks on the beams indicate the spacing. 1 mark represents the maximum spacing for transverse beams, 2 marks are the maximum spacing for props, and 4 marks show the maximum spacing for longitudinal bems.

4.2 Pouring of concrete

Pouring of concrete is made with concrete bucket always when possible and with concrete pump when necessary. The rate of pouring concrete with pump is much faster so it should be used if schedule is tight or if the crane is busy for example with form installation work.


Ready mixed concrete is ordered from concrete plant at least 2 days before pouring. Responsible person is task's foreman.

5 COSTS

Cast in situ frame's amounts and cost estimations are shown in a chart below. These amounts are calculated from one building only. The sum reserved for one building's cast in situ works is **87 133 906 Rubles.**

Structure	Amount	Unit	Rubl./unit	Rubl
3 FRAME AND ROOF STRUCTURES	2514	m2	2 980,91	29 976 069,75
32 BEARING PARTITION WALLS AND COLUMNS	0		-	7 444 422,25
321 REINFORCED CONCRETE WALLS	0		-	7 160 397,25
321100 FORMWORK FOR WALLS HEIGHT < 3M	5048,5	m2	112,50	2 271 825,00
321110 FORMWORK TO EDGES OF WALLS AND DEMOLITIO	1101,25	m	112,50	495 562,50
321130 FORMWORK FOR WALLS OF LIFT SHAFT	264,5	m2	112,50	119 025,00
321180 DEMOLITION AND CLEANING OF FORM-WORK	5313	m2	-	-
321209 REINFORCEMENT NEETTING AIII 200 4C -OF	877	kg	8,75	30 695,00
321210 REINFORCEMENT A-400	18875,3	kg	8,75	660 633,75
321211 REINFORCEMENT A-240	4150	kg	8,75	145 250,00
321219 CONCRETE B-25	55,5	m3	1 662,50	369 075,00
321222 CONCRETE B-20	450	m3	1 662,50	2 992 500,00
321230 AFTERWORKS OF CONCRETE	5313	m2	-	-
321965 STYROFOAM 300- A 50MM OF LIFT SHAFT	157	m2	120,75	75 831,00
322 REINFORCED CONCRETE COLUMNS	0		-	284 025,00
322100 FORMWORK FOR COLUMNS, RECTANGLE 192 COLU	159,25	m2	112,50	71 662,50
322180 DEMOLITION AND CLEANING OF FORM-WORK	159,25	m2	-	-
322210 REINFORSEMENT A-400	2960	kg	8,75	103 600,00
322211 REINFORSEMENT A-240	400	kg	8,75	14 000,00

322222 CONCRETE B-20	14,25	m3	1 662,50	94 762,50
322230 AFTERWORKS OF CONCRETE	159,25	m2	-	-
33 SLABS AND BEAMS	0		-	11 381 460,00
330 REINFORCED CONCRETE SLABS	0		-	11 381 460,00
330100 FORMWORK FOR SLABS, SUPPORTHEIGHT < 3M	3664	m2	266,25	3 902 160,00
330110 FORMWORK FOR CHEEK BOARDS OF SLABS	206	m2	266,25	219 390,00
330180 DEMOLITION AND CLEANING OF FORM-WORK	3870	m2	-	-
330209 REINFORSEMENT A-240	901	kg	8,75	31 535,00
330210 REINFORSEMENT A-400	62600	kg	8,75	2 191 000,00
330222 CONCRETE B-20 THICKNESS < 250MM 12111	757,5	m3	1 662,50	5 037 375,00
330230 AFTERWORKS OF CONCRETE	3664	m2	-	-
330251 ROOF COVERING SLABS, EXTRA TILT SUR-FACE	628	m2	-	-
34 STAIRS	0		-	226 730,00
341 REINFORCED CONCRETE STAIRS 4PCS	0		-	10 890,00
341101 FORMWORK FOR STEP	1,25	m2	500,00	2 500,00
341102 FORMWORK FOR LEVEL	1,5	m2	500,00	3 000,00
341180 DEMOLITION AND CLEANING OF FORM-WORK	2,75	m2	-	-
341210 REINFORSEMENR A-400	35	kg	13,50	1 890,00
341220 CONCRETE B-20	0,5	m3	1 750,00	3 500,00
341230 AFTERWORKS OF CONCRETE	2,75	m2	-	-
342 CONCRETE STAIR ELEMENTS	0		-	207 840,00
342100 FORMWORK FOR SLABS, SUPPORT H < 3M, SI	16	m2	265,00	16 960,00
342110 FORMWORK FOR CHEEK BOARDS OF SLABS	4,25	m2	265,00	4 505,00
342180 DEMOLITION AND CLEANING OF FORM-WORK	20,25	m2	-	-
342210 REINFORSEMENT A-400	227,5	kg	8,75	7 962,50

342222 CONCRETE B-20 THICKNESS < 250MM Slice	3,25	m3	1 662,50	21 612,50
342230 AFTERWORKS OF CONCRETE	16	m2	-	-
342500 CONCRETE STAIR ELEMENT SYPPLY, 32 PCS	0,25	lot	-	-
342510 STAIR ELEM., WIDTH=1200MM, HEIGHT=1400MM	7	pcs	4 000,00	112 000,00
342511 STAIR ELEM., WIDTH=1200MM, HEIGHT=1450MM	1	pcs	4 000,00	16 000,00
342550 CONCRETE STAIR ELEMENT ASSEMBLY	8	pcs	900,00	28 800,00
342570 AFTERWORKS OF CONCRETE STAIR ELE-MENT	8	pcs	-	-
342590 MATERIALS OF INSTALLATION OF CON-CRETE ST	8	pcs	-	-
345 REINFORCED CONCRETE STAIRS 4PCS-MACHINE	0		-	8 000,00
345251 CONCRETE STAIRS 900X300X400, 2-STEP, E	1	pcs	2 000,00	8 000,00

6 QUALITY

6.1 Quality requirements for finished structures

Grade 2 is used in normal housing construction

	Grade 1	Grade 2	Grade 3
Nodules			
Biggest height	1mm	3mm	6mm
Biggest width	2mm	9mm	20mm
Hollow			
Biggest depth	2mm	4mm	7mm
Biggest width	4mm	9mm	15mm
Racking	0,5mm	2mm	5mm

Barbs at form joints			
Biggest height	2mm	4mm	
Biggest width	2mm	4mm	6mm
Maximum amount	5%	20%	30% of joints length
Pores			
Biggest diameter and depth	7mm	10mm	12mm
Maximum amount	40/sqm	60/sqm	100/sqm
Defect in casting			
Biggest size	Not allowed	0,2sqm	0,3sqm
Maximum amount	Not allowed	3/sqm	2/sqm
Camber and surge of surface	2mm/1,5m	5mm/1,5m	8mm/1,5m

6.2 Dimensional accuracy requirements

6.2.1 Walls

Measured matter	Normal grade tolerances (mm)
Height (H)	±10mm
Length (L)	±10mm or L/750
Thickness (b)	±8mm
Camber	±10mm
Height and width of openings	-5…+15mm
Height of opening from floor surface	±15mm

Height difference between opening's lower corners	10mm
Warp or deviation of wall's vertical structure	L/300
Side location (S)	±15mm
Side location from upper or lower wall	±10mm
Clear distance (V)	±15mm
Level of upper corner while jointing to horizontal structures (K)	±10mm

6.2.2 Slabs

Measured matter	Normal grade tolerances (mm)
Thickness of the slab	±15mm
Slab's surface	By31/BLY4
Slabs bottom	By40
Level of surface and bottom at the supports	±15mm
Side location	±20mm
Racking of side location (mm/100mm)	10

6.3 Form work

Form work includes prefabrication, installation, supporting, bonding, dismantling and cleaning of forms as well as measurement, scaffolding works, oiling of forms and moving and arranging of equipments. Also making of lift joints, through holes and installation of ties are included.

6.3.1 Quality assurance before form work is started:

Form work, lift joints, form cycles and dismantling and cleaning of forms are planned as well as structural dimensioning, durability and quality of form materials.

Through holes, piping, tie bars, reinforcements and possible heating are checked.

Base has to be ready, levelled, clean and planned tie bars have to be installed. Forms and spacers are measured and marked to right spots.

Enough space has to be reserved for lifting and moving of forms and other equipments in sites general plan. Safety of lifting and moving equipments, passages, scaffoldings and safety rails has to be observed.

Sufficient lighting and removal of ice and snow are arranged to working place. Cleaning has to be taken care of after every working shift and after the work is finished. Needed personal safety equipments have to be available at the site.

6.3.2 Quality assurance during form work:

Work place and passages are kept clean and the safety of scaffoldings and safety rails is under control during the work. Proper fastening of forms to lifting hooks is observed during lifts. Lifting chains cannot be rotated before the lifting is started.

Surrounding structures have to bewared while spaying form oil. The whole form face has to be oiled with the right amount of oil. Through holes, piping, tie bars, form ties, reinforcements and possible heating wires are checked before doubling the forms. Oiling has to be done and forms and their bottoms have to be cleaned.

Straightness, locking and tightening of form ties, supports, thrust blockers, tie bars and sealing of forms are observed after form doubling. Fire safety has to be taken care of when heating of forms is used.

Observance of form plan and the durability of forms are ensured during concrete pouring. Concrete has to be poured in to forms with planned speed.

The timing of forms dismantling has to be verified with calculations. Horizontal structure's forms can be dismantled when concrete has reached 60% of its nominal strength. Non bearing parts of forms can be dismantled when concrete has reached compression strength of 5MN/m2. Forms are dismantled in a way that no additional loads are caused for structures.

Form faces of recycled forms are cleaned right away after dismantling. Workers have to be careful not to harm form faces at this stage. Forms are stocked and supported to flat area inside the construction site.

6.3.3 Quality control after form work:

Fulfilment of sealing of forms, dimensional accuracy, and durability and safety demands shown in contract documents has to be ensured. Cleaning of work site has to be done after forms are dismantled and moved to another place. Cleaned form materials, locks and ties are sorted and stocked to agreed place. The needed amount of post supports is ensured together with structural designer.

6.4 REINFORCEMENT

Reinforcement fixing includes installation of reinforcement bars, reinforcement mesh and prefabricated reinforcements. Task also includes prefabrication of reinforcements at the site, cutting, bending, installation, bonding and assistant works such as reception and moving of materials.

6.4.1 Quality assurance before reinforcement work is started:

Reinforcement work is synchronized with other tasks in a way it is planned in schedules. Availability of resources has to be ensured. Enough space has to be reserved for stocking and moving of reinforcements. This area should be covered and properly lighted. It should be chosen in a way that moving of reinforcements from this spot to their final position can be done safely.

Quality of reinforcement bars and prefabricated reinforcements is checked at the moment they are brought to the site.

Welding works are done in a place which is covered from wing and moisture. Also fire regulations are considered. Proficiency of the welder has to be checked before the work is started.

6.4.2 Quality assurance during reinforcement work:

Reinforcements are cleaned and checked before they are installed in to form. Also possible through holes and piping have to be checked. Reinforcements are tied as planned and tie wires are turned inside reinforcements. Concrete cover has to be sufficient. Ends of installed bars are covered for example with plastic hats near passage ways to ensure safety at the site.

6.4.3 Quality control after reinforcement work:

Finished reinforcement work has to fulfil all the requirements of materials and installation agreed in contract documents. Reinforcement has to be clean and well supported with ties and spacers to stop it from moving during concrete pouring to achieve planned concrete cover in finished structure.

6.5 POURING OF CONCRETE

Pouring of concrete includes reception, moving, pouring, compacting, levelling and assistance works such as cleaning and water spraying of forms before the actual pouring is started, concrete curing, water spraying and protecting of poured concrete.

6.5.1 Quality assurance before pouring of concrete

Availability of resourced is ensured before the task is started. It has to be checked that the work-ers are qualified enough for concrete works. It has to be observed that the road from sites gate to concrete’s reception spot is wide and bearing enough for truck traffic. Work site’s readiness, safe-ty, weather and working conditions are checked together with work performers before the work is started.

6.5.2 Quality assurance during pouring of concrete

Dropping altitude of concrete can be no more than 1,5 meters to avoid separation. Flexible drop chute can be used in high vertical structures. Visual or telephone communication must exist between pouring spot and operating station.

Reinforcement should not be damaged during pouring and compacting. Concrete is poured in layers of no more than ~300mm. Pouring of wall structures advances all the time to same direction in order to ensure even quality to the structure. Concrete is compacted completely in a way that it does not cause separation.

Lift joints are made by roughening and vertical joints with the help of construction joint nets. Installation of planned equipments, structural parts and grips has to be ensured before the work is started.

Sufficient strength of concrete has to be ensured before dismantling of forms is started. Concrete curing has to be taken care of also during weekends and holidays. In summer time the concrete has to be protected against sun shine and in winter against frost and snow.

6.5.3 Quality control after pouring of concrete

Cleaning of work site and forms is done right away after the task is completed. Concrete structures are checked before other structures are built on top of them. Quality of concrete's face, strength and dimensional accuracy are ensured to be as agreed in construction documents.

6.6 Guidance and quality control during the work

Quality control tools to be used during the construction of cast in situ frame are the following:

- Kick off meetings
    - At least one week before each task is started
        - Form work, Reinforcement, pouring of concrete
- Reception inspections of the work site

  - Made from each block

- Mock up installation
  - Made from first floor's block A's cast in situ works.
    - Form work, reinforcement, pouring of concrete
- Reception inspections
  - Made from each block

Record is made from each inspection and it is filed to Hakkapeliitta Village's quality control folder by site engineer. Participants of these quality control inspections are at least general foreman, task's foreman, construction supervisor, contractor's and worker's representative and site engineer.

Cast in situ work as well as finished structure needs to fulfil requirements set by approved mock up installation, contract documents, general quality requirements and good method of construction.

Mistakes and defects detected in inspections are written to records and repaired in a way agreed. Post inspection is made after repair work is done.

7 SAFETY

7.1 Protection against falling

Safety rails are used starting from 2nd floor at all edges of the slab where falling can happen. Safety harness is used while installing safety rails. Openings in the slab are covered with plywood and marked with red cross.

7.2 Safety inspections

Commissioning inspection of lifting and moving equipments is done before the work is started and they are also inspected weekly during the work. Weekly work safety inspection is made by site's foreman and by workers' safety representative. Results are filed and the memo is presented for all the workers in weekly information meeting by site's general foreman. Failures are repaired immediately by person responsible for the particular work safety violation.

7.3 Personal safety equipments needed in the work phases

- **Frame work generally**
  - Protective helmet, protective gloves, protective clothing and protection shoes, hearing protection, Eye protection
- **Form work**
  - Oil resistant clothing ,protective gloves, eye protectors or a mask while oiling the forms
- **Welding**
  - Welders face shield and protective clothing
- **Pouring of concrete**
  - Eye protectors while pouring.
  - Hearing protectors.

7.4 potential problems analysis

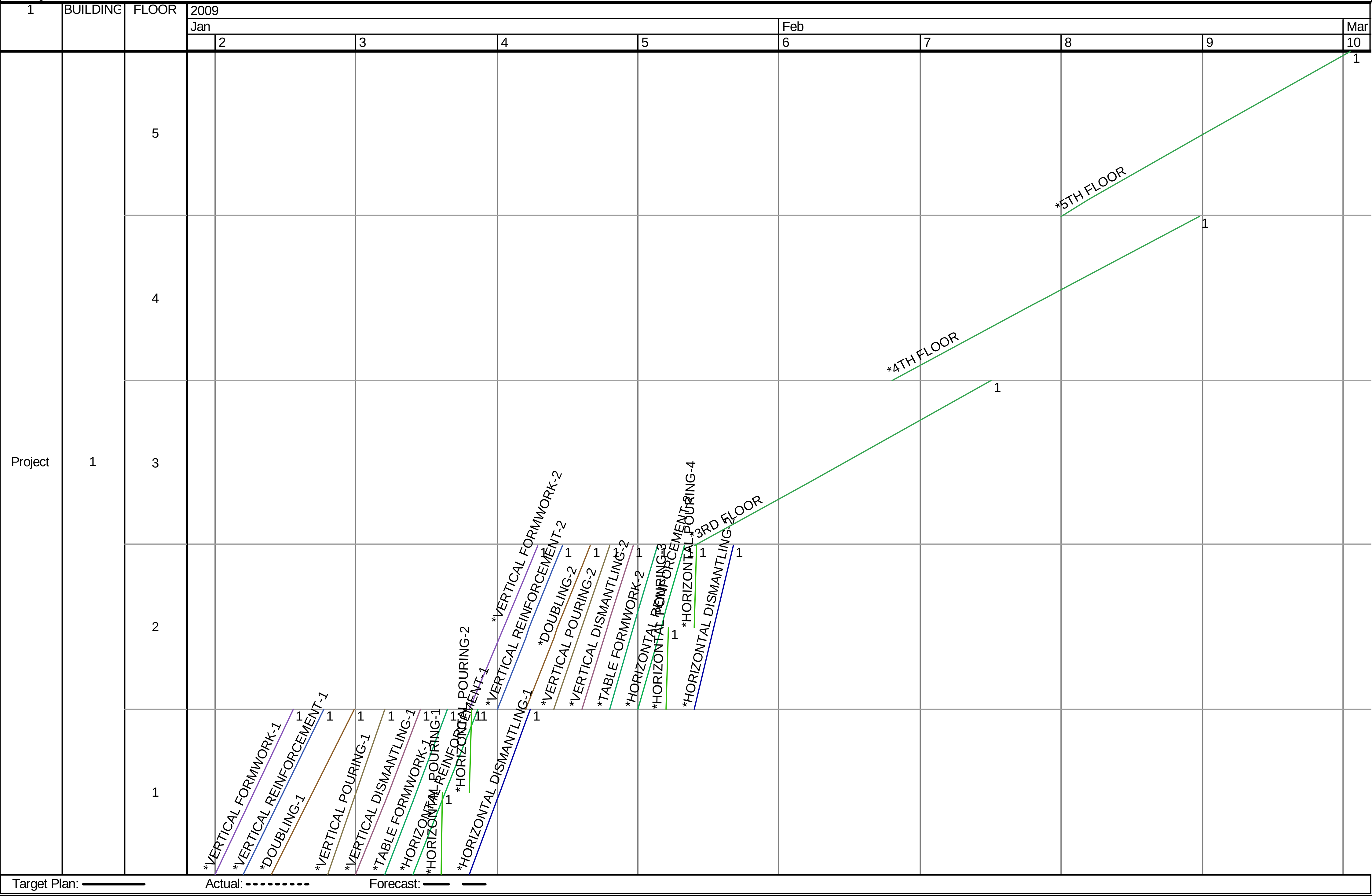
Problem	Alarm	Preparing for the problem
Bad shape of foundations	- Delivery inspection of foundations is not done - A lot of shortages are noticed in work site`s reception inspection. - Foundations are finished too early.	- **Work site's reception installation is carried out early enough to make sure that there is enough time to do all the repairs before form work of the frame starts.** - **Dimensions are checked and required repairs are done.**
Bad weather conditions	- Work is carried out in winter, fall or in some other time when weather can cause problems.	- **Heaters and covering materials are reserved in to site.** - **Equipment for measuring structural strength and heat are reserved to site.** - **Frost resisting concrete to be used when needed.** - **Weather forecasts to be**

		followed.
Problems with machinery.	- Many stops in the work. - Rented equipment is used and its maintenance is not agreed. - Equipments are old and maintenance has not carried out properly.	- **Condition of equipments is always checked before the start of concrete pouring.** - **Equipments are maintained always after use and also when the work is in stop.** - **Equipments are protected against mechanical damages and rain.** - **Back up equipments to be reserved in to site.**
Forms are damaged in site	- Long term stocking of forms and insufficient protection. - Wrong kind of lifting equipment is being used. - Site area is very small.	- **There must be big enough storage for forms in the site and also an area where they can be treated.** - **Materials are protected from rain and snow and from mechanical damaging**
Schedule problems in concrete delivery	- Changes in pouring schedules - Long distances - Late order - Malfunctions in concrete plant	- **Pouring plan is made** - **Order is made in time** - **Changes are informed early enough to concrete plant**
Reinforcement is not as planned	- Reinforcement plans are late - Plans are altered during the work	- **Changed reinforcement plans are delivered to steel fixers immediately** - **Changes during the work are only made by designers authorisation**
Vibrator does not fit between steel bars	- Densely planned reinforcement - Complicated reinforcement solutions - Complicated form work and structural solutions - Only 1 big vibrator at the site	- **Density and the size of vibrator are checked well before pouring of concrete** - **Suitable vibrators are purchased to the site**
Forms bend Heat insulation or reinforcement move during pouring of concrete	- Problems in tying and supporting of forms - Gap between form and reinforcement is tight and bothers compacting - Narrow and tall forms - Dense reinforcement	- **Forms are tied and supported carefully and fastenings are observed at all times during the pouring of concrete** - **Forms and supports are strengthened if needed**

		- **Drop chute is used if necessary** - **Concrete should not be poured against form structures** - **Concrete is poured evenly in to the form** - **Vibrating of reinforce-ments and forms should be avoided**
Concrete dif-ferentiates during pour-ing or com-paction	- High dropping altitude - Dense reinforcement - Drop chute is not in use - Plastic concrete	- **Dropping altitude shouldn't be higher than 1,5m** - **Drop chute is used** - **Vibrator is lowered to concrete in 90 degrees angle, not glancing** - **Planned compaction time should not be ex-ceeded**
Forms are not well sealed	- Many big reserves - Pleomorphic structure	- **Forms are sealed with batten strips, silicon etc.** - **Board forms are watered carefully**
Wrong size of hardened con-crete	- Conflictive levels in plans - Observation measurements are not done before and after pouring of concrete	- **Correct level is checked before and after pouring** - **Be prepared for repair pouring or chipping**
Poor quality of finished surface	- Defective or wrong kind of honing - Hot, dry or windy weather - Wrong mix or breaks in de-livery of concrete - Bad quality of forms - Form oil is not used or used in a wrong way	- **Honing is planned: time, circumstances, working instructions** - **Protective materials are reserved to construction site** - **Concrete is cured as planned** - **Right kind of form oil is used in a right way**
Concrete sticks to forms	- **Old forms with bad quality** - **Form oil is not used or used in a wrong way**	- **Old form materials are changed to new ones** - **Right kind of form oil is used in a right way** - **Compatibility of forms and form oil is checked**

APPENDIXES : **1. Schedule**

NCC | Flowline view | HAKKAPELIITTA VILLAGE
Manager: PEKKA ESKOLA | version 16.4.2009 10:17 | Planner: MIKKO MÄKELÄ



Design mode

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