BIM Outsourcing: Opportunities and Challenges for Construction Design and Management in Cross Country Collaboration

Master Thesis

International Master of Science in Construction and Real Estate Management

Joint Study Programme of Metropolia UAS Helsinki and HTW Berlin

Faculty 2

from

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Date:

Helsinki, 29.10.2020

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Acknowledgement

I would like to express my deep gratitude to both my first and second supervisor Senior lecturer Sunil Suwal and Director Matti-Esko Järvenpää from WSP Finland Oy, whose insights and expertise into the thesis topic steered me through this research. The inspiration and idea definitely started with WSP Finland Oy internal project program which led by Matti-Esko Järvenpää, whose guidance and full support made this topic possible. The thoughtful comments and recommendations from my supervisors were invaluable and have helped me realize the goals of this research.

Furthermore, the knowledge gained from the WSP Finland Oy inspired me to think out of the box and pursue the topic of research. I wish to show my gratefulness to all the colleagues for their support throughout my studies. Special thanks should be given to my colleagues from the course who stood by me during the last two years of study.

I am indebted to my family and friends for their unwavering support throughout the course of research. The unconditional love bestowed by them encouraged me to keep going ahead with confidence during difficult times. Without their support, this thesis would not have been the same!

[Copy of proposed conceptual formulation]

Metropolia

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International Master of Science in Construction and Real Estate Management
Joint Study Programme of Metropolia Helsinki and HTW Berlin

date 29.05.2019

Conceptual Formulation
Master Thesis for Mr./Ms. Jue Wang
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Topic:
BIM outsourcing: opportunities and challenges for construction design and management in cross country collaboration

Introduction:
Nowadays with the increasing number of projects and shortage of technicians in some countries, more and more companies are trying to utilize resources overseas to provide enough workforces for its domestic projects. therefore, BIM outsourcing is becoming the new trend, it is the future not only because it is efficient and economically friendly, but also it fulfills the goal of sustainable development as a shared model to redistribute resources globally in a more reasonable way.

This new model of remote working and data exchange can be done with BIM software, in this case mainly Tekla, however, it is far from perfection, the efficiency of the model can be improved by more accurate communication with other software and program to help.

With the help of WSP Finland Oy, which hopes to improve this model to a better stage. Real projects are provided as case studies to compare and data analysis. Mainly the cases are focusing on collaboration between Finland and India. Other companies' cases will be discussed as well for comparison.

The goal of this thesis is to introduce BIM outsourcing model and improve its efficiency by applying different methods in real projects.

Research questions:
1. Why BIM outsourcing is becoming the spotlight and drawing attention
2. how to achieve basic BIM outsourcing
3. what are the pros and cons of current BIM outsourcing
4. How other companies and society responding to BIM outsourcing
5. How BIM outsourcing can be improved
6. With BIM projects tests, how much profit margin can it improve comparing to traditional projects
7. what's the future of BIM outsourcing and where it would lead us to.

Time line:
Start: 7th of Oct, 2019
First final version: March, 2020
Frame and draft ready: Jan, 2020

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Abstract

This thesis mainly discussed the definition of BIM outsourcing in construction design and management and the potential of BIM outsourcing. The aim of this thesis is to spread the influence of BIM outsourcing as well as discuss the potential method to increase the efficiency of it by analyzing different case studies from the real project provided by WSP Finland Oy.

The thesis contains first the introduction of BIM outsourcing and how it works, the total three case studies were analyzed for the solution to increasing efficiency, and then solution was given at last.

The method and solution given within this thesis will increase the efficiency and productivity of BIM outsourcing eventually benefit the profitability of the project as well as the competitiveness of the company.

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List of Abbreviations

Fig.	Figure
BIM	Building Information Modeling
SKOL	The Finnish Association of Consulting Firms
PRF	Project Requisition Form
iCRC	Integrated Complementary Resource Centre
LOD	Level of Detailing

1. Introduction

Nowadays with the increasing number of projects and shortage of technicians in some countries, more and more companies are trying to utilize resources overseas to provide enough workforces for its domestic projects. therefore, BIM outsourcing is becoming the new trend, it is the future not only because it is efficient and economically friendly, but also it fulfills the goal of sustainable development as a shared model to redistribute resources globally in a more reasonable way.

There is a shockingly small number of researches have been done for this topic, however, surveys have been made about the general idea and what are the opinions of applying it within construction company, but there is very limited data can be found about how to do it, and how to improve it.

Therefore, this thesis will go into details about how and how, based on this new model of remote working and data exchange with BIM software, in this case mainly Tekla, however, it is far from perfection, the efficiency of the model can be improved by more accurate communication with other software and program to help.

With the help of WSP Finland Oy, which hopes to improve this model to a better stage. Real projects are provided as case studies to compare and data analysis. Mainly the cases are focusing on collaboration between Finland and India. Other companies' cases will be discussed as well for comparison.

The goal of this thesis is to introduce the BIM outsourcing model and improve its efficiency by applying different methods in real projects.

As a summary of this thesis, the following research questions will be answered:

1. Why BIM outsourcing is becoming the spotlight and drawing attention
2. how to achieve basic BIM outsourcing
3. what are the pros and cons of current BIM outsourcing
4. How BIM outsourcing can be improved
5. what's the future of BIM outsourcing and where it would lead us to.

2. Trend of Distance Work by BIM in Construction Design

With the rapid pacing up of globalization, efficiency and cost-saving become more and more vital for industrial companies to stay competitive on the market. In the design phase of construction Production line are no longer in one company, but cooperation between different companies. Besides, the Internet also makes online discussion and meeting possible, sending and receiving documents, files, and digital drawings could also be done through cables.

The era of Distance work in 2D

In the construction design field, distance work can be possible and been used in practice in the early 21st when the first CAD software was invented, drawings can be created in PDF form and exchanged through Email or fax. Every information created and transferred in two dimensional. The downside of it is also straight forward:

- Requires a huge amount of 2D drawings
- Massive time in communication
- High chance of collision and mistake

Summarized into one key factor: inefficiency. therefore, in the past ten years, when the site or designers are geographically far away from each other, designers always prefer to travel to site and work locally rather than do the distance work, or simply the clients are forced to choose local designers to do the work.

The era of Distance work in BIM

With advanced technology in software and programming, the rapid growth of internet speed. BIM stands for Building Information Modelling, it doesn’t mean just one software or technology of specific term, but an integrated system/environment in the construction field, which including:

- Software which can generate 3D model of buildings and objects
- A general/universal form of file with high compatibility
- Cloud platforms which allows massive data storage and exchange
- Audio/Video communication between different parties

With the help of BIM, distance work becomes much more efficient, which then profitable, and in the modern capitalist society, no one can resist profit.

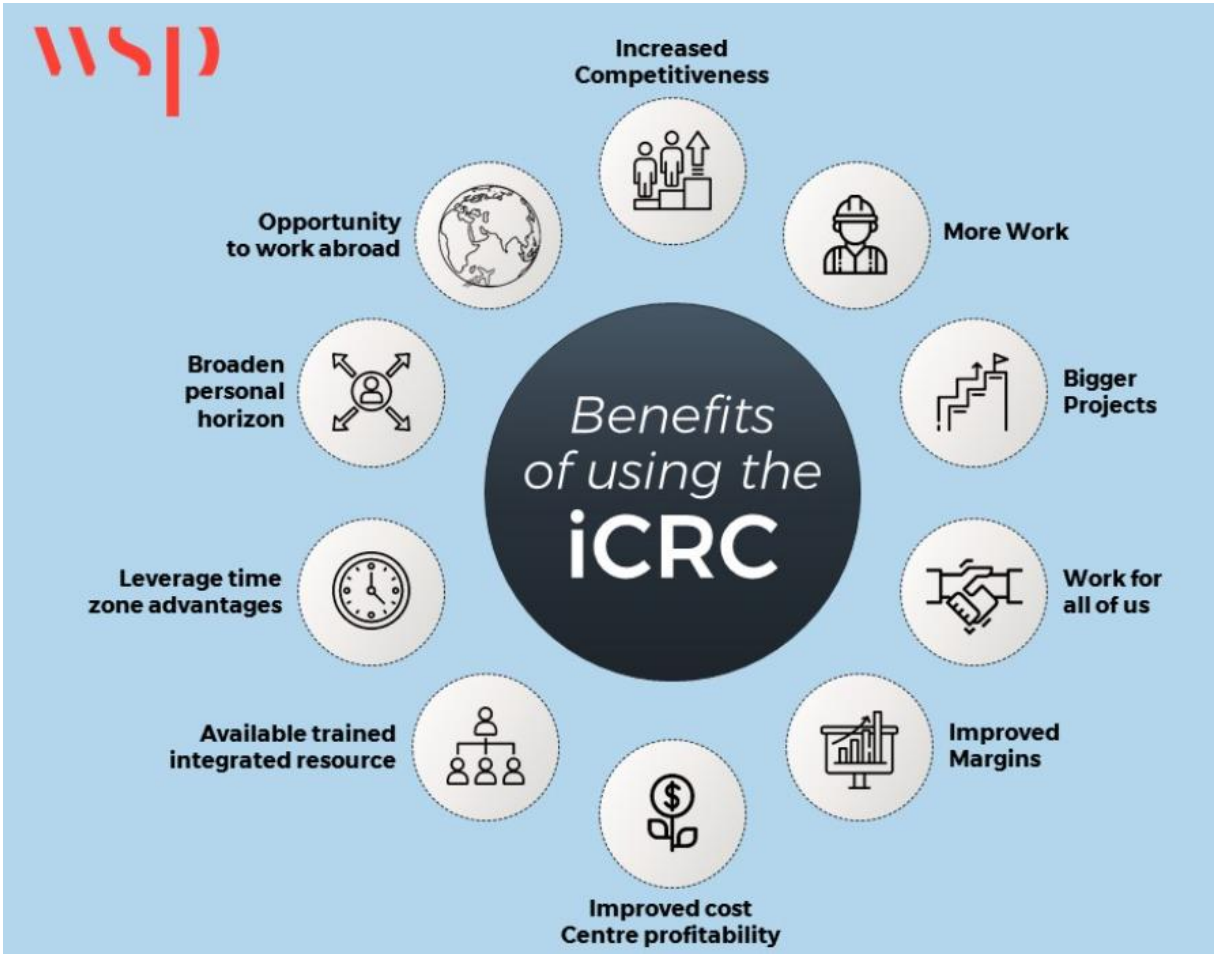

Fig. 1 Advantages of distance work by BIM

Without the geographical limitation, the advantages of distance work by BIM are tremendous. which can be categorized into four aspects:

Increased Competitiveness (External)

With a fast-growing economy and urbanization on a global scale, there is a huge increasing demand for construction design, and inevitably, the problem of lacking human resources for design and making drawing came to the surface of the water, especially in developed countries in Europe.

Take Finland for example, whenever a project been released to the public for bidding, one of the key factor which limits the potential design company as a bidder is lack of resources or failed to distribute resources quickly and correctly within the given time.

Both domestic and export business turnover continued to increase in Finnish consulting business, but profitability stayed in low level. A shortage of professional staff is now considered the biggest obstacle to growth. (SVENSKA TEKNIK&DESIGNFÖRETAGEN, 2018)

With cooperation between BIM-distance work companies, it gives almost unlimited resources for a local company to choose from on a global scale. It allows local design companies to send more bidding papers to stay competitive in the market and being active, which is also a positive sign for company marketing purposes.

Leverage Time (External)

One of the other advantages of using BIM distance work is that when choosing a company which is far away from local offices, for example, India, the time zone difference between India and Finland is 2.5 hours. the time difference can be used to make the project process faster, if managed correctly, every day there are 7.5+2.5 = 10 hours of working time can be utilized for the project.

When a client is in a hurry or a project is urgent in a time schedule, time zone difference will increase the efficiency of resources with a limited time span, which gives confidence and increase the margin of error for the clients.

Trained Integrated Resources and Administration (Internal and external)

When applying for BIM distance work, it certainly requires more advanced software for design, communication, coordination, and negotiation. In other words, it needs a higher level of efficient administration and management. Normally a new division needs to be created for BIM distance work in the local office. The main challenges/tasks of this division are including

- Negotiation of Contract
- Distribution of Resources
- Constant Communication and Discussion of Project
- Quality Control
- Feedback and Improvement

In the beginning stage of this cooperation, in most cases, it also heavily relies on responsible managers on both sides, between local office and distance work office. After the trust and confidence have been built, a systematic standard procedure should be

applied to partly replace or at least decrease the human influence on the cooperation, therefore to make the cooperation more sustainable regardless of whether managers are relatively responsible or not

Improved Margins and Profitability (Internal and External)

For every design/consulting company, improving profitability is the most important factor to use BIM distance work cooperation. Within Finland, even though the market is booming and the client generally has confidence in the economy, but the profitability is still relatively low.

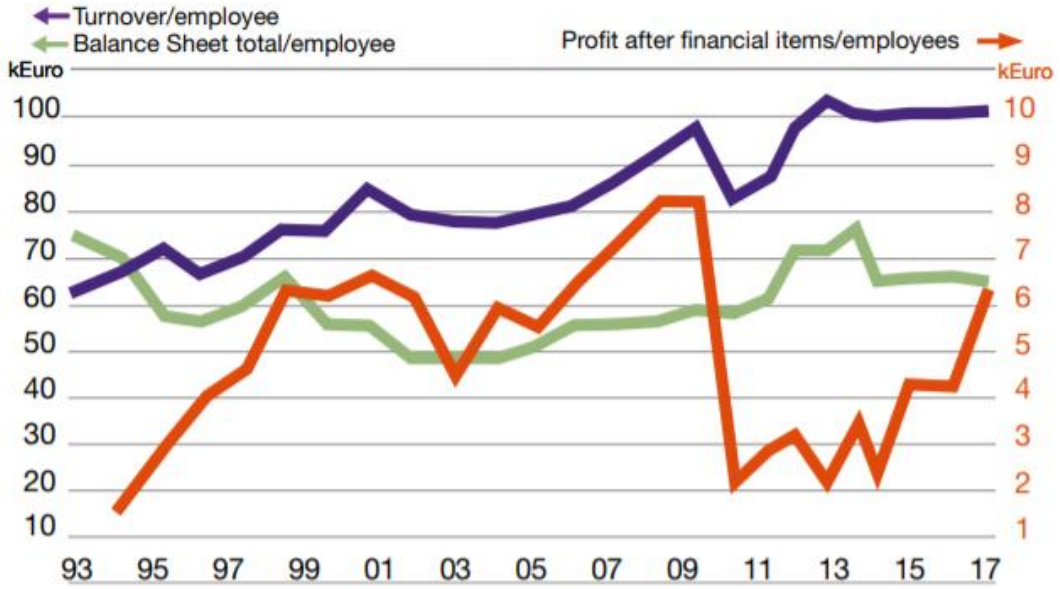

Fig. 2 Top 30 Finnish companies financial figure from 1993-2017

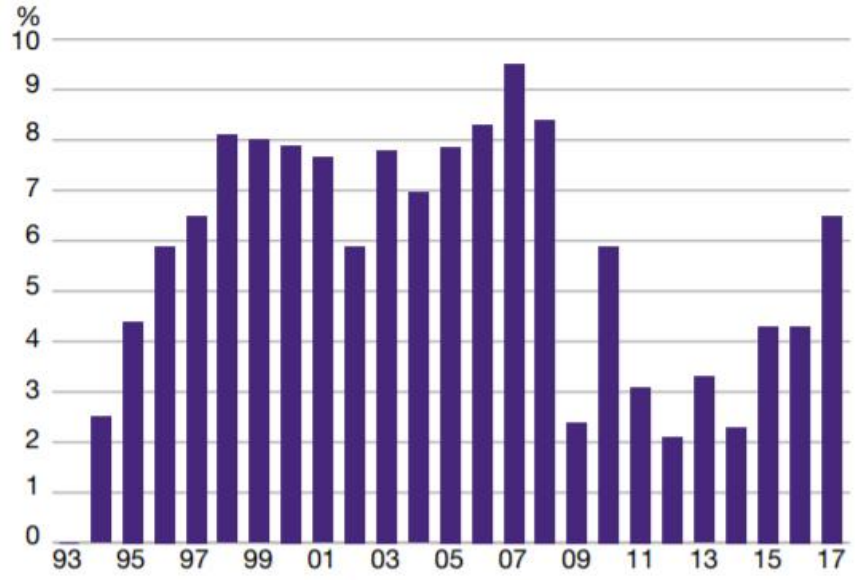

Fig. 3 Top 30 Finnish companies Profit Margins (except pöyry) from 1993-2017

The turnover for the 30 largest groups in 2017 increased by 10% to €2,291 million (€2,077 million in 2016). The average number of employees grew by 9% to 22,722 (20,870). The turnover per employee was €101,000 (€100,000). The profit before tax was €6,500 per employee (€4,100 the previous year). The profit margin for the 30 largest groups improved to 6.5% (4.2%). The average balance per employee was €65,800 (€67,100). (SVENSKA TEKNIK&DESIGNFÖRETAGEN, 2018)

Generally speaking, it is risky business making direct comparisons between key business ratios for the largest firms and corresponding figures for the medium and small-sized firms. for latter firms, it is more vulnerable and lack of financial rescue options when extensive partner left or having a recession. In addition, putting resources for extra division in order not to put all eggs in one basket is more difficult for smaller firms.

SKOL is the employer's association for independent and private consulting companies in Finland. SKOL has 165 member companies in the fields of industrial, building and infrastructure design and consulting, as well as management consulting and training. SKOL standard gives approved resources hourly cost for clients.

While in India similar grading system also used for calculating cost:

Grade	Job Title	Per hour rate (INR) 2020 (On 1800 hours)
4A	Head / Associate Director	
4B	Head / Associate Director	
5A	Head / Associate / Deputy Head / Manager	
5B	Team Lead / Associate / Manager	
6A	Principal Engineer / Manager	
6B	Principal Engineer / Manager	
7A	Senior Assistant / Senior Engineer / Coordinator	
7B	Senior Engineer / Coordinator	
8A	Senior Technician / Coordinator	
8B	Senior Technician / Engineer / Consultant	
9A	Assistant Engineer / Modeler / Technician	
9B	Assistant Engineer / Modeler/ Technician / Graduate	
10	Modeler / Junior Technician	

***** per hour rate for Expats will be charged as per their actual CTC***

Fig. 4 Indian Garding System in 2020

In comparison with SKOL system in Finland:

		Hourly rate	
Grade	SKOL	Indian Rupee	Euro
4A	2		
4B	2		
5A	3		
5B	3		
6A	4		
6B	4		
7A	4		
7B	5		
8A	5		
8B	5		
9A	6		
9B	6		
10	7		

Fig. 5 Converted to SKOL system with Indian hourly cost in Euro

The corresponding Indian standard grade and Finnish standard SKOL indicate the similar technical skills level which the employee has. For example, in Finnish standard, SKOL 2 stands for experts who have many years of expertise in a certain field, and only design work and creative work can be counted as valid experience, repetitive work shall not be taken into consideration when qualifying the SKOL. A similar regulation also applies to Indian grade.

Therefore, professionally speaking, SKOL 2 = grade 4A and grade 4B, however, the cost in Fig. 5 only indicates the internal Indian standard cost for the grade, not the Finnish standard cost for SKOL.

For a standard project in Finland, the majority of resources for design and consulting is SKOL 4 and SKOL 5, normally there are few SKOL 1 or 2 experts for the final quality checking and supervision. SKOL 4 and 5 corresponding to Indian grade 6A to 8B. As a normal hourly rate for SKOL 4 or 5 s Finnish employees are relatively 300%-400% higher than these numbers approximately.

By comparing the different hourly rates between Finland employee an Indian employee. there are two options for increasing profits for the company:

Option 1

When the company is competing for the project with a provided resources list and estimated hourly cost, instead of showing the Indian grading system, Indian resources are presented as corresponding Finnish SKOL level, so that the client will be charged as normal SKOL level. There is no doubt that the client must be aware of this, and the quality of the product made by Indian fellow resources is as good as the same SKOL level Finnish resources have been approved by the client as well.

And this allows the company to compete for a bigger project that clients can have some relief on the problem of lacking resources.

The advantage of option 1 mainly focus on:

- High internal profit for the consulting company
- More competitive on more project and bigger project
- For clients which cares speed and quality of project more than cost

Option 2

When the company is competing for the project with a provided resources list and estimated hourly cost, the Indian grading hourly cost is directly showing to the client, but also the corresponding Finnish SKOL system as well, to approve the quality of the product made by Indian fellow resources are as good as same SKOL level Finnish resources, by example end product provided to the client.

Therefore, in the final bidding process, the input resources hourly cost will be based on Indian grading hourly cost plus some extra administration and software fees. which is still much lower than the market price of corresponding SKOL Finnish resources.

The advantage of option 2 mainly focus on:

- More competitive on projects due to lower bidding price
- Higher market occupancy rate
- More flexible in urgent situation for the consulting company

3. Distance Work by BIM in Construction Design(Current)

The current stage of Distance Work by using BIM in construction Design is introduced below. The main focus of this chapter is to understand how it works in developed countries, in which societies have already the fundamental necessary educational environment, a well-regulated construction field that embraces new technologies.

In general, in the traditional construction field, to start construction site work, 2D Detail workshop drawings were needed for workers on-site to read and follow, the workshop drawings are the result of design work done by design/consultant companies, which nowadays were generated by 3D modeling software. With distance working, the design company gives tasks to 3D modeling companies that can be located anywhere in the world. The 3d modeling companies than creating the BIM model of structures based on the guidance and communication from the design company, in most cases, which also represent the client, and convert it into 2D workshop drawings, normally as PDF and DWG form, and then sending it to the client for inspections and revisions.

All the above processes are done remotely through a lot of communication software and special BIM modeling software which allows the client to check the model simultaneously as the modeler is modeling.

3.1 Technical Approach

The normal process of project delivery within WSP Nordics indicates below, which serves as an example pattern:

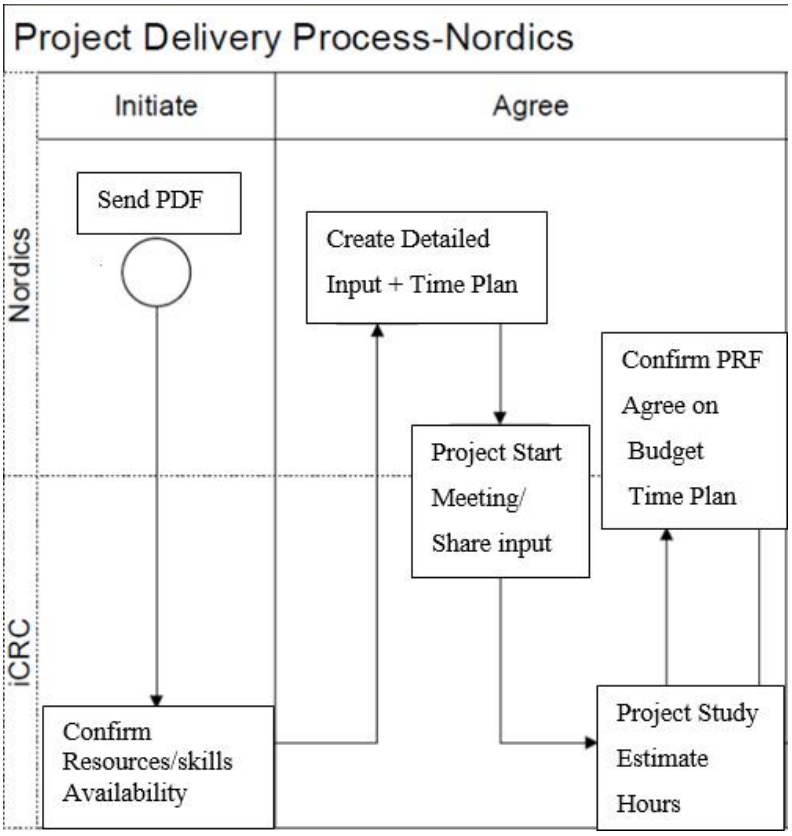

Fig. 6 Project Delivery Process-Nordics (first two phase)

In the first part of delivery process, it including two phases: Initiate and Agree

Phase one (Initiate):

Nordics in this case stands for WSP branches in Nordic countries which including Finland, Sweden, Denmark, and Norway. Normally these countries receive contracts from local or international clients, both for structural design and detailed workshop drawing a delivery contract.

Due to the fact that in most design companies in west European countries, there is always a shortage of resources when comes to BIM modeling and workshop drawing creating. This creates a huge demand to outsource these works to other companies, in this case, as WSP has a branch in India, and they do have enough resources for these works.

Naturally, the request for resources was sent to the Indian branch with a document called PRF, which stands for Project Requisition Form. It is a document with only one or two pages demonstrate the basic information as the following indicates:

- Introduction of Project
- Scale of project (in estimated working hours)
- required skills
- Basic time schedule with deadline
- Contact person (more than one)

Signed PRF can only be sent by Email to iCRC, which stands for Competence Resource Center in India. which is WSP Indian branch. After a short discussion with managers, ICRC will decide whether they can proceed with the next phase or not, sometimes if the project is too big or more information is needed, the discussion between Nordics and ICRC will continue for days until it can be agreed for the second phase.

Phase Two (Agree)

After phase one has been agreed upon, a more detailed discussion about the project will immediately start, in this phase, the project will be calculated and divided into different zones for management purpose. Within zones, there will be a project time plan, with marked benchmarks, meeting frequency.

Resources are presented to Nordics and exanimated, to determine the list and approximated hours based on different people and skill levels. Normal this is the tricky part which involves negotiations, resources hourly prices can vary quite a lot.

After resources have been decided, the most important detail part needed to be agreed upon is the way of share input. This the key to the success of the project, how fluence the flow of internal information is directly reflecting on the quality of the final product. Therefore, what kind of online platform the client requires to share information, if not, what should be the best one to exchange data between Nordics and iCRC, and in what frequency. Setting up the information sharing system correctly and in time, would lay a solid foundation for future communication. The agreed schedule and price must be followed. However, it should also reserve some extra time/resources for the margin of error and changes.

Finally, the estimated schedule and budget of the hour has been decided and agreed.

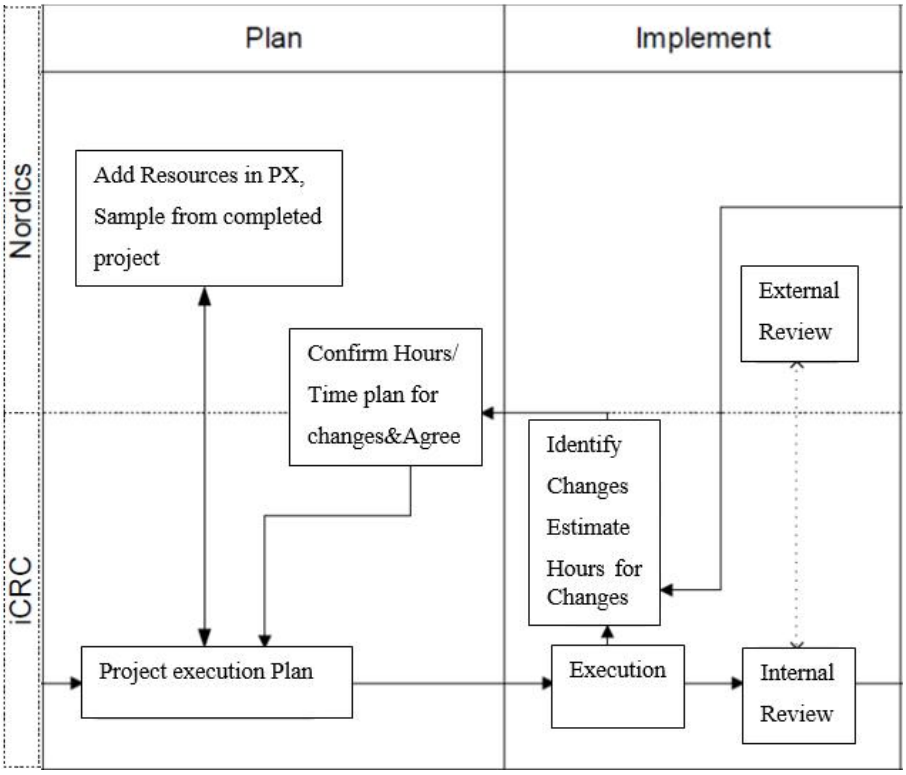

Fig. 7 Project Delivery Process-Nordics (second two phase)

In the second part of delivery process, it including two phases: Plan and Implement

Phase three (Plan):

After phase two, the agreed written form of contract has to be put into practice, therefore the administration work will begin from here to make it financially possible in company scale, adding resources into company work hour management system so-called PX is one of the most important paperwork, only after this process has been put into the system, everyone in the project can financially working/putting hours legally on the particular project.

Then it will be followed by Nordics provides the detailed information and requirement for the end product that iCRC will have to provide. Normally this was done by providing a lot of example drawings and example design/calculation from old projects approved by the client. Furth more, providing information alone will not suffice, communication through audio/video chat to explain important example requirements and drawings will also be necessary. There is no doubt that this step is crucial to the project as well, for iCRC to correctly understand what Nordics and clients want at the beginning of the project will save a lot of trouble in the future and the potential of complete project failure.

Noticeably, the project manager in iCRC will then form the project execution plan, this plan including the distribution of resources and distribution of the area of work and type of work. Arrange the right resource into the right type of work and area is not an easy job, this requires previous co-working experience to make the right decision, if not, asking opinion to colleagues who has co-working experience and then decide. Normally this execution plan will also be first previewed by Nordics for safety issues.

Phase Four (Implement)

This is the phase of the actual working process. similar to all other construction/design projects, it involves a lot of uncertainly comes from all aspects, for example, changes from the client; difficulties from contractor or sub-contractor; weather issues; union issues, mistakes from the designer. It is inevitable, therefore preparing a tactical standard response procedure would be the best way to counter this kind of thing. In this case, the source party of changes (Nordic; client; contractor) will identify the changes, evaluate the influence of changes on to project, both financially and timely, choose the best way for the project to make the changes, and then calculate the necessary estimated extra hours with extra costs.

Therefore, changes will be considered as a new sub-contractor extension of the current contract and send to iCRC for evaluation and resource distribution, agreeing on the changes financially and timely. basically, repeating the process of phase three.

Execution is separated into different multi zones and stages. Within the project, for every internal and external milestone has been reached, part of the end product needs to be first internal review and quality checked by iCRC first, and then it was sent to Nordic for external review, what needs to be reminded in here is that in the terms of client, Nordics external reviewing can still be viewed as internal review, only after Nordics approved the end project, it can be sent to client information exchange platform for a final inspection.

Additionally, in the cross-checking and reviewing process, which is also called quality checking. what also needs to be agreed upon for each project is that iCRC internal checking is necessary or not, since quality checking in iCRC usually takes one extra high-end resources, sometimes when the project is not big enough or budget is not enough, or even time is urgent for the project, the iCRC internal review can be neglect

temporarily. This also can reduce internal communication costs financially and timely. However, this means extra work on the Nordics external review, since they now bear the burden of last chance checking to find a mistake before it was published to the client.

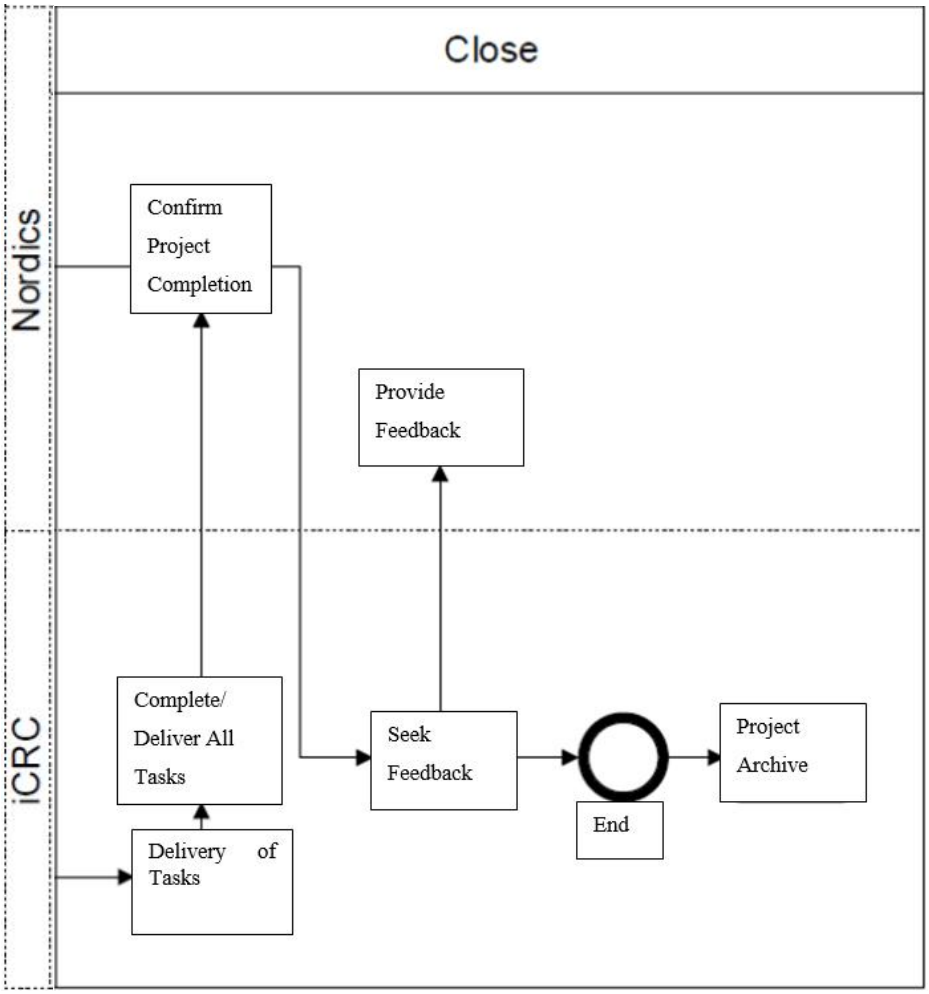

Fig. 8 Project Delivery Process-Nordics (last phase)

Final stage, Stage 5(Close)

After the end product has been accepted by the client, if there is no further extension of work from the client-side, Nordics will confirm the project completion. and iCRC will ask for feedback from Nordics about the project. Feedback normally including the following aspects:

- Project Administration
- Time & Cost
- Quality
- Overall Resources Performance

- Follow up/Repeat Work
- Comments

This feedback is a PDF document which can be filled online, Nordics will give comments on this feedback with honest, therefore to learn from mistakes and improve it in the future. Even more, feedback is not unidirectional, Nordics also needs to seek feedback from iCRC as well. PDF form of feedback is just one way to be archived, but in most situations, a video meeting is necessary to make the feedback efficient.

3.2 Design Software

The core design software which makes this BIM distance work possible in the construction design field is Tekla Structure. one of the most popular software to create a Structural BIM model in Nordic countries and even Europe, originally developed in Finland. For publishing a massive amount of Concrete and Steel workshop drawings in big projects, Tekla Structure has unchallengeable advantages in comparison with other software.

However, what truly makes the BIM distance work possible is one of the add-ons that Tekla Structure launched in 2018. Which is called Tekla Model sharing.

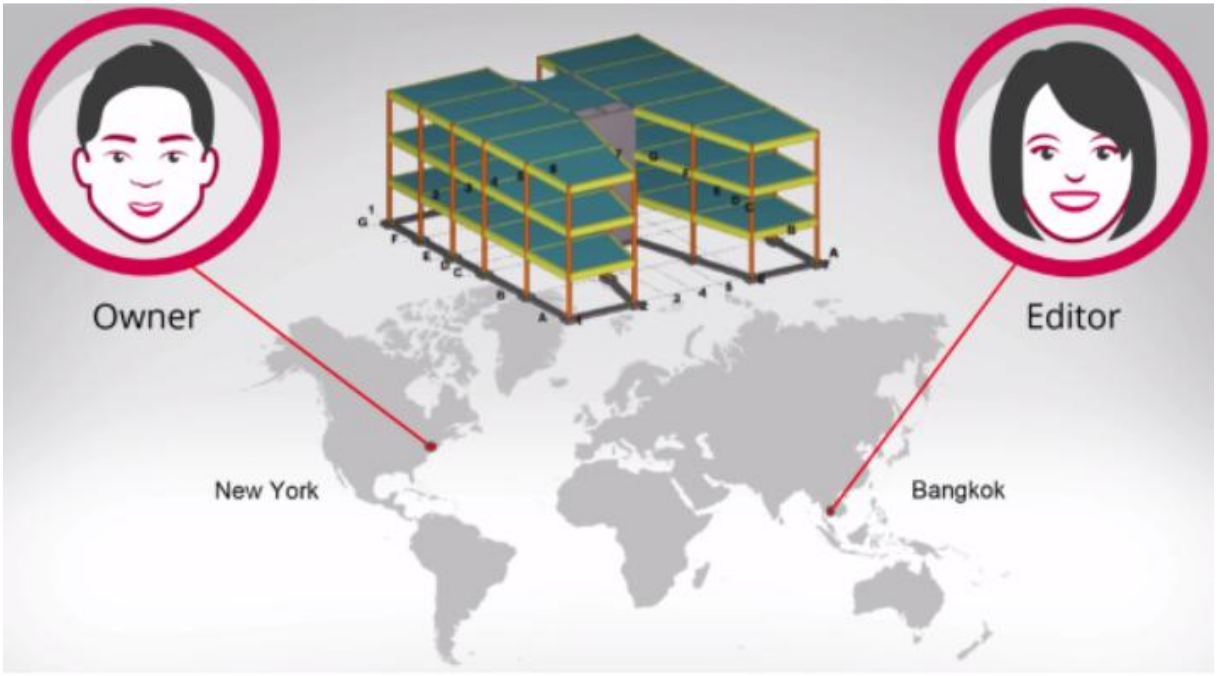

Fig. 9 Example of Tekla Model sharing

Tekla Model Sharing enables efficient global collaborative modeling within one Tekla Structures model. Tekla Model Sharing gives users the freedom to work with the same model at the same time in different locations and time zones. (Trimble, 2020)

When using Tekla with this Model Sharing add-on, the employee can work locally and share the model changes he/she made to all other users without the physically geographical limitation. For example, one Tekla Model Sharing team of users can work in New York, one in London, and one in Bangkok. They all contribute to the same model, working around the globe during their office hours in different time zones while the model keeps building up all the time.

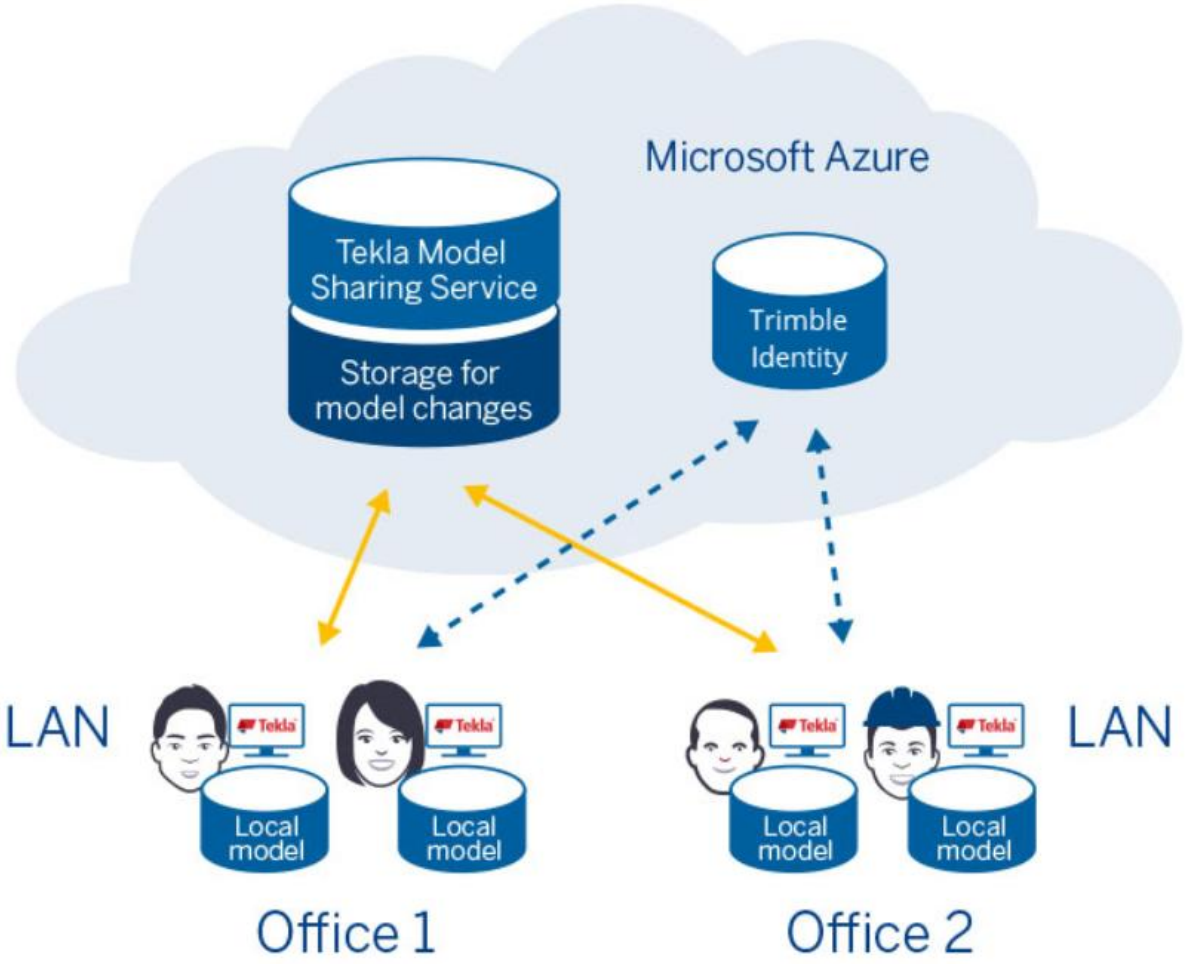

Fig. 10 Tekla Model Sharing Cloud Service

In Tekla Model Sharing each user has a local version of the model on their computer or on a network drive, and the model data is shared and synchronized over the Internet using a Microsoft Azure cloud sharing service. When a model is shared, it is connected to the cloud-based sharing service. and the sharing service is running non-stop, anyone in the project team has access can check it any given time.

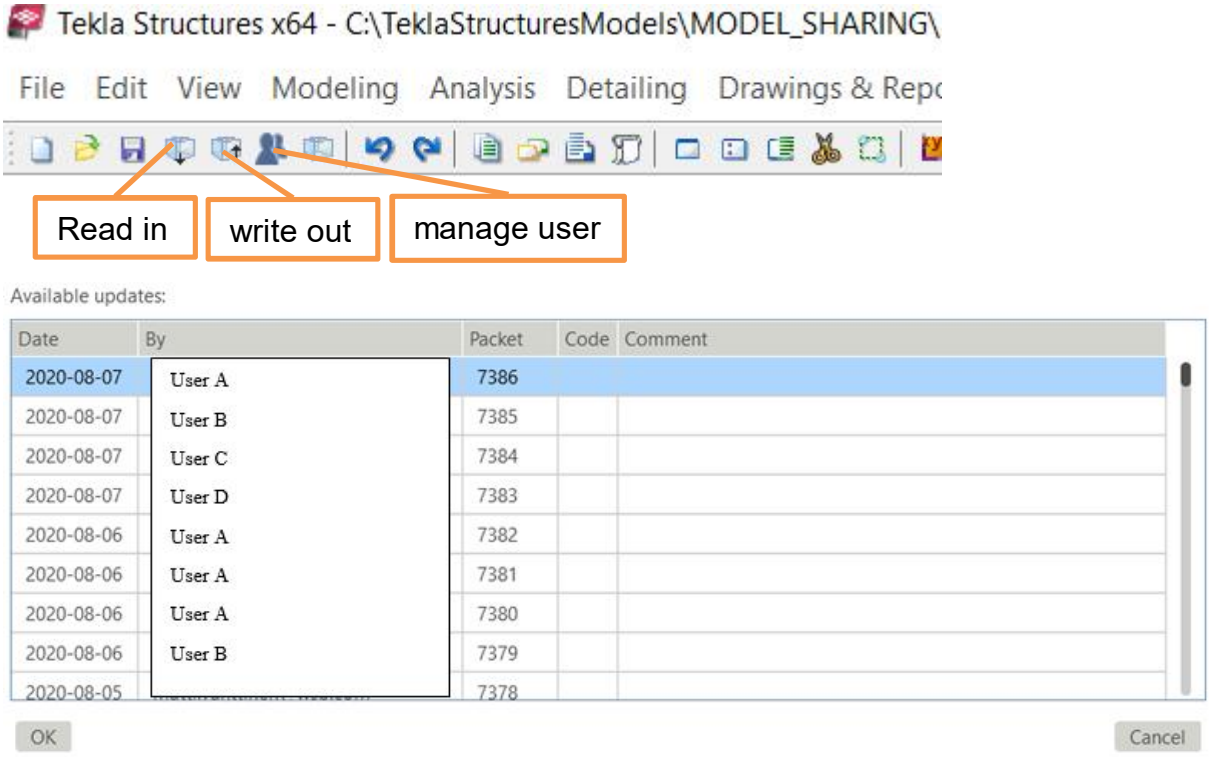

Fig. 11 Example of Model Sharing updates as packages

When starting to share a model using Tekla Model Sharing, the model is connected to the cloud-based sharing service.

- To send model changes to the sharing service, it is called write-out.
- To fetch other users' model changes from the sharing service, it is called read-in.

When one user read in other users' changes, the updates to this user local version of the shared model are delivered to him/her as incremental packets. This means that when user read in, the data that is fetched from the sharing service is merged with the data on user computer. Noticeable in order to write out own changes to the sharing service, user need to read in first all shared changes. (Trimble, 2020)

One of the most outstanding advantages of having a cloud server and local working station is that users can work in any office around the world any time, without connecting to the could server, only when necessarily needed, given the updates/modification to the server by write-out. Each time when a user did a write-out, a package of modification has been generated in the cloud, the server itself will not contain any model but only packages of modification.

This will have minimized the collision caused by a different user, and when collision still happens, Tekla will give a list of collisions regarding who did what and when.

3.3 Communication Software

- Microsoft Outlook (Internal and External)
  The most common communication software used on daily basis both internally and externally, since everyone is using it, sending Emails with correct addresses linked to a team member will always draw the attention and trigger a quick response.
  However, during the project starting phase, there is always a huge amount of information, which means a lot of Emails discussing and negotiating terms, in additional, during the execution phase, the data exchange is even more frequent, in the peak period, there could be more than 50 Email per day just for one project. This can lead to chaos of managing information and it will be difficult to find the needed information if the project scale is relatively large and the project time span is long.

- Microsoft OneNote (Internal)
  One of the new communication software, which is commonly used only internally, serves as a shared file with editing right for everyone, within pages, customize subpages, tables, formats and pictures are allowed, it can be easily categorized and documented.
  For a distance work project through Nordics and ICRC, a standard sample OneNote file was prepared, normally the sample file contains the following pages:
    - Work Order
    - Technical Description
    - Assignment Specification
    - Time Plan
    - List of Changes
    - Q and A
    - Modelling to do
    - Review

Within the pages of List of changes and Modelling to do, there are usually sub-pages sequenced by timeline, and every single one of the changes is marked with pictures about what to do, who should do it when it should be done.
The advantage of OneNote is clear on-sight, in one sentence, it manages and stores massive information in a logical, traceable manner automatically. In case of future disputes or claims, this document will be of great help.
However, OneNote will not notify every team member when each time someone updates something in it, otherwise, the snowflake of notification will just be annoying for team members. This creates a dilemma, if someone failed to update or check OneNote frequently enough, the whole system then is not completed and lost its meaning.

- SokoPro (External)
  One of the common data exchange cloud platform used in Europe and the UK. This is mainly used in a big project which involves many different companies, data exchange, mostly models and drawings in IFC and DWG format between Architects, Structural engineers, HVAC, electrical engineers, and client or third-party inspectors.
  Many of the single file sizes are calculated in GB, which can still be uploaded to the cloud with relatively fast speed, also with the marked uploader, time, and even revision of files.
  There are many other similar platforms which can be used and provide a similar function, the important factor to make this efficient is to mandate the use of an appointed cloud platform and the frequency of uploading model with the written contract.

4. Case Study A

4.1 Introduction

Case Study A is based on a real project between WSP Finland (as Nordics) and WSP India (As iCRC). The project is located in Finland, the building is designed to be an elementary school. with a combined sports hall and bomb shelter within.

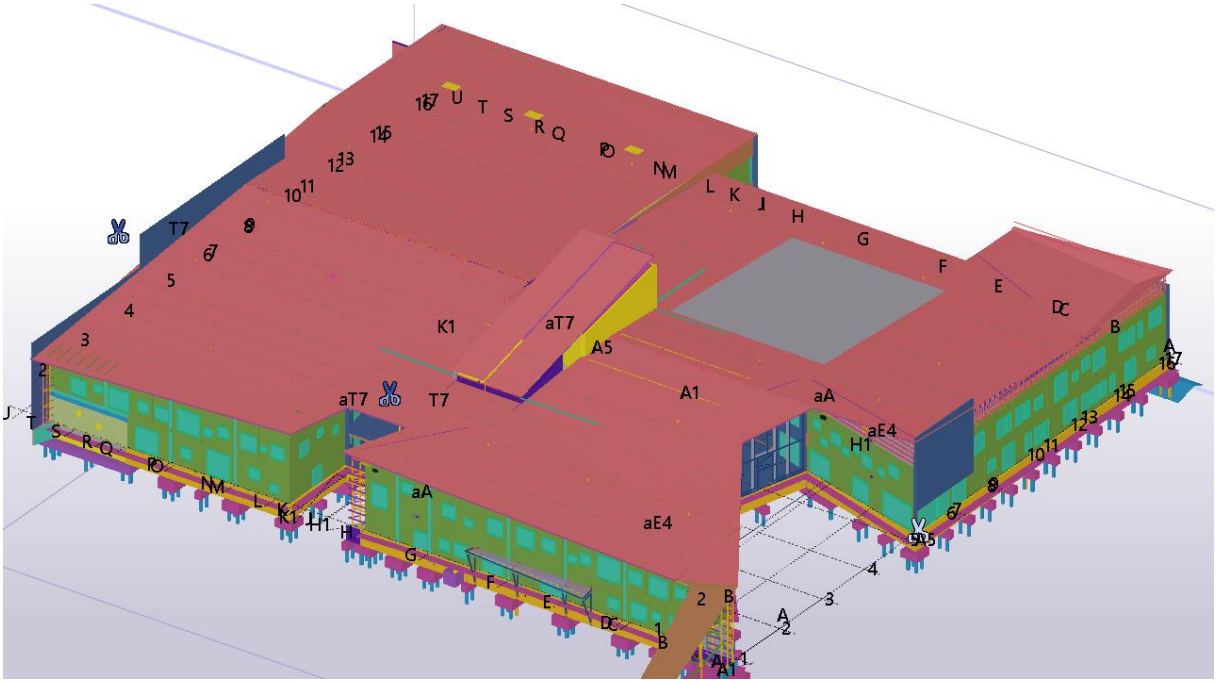

Fig. 12 Overview of school building in Tekla BIM model

This project starts at a normal pace according to the plan in the beginning phases, full resources are reserved with the local Finnish office. However, in the spring of 2019, when the project reached maximum speed on-site construction, within the office, one of the major project managers who has been leading the project since beginning developed an illness and had to leave the project abruptly. While the replacing manager did the best to cover the emptiness, the project still took a strike and the construction process has been delayed. therefore, during the summer of 2019, resources were still needed to be full capacity even though it is summer holiday time for traditional Finnish.

The urgent demand has been created, to ask for help from iCRC for more resources to cover the workload gap.

4.2 Negotiation and Zone Distribution

During a short meeting between the Finnish CRC coordinator and deputy project team manager, a basic agreement has been reached that the concrete part of bomb shelter reinforcement workshop drawings should be delivered by iCRC.

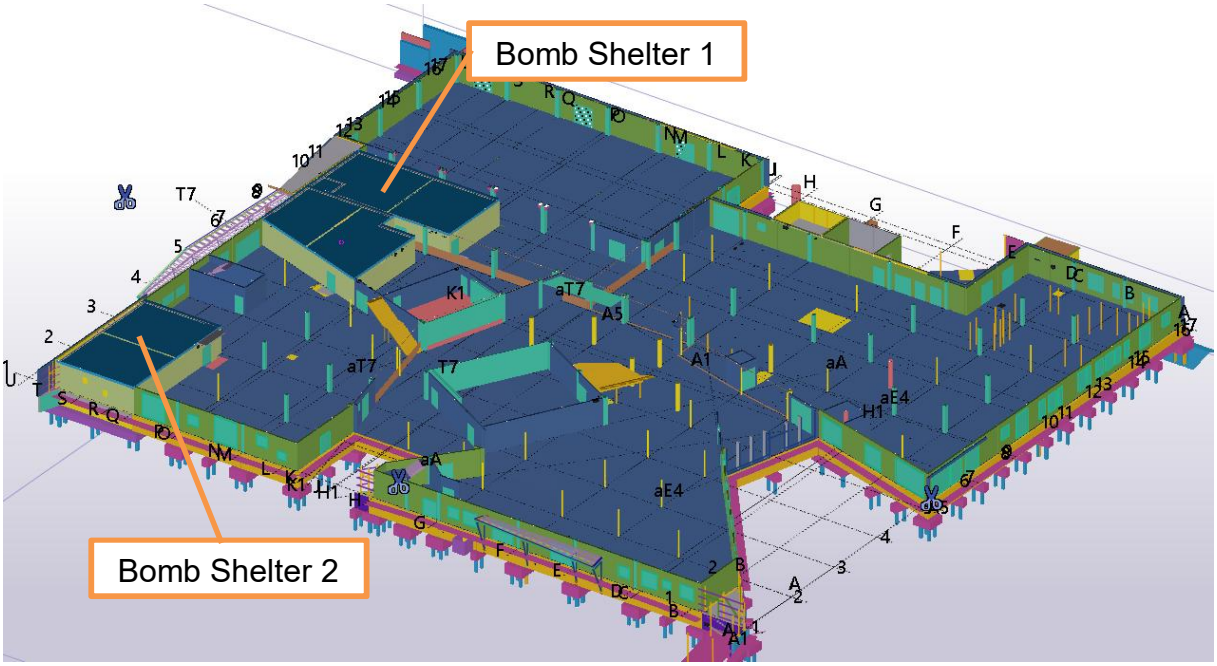

Fig. 13 Agreed working zone for iCRC

There is two Bomb shelter room in this building, both including concrete line foundation, floor, wall, and roof. Due to the fact that bomb shelters are isolated from other structure, therefore during model sharing process, there will be easier to separate these structure from others when other team members are working different or adjacent areas and reduce the chance of collision.

The scope of work is including modeling the reinforcement of these mentioned structures in the Tekla BIM model and create the reinforcement workshop drawings as an end product for the delivery for site construction.

The agreed time is two weeks' time, for each bomb shelter shall take about one week, in general, there is no estimated hour limitation, what matters most is to deliver the end product to the client with the agreed deadline.

In general, this project for iCRC is not big in terms of agreed working hours, which is estimated to be 160 hours, calculated as two resources working for two weeks.

4.3 Resource Distribution

In iCRC, there is corresponding resources grade and availability map that can be checked.

Right after the short meeting with the project manager, iCRC Finland has been reached by the coordinator and discussed shortly the possibility of such an urgent yet small project, with such short notice, there is no resources can be spared from iCRC Finland branch.

However, within the same day, team leader operating Sweden and Finland iCRC responded and mentioned that iCRC Sweden has two resources that can be borrowed to do this work, both employees have the experience of working with Finnish project before and has relatively good experience for making concrete reinforcement drawings.

Sr. No.	EMP ID	Invoice ID (As per India)	Invoice ID (As per Sweden)	Employee Name	Grade	Job Title
1					4A	Head of iCRC Sweden & Finland Building Structures
2					8A	Senior Revit Technician - Structures
3					9A	Tekla Technician - Structures
4					7A	Tekla Coordinator - Structures
5					8A	Senior Revit Modeller - Structures
6					9A	Revit Modeller - Structures
7					7A	Revit Coordinator - Structures
8					8B	Senior Tekla Modeller - Structures
9					8B	Senior Tekla Modeller - Structures
10					9B	Revit Modeller - Structures
11					8B	Senior Tekla Modeller - Structures
12					7A	Tekla Coordinator - Structures
13					9A	Tekla Modeller - Structures
14					9A	Tekla Modeller - Structures
15					8B	Senior Tekla Modeller - Structures
16					9A	Revit Modeller - Structures
17					9A	Tekla Modeller - Structures
18					10	Junior Tekla Modeller - Structures
19					9A	Tekla Modeller - Structures
20					9B	Revit Modeller - Structures
21					9A	Tekla Modeller - Structures
22					6B	Senior Quality Coordinator - Structures
23					8A	Senior Tekla Technician - Structures
24					9B	Tekla Modeller - Structures
25					6A	Principal Engineer - Structures

Fig. 14 List of employees in WSP Nordic iCRC branch in India (marked red as used resources in case A)

In conclusion, due to a lack of higher grade employee availability. two employees of grade 9A have been assigned to the project, which is roughly categorized into SKOL 6.

4.4 Execution Process

One coordinator from Finland was assigned to help with the actual execution process of modeling and drawing creating. Due to the fact that Bomb shelter is a special structure with a lot of reinforcement and iCRC lack of experience in modeling such a complicated structure.

Therefore, at the beginning of the modeling process, communication, and modification through video chat and OneNote between the coordinator and Tekla modeler are relatively frequent.

the Execution process was divided into the following part with a sequenced timeline

Bomb shelter 2 => structure modelling

Bomb shelter 2 => reinforcement drawing publishing

Bomb shelter 1 => structure modelling

Bomb shelter 1 => reinforcement drawing publishing

Structure modelling

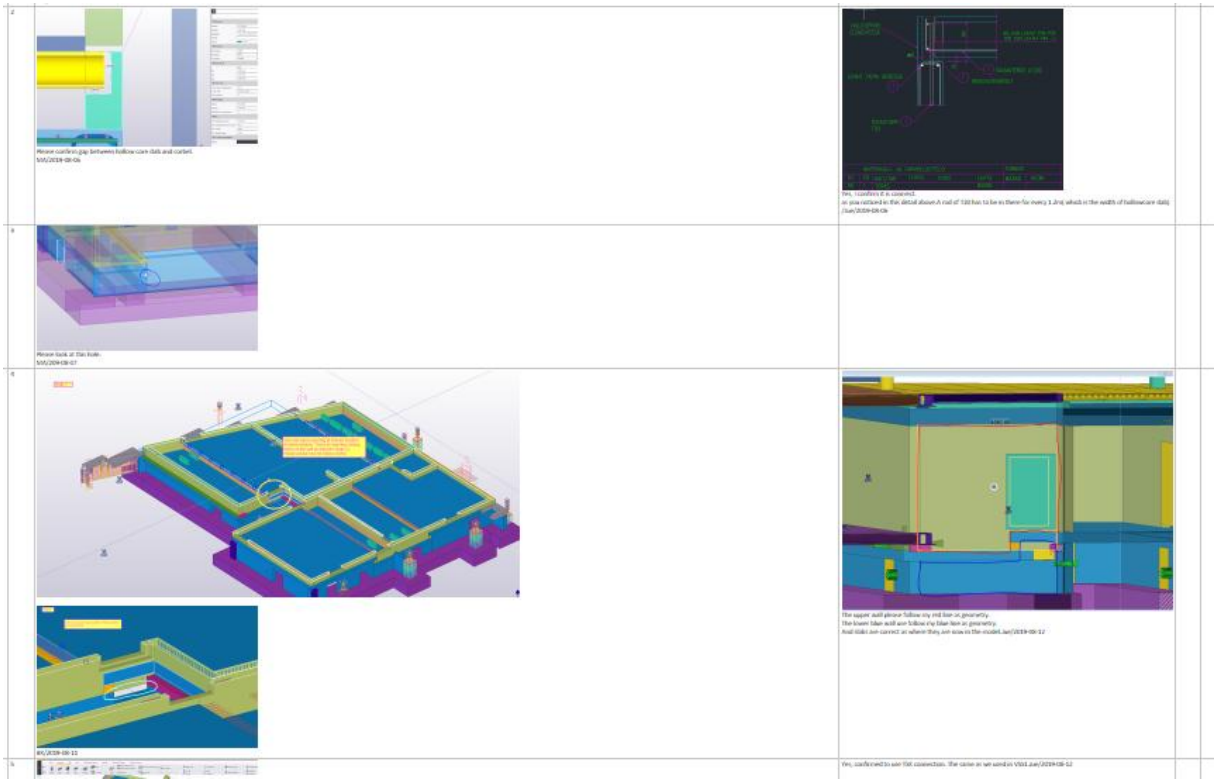

Fig. 15 Example of modelling issue in OneNote (Problem post on left column, solved on right column)

As indicated above, Questions regarding modeling are input to the left side, when bomb shelter 2 started the modeling process, there are almost 20 questions per day that needs to be solved. In addition, the reinforcement modeling is even more complicated and there were too many questions from both of modeler that render OneNote inefficient, skype and audio connection has been used every day for quicker communication and problem-solving.

Reinforcement drawing publishing

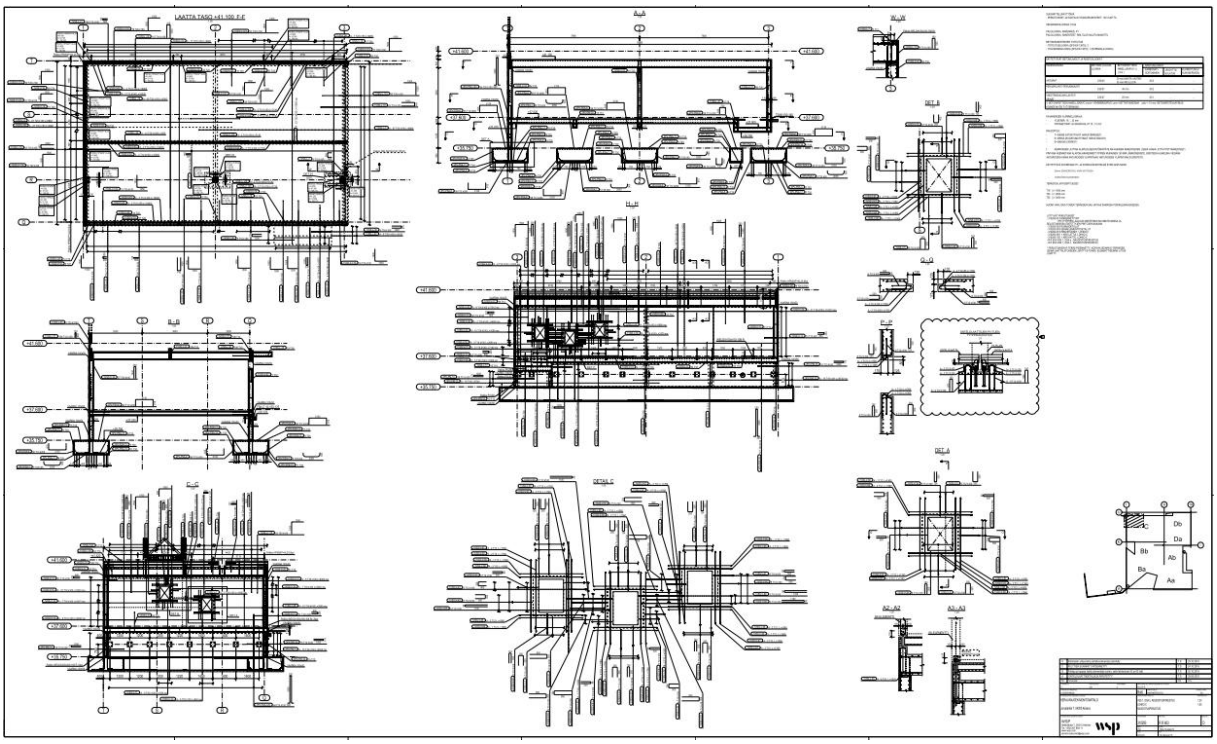

Fig. 16 Example of Reinforcement drawing of bomb shelter

As normally bomb shelter do not have complex geometry to model, nevertheless, it has a massive amount of reinforcement inside of concrete walls and slabs. Therefore, it is relatively difficult to indicate all rebars clearly on a 2D drawing when comparing to other simple objects.

Even more online discussion was held when checking and correcting the drawings, more comments are made, in addition, the drawings need to be in Finnish for all mentioned text since obviously client is Finnish, translation became also one part of the extra workload for the coordinator.

Changes

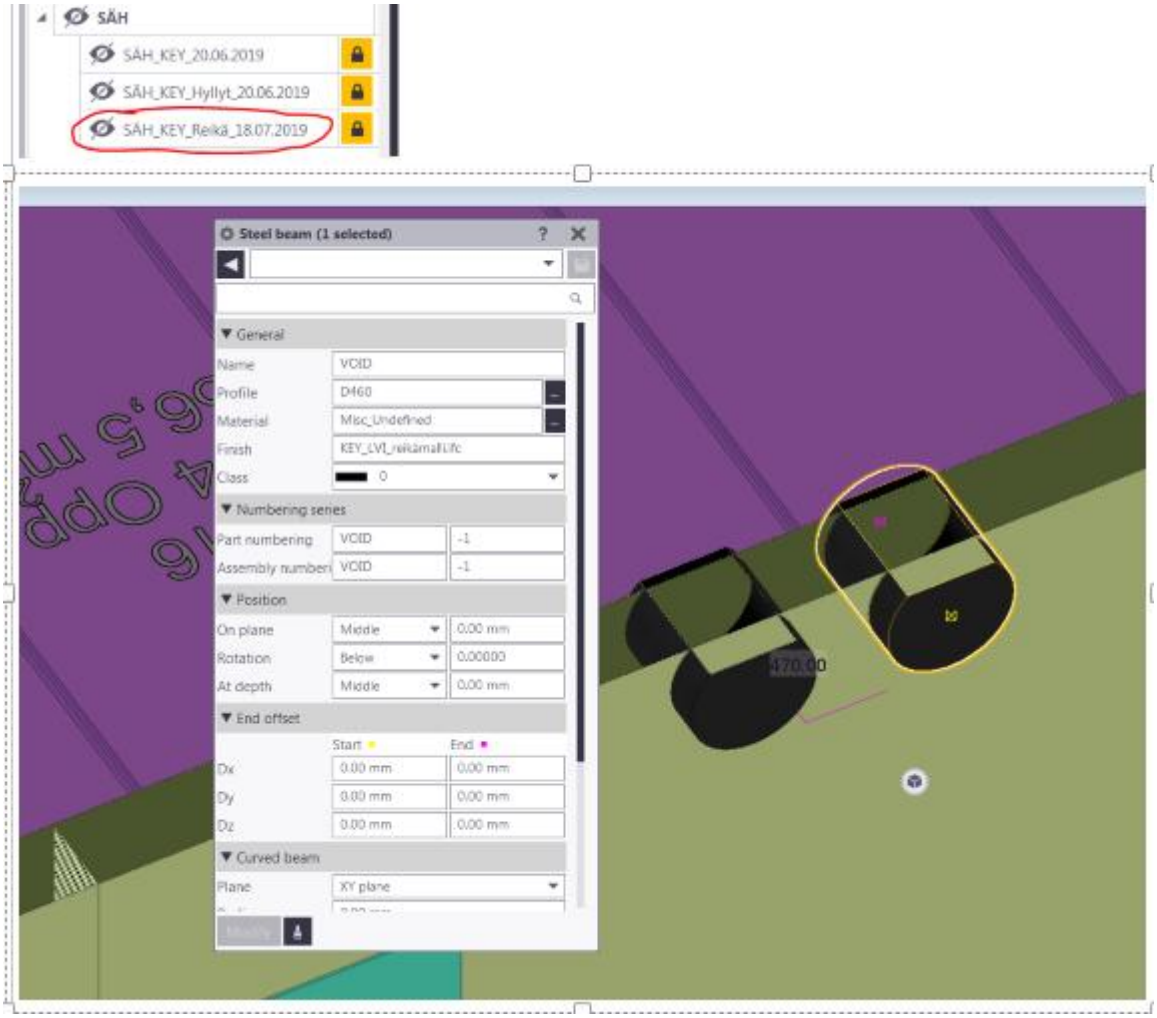

Fig. 17 Example of hole changes

Under perfect circumstances, it would be two weeks job with clear instruction and all information needed, but in the construction field, there is no such thing called perfect.

When modeling both bomb shelters, there are already some openings and holes were in the wrong place, noticed by the modeler, which later proved to be outdated IFC files from HVAC and electric companies.

After received updated new location of openings, revision in modeling and drawings were both made relatively quickly, for two weeks of working and training have already shown positive effects on the cooperation.

4.5 Quality Control

In this project, quality control was done by both parties, one quality drawing checker from iCRC and one coordinator from WSP Finland. No checklist was used. Manual cross-checking of each drawing takes a lot of extra resources on both iCRC and lead country.

5. Case Study B

5.1 Introduction

Case Study A is based on a real project between WSP Finland (as Nordics) and WSP India (As iCRC). The project is located in Helsinki, as one of the new metro station design that served the purpose of client Länsimetro, a government-owned company that concentrates on the metro operation and planning in the Helsinki region, so-called west extension line. The metro is extending west from Matinkylä. A rail line comprising seven kilometers and five new stations are being built on the West Metro's Matinkylä–Kivenlahti section: Finnoo, Kaitaa, Soukka, Espoonlahti, and Kivenlahti.

Many different companies are right now involved with this project for different station designs at the same time, and WSP Finland on board with them to design one of the stations: Finnoo.

Fig. 18 Finnoo Station (Revit Rendered model)

The Finnoo station contains two public ground entrances, two technical entrances, and one fire emergency entrances, as well as the connection tunnels and public platform. According to the contract signed with the client, WSP Finland was assigned to make

the structure design of the whole Finnoo station, the workshop drawings (including both steel assembly and concrete reinforcement drawings) of the whole station.

This contract is such huge both in scales and working hours that WSP Finland surely does not have enough resources to finish the project itself. Hence the possibility of using ICRC was under discussion with the client at the beginning of the project, for such a big governmental project, knowing the background of the resources needs to be verified and checked.

5.2 Negotiation and Zone Distribution

Trial Period

In the early negotiation phase, when the client (Länsimetro) are still doubting about the ability of iCRC, the head of iCRC decided to do a sample drawing for a trial run for zero charges, few iCRC resources working for two weeks to publish the final end product: reinforcement drawing.

the result was astonishing, and the drawing quality satisfied the client, which then bring the project into the next phase, zone distribution.

Since in this project, the area of the design site is relatively large, there are two ways of zone distribution has been used in this case.

- Zone Distribution by entrances (For ground structure)
- Zone Distribution by Grids (For underground structure)

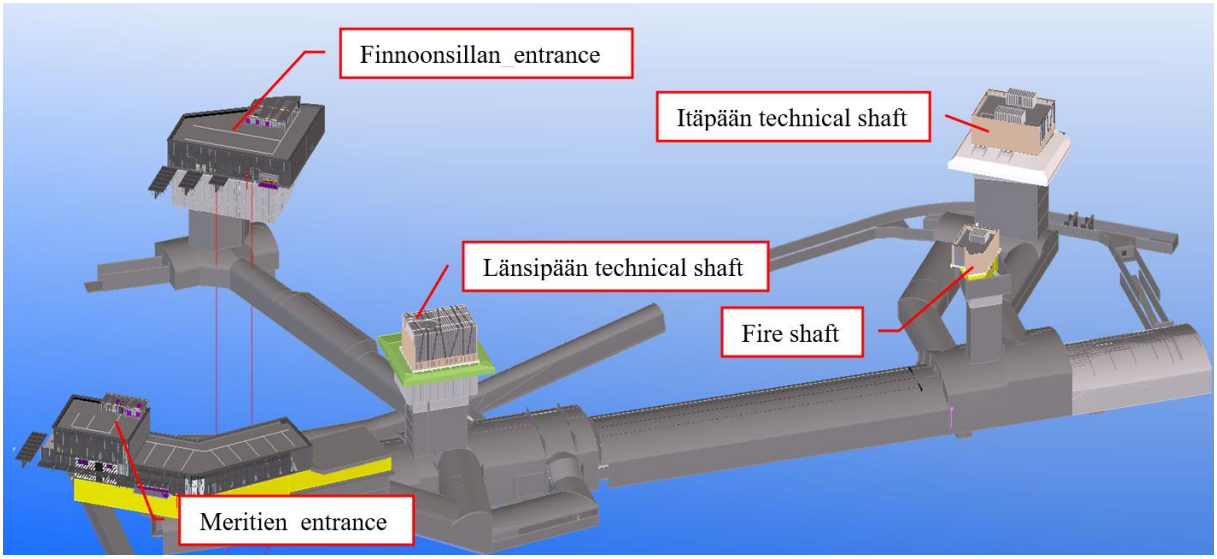

Fig. 19 •Zone Distribution by entrances

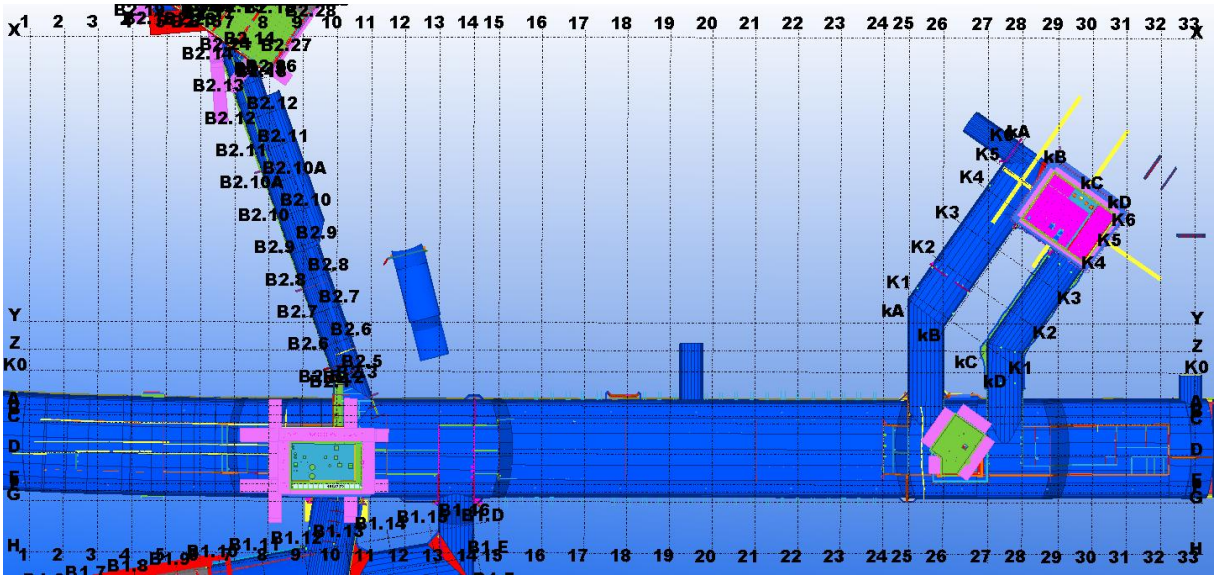

Fig. 20 Zone Distribution by grids

It was considered to be more than 50 designers are working in one Tekla model simultaneously, therefore it is crucial to distribute the zone and marked different phases to avoid/reduce the chance of potential collision.

5.3 Resource Distribution

Sr. No.	EMP ID	Invoice ID (As per India)	Invoice ID (As per Sweden)	Employee Name	Grade	Job Title
1					4A	Head of iCRC Sweden & Finland Building Structures
2					8A	Senior Revit Technician - Structures
3					9A	Tekla Technician - Structures
4					7A	Tekla Coordinator - Structures
5					8A	Senior Revit Modeller - Structures
6					9A	Revit Modeller - Structures
7					7A	Revit Coordinator - Structures
8					8B	Senior Tekla Modeller - Structures
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22					6B	Senior Quality Coordinator - Structures
23					8A	Senior Tekla Technician - Structures
24					9B	Tekla Modeller - Structures
25					6A	Principal Engineer - Structures

Fig. 21 List of employees in WSP Nordic iCRC branch in India (marked red as used resources in case B)

The initial agreed estimated working hours between WSP Finland and iCRC are more than thousands. and certainly, further, hours are also booked for potential changes as the project is supposed to last for more than two years. Therefore, the resource distribution is on a larger scale and more general and flexible to execute when changes come.

As Fig .21 indicates, originally five people will be involved in the project, four Tekla modelers, with relatively higher grade, and one senior quality coordinator, to ensure the end product quality internally before it was sent to WSP Finland. And within the project team, one of the senior Tekla modelers is acting as iCRC project manager internally.

As the project proceeds with schedule, the demand for Tekla modeler peaked in the middle of the project as it expected, ICRC did quick response by re-distributing other resources to this project for a short period, which solved the issue. In general, there are more than 20 different resources have been involved in this project in a different stage of the project. And vice versa, at the end of the project, there are only one or two people from ICRC were still working on it, and other resources have been distributed to another project that WSP Finland did not have to worry about. therefore, the final effective utility rate was promising.

5.4 Execution Process

Structure Modelling

Even with an experienced Tekla modeling technician doing the modeling work, there is still a relatively large amount of detail needed to be discussed and modified according to Finnish regulation and custom. The main modeling process system for such amount of modeling were listed:

1. Tekla Modelling setting and format learning
2. Sample modelled structure made by WSP Finland
3. Testing modelling and checking by WSP Finland
4. Email with list of sequenced questions waiting response Email
5. OneNote question list

6. Archive

At the beginning of the project, the introduction PDF regarding the correct setting and format for Tekla modeling has been sent to iCRC and be given time for iCRC employee to learn from it, any general questions can be answered from PDF, especially for the iCRC local project manager to learn and understand.

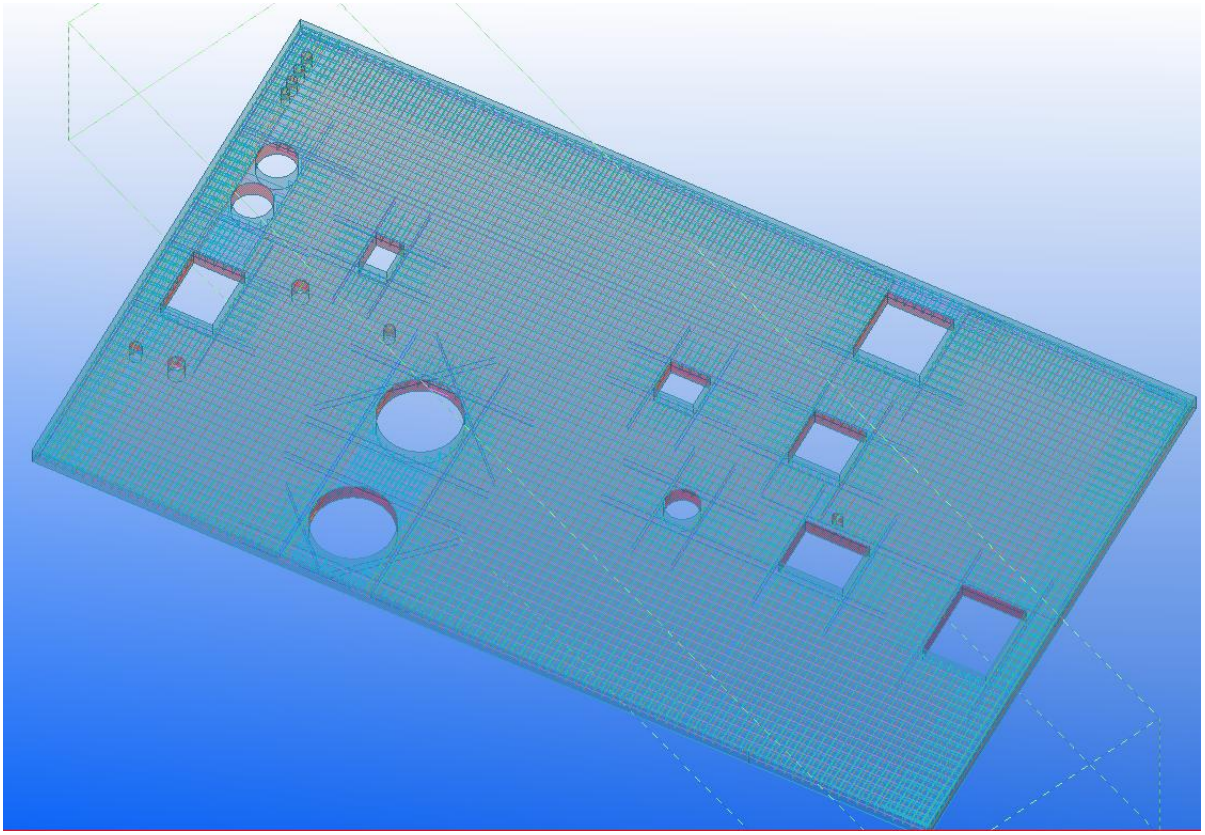


Fig. 22 Sample Modelling Block for Slab

Secondly, as Fig. 21 indicated above, a sample modeling block has been provided in the same Tekla model and shared with iCRC, modeling block including reinforced element wall, slab, column, beam, and connection reinforcement. In addition, a normal structure reinforcement amount has been also provided. For example, without further calculation input, a 300mm thickness slab shall use T16 mesh on both sides.

With all project-specific sample blocks provided, iCRC learned and understood the basic principle so that in the next step, which is the testing modeling phase, they did the testing modeling and inspected by the coordinator.

Thirdly, in the real project model, the location and grid line system has been set, with sample geometry or architecture IFC model been input as a reference model, iCRC

modeler can start the testing modeling for the reinforcement of concrete structures and create new structure according to the IFC model.

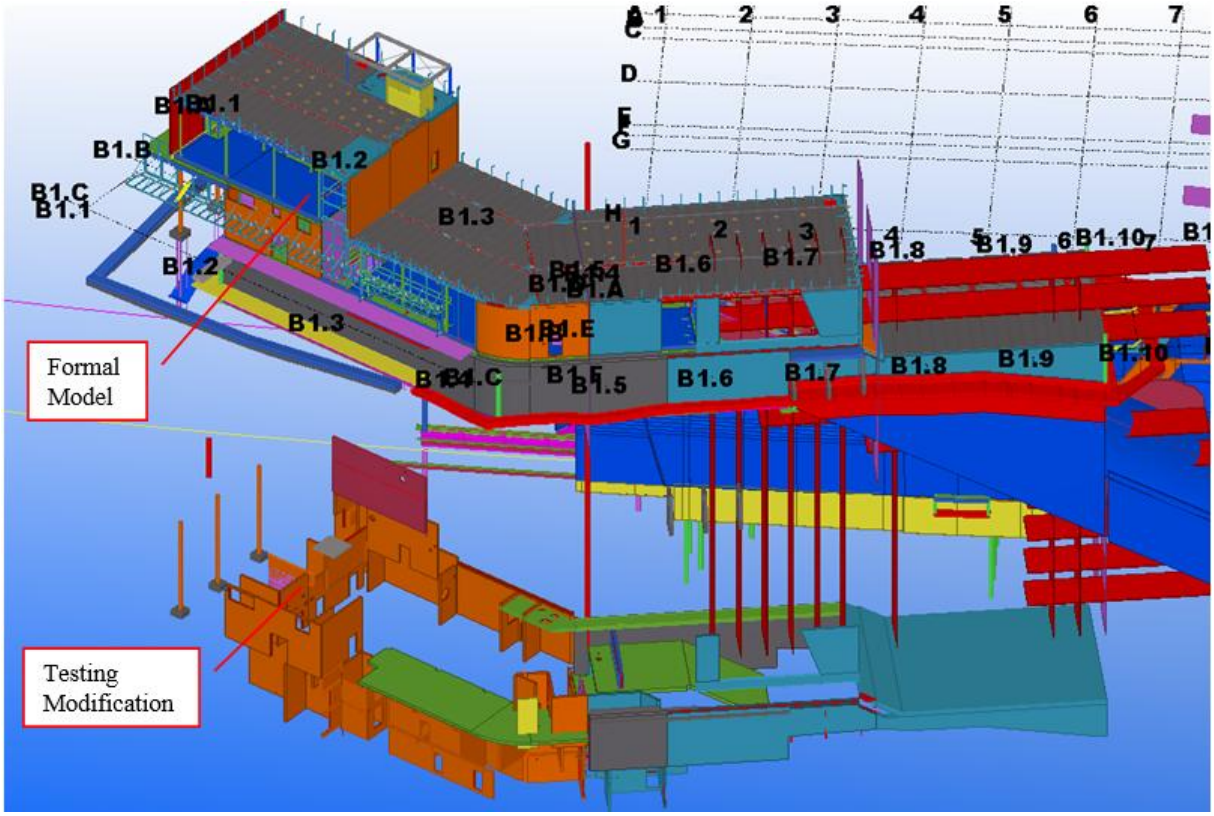


Fig. 23 Testing Model and Formal Model

Furthermore, as Fig. 22 indicated, the testing model created by iCRC is deviated from the correct location in the global Z-direction by purpose. to avoid any future potential collision or numbering issues, the testing model is modeled strictly according to instruction by using different class, phase, and prefix for marking differences.

The rest of the procedures regarding modeling mostly appeared in the changes/modification stage.

Workshop Drawing Publishing

Different types of sample drawings also provided standard wall reinforcement drawing, slab reinforcement drawing, and steel general arrangement drawing. In this case, ICRC team members are already quite familiar with the Finnish language and the way of Finnish workshop drawing standard.

The standard drawing publishing process is listed below:

1. Receive order of drawings based on client priority
2. Agreed on the deadline

3. upload the drawings by file folder as packages to public intranet folder
4. Inspection internally by WSP Finland
5. Modification
6. Drawing uploaded to client approved cloud server for third party inspection
7. Approved

If it is not approved by a third party, the drawing package will go back to procedure 5 and repeat until it is approved.

Changes

Since this project is one of the biggest single project WSP Finland taken part with dozen other companies which responsible for architectural design, HVAC design, Electrical design, a lot of data and BIM model exchange has been done all the time through a client cloud platform, therefore the number of changes in this project is massive and size of changes can be also huge.

When comes to the structure design, WSP Finland and ICRC are always waiting for the new updated pipe BIM model and architecture model. There are two types of changes, the smaller changes within the contract deviation percentage. the other one is the contractor site changes which may lead to massive design change or re-design, and contractor site changes require new side cost estimation with contract and agreement.

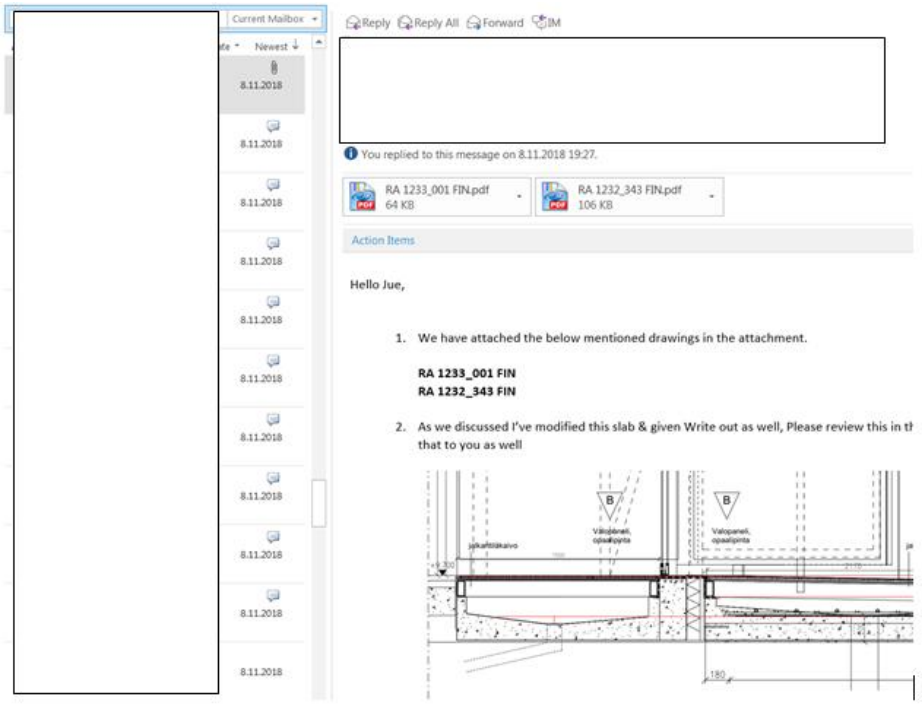
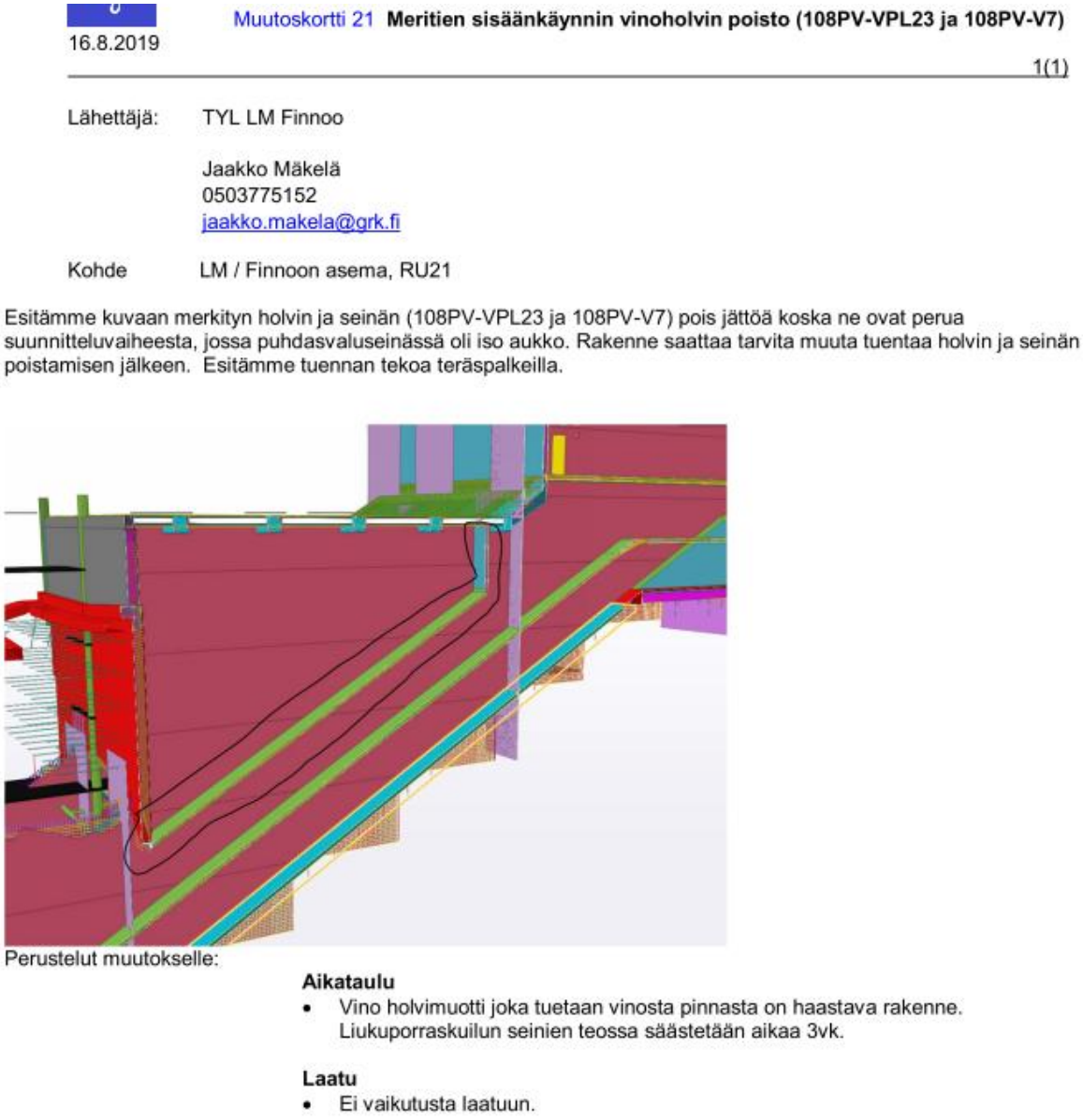


Fig. 24 Example of change solving by Email

In the beginning stage, for smaller changes, as it indicated in Fig. 24, Email communication was used, however later it turns out even for one simple change, it would take dozens of Emails back and forth between WSP Finland and ICRC to solve it, which would cause seriously overflow of each participant's Email boxes. Therefore, it has been soon changed to the OneNote system as a communication method for changes and keeping a record.

For bigger changes, it usually comes from the site contractor when unexpected things happen, or the design cannot be achieved in the real world due to limited resources or period. Therefore, structural changes or re-design partially the structure would be necessary.



16.8.2019

Muutoskortti 21 **Meritien sisäänkäynnin vinoholvin poisto (108PV-VPL23 ja 108PV-V7)**

1(1)

Lähettäjä: TYL LM Finnoo

Jaakko Mäkelä
0503775152
jaakko.makela@grk.fi

Kohde LM / Finnoon asema, RU21

Esitämme kuvaan merkityn holvin ja seinän (108PV-VPL23 ja 108PV-V7) pois jättöä koska ne ovat perua suunnitteluvaiheesta, jossa puhdasvaluseinässä oli iso aukko. Rakenne saattaa tarvita muuta tuentaa holvin ja seinän poistamisen jälkeen. Esitämme tuennan tekoa teräspalkeilla.

Perustelut muutokselle:

Aikataulu

- Vino holvimuotti joka tuetaan vinosta pinnasta on haastava rakenne. Liukuporraskuilun seinien teossa säästetään aikaa 3vk.

Laatu

- Ei vaikutusta laatuun.

Fig. 25 Example of changes for re-design from contractor

From above Fig. 25, the contractor is given the location for the proposal of re-design, and it listed the cost comparison between original design and re-design, the reason for a contractor doing this proposal is mainly the original design will cost much more than the re-design proposal, even with the re-design consulting fee.

In this case, the consulting company which is WSP Finland will evaluate and calculate the possibility of this proposal, if it possible technically, then WSP Finland will grant green light to this change and inform all related companies, which including ICRC, for making the change in the model and updated relevant workshop drawings.

5.5 Quality Control

As the final product from iCRC are mainly workshop drawings, the procedure for quality control is process 4-7 from drawing publishing sequence.

Before the final drawings have been checked by WSP Finland, internal checking from iCRC senior quality coordinator or project manager has already been done. Then it flows to process 4 and 5:

4. Inspection internally by WSP Finland
5. Modification

the checked drawings will be uploaded as one package, usually named by date, to the WSP internal public folder for the WSP Finland coordinator to check, mainly for drawing format and Finnish text. The comments will be left on each drawing and marked as drawing commented, for iCRC to do the modification. These two processes are the circle process until the drawings are inspected to be no error.

Process 6:

Drawing uploaded to client approved cloud server for third party inspection, within this project, the third-party quality coordinator is a senior expert. All drawings have been uploaded again to an external cloud platform client provided, which every other company can check and download.

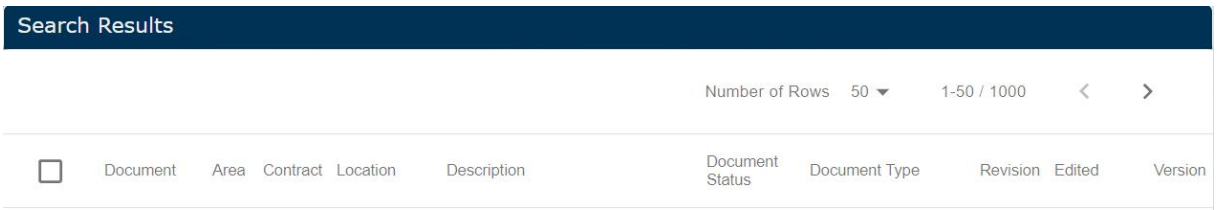


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Fig. 26 Example of list drawings in cloud platform

The status of the drawing can be seen, it would be waiting for acceptance, accepted, waiting for review, and not accepted. Only the third-party quality coordinator has the right to mark on the drawing status. In addition, the revision/version mark and edited time are also showing in the platform for a clear understanding of drawing.

Finally, in process 7, after the drawing is showing accepted in the platform, can the drawing be allowed to be seen by the site contractor, which did the actual construction work based on printed our drawing from this platform.

And to be noticed that even drawings which are in contractor's hand, doesn't mean it will be the final product, in many cases within this project, the contractor also did find some mistake or unrealistic part for the site to operate, which leads to the bigger change.

When it happens, for change related drawing will follow the process again to be up-dated and revised.

6. Case Study C

6.1 Introduction

This case study example project was located in Gothenburg, Sweden. Förlossning och Neonatal (FoN). FoN is a new hospital building to be built in Gothenburg.

Input is structural sketches in the Tekla model, Assignment for iCRC is to model the reinforcement for the foundation and bottom slab of the building. and create reinforcement drawings for these concrete structures.

The project itself is big in scales, however, the assigned task for iCRC is relatively small, roughly estimated working hour is 190h based on initial PRF. In addition, the task time span is also short, the client wishes it to end within 20 days if there is no revision or changes.

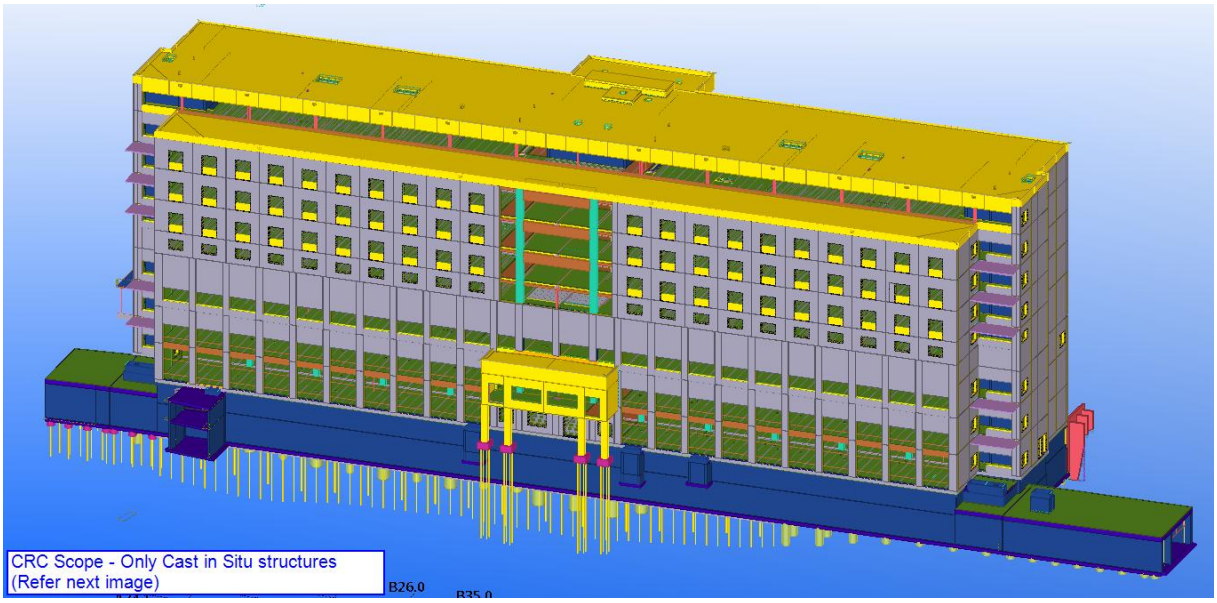


Fig. 27 Example of Tekla model of project building and CRC scope

6.2 Zone Distribution

It was agreed that the cast in situ structures is in the scope of iCRC, which including the concrete foundation and base floor slab, reinforced columns, and related walls. These structures require a lot of customized design that takes time to model and publish drawing out of it. The above-precast elements are relatively simple and easy to

duplicate, therefore iCRC was assigned to this task. Which on one hand, it also shows the confidence of the client and WSP Sweden has in iCRC.

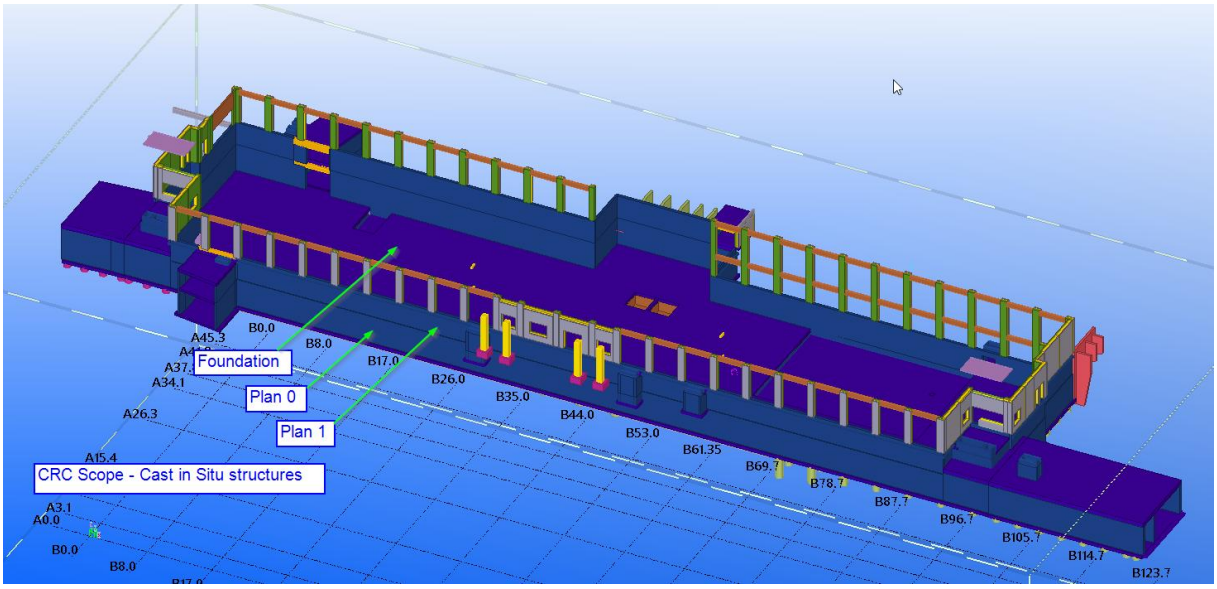


Fig. 28 CRC scope, cast in Situ structures

6.3 Execution Process

Structure Modelling

At the beginning of the execution process, iCRC sends the checklist to WSP Sweden, as a reminder to remind what documents and input that WSP Sweden has to provide or provide as much as possible. which so-called project startup meeting checklist. The main point for checking before starting the project would be:

1. Brief description of project, Software, Service pack
2. OneNote
3. Level of Detailing(LOD); Time frame/Delivery date
4. Model setup, if not, when and who?
5. Elements need to be modelled
6. Sample drawing and other available input
7. Weekly progress meeting and budget for CRC?
8. Any changes expected or specific standard within the project?
9. Link to common folder for upload documents

All these mentioned points were answered and checked by WSP Sweden, therefore it is straightforward for iCRC to know what is provided and what is missing in one paper.

When these mentioned documents were provided by Sweden, the online share file AU was used to store these inputs and outputs. As the input can be many different categories and sometimes it is hard to find the necessary ones that iCRC is looking for. In this case, C, WSP Sweden has used a special tool to help iCRC.

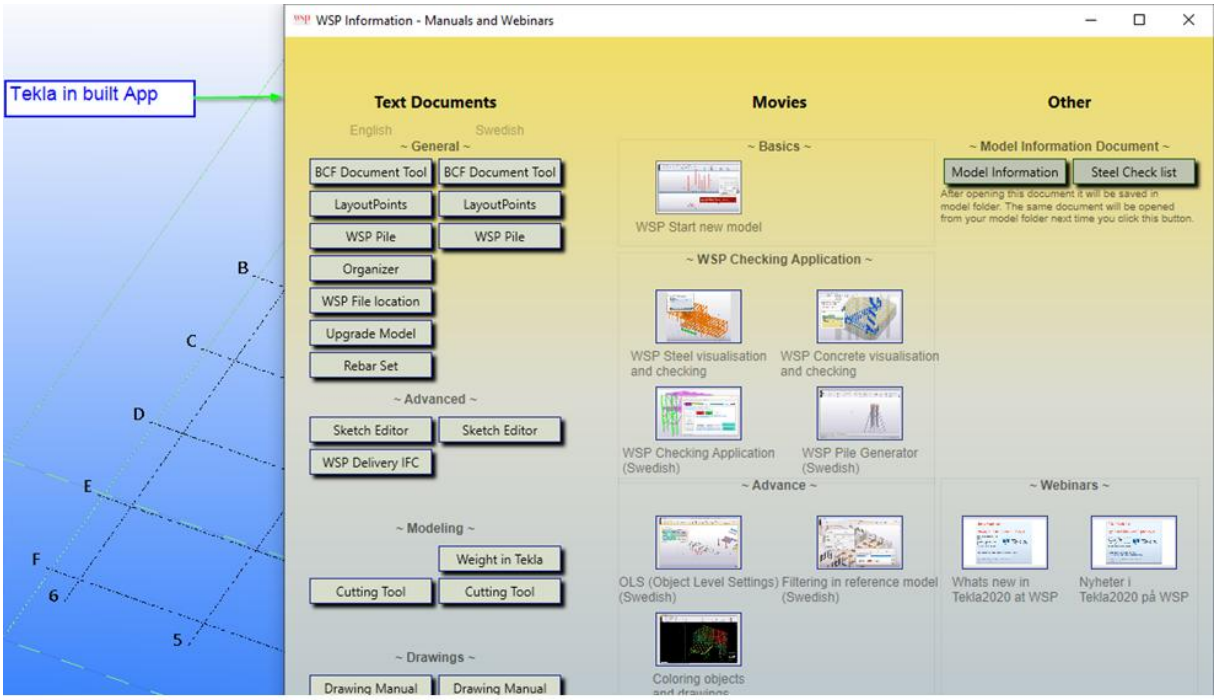


Fig. 29 Example of WSP Sweden Tekla in-built App

Given that the majority of iCRC work will be done within Tekla. Therefore, this in-built Tekla app which can be easily seen and checked by iCRC employee, within this app, all documents can be found regarding modeling issues, checking issues, and drawing requirements. also, this App is constantly improving to fit each project-specific. Which save the time for iCRC to look for different document save in multi-locations that is too chaotic to find it.

Changes

The main changes are documented in OneNote, however, in this Swedish case, the client demand to use new software called BlueBeam.

BlueBeam is a software can be used for better communication between all parties within the project, it is a cloud platform which uses such as architect, engineer, contractors, superintendents, and owner can upload, download and inspect all kind of files online instantly.

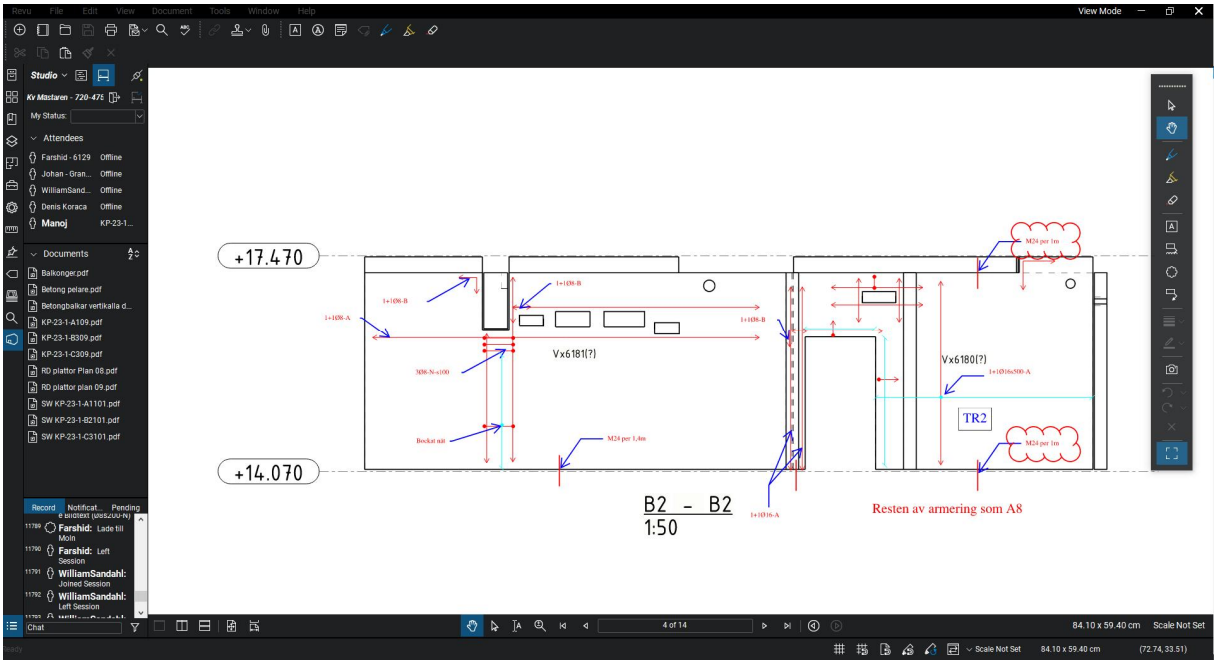


Fig. 30 Example of BlueBeam drawing checking within case C

Through BlueBeam, each drawing is uploaded to this platform, and be checked by all related parties online, when changes appear, these drawings were changed status from approved to not approved, and waiting for revision, the changes were marked as comments and added cloud for iCRC to see and check, make the advised update and upload the revised drawing to the platform.

Comparing to OneNote, this software is more automatic and systematically, for OneNote is still heavily reply on the coordinator to document everything manually, if the project is on large scale and there is more than one coordinator or editor, there also could be missing input and dis-coordination.

With BlueBeam, each companies' employee has its role and corresponding level of authority.

6.4 Quality Control

Within this case project, as limited hours can be allocated, there is no luxury to have one expert who only does the quality checking internally within iCRC, therefore for such a small project, WSP Sweden has developed another checklist for modelers themselves to check before it was sent to WSP Sweden for checking.

SE006-Reinforcement Checklist

Project Number		**Project Name**	
Task Number		**Drawing/Model Number**	
Drawing/Model Status		**Date**	
Points For Checking		**Checked (Yes/No)**	**Notes**
	General		
1	Software Version		
2	Input Details		
3	Concrete/Steel Grade		
4	Bar Diameter/ spacing/ number of bars matching with Input		
5	Bar shape is correct (A, B, C etc.)		
6	Lap and Anchorage length		
7	Bars arrangement is matching with Input/Std. Library		
8	Cover to Reinforcement (Top, Bottom and Sides)		
9	Closing and additional bars around openings, recesses etc.		
10	Bending radius		
11	Maximum bar length		
12	Clash check done as appropriate		
	Mesh Reinforcement		
1	Mesh Grade / Class / Type		
2	Mesh Schedule and Callouts		
3	Check mesh around openings and recesses		

Fig. 31 Example of reinforcement quality checklist

The above figure only indicates one of the checklists for checking reinforcement modeling, such a checklist allows every project modeler in iCRC to first self-check the modeling and the drawing issues, without the additional help or existence of a quality inspector. This not only saves the internal cost of hiring another employee but also improve the employee's self-awareness of finding mistakes and increased their ability as well as efficiency, due to one less layer of communication. In addition, it also benefits the project and employee self-gain in a long period of time.

7. Feedback and Problems

7.1 Feedback for iCRC

iCRC has conducted an online feedback system so-called i360 for the client to review and share the comments based on project experiences. Starting from 2017, the online survey platform has sent 7553 surveys and 4920 has been responded to by the client or so-called lead countries globally from WSP companies.

Since iCRC has been involved deeply and widely in this filed, which including mainly five business unit: Business Support, Environment, Industrial and Energy, Infrastructure, Property/Buildings.

Within this thesis, the main business unit under discussion will be mostly on Property and Buildings, or more precisely, on the building services and building structures as two sub aspects.

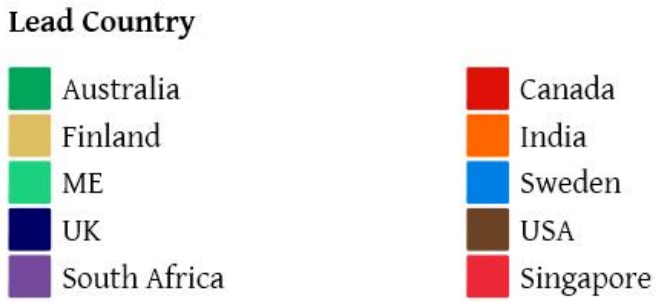


Fig. 32 Color of Lead Countries

As the below circle indicated, the most inner circle stands for the main aspects, and the black color stands for Property and Building, the middle circle stands for two sub aspects, one darker blue for building services and the other light blue for building structures. the most outer circle stands for lead countries' number of the ratio which response to the survey.

Building services mainly including the internal design of the building, electrical design, HVAC design, and so on, while the Building Structure focuses on building BIM model modeling for the structural part and corresponding workshop drawings making.

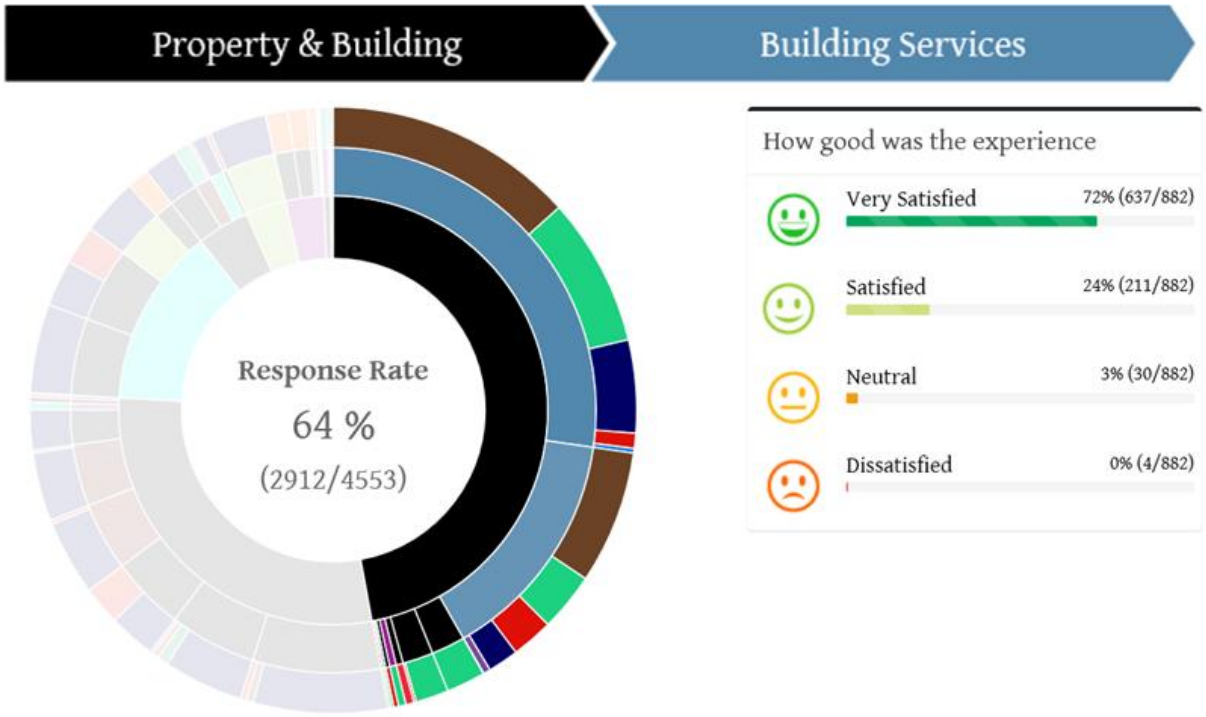


Fig. 33 Satisfactory Survey of Building Services from 2019-2020 For iCRC

As Fig 32 demonstrated, the ratio between Building Services and Building Structure is relatively even, in terms of response rate. For the satisfactory rate, it was calculated by the average percentage of all countries, which gives the number of 72% out of 882 for very satisfied, this positive number would indicate the high possibility and willingness of client hiring iCRC for a future project.

The percentage of satisfied is 24% out 882, this would imply that 24% of lead countries(clients) are feeling okay to use the services of iCRC as a supplementary way of increasing resources, but will not consider it as a way for a higher profit or gain any extra efficiency out of it. Therefore, these cases are going to be the passive acceptance of the involvement of iCRC in the future.

The percentage of neutral is 3% out 882, even though it says neutral, however to some extent, it is rather a polite way of rejection. This would imply the cooperation project between iCRC and lead countries didn't reach the expectation in many ways, for example, in some comments left by these neutral responses mentioned that the agreed profit or time limitation was not fulfilled as it promised. These cases will most likely reject any future involvement of iCRC.

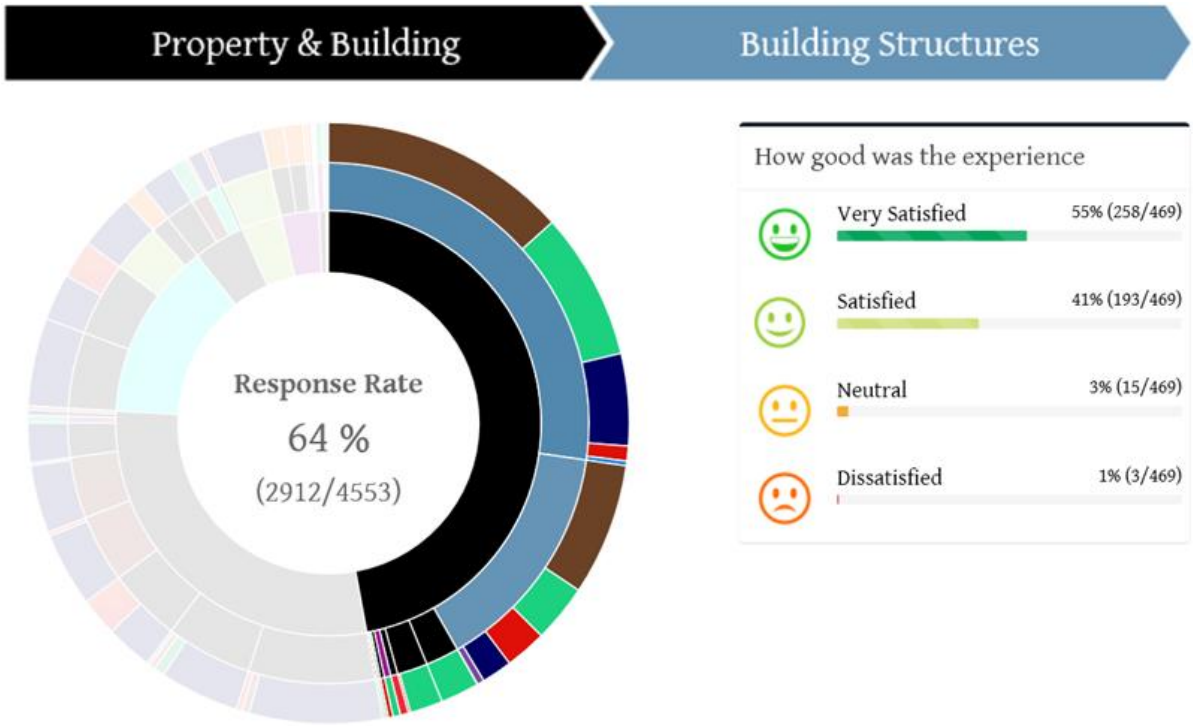


Fig. 34 Satisfactory Survey of Building Structures from 2019-2020 For iCRC

The last 1% of dissatisfied can result in only total rejection of iCRC, which represent that the cooperation ended with project failure or with negative profit and it exceeds the time limitation, which all leads to bad reputation on the lead countries the upper level of client and jeopardize the relationship between WSP company as a whole to another external public client. For the previous three attitudes towards iCRC can still be contained inside of WSP company internally, while the last unsatisfied demonstrate external public client lack of trust toward WSP.

By comparing Fig 32 and Fig 33, there is a relatively obvious drop in the satisfactory rate, which can be comprehended by Building Structure is a bit more complicated to communicated and coordinate comparing to Building Services. Building Structure is only one part of the building system which relies heavily on coordination with other related professional companies located in lead countries.

Building Structure usually involves the heavy use of BIM modeling software Tekla, depending on the level of detail, to fully and correctly understand the client's way of thinking and demand, the work load on the communication and design can be rough. especially when there is a lack of automatic system, and mostly the responsibility falls into a good iCRC local project manager and a professional lead country coordinator.

In the comments of neutral satisfactory for building Structure, the inconsistency of quality was mentioned.

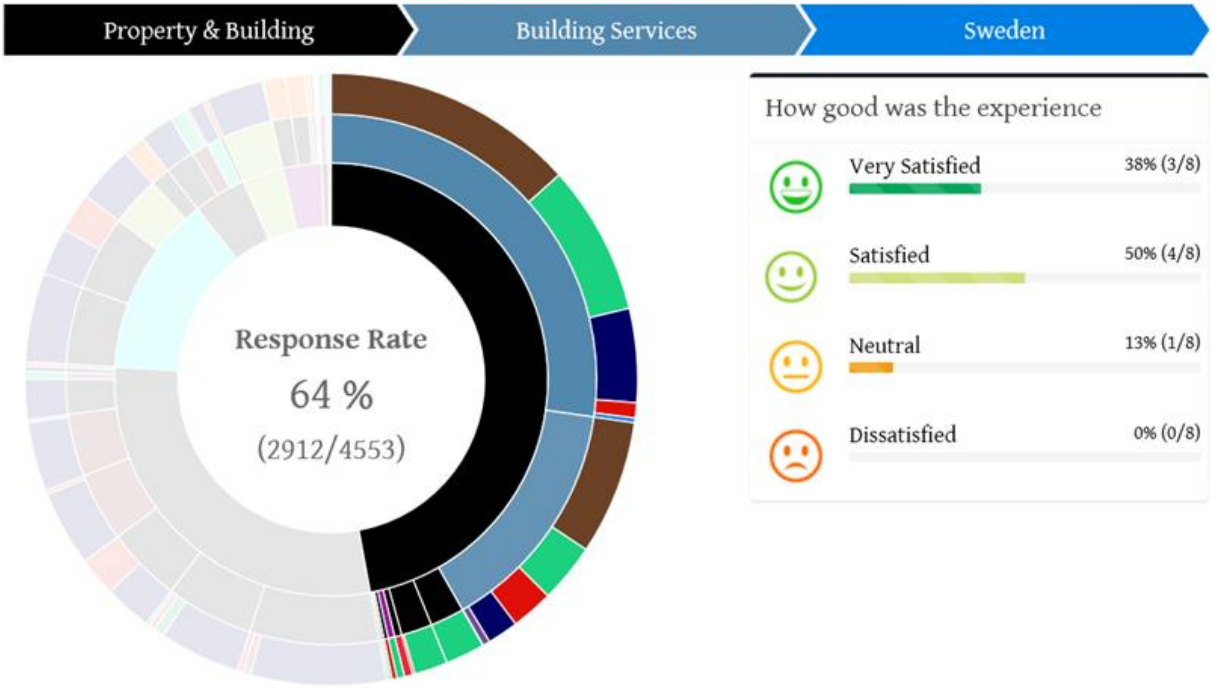


Fig. 35 Satisfactory Survey of Building Services from 2019-2020 Sweden For iCRC

From Fig. 34, it is obvious that when comparing the different countries, Sweden as one of the Nordic countries has a lower satisfactory rate than other countries. One of the main reasons could be the majority of other countries or regions, for example, UK or ME (Middle East) are all using English as mother tongue, at the moment the only non-English speaking countries on the list are all Nordic countries which including Sweden and Finland.

Therefore, the communication can be difficult in terms of language issues, most of the input data provided by Sweden and Finland also needs extra translation by the coordinator for iCRC to be utilized, and vice versa, the final product workshop drawings also needs to be translated into Swedish or Finnish for the client to publish and utilize.

Thus, the reason for the percentage of satisfaction is as high as 50%, higher time cost leads to the passive attitude of utilizing iCRC. However, the unsatisfied rate is 0%, which means there is no project or case that the failure of iCRC leads to the failure of the project. There is still huge potential for the Nordic countries yet to be developed.

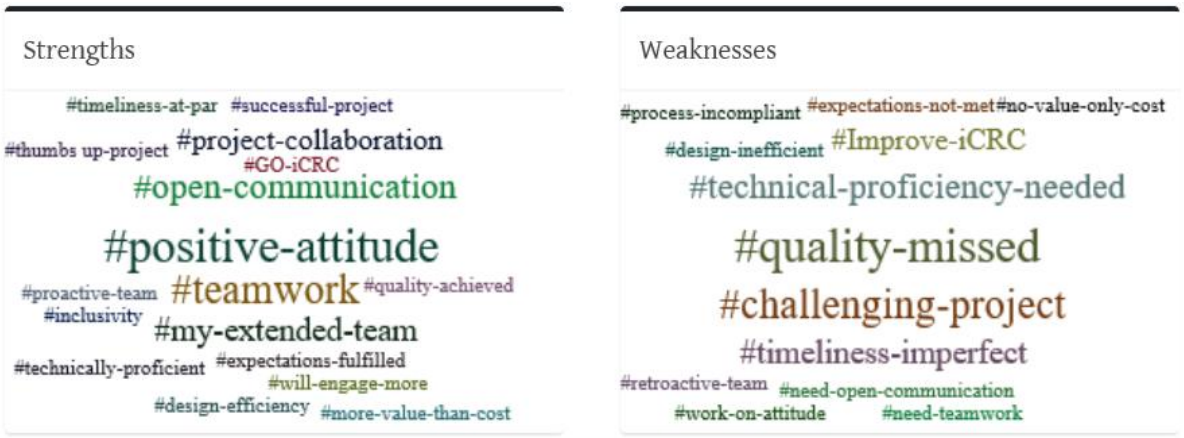


Fig. 36 Most scored comments for Strengths and Weaknesses of iCRC

As Fig. 35 indicated, as bigger as the size of the font, the more importance and priority should be a focus on.

Strength:

- Positive-Attitude
- Team Work
- Open-Communication
- Project-Collaboration

Weakness:

- Quality-Missed
- Challenging Project
- Technical-Proficiency-Needed
- Timeliness-Imperfect

As a summary of comments given to iCRC, when given certain tasks, iCRC employee will do its best to accomplish it as soon as possible, to leave a good impression on the client, and due to this reason, there are many things were supposed to but not taken into consideration during the execution process, sometimes which leads to below expectation quality to the client.

Despite the teamwork and open communication, iCRC still lacks pro-active coordination regarding details or difficulties encountered in the project. Quite often they seek to solve the problem by themselves without informing it to the coordinator.

In addition, a lack of technical proficiency is also one key factor that may directly lead to errors and mistakes in the project. This can be solved by proper training and samples provided by the lead countries for an employee to learn.

Summarized solution based on weakness:

- Quality-Missed
  => Better open communication with coordinator, frequent discussion
- Challenging Project
  => Better open communication with coordinator, frequent discussion
- Technical-Proficiency-Needed
  => Project specific training and sample provided by lead country
- Timeliness-Imperfect
  => Reasonable timeline provided, margin of error provided, Over-time work enable

7.2 Feedback from iCRC

In the i360 platform, there is also feedback from iCRC to lead countries regarding the projects it worked with. Also indicated as a satisfactory rate, but the focus area should be the commentary.

Fig. 37 Experience shared by iCRC

Comparing to thousands of responses from lead countries over thousands of projects, iCRC only shared their experience working with lead countries with 56 of them, the response rate is extremely low. In addition, unsurprisingly, the satisfaction rate for lead countries are high, for there is 0% for neutral and dissatisfied opinion, and the very satisfying rate is as high as 86%.

The reason for this high satisfied rate is the same as being polite and out of courtesy, and due to cultural reasons, this factor has been amplified while iCRC would like to show this satisfied altitude to the lead countries as a client.

Therefore, to get a closer real opinion on what iCRC really comments on lead countries during the cooperation of the project. It is best to check the strength and weakness.

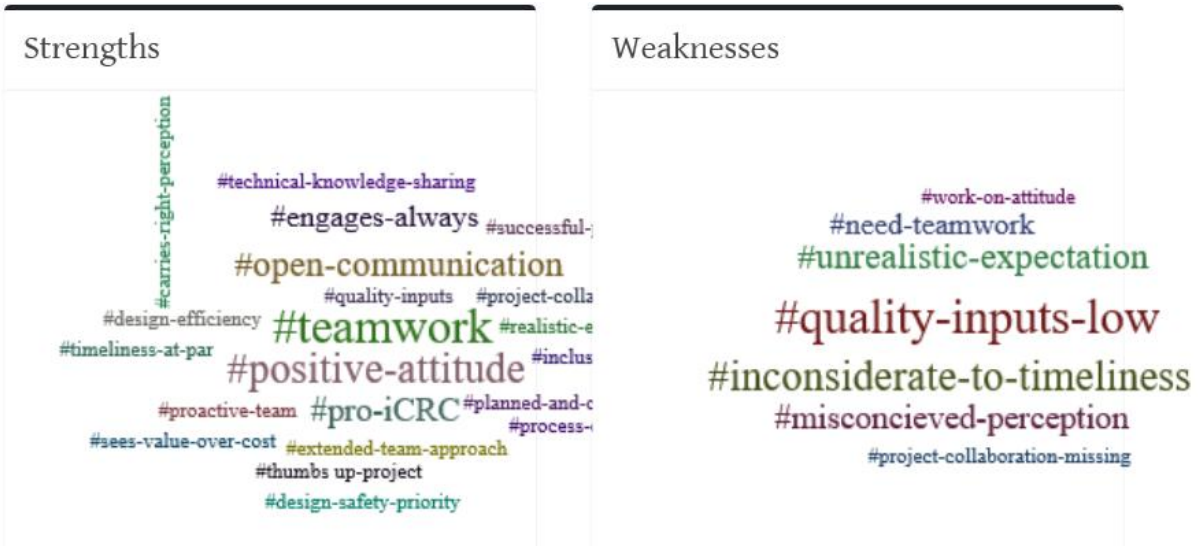


Fig. 38 Most scored comments for Strengths and Weaknesses of lead countries

Strength:

- Positive-Attitude
- Team Work
- Open-Communication
- Engages-Always

Weakness:

- Quality-Inputs-Low
- Inconsiderate-To-Timeliness
- Unrealistic-Expectation
- Misconceived-Perception

Noticeable, the strength mentioned for lead countries are almost identical comparing to the strength for iCRC, which is a good sign of showing the very strong intention of getting the project done on both parties (iCRC and lead countries)

However, the key lays in how to communicate efficiently, it is not achieved by constantly random skype call or Email bombing, but by agreed regular meetings and systematically documenting and exchange problems and solutions by both parties.

For the weakness part, the first one would be quality input low, which means when the project started, the input data are not always there or missing, so it is hard to really start work while not knowing what the client's real intention and requirements.

As the second weakness, timeliness is inconsiderate, this corresponding to the iCRC weakness mentioned by lead countries as timeliness imperfect. this indicating the direct conflicts about timeliness. On the one hand, iCRC needs to work on efficiency issues and it also depends on the technical skill levels of the employee. On the other hand, lead countries to need to understand the full capacity of iCRC and estimate the iCRC project time more reasonable.

In some rare cases, without fully understanding the capacity of chosen resources abilities, lead countries would set the expectation too high that can only be achieved if iCRC putting more resources and profit margin went negative figures.

Summarized solution based on weakness:

- Quality-Missed
  => Better open communication with coordinator, frequent discussion
- Challenging Project
  => Better open communication with coordinator, frequent discussion
- Technical-Proficiency-Needed
  => Project specific training and sample provided by lead country
- Timeliness-Imperfect
  => Reasonable timeline provided, margin of error provided, Over-time work enable

8. Solution

8.1 Project Initialization

From case studies mentioned before and feedback from both iCRC and other countries, the Initialization of a Project plays an important role in the success of the project.

Therefore, two sets of starter kits will be used for the initialization of the project, both being used by iCRC and lead countries. The size of the project (estimated working hours) will determine which set of the starter kit will be applied, one for a smaller project and the other one for the bigger project.

8.1.1 Starter kits for Small Project

The small project does not necessarily mean the budget is small in number, it also includes the projects which are urgent and client-first priority is to get things done, therefore in these kinds of case, speed/efficiency is the key to satisfy the client.

within the Starter kits for Small Project:

1. PRF
2. FI001-Project-Startup-Meeting-Checklist
3. Simplified OneNote
4. Finnish Drawing Manuals

PRF will be the foundation stone for the project, it is already being used in projects, usually, it will be filled and signed by both iCRC and lead countries, in one A4 paper format. which indicating the estimated working hours, clients' demand, and time limitation.

FI001-Project-Startup-Meeting-Checklist will be filled by lead countries, as the list is mainly for lead countries to prepare the necessary input data for iCRC. The list contains the following questions to be checked.

1	Brief description about the Project
2	Software ,Version, Service pack, Build No. etc.
3	OneNote ready? If not when?

4	Existing structure/New structure?
5	Purpose of the Model (If existing building)
6	What is the Level Of Detailing (LOD)
7	Time Frame/Delivery dates task wise
8	Model setup done? If not who will setup?
	- Numbering series, Phases?
	- Worksets, Partitions?
9	Deliverables Required
	- 3D Model
	- Drawing Sheets (GA and RC Drawing)
	- Bar Bending Schedule and which format
	- Erection drawings for steel?
	- IFC or other type of model delivery?
10	Elements need to be modelled/not be modelled
	- Structural Elements
	- Reinforcement
	- Architectural Elements
	- Wooden Roof
	- Façade
	- Stairs
	- Wall Layers separate or Single layer
	- Slab Layers separate or Single layer
11	Sample Drawing, Finland or CRC provides?
12	Available Input (PDF/CAD/IFC/Point cloud)
13	Weekly progress meeting required? (Day and Time)
14	Budget for CRC? or CRC will provide the estimate?
15	Any specific standard other than WSP standard?
16	Any Changes expected in the Project ?
17	Project link in platform (To upload the documents)

It takes a few minutes to finish this checklist by lead countries, to determine what needs to be added or what is missing, iCRC could check this checklist and demand for it. Comparing to PRF or OneNote, this checklist will be easier to read and clear for anyone who is searching for basic information about the project and how the project should have been done.

As for simplified OneNote, it will have limited subpages only concerning the most important information for the project. Usually, for small projects, iCRC involvement is not from the beginning of the project, rather in the middle of the end of the project or when the project hit some serious bump and iCRC ability is needed. In these cases, the OneNote for the project is made already. And there is no need to create a new OneNote just for part of the project where iCRC starts to involve.

Therefore, only adding two subpages based on the original OneNote would be sufficient.

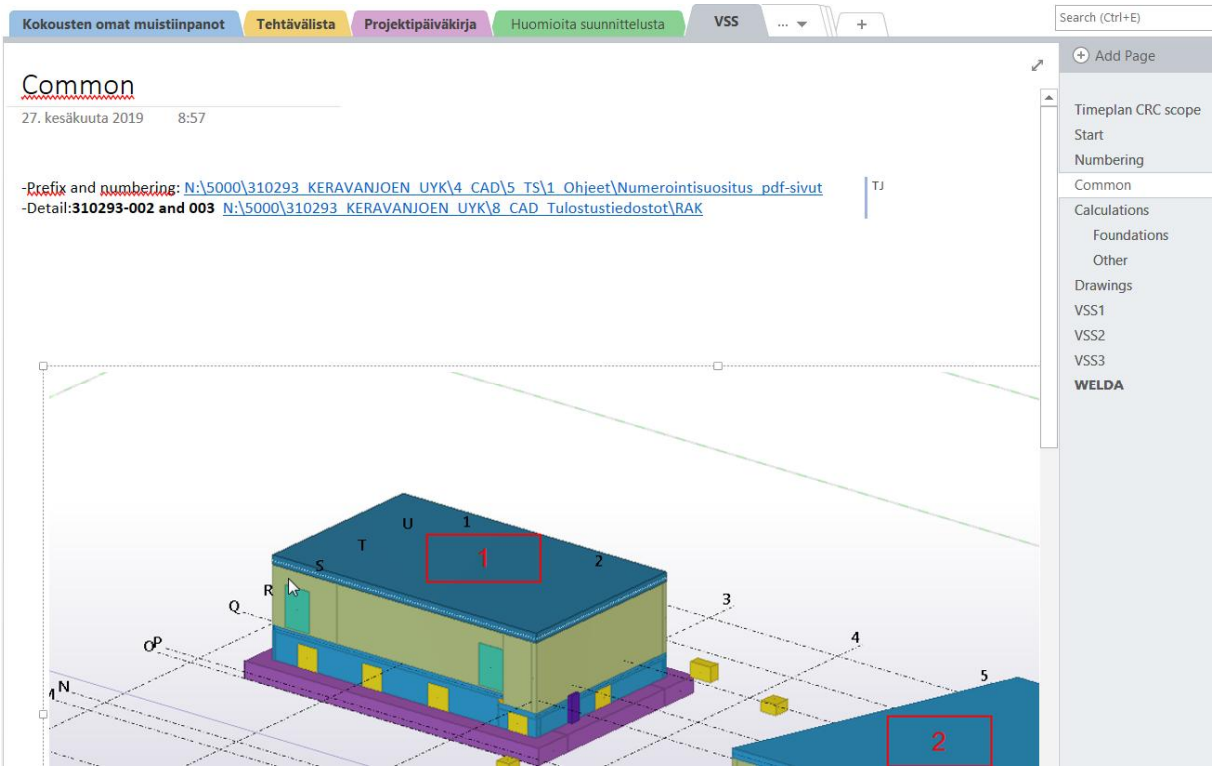


Fig. 39 Example of CRC OneNote Subpage One

As the Fig.38 example indicated, the first subpage will be named as the area iCRC will be working with, within this subpage, there are the pages regarding about CRC time plan, scope, and then comes with technical issues within Tekla, which including start numbering, prefix, link to some categorification. and then the calculation input where

iCRC could check and understand the process behind the modeling. At the end of this subpage is the requirement for drawings or the link to sample drawings if existing.

The second subpage normally only contains Q and A, representing the communication part between iCRC and leading countries. As it explained before, this page will document all potential future changes and discussion in the form of picture and text, sequenced by timeline, usually in month or week, depending on the size of the part of a project that iCRC involved.

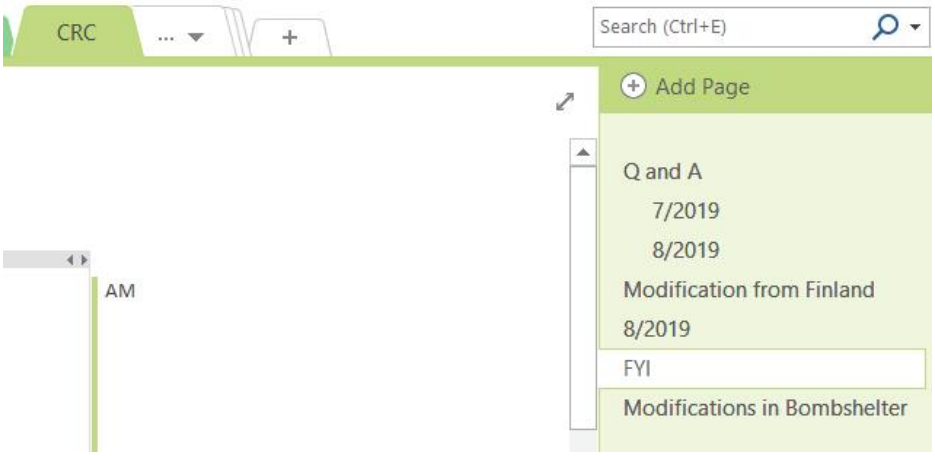


Fig. 40 Example of CRC OneNote Subpage Two

As for the Finnish Drawing manuals, unlike other manuals which are more than 50 pages, it is rather a short one with only critical problems are listed in there. Hence gives initial motivation for the iCRC employee which involves in the project is willing to read. Based on feedback from iCRC employees, if the manual is rather long and not project-specific, they do not have the interest or extra working hours that can be used to actually read and learn it properly.

Therefore, to keep the Finnish drawing manuals simple and critical are the key.

1. General 2
1.1. Arrangement of drawing 2
1.2. Size of drawing 2
1.3. Preferred scales 4
1.4. Line types 4
1.5. Drawing symbols 5
2. Steel drawings 5
2.1. General information 5
2.1.1. Steel grades 5
2.1.2. General texts 6
2.1.3. Bolts 6
2.1.4. Welds 7
2.2. GA drawings 7
2.3. Assembly drawings 8
2.4. Part drawings 9
3. Planar drawings 10
4. Reinforcement drawings 10
4.1. Slabs 12
4.2. Walls 13

Fig. 41 Content of Finnish Drawing Manuals

In the General part, it demonstrates the basic rules of drawing and translation for Finnish technical words. And then it is separated into steel drawings or reinforcement drawings, which depending on the project demand, iCRC employee can read only the project-related ones.

8.1.2 Starter kits for Big Project

Respectively, the big project in this content does not solely mean the budget or the estimated working hour is big in number, it also including the projects which will last for a long time, preferably more than 6 months, which the client is not hurry to get the quick result but more inclined to quality, even it takes more time or cost. Therefore, in these cases, quality and cost control are the key to satisfy the client.

within the Starter kits for Big Project:

1. PRF
2. FI001-Project-Startup-Meeting-Checklist
3. Complete OneNote

4. Finnish Drawing Manuals
5. Specific-Project drawing Sample
6. Specific-Project model Sample
7. LOD Geometric
8. Other checklist for Steel, Concrete and Wood
9. Project Platform
10. Meeting arrangement

Within this mentioned list, the first four items are the same comparing to the starter kit for the small project except for Complete OneNote. Since it is very likely that the big project where iCRC involves in an early stage of the project, therefore there is time and resources for lead countries to create their own iCRC complete OneNote.

The main pages of complete OneNote would be:

- Worker Order
- Technical description of the project
- Assignment specification
- Time plan
- Modelling to do
- List of Changes
- Specific Q and A regarding to project area
- Reviews

Lead countries CRC coordinator should fill the necessary input information to the corresponding pages and keep o track of the update. For modeling to do and List of changes will have subpages named and sequenced by week or month time stamp. And in the Q and A page, there could be more than one page, since it refers to different project areas. The main purpose of this complete OneNote is to get rid of Email bombing as much as possible.

From 5th to 6th, providing project-specific modeling and drawing samples is the job of the CRC coordinator, to meet client's demand, there are always some certain requirements regarding the drawings and modeling, which has been checked and approved by the client, the coordinator responsibility is to pass these approved requirements to iCRC in the form of sample modeling block and drawings.

For the 7th, LOD Geometric stands for a PDF marked with the level of details that iCRC should reach for. Both in the model and drawing.

ii. LOD Geometric definitions

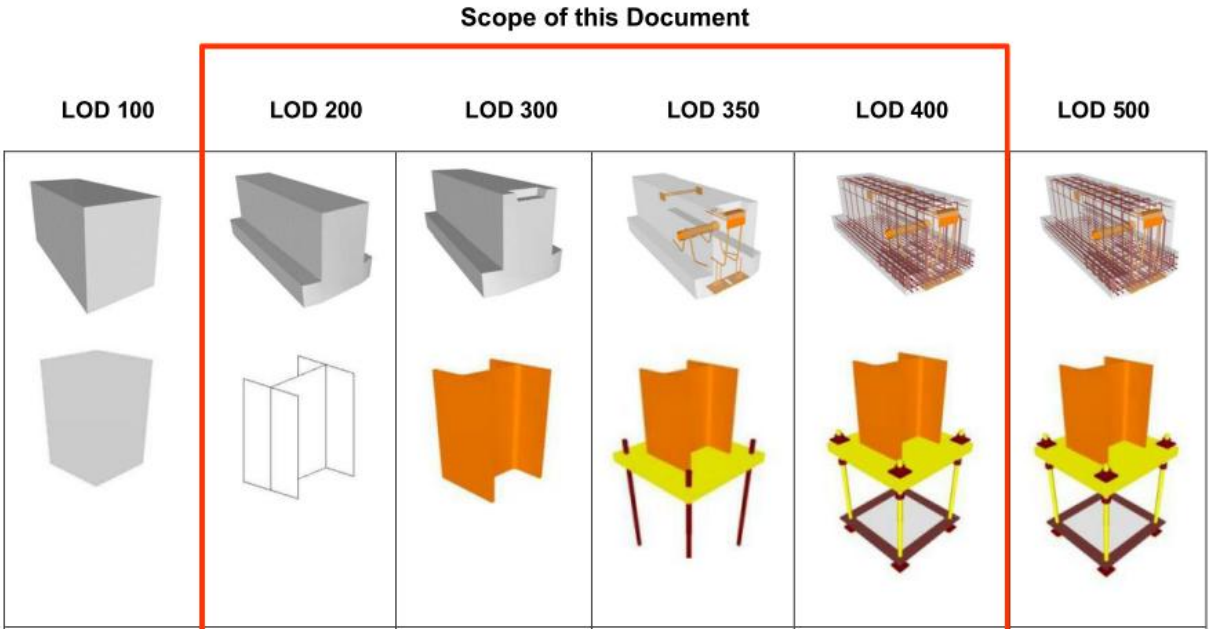


Fig. 42 Example of LOD document

LOD document demonstrates clearly in what level of detail iCRC needs to achieve, both in concrete or steel structures.

LOD 200-

The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.

LOD 300-

The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information should be attached to the Model Element.

LOD 400-

The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, orientation, and interfaces with other building systems. Non-graphic information should be attached to the Model Element.

LOD 500-

The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information should be attached to the Model Element.

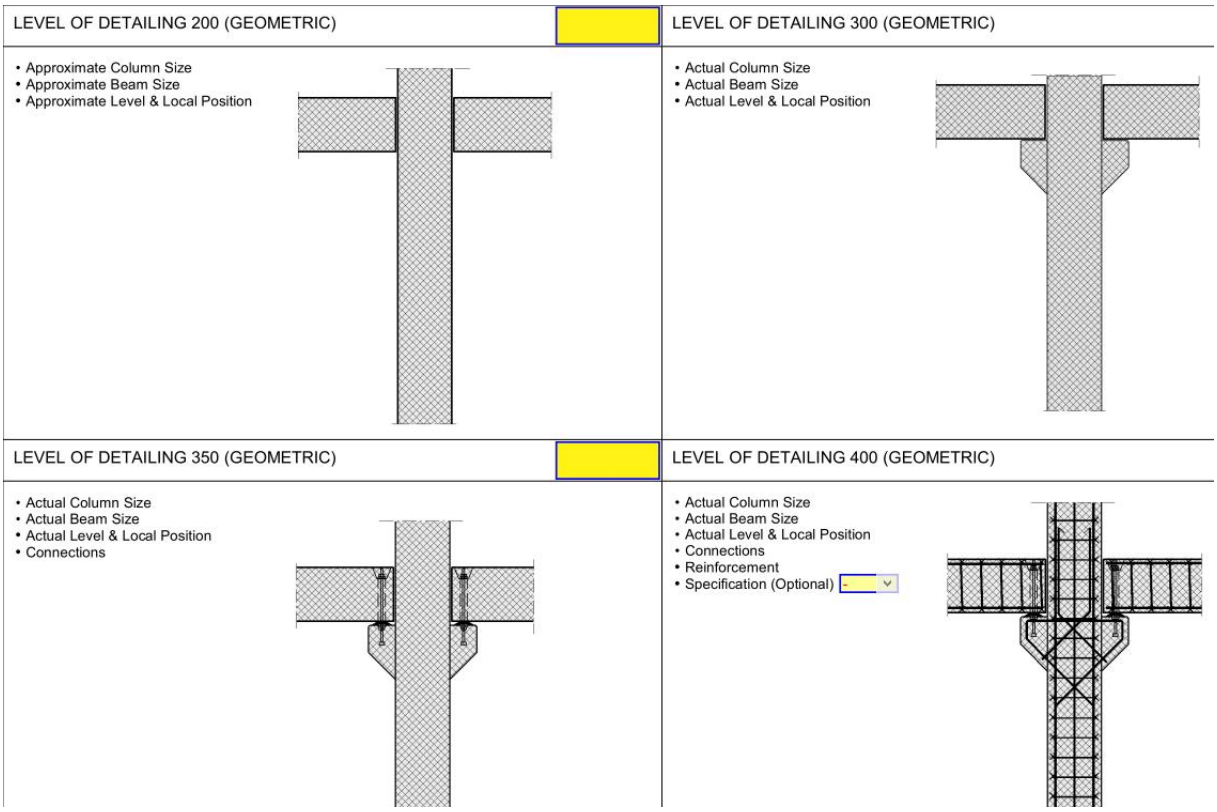


Fig. 43 Example of LOD in concrete modelling

As Fig.42 indicated, this shows a normal reinforced concrete column with corbel, with concrete beams sitting on the corbel. Usually, in a real project, the input Tekla model or IFC model only reaches the level of detailing 200, which only has an appropriate size of beam and column, as well as its locations.

And mostly iCRC will be given the task to deeper the design until it reaches the level of detailing 500, this involves the design of corbel, reinforcement calculation, and connection design. With the help of lead countries' designers and coordinators, the final detailing can be done.

Similar concrete structure examples are all included within the LOD document, beam-beam connection, foundation, pile footing, slab-beam connection, etc.

The same applies to Steel structures as well.

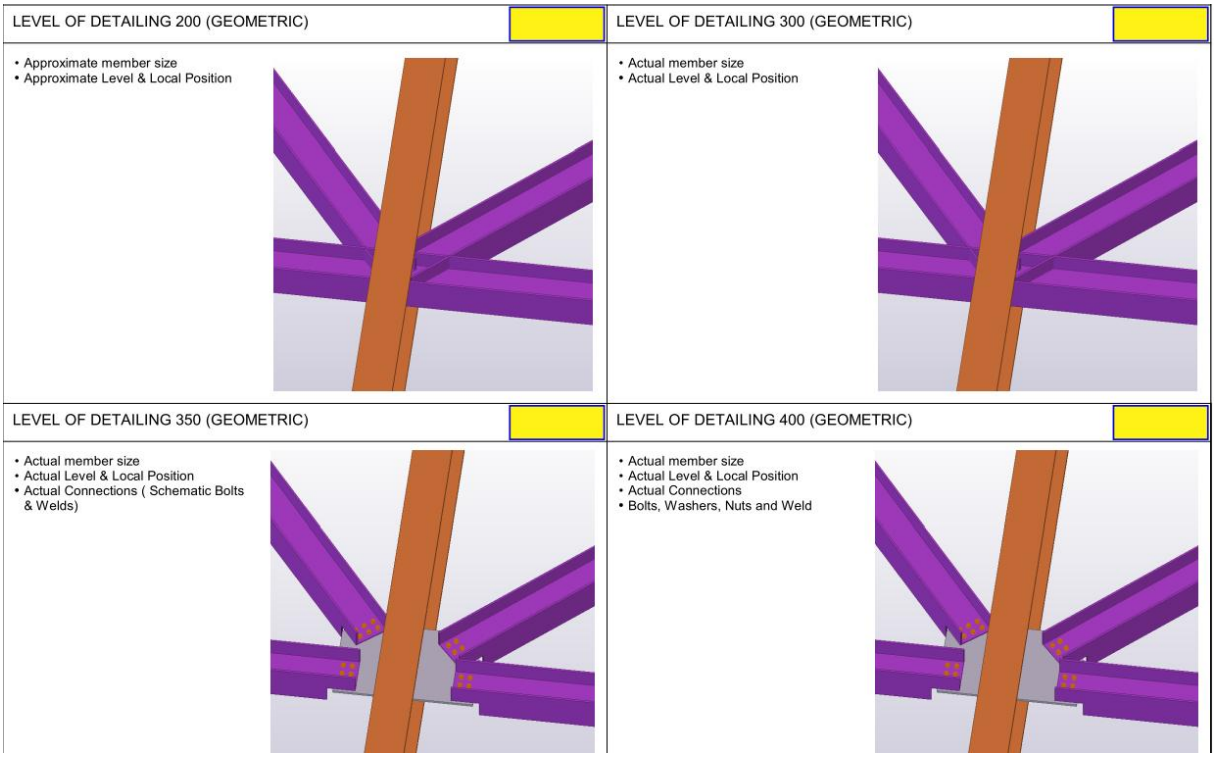


Fig. 44 Example of LOD in Steel modelling

As the above picture mentioned, this indicating a normal steel structure connection between columns, beams, and bracings. General input normally from other companies with IFC, with a level of detailing of 200 or 300 if lucky. The level of detailing 300 means the accurate member size and three-dimension position.

Then it is the scope of iCRC and leads countries designer to design the connection types and model it in Tekla software, several bolts, size of bolts and distance between them should be determined and modeled precisely, so it can reach the level of detailing 500, for future workshop drawing purposes.

Similar steel structure examples are all included within the LOD document, beam-beam steel connection, steel foundation, bracing connection, column-beam connection, etc.

With these LOD settled, which will reduce the chance of overwork by the iCRC with details that clients do not need. Based on previous experience, in some cases, iCRC tends to do more detail than the actual client demand, which is causing efficiency and waste of resources.

For the extra checklist which 8th mentioned, it will be provided by the lead countries CRC coordinator, but filled by iCRC employee when they are doing the self-checking internally.

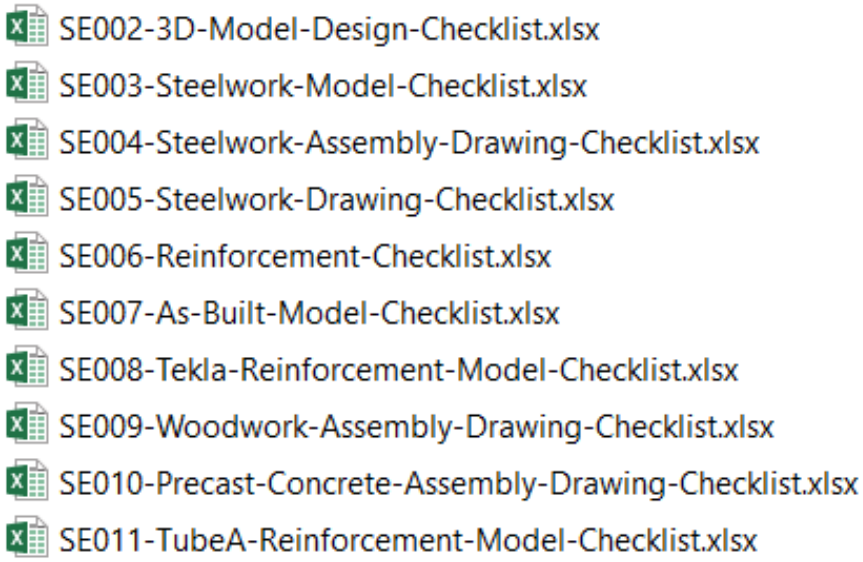


Fig. 45 Checklist for starter kit of big project

These lists are used for different areas including steel, concrete, and wood, depending on the project specification, iCRC can use one part of it which is related to checking. This usually means more resources will be spent in terms of project expenses, but it reduces the work of quality checking and coordinating by lead countries coordinators and improved quality internally, which saves a lot of administration and communication costs.

Besides, it also helps the iCRC employee to learn from their mistakes and increase their technical abilities. If normally without these checklists, lead countries quality supervisor or coordinator will do the checking and most probably to fix the mistake by themselves instead of asking iCRC employee to do the fixing. Because this way costs less communication and coordination. However, in the long-term period, it is more benefit able both for the iCRC personal employee and company that iCRC employees do the internal checking using checklists.

For the platform which 9th mentioned, it is the next-generation technology that heavily relies on cloud services. However, it is the key to connecting the dots in the design phase of the construction project, which is called an online interactive platform for the project.

there are many platforms currently on the market, for the dirt need of the construction field, a lot of local platforms have been created and used, which is rather small and incomplete and limited in function and scales. Not suitable for global communication and coordination. For standardization and generalization, BIM360 by Autodesk is the most suitable platform which can be used in the construction field. Further evaluation and analysis will be included in the next chapter.

8.2 Project in Process

With all the input information correctly settled, the actual work starts, and it will be involving tons of information exchange with commentary. to really increase the efficiency of work, the key is to increase the speed and quality of data exchange.

Among those tools which can achieve this demand, cloud platforms are the ones that trigger the evolution, however, how to choose the proper one to be standardized and generalized for the whole company to use, can be a hard choice to make.

based on the rating survey done by TrustRadius:

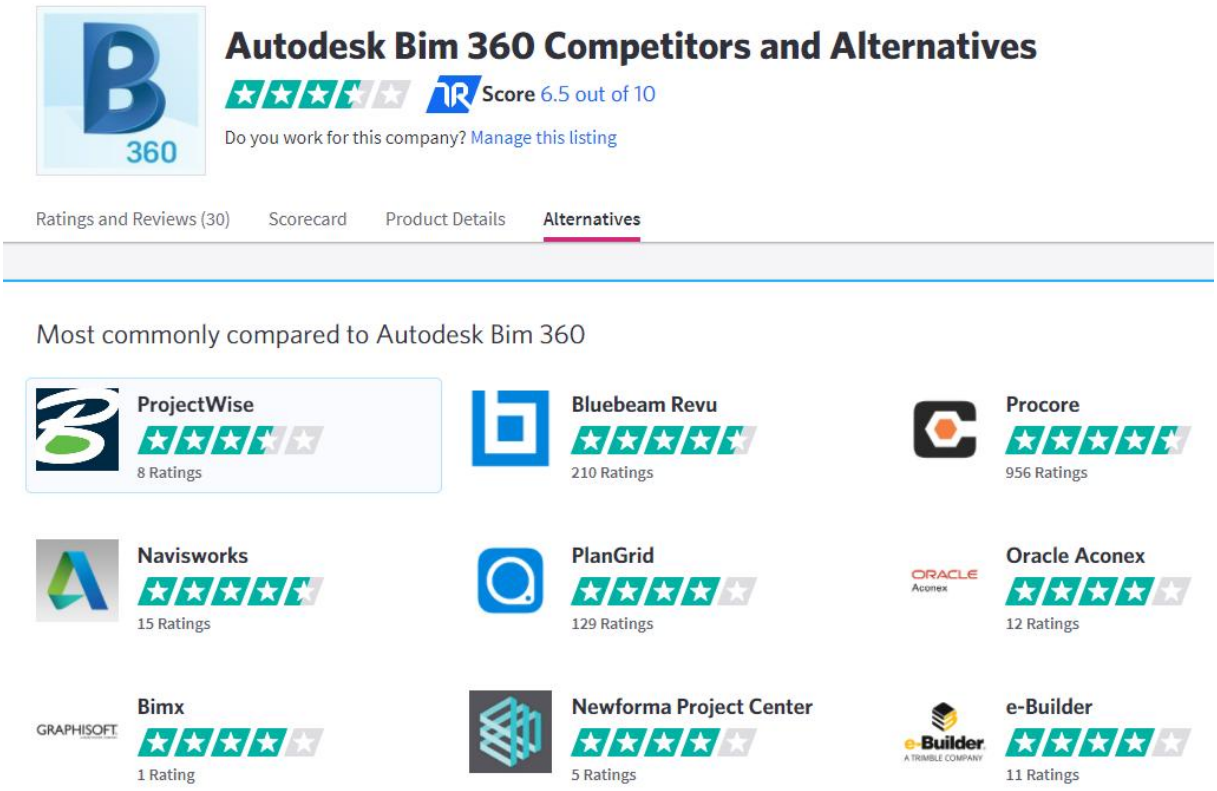


Fig. 46 Rating of Cloud Platform (TrustRadius, 2020)

As indicated in Fig.45, BIM360 is not the highest rating at all from the survey, instead, Navisworks and Bluebeam Revu are having a top rating.

based on the experience of using both of these three products, the author has a different point of view regarding the rating. Since during the project workflow, it involves a lot of corresponding parties including dozens of companies that need to share, inspect and comment on the information/data as fast as possible, as accurately as possible and documented well.

Which can be summarized into four aspects:

- Accessibility
- Functionality
- User Friendly
- Reviewing and Commenting ability

These four aspects indicating the most important features the platform should have. share, inspect, and comment on the information/data as fast as possible, as accurately as possible and documented well.

	BIM360	Navisworks
Accessibility	• Web Browser • iPad • Phone • Software	• Software
Functionality	• Importing model(IFC) • Importing PDF • 3D-checking • Collision-Checking	• Importing model(IFC) • Importing PDF • 3D-checking • Collision-Checking • Large scale model
User Friendly	• Simple User Interface • Admin setting complex • Small size software • Browser ability • Loading time short	• Complex User Interface • Big size software • Operating complex • Loading time long
Reviewing	• Review on drawing • Review on PDF • Review in model	• Review on drawing • Review on PDF • Review in model
Commenting	• Comment on drawing • Comment on PDF • Comment in model	• Comment in model

Due to the complexity of the project, from the author's point of view, these four aspects also have different priorities. For example, the most complex the project is, the more important the accessibility becomes. With more and more companies involves, more and more employees will join the project, from engineers, architects, electricians which has a technical background to managers, site workers, and inspectors which may lack software operating abilities.

Therefore, accessibility and user-friendly UI can be crucial and more important than functionality. take an interface comparison as a demonstration of these two different platforms:

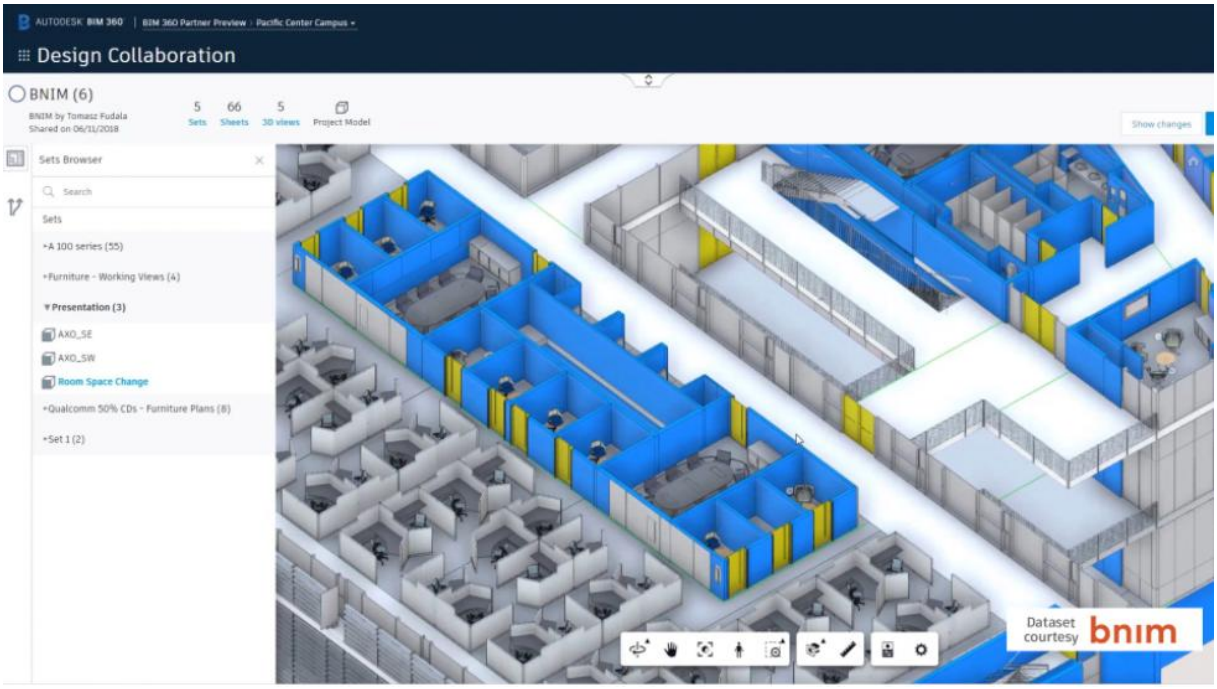


Fig. 47 BIM360 3D model interface (AUTODESK, 2020)

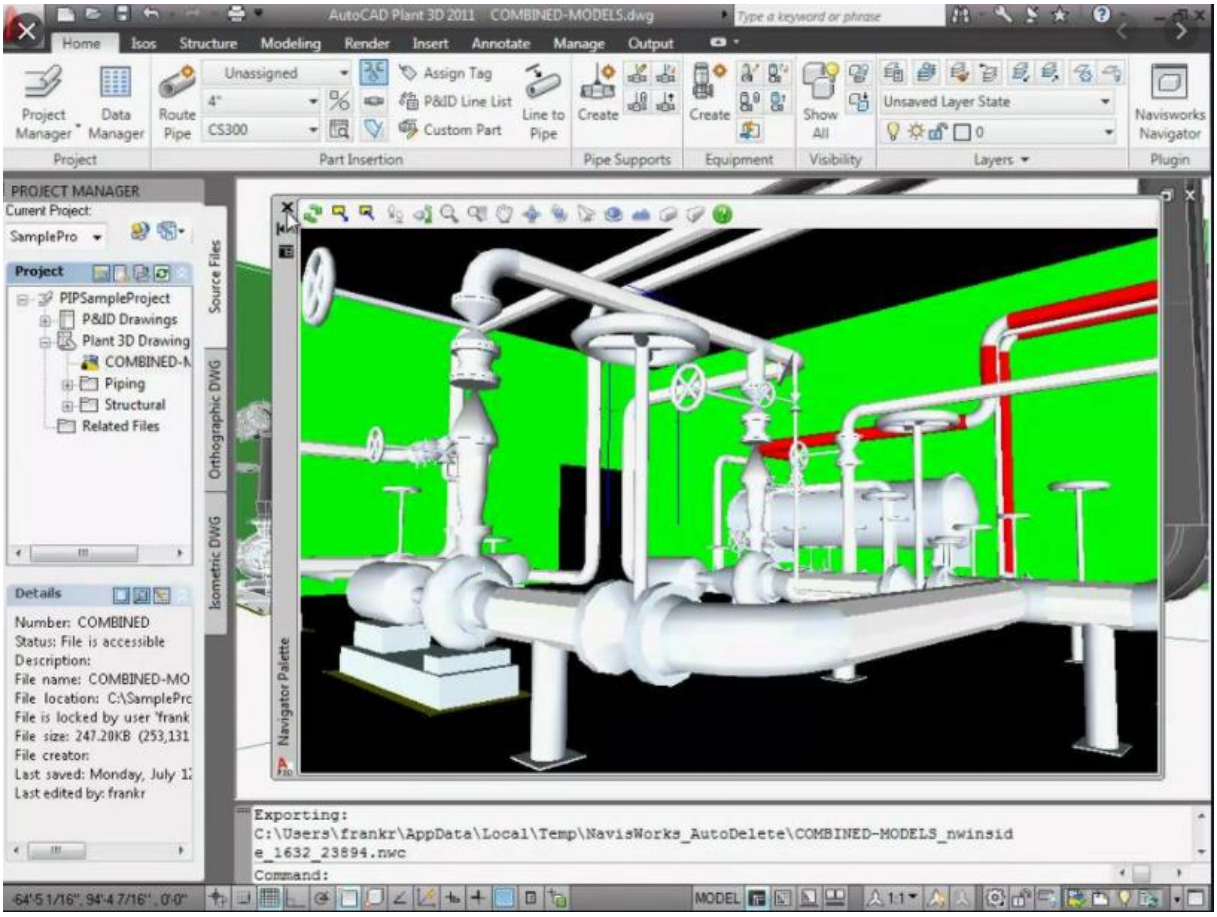


Fig. 48 Navisworks 3D model interface (AUTODESK, 2010)

It is rather obvious that BIM360 has a far easier and cleaner interface than Navisworks. For an employee who is not familiar with AUTODESK software and interface, it is impossible to use and operating Navisworks without proper training. By proper training, it means days of courses and self-learning. And by BIM360, the simple interface with much fewer buttons, the same employee would only take a few hours of workshop to be able to operate the system.

There is no doubt that the functionality of Navisworks is much more enhanced than BIM360, and it can process bigger and more complex projects. However, it also takes much more time to install the software, and also it takes a powerful computer to achieve it, and no other portable device can take this capacity demand.

When using BIM360, the biggest advantages are summarized as follows:

- Much less training time for employee to use
- Less cost on device hardware resources
- Web browser ability enable all portable device to operating
- Fast responding
- Better UI for non-professional to understand
- Interact with drawings and models with comments and markups

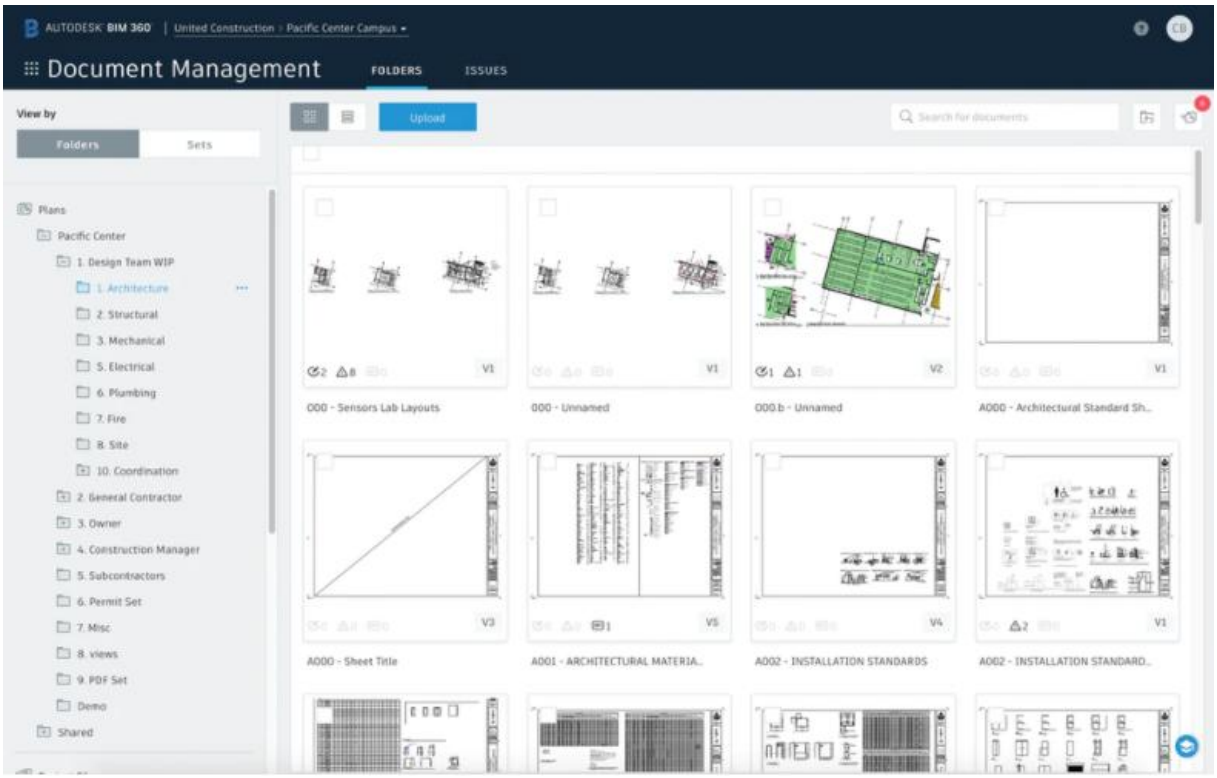


Fig. 49 BIM360 document management (Software Advice, 2020)

As it is shown in Fig.48, The platform allows user roles and permissions to be managed and controlled by project administrators. All documents can be listed and marked by different users with corresponding authority, and it will mark on the time stamp on drawing who did what and when. Which makes real clear about each participant's responsibility.

No doubtable that there are also cons about it, which also can be summarized into:

- Huge model makes loading defective
- Cutting plane of model is not accurate
- Overcomplicated coordination process

These are details technical flaws that can be fixed by updates of the platform in the future, generally speaking, BIM 360 is that it’s a collaborative tool that enables many users to work together on similar tasks and bring in a great contribution which is productivity. and most importantly, it allows the user to have access to it regardless of geographical locations, which makes it a perfect tool for iCRC and international collaboration.

8.3 Project Handling and Feedback

8.3.1 Project Handling

Project handling representing the last phase of the project, which involves even more coordination and communication, since there are plenty of comments and changes that need to be discussed.

To avoid any chaos in the document management or confusion of each participant’s responsibilities, every changes and modification will be recorded in OneNote strictly.

8.3.2 Project Feedback

Whenever the project is closed, the feedback form will be sent to both iCRC and lead countries project managers for the comments and summary of the project on each other.

Currently, the responding rate for lead countries project manager is really low, therefore a reminder Email will be sent to project managers and also the feedback form is simplified to takes only a few minutes to increase the motivation for fulfilling them.

The feedback form contains the following key aspects:

- Project Administration
    - Understanding of the Scope of Work and of Deliverables
    - Project Set up - Estimation of Budget and Delivery Timelines
    - Variations and Change management
    - Overall performance – “Project Administration”
- Time and Cost
    - Meeting agreed deliverables / milestones
    - Delivering within the agreed budget
    - Communicating effectively and helping manage any delays
    - Overall performance – “Time & Cost”
- Quality
    - Technical quality of deliverable
    - Implementation of design check
    - Follow up on QA-DC plan
    - Overall performance – Quality
- Follow Up/Repeat Work (yes/no question)
    - consider CRC for these types of services again
    - consider CRC for different kinds of services
    - refer or recommend CRC services to other teams

Self-Comments are list in the last, for the commenter to write freely about the experiences from the project and things can be improved.

9. Conclusion

9.1 Case Studies Analysis

Case A

Despite a limited period of time, iCRC managed to pull this small project done with a very short response time. However, there are significant issues that need to be addressed as well.

Pros:

- Quick response time
- Quick organized distribution of resources
- Hard-work
- Resolve to get the project done

Cons:

- Input data insufficient (Coordinating)
- Professional experience lacking (CRC and Lead country)
- Time wasted on defective communication
- Finnish environment/requirement understanding lacking
- Documentation not fulling utilized

Most of the cons are due to the urgent situation with lack of time for both the coordinator and iCRC project employee, it needs to be more prepared on both sides for input information and the communication method needs to be constantly on OneNote.

Case B

Considering the project done in case study B is the longest and biggest project iCRC Finland ever done. In general, it gives much of a positive signal and draws the attention of others for knowing and advertising BIM international collaboration. It certainly is a good project.

Nevertheless, there is also space for improvement as well, during the project, a lot of methods can be done in a more organized way.

In general, the project of case study B can be summarized as follows:

Pros:

- Full support of iCRC in management level(Globally)
- Excellent resource management
- Satisfied quality, approved by client
- Gradually reply on more systematically handling method
- Employee self-learning/gaining
- Fluent communication
- Good efficiency
- Resolve to get the project done

Cons:

- Too much reply on good manager in iCRC
- change/modification handling lacking experience
- Still space for technical improvement
- Communication method needs improving
- documentation method needs improving

The first and the most important lesson learned from this case study B was that the success of the project heavily relies on employee personal performance, especially the managers from both iCRC and lead countries.

This is why it being important to reduce the human factor influence by standardizing the procedure, generalize, and regulate the method, and strictly follows it. Because there is no guarantee each and every time such excellent managers can be meet for future projects.

Secondly is the documentation and communication method needs to be improved, for example, it was only in the middle of the project, OneNote has been used, still tons of Email is sent which cause certain extend of chaos when trying to find the certain information afterward.

Case C

Case Study C was one of the example projects WSP Sweden has done with BIM international collaboration by iCRC. Within this project, the iCRC number of resources involved is rather small, by scale or estimated work hours it is not a big project.

However, these projects set an example of how to follow the regulation and standard set previously, as well as utilization of the BIM cloud platform of BlueBeam, even it is under the request of the client.

Pros:

- Quality work
- Standard OneNote
- Use of BlueBeam
- use of Tekla in-built app
- Checklist enables
- Efficient work

Cons:

- Nothing from Swedish clients

This project can be called as a sample of BIM international collaboration between iCRC and the lead country. Although there is no doubt that WSP Sweden has much more experience applying the BIM international collaboration and much more resources to do it when comparing to WSP Finland.

Which more cooperation and communication should be discussed between WSP Finland and WSP Sweden, to improve the iCRC together.

It is also noticeable that not only case studies within the one company leads to this conclusion, as other countries researcher also came into the same or similar conclusion as this study indicated, take America for example, one of the article has conduct survey about BIM outsourcing among general contractors in America. and some the of data are listed below for comparision.

Reasons not to outsource BIM.

Ranking	Reasons not to outsource BIM (1: most important, 5: least important)
1	Communication gap
2	Lack of ability to manage project
3	Poor quality
4	Poor service
5	Poor contract management

Fig. 50 Reason not to outsource BIM (Langar, 2018)

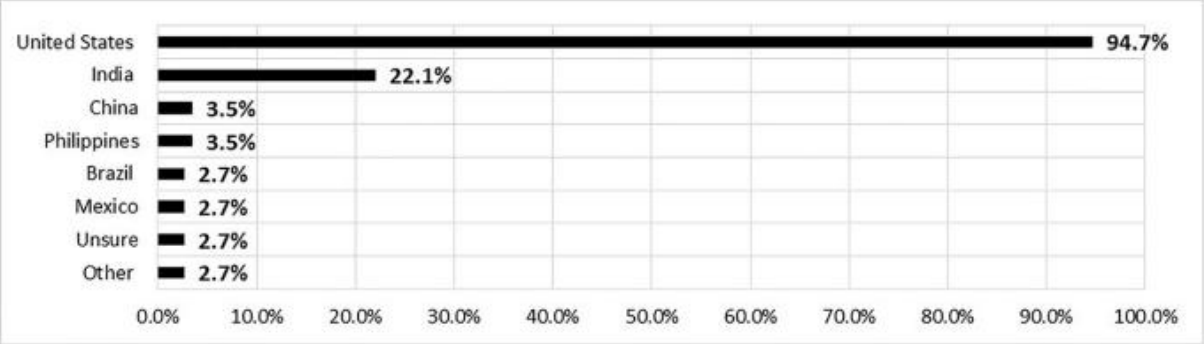


Fig. 51 Nations to which BIM tasks are outsourced (Langar, 2018)

Within the article, the main key points which related to this study were mentioned below: (Langar, 2018)

- BIM is outsourced primarily to companies located in the US (94.7%) and India (22.1%).
- Most commonly implemented and outsourced BIM functions were clash detection, visualization, and as-built and shop drawings.
- 41% of contractors with in-house BIM capabilities choose to outsource BIM instead.

With majority of the respondents reporting most of outsourcing BIM happened within USA (94.7%) and India (22.1%), which language should not be a barrier. However, from Fig. 50, the Ranking one obstacle for contractor not to use outsource BIM is still communication gap. Interesting enough, both ranking 1 and 2 can be categorized for communication and management. Therefore, it is positive to indicating that most of companies/contractors are willing to use outsource BIM if they are confident on the management skills, which can bring more positive result for the projects.

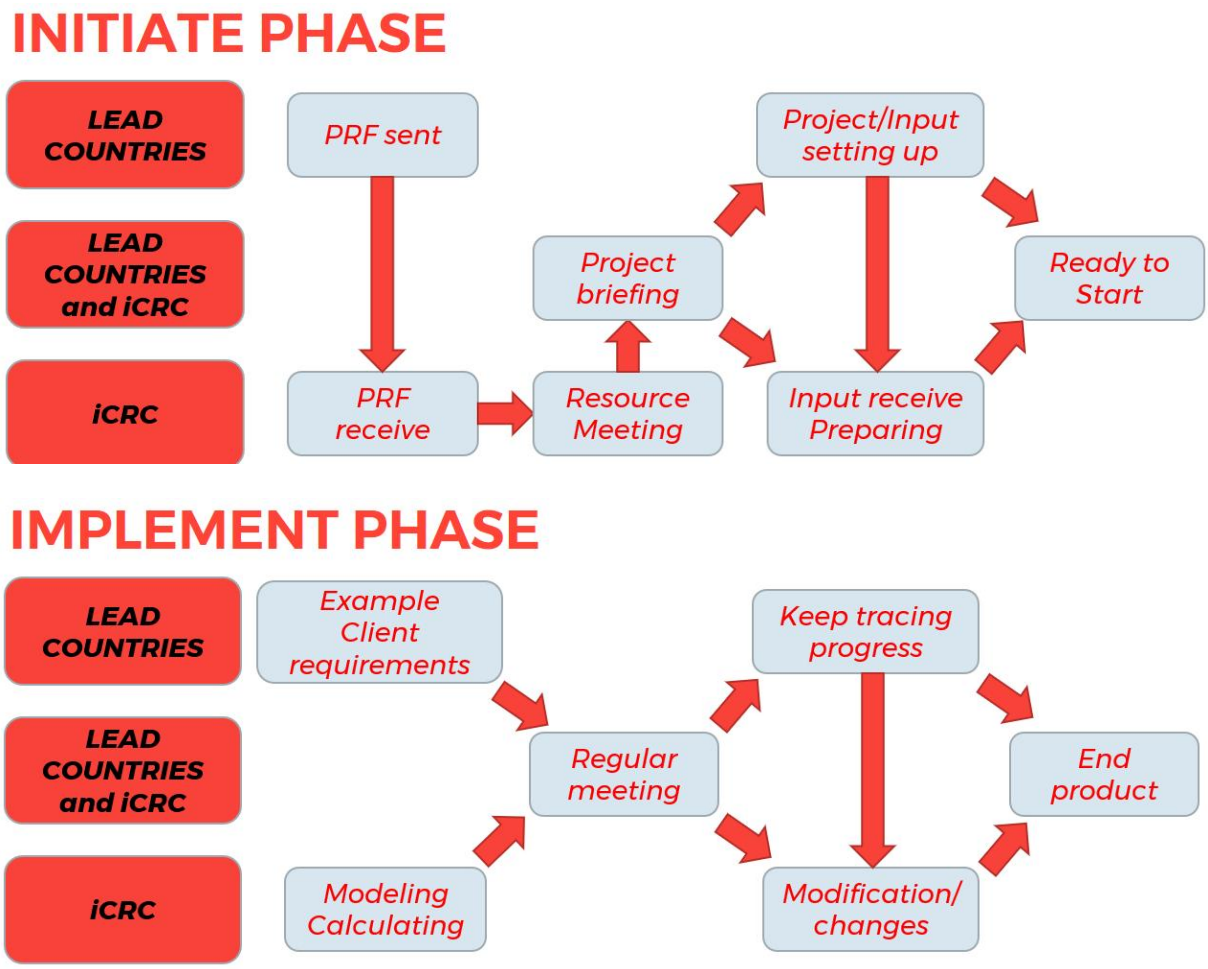
9.2 General conclusion

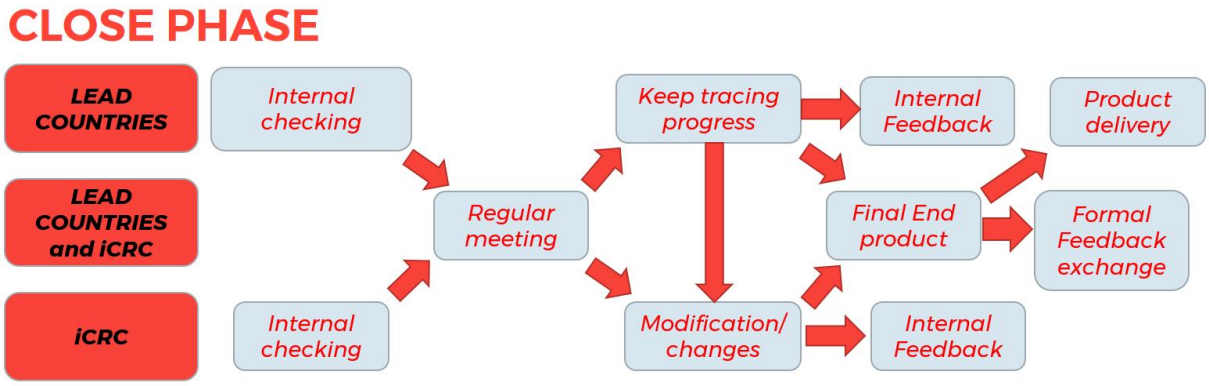
The whole process of BIM international collaboration during construction design and management is relatively new to the world, as well as lack of real project experience, therefore it is difficult to draw a conclusion that gives a guaranteed improvement on the efficiency or profitability of it.

However, based on three case studies provided by WSP Finland and analyzed by the author. Noticeably, these case studies are following the sequence of improvement, every case study is doing better than the previous one.

there are certain points that can lead the correct way for future cross-country cooperation by using BIM.

Process map:





First of all, formulate and standardize the process map of iCRC and lead countries. Without the standard or procedure, no one knows how to do it systematically at the beginning of the project, which will definitely turn into chaos in the future for project management.

Secondly, generalize the processes/standards to an extent that they are relatively easy to follow/understand by most people, simplify it if necessary.

Thirdly, the beginning stage of the project lays the foundation stone of success, therefore complete input information and preparation with proper quick response with can-do altitude for involved iCRC participants and coordinators are the keys.

Fourthly, technical tools such as Tekla model-sharing, OneNote, and cloud platform BIM360 are the essential keys to improve the efficiency and productivity of the work. Which needs to be applied as much as possible.

Last but not least, which is the most subjective point, is to change the manager's mind or increase the acceptance of BIM outsourcing as a competitive way for the company to stay in the market, after all, there is no doubt that it is the unavoidable trend globally and one or two politicians will not set the tide back.

Declaration of Authorship

I hereby declare that the attached Master's thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

(Associates, 2018) (JOHN, 2020) (BIM modeling Services, 2020) (CHOUDHURY, 2020)

Helsinki, 30.10.2020

Location, Date

Signature of the student

Appendix

Appendix A

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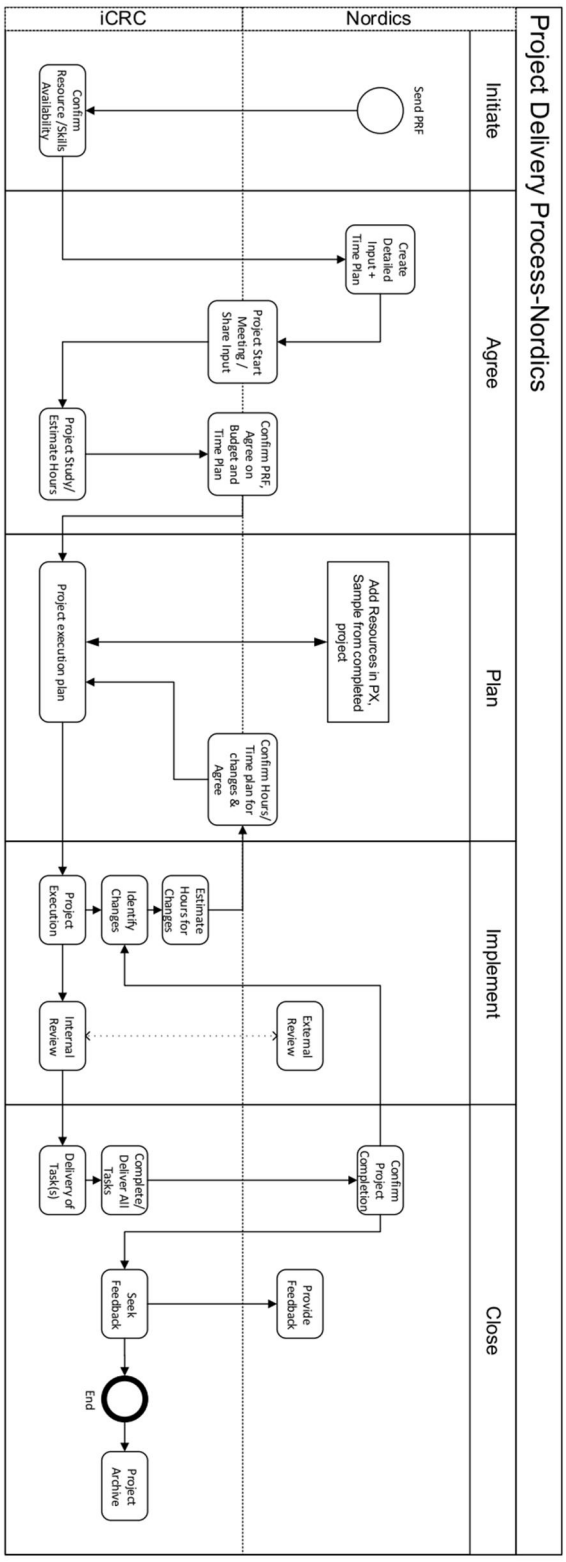

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Noted: the detail of this document is under confidential clauses which will not be published.

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