# The Role of Interoperability in Construction Projects.

## Communication and the Implementation of CoClass.

Master's thesis in Civil Engineering; Design and Construction Project Management

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ABSTRACT

This report presents the role of the interoperability in construction projects. Bad communication leads to projects losing both time and money. Communication and classifications are essential aspects of the construction projects. Therefore, the implementation of the new classification CoClass becomes an interesting subject. Study have shown that the previous classification BSAB 96 has some limitations. The classification does not support the entire project lifecycle and is not developed for implementation with today's modern technology. Therefore, there is a demand to improve the classifications. CoClass is intended to be an improved classification for the construction industry in Sweden. Accordingly, the aim of this study is to look into the implementation of CoClass. The report uses the method of qualitative research. The chapter, Framework of understanding explains in depth the two classifications. The case study investigates Västlänken and the sub-project Centralen. Centralen is working with CoClass and the empirical data is based on interviews conducted and analysed. The conclusion is that proper communication is important and to use a common language is vital. In the project Västlänken, CoClass have been implemented and no problems have occurred in the transition to the production phase. Trafikverket is confident in the ability of CoClass in regards of the implementation in the entire project lifecycle. Moreover, it is highlighted that the construction industry in Sweden is not communicating well. Improvements are essential in this area. With the implementation of CoClass the ability to communicate properly is a factor that might lead to successful projects with the results of saving both time and money. In the comparison between CoClass and BSAB 96 the most important improvements with CoClass are highlighted. CoClass have shown to be an improvement over BSAB 96. It covers more of the project lifecycle. CoClass together with some software programs will aid the projects and the use of BIM.

Key words: Trafikverket, Standards, BIM - Building Information Modelling, Classification, BSAB 96,

Rollen av Interoperabilitet inom Byggnads Projekt
Kommunikation och Implementering av CoClass

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SAMMANFATTNING

Denna rapport presenterar rollen av interoperabilitet inom byggnadsprojekt. Dålig kommunikation leder till att projekt förlorar både tid och pengar. Kommunikation och klassifikationer är viktiga delar inom ett byggprojekt. Därför blir implementeringen av den nya klassifikationen CoClass ett intressant ämne. Studie har visat att den föregående klassifikationen BSAB 96 har vissa begränsningar. Klassifikationen stödjer inte hela projektets livscykel och är inte anpassad för dagens moderna teknologi. Således, blir det ett krav att förbättra klassifikationen. CoClass är följaktligen avsedd att vara den förbättrade klassifikationen för byggindustrin. Syftet med studien är att undersöka implementationen av CoClass. Rapporten är baserad på en kvalitativ forskning. Rapporten förklarar utförligt dessa två klassifikationer. Fallstudien undersöker Västlänken och delprojektet Centralen. Centralen arbetar med CoClass och den empiriska delen är baserad på intervjuer som har utförts och analyserats. Slutsatsen är att kommunicera är viktigt. I projektet Västlänken har CoClass implementerats och inga problem har inträffat vid övergång till produktionsfasen. Trafikverket är övertygade om CoClass förmåga när det gäller genomförandet under hela projektets livscykel. Kommunicera med ett liknande "språk" är nödvändigt. Fortsättningsvis, det har markerats och diskuterats att byggindustrin inte alls kommunicera väl. Förbättringar är en viktig aspekt in detta området. Med implementeringen av CoClass möjligheter att kommunicera är en faktor som kan leda till framgångsrika projekt med resultat av att spara på både tid och pengar. I en jämförelse mellan CoClass och BSAB 96 har de viktigaste förbättringarna med CoClass lyfts upp. CoClass har visat sig vara en förbättring över BSAB 96. Det täcker mer av projektets livscykel. CoClass tillsammans med några programvaror kommer hjälpa till i projekten och i användningen av BIM.

Nyckelord: Trafikverket, Standards, BIM - Building Information Modelling, Classification, BSAB 96,

# Contents

# Preface

This study is carried out at the Department of Architecture and Civil Engineering. The project has been ongoing between January and September 2018 and is a final part of the Master's program Design and Construction Project Management. The thesis has been conducted with the help of Trafikverket.

The authors of this report would like to thank Mikael Törnqvist at Trafikverket. Mikael have helped providing material and recommendations for interviews. Most importantly, big thanks to the supervisors Christian Koch and Sjouke Beemsterboer. Both supervisors have helped and guided the whole project and provided material for this study. Their recommendations and guidance have been a big help during this project. Special thanks to Trafikverket for this opportunity to work with Västlänken and to be able to perform this Master´s Thesis. Furthermore, thank you to everyone involved who helped to perform this Master´s Thesis and providing information during the interviews.

# 1. INTRODUCTION

Several actors in the Swedish construction industry has together developed a new standardized digital classification system which will gradually replace the old classification BSAB 96. The new classification CoClass is planned to be used by all organizations in the construction industry. Today, many projects are losing money because of the lack of communication between the actors. The information is not used properly and therefore will not provide necessary knowledge about the project (Smart built environment, 2017).

## 1.1 Background

In most of the project-based organizations, the method of communication is standardized in a specific way by the organization. This can create problems in the data exchange between the organizations. Investigations and studies has shown that poor communication have serious financial losses for an organization. One area of conflicts regarding communication is in the interoperability of a project since there are several actors collaborating, there is a huge risk that they don't fully understand each other. Especially in the construction industry, the importance of good communication is vital for the success of the project. There can be several organizations collaborating to build one building and a lack of communication can result in a flaw in the construction which can have economic repercussions for everyone involved (Smart built environment, 2017).

In the Swedish construction industry, currently, there is a national classification system BSAB 96 that is used to standardize the technical communication. This classification system was developed by the industry leaders and became more and more implemented as the technology evolved. With the development of the model-based three-dimensional way of presenting constructions, the need for a better classification system was increasing (Smart built environment, 2018). Therefore, the leaders of the construction industry, the government, and other organisations and associations invested in a project to develop a new classification system which was named CoClass. This new classification system is intended to improve the communication between all the parties involved in a construction project and to complement the need of classifications for today's construction technology. CoClass is primarily developed to be compatible with Building Information Modelling (BIM) (Svensk Byggtjänst, 2016a).

Today, the new classification CoClass is only used in a few projects and is implemented in the pilot project Centralen which is a sub-project of Västlänken. Trafikverket, which is the Swedish government organisation for the traffic and transportation, is one of the first in implementing the new classification system in a project.

## 1.2 Purpose

The purpose with the thesis is to get a better understanding of the Swedish classification systems. To investigate the implementation of classifications and to look at how the different actors within a project communicate with each other. The aim is to learn and understand the Swedish classifications and how they are applied in construction projects. Both the old BSAB 96 and the new CoClass will be analysed in this report. The collaboration with Trafikverket will show the possible benefits and setbacks in regards of the application of the new classification, to help with answers with the research questions. The master thesis is an opportunity to work both practical and theoretical.

Basically, the concept of CoClass is an interesting topic for the development of the construction industry. Therefore, it is compelling to investigate considering no comparative research was found about this classification. Also, through this thesis work, it will raise awareness about the newer classification CoClass.

## 1.3 Objective

To communicate properly and understand each other well, it could be beneficial to have a common understanding, a common ``language´´. CoClass is intended to be the classification that represents a collective and united industry. Although, BSAB 96 have been used these past years, the potential of CoClass needs to be scrutinized. The objectives of this report are:

1. To determine if the sector needs CoClass and investigate the perspectives the construction sector and organisations have regarding the classifications.

2. To investigate the advantages and disadvantages with the implementation of CoClass.

## 1.4 Research questions

- How is the new Swedish classification CoClass intended to be used in Västlänken and Centralen? How is CoClass going to be implemented in the projects?

- Is CoClass an improvement compared to BSAB 96? Is CoClass a new and improved classification system?

- How is CoClass used in collaboration with BIM and three-dimensional models?

## 1.5 Method

The thesis will be written with the help of articles and literature which the framework of understanding and empirical framework will be based upon. The intentions are to cover the topic, regarding the implementation of classifications, communication, and projects using different classification systems, with the help of reports, articles and books. The empirical data also includes several different interviews with professionals working with CoClass. The articles that were used was found through google, google scholar, and Chalmers library. The articles were reviewed both critically and analytically.

The study aims to investigate CoClass and its implementation. Therefore, it is important to collect relevant information regarding CoClass and the projects it is implemented in. The information will be provided with the help of articles that have been analysed critically. Interviews will be conducted with people working with this topic and it is an important aspect of the study because it provides the perspective of the people involved. The information is compared with other sources to become justified and to avoid misinformation. Articles used are in form of: Svensk Byggtjänst reports, Smart built environment reports and more.

## 1.6 Limitations

The interoperability of a construction project will be focused on the implementation of CoClass. The report will not focus on the individual leaders/persons involvement in CoClass. The focus of the case study will be on the subproject Centralen. The focus will be divided on Centralen and the involvement of Trafikverket. Also, there are no fully finished projects to compare with the theory of CoClass. Therefore, the only possible comparison is between the framework of understanding and the interviews.

# 2. FRAMEWORK OF UNDERSTANDING

From the perspective of the Swedish classifications, the currently used classification BSAB 96 has been the primary option. To be able to comprehend these classifications, the framework of understanding data in this report will introduce and explain CoClass and BSAB 96. CoClass will also be explained and examined with its collaboration of BIM.

Communication might be the most important aspect of a project. Communication lays the foundation of the work. In order to communicate properly and in an understanding manner there has to be a common language. CoClass is a classification system intended to be used as a method to describe the construction system in a collective way and therefore, avoid mistranslations. When there is a method where every actor can understand the information, it will help to improve the communication (Svensk Byggtjänst, 2016a).

It is essential to have the same language system within the entire construction industry and for the whole project lifecycle. This will result in an effective and faster information transfer between all the project processes. Especially between the construction process and the facility management process. There has been research conducted that has shown that effective communication can lower the construction cost in the entire Swedish industry by 60 billion SEK (Smart built environment, 2017) Another research presented by Olanirah (2015) shows that in Nigeria around 50% of the construction projects fails to succeed because of the poor communication.

## 2.1 Classification

Communication is important when there is any kind of collaboration between people. Ekholm (2016) describes it as imperative for human interaction and also for the interoperability within projects. The author defines classification as a system that gathers and describes information from a specific field and uses a logical approach to categorise them. Specific for the construction industry is that the classification has to be developed so that it covers the entire project lifecycle. Meaning, that the classification system has to be implemented in the planning process, construction process, and the facility management process. Additionally, in these modern days, the classification system also has to be implemented with BIM (Ekholm, 2016).

Lou and Goulding describe classifications as something that is basically directing information flow. The objective of the classification is to collect data and transform it to information so that people can collect the knowledge that they need. Since the increase in implementation of technology, the order in which the information is gathered and stored is much more important so that it is easily accessible and used more efficiently. The authors argue that nowadays with the help of computer

programs, the classification tables ability to be efficiently integrated and organised is much more important than how they are classified (Lou & Goulding, 2008).

Apparently, the method of categorising the information in a classification system is of the utmost importance when it comes to the application. Ekholm (2016) argues in his report that in the construction industry, the classification systems has to categorise the classification tables regarding the properties that are crucial and objective. Homogenous properties in the structure or the composition is to be prioritised over the function in the classification tables. The reason is that one function can be provided by several different construction elements. For example, regulating room temperature can be provided by electric systems, ventilation systems, or liquid-based systems. The function is mostly a requirement from the end-user and it is therefore important for the professionals who develop the technical solution to the function to see the structure or the composition of the element. The categorisation in regards of the structure and the composition is also a means to easily identify the need for the different field of engineering necessary in the whole project lifecycle (Ekholm, 2016).

The authors Lou and Goulding discusses in their report the importance of classifications in the construction industry. Their main focus is not only on the local country but rather on the international community. In their report, the authors mention that the demand for an international classification is increasing with the development of more advanced and practical ways of communication. Also, since the construction industry brings together several different fields of work, the information sharing can be difficult. Every construction project is different to another and therefore needs different kinds of information and documentation. With consideration of the international collaboration in construction projects, the need for classifications become much more important and also difficult to implement (Lou & Goulding, 2008).

### 2.1.1 International standard

During the last decade of the 20th century, the International organisation for standardisation developed a framework of standard for classifications. The development of the standard was intended to enable an international approach to classifications for the construction industry. The framework of this standard is to provide organisations in the civil- and building engineering with guidelines to develop their own information tables. The international standard is titled *ISO 12006-2*. This standard includes classifications for information sharing for the entire project lifecycle (Ekholm & Häggström, 2011).

The international standard had some weaknesses and was not compatible with BIM so in the year 2015 a revision, *ISO 12006-2:2015,* was published that enabled BIM compatibility. The revision introduced new definitions and other improvements. For example, the *construction elements* were now defined as a part of the *construction*

*entity* and the *work result* was separated and defined as a specific view on *construction result*. Visualised by the figure 2.1, a concept can have internal relation and be related with another concept. For example, *built space* can be defined as a system of different parts that have internal relation and as one concept defined by *construction result* (Ekholm, 2016).

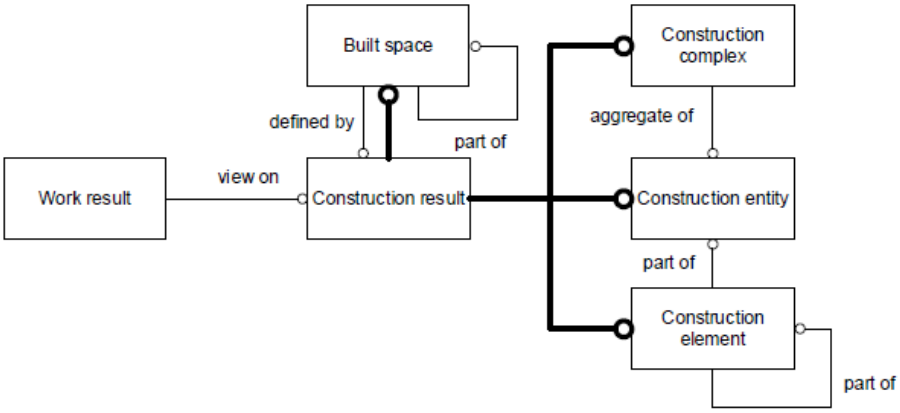


Figure 2.1 - Concepts and definition of ISO 12006-2:2015 (Ekholm, 2016)

The weakness that the older version of the standard had was that the construction elements were only categorised regarding the function. This lead to difficulties in identifying different compositional structures of the elements. The new and revised standard introduced two new properties to be used when categorising construction elements. Now the form and the location can be used together with the function. This was important for the BIM compatibility since the form of an object is necessary to able to visualise it (Ekholm, 2016)

## 2.2 BSAB 96

Several countries around the world used the international standard ISO 12006-2 in their development of their own classification system and in Sweden, it leads to the development of the national classification system called BSAB 96 (Ekholm & Häggström, 2011). At the time of development of the classification system, the building information technology had evolved to computer programs such as *Computer aided design (CAD)*. This new development was adapted to in BSAB 96 and provided tables of classifications for the CAD program. The new classification system was intended to make the information sharing easier in the design and planning phase, and to make the project transition to the production phase more compatible. The classification provides tables of information on how to develop documents, blueprints, and descriptions for the project so that it is easily understandable for all the parties involved (Ekholm, 2001).

### 2.2.1 System structure

In the design and planning phase of a project, the focus is mostly on the function. For example, a building and all of its parts are described with the purpose and the function they are providing. In this phase, the recommended classifications are different compared to the production phase. In the transition between the planning phase and the production, the project documents that are written focuses on the construction technologies that are required for the production. With the help of the classification system, procurement documents such as the cost calculation can be derived since it provides a standard approach to the quantity calculation. Furthermore, documents that are necessary for the production phase, such as blueprints and descriptions, can be made in a standardized way so that the construction is clearly described. The classification tables in BSAB 96 has a functional approach to their division of building components. The tables in the classification system focuses on the attributes that distinguish the construction and the construction parts in order to standardize a definition (Ekholm, 2001).

Earlier in the report, it was mentioned that BSAB 96 follows the international standard ISO 12006-2. This standard defines some main classification tables that has been translated to the Swedish classification system. The five main classification tables are: *Construction, Construction complex, Element, Work result, and Spaces* (Ekholm & Häggström, 2011). To easily distinguish between different classifications within a classification table, codes are used in a hierarchically method. The identification codes can be alphabetical or/and numerical. For example, *"B"* stands for *tunnels and caverns* and *"BB"* stands for *tunnels* and *"BC"* stands for *caverns*. This means that the second letter in the code indicates that the classification is a type of the first letter in the code (Svensk Byggtjänst, 2018a)

### 2.2.2 Construction entity

A construction is described as something that is permanently settled on the ground and has attributes that are load bearing, defining, and distributing. The construction is facilitated by one or several organisations for their specific purpose. There are two main divisions that are defined within the term construction, which are houses and plants. Constructions are categorised within the classifications system in regards of the purpose of the construct (Ekholm & Häggström, 2011).

The classification tables in BSAB 96 divides Construction in 16 categories. These categories are specified with different letters and as mentioned before, they are hierarchical. Therefore, a main category can be expanded to several subcategories. Some examples of categories and their subcategories are presented below in table 2.1.

| Class code | Description |
|---|---|
| **A** | Compound constructions |
| **B** | Tunnels and caverns |
| BA | Compound, Tunnels and caverns |
| BB | Tunnels |
| BBA | Tunnels for other purpose |
| BBB | Tunnels for road traffic |
| BBC | Tunnels for rail bound traffic |
| BBD | Tunnels for cables and pipes |
| **H** | Circuit grid |
| HB | Cables |
| **U** | Ground area |
| UB | Natural ground area |
| **Z** | Other constructions |

Table 2.1 - Classes for Construction entity of BSAB 96 (Svensk Byggtjänst, 2018a)

### 2.2.3 Construction complex

The classification system defines a construction complex as a group of adjacent constructions that are used by an organization for one or more specific operations. A construction complex is categorised by the type of operation that the organisation is performing (Ekholm & Häggström, 2011).

### 2.2.4 Element

In the classification system, an element is defined as a part of the construction that has a main function within the construct. There are three different main functions that can be ascribed to an element, it can be *load bearing*, *room defining*, *or/and distributing*. The classification tables allow only one main function to be used to categorise the element. If an element has more than one main function, then one has to be chosen as the categorising function. An element cannot be part of several classification tables and the *load bearing* function is always prioritised above the other two. If an element is not load bearing but has two other main functions, it falls under the category of compound element (Ekholm, 2001). BSAB 96 is inadequate in the level of details in the classification tables. Therefore, the Swedish regulations AMA has to be used when deriving technical descriptions of the elements. The regulations are also used to develop the calculations and blueprints (Ekholm & Häggström, 2011).

In BSAB 96, the elements are categorised in 10 different divisions. The main category *(0)* is for compound elements and installation systems. The categories *(1-9)* defines elements that have different main functions (Ekholm, 2001). The classification tables of elements are specified with numbers for the main category and letters for the specialisation. Some examples of categories and their subcategories are presented below in table 2.2.

| **Class code** | **Description** |
|---|---|
| **0** | Compound elements and installation systems |
| 01 | Compound elements |
| 01.B | Compound element for plants |
| 01.S | Compound element for houses |
| **1** | Ground, substructure, protective layer in the ground, foundation and support construction |
| 11 | Ground |
| 11.B | Unprocessed ground |
| 11.C | Processed ground |
| 12 | Substructure |
| 12.B | Filling |
| **2** | Load bearing construction |
| 20 | Compound load bearing construction |
| 21 | Load bearing construction in plants |
| 21.B | Load bearing construction for bridges and docks. |
| 21.BB | Load bearing construction for bridges |
| 21.BC | Load bearing construction for docks and piers |

Table 2.2 - Classes for Elements of BSAB 96 (Svensk Byggtjänst, 2018a)

### 2.2.5 Activity and resource

The classification system defines the term production-activity as an activity on the construction site for producing a part of or the entire construction. To be able to produce, the activity must use resources to achieve the production results. The main purpose of the production-activity is to produce construction parts that are following the demands and regulations. In BSAB 96, a resource is defined as an object that is used during the activity. This includes labour, construction goods, equipment, machinery, tools, capital, lands, and documents (Ekholm, 2001). Resources are the only objects that have the property of cost and all other objects have to refer to resources to calculate the cost. Therefore, are the classification tables of resources very important for the cost calculation (Ekholm & Häggström, 2011).

### 2.2.6 Work result

A work result is characterised in the classification system regarding the material and the production method. The term is defined as the result of an activity for producing a part of or the entire construction. A work result is not classified by its main function, rather it is classified by the result of the work. However, when it comes to the division to the classification tables, the main criteria are the type of activity in the production, for example, masonry or plumbing. Mainly, the term work result refers to the different construction parts in a construction system, but it also refers to other things necessary to the production. For example, preparatory work on the construction site or the assembling of the construction sheds (Ekholm, 2001).

Ekholm (2001) describes work result as the answer to *How* a part of a construction is produced and the term component as the answer to *What* a part of a construction is. It is not necessarily imperative for a work result to have a main function that characterise a component. However, a combination of relevant work results will have characteristics of a component. In BSAB 96, there are 23 main classification tables for work results. Some examples from the work result classification tables are presented below in table 2.3.

| **Class code** | **Description** |
|---|---|
| **B** | Preparatory works, sanitation work, transportation, dismantling, demolition |
| BB | Preparatory work |
| BBB | Conducted investigations |
| BBC | Investigations |
| BC | Means works |
| BD | Sanitation |
| **C** | Terracing, piling, ground reinforcement |
| CB | Excavation |
| CBB | Soil excavation |
| CBC | Rock excavation |
| CC | Piling |
| CD | Ground reinforcement |
| **X** | Furnishing and appliances |
| XB | Furnishing in housing, office, classroom, hospital, store |
| XBB | Display units |
| XBB.1 | Floor mounted display units |
| **Z** | Miscellaneous packing, complementing, mounting |

Table 2.3 - Classes for Work result of BSAB 96 (Svensk Byggtjänst, 2018a)

### 2.2.7 Built spaces

A space within a construction is dependent on several construction elements. Only when specific elements such as, walls, floor, and ceiling are connected can a space or more specifically a room emerge. The space has defining aspects that barricades sound, light, and air. Within the space can different operations be conducted by one or several organisations. In BSAB 96, the definition of space is a *functionally defined environment*. Since a space can offer different functions, it is categorised in regards of the usage of the space, for example, living space, office space, or storage space. The classification for the different spaces has 2 main categories in BSAB 96. Some example of the categories is presented below in Table 2.4 (Ekholm & Häggström, 2011).

| **Class code** | **Description** |
|---|---|
| **1** | Space for outdoor activities |
| 11 | Space for traffic |
| 111 | Space for road traffic |
| 112 | Space for railbound traffic |
| **12** | Space for commerce, agriculture, industry |
| 121 | Space for commerce or service sales |
| 122 | Space for agriculture, forestry. fishery, industry, production, reparation |
| 122.B | Space for agriculture |
| **13** | Space for education, play, sports, recreation, culture, religious activities |
| 131 | Space for education and practice |
| 132 | Space for play, sports, or recreation |
| **2** | Space for indoor activities |
| 21 | Living space |
| 211 | Space for personal hygiene, dressing, or textile care |
| 211.G | Space for textile care |
| 211.GB | Laundry space |
| 211.GC | Drying space |
| **22** | Space for public activities |
| 221 | Space for temporary living |
| 222 | Space for production, exposure, sale |

Table 2.4 - Classes for Built space of BSAB 96 (Svensk Byggtjänst, 2018a)

## 2.3 CoClass

The project BSAB 2.0 started in the year 2015 with the purpose to establish a new system of a classification for the Swedish construction industry. During the final stages of development of the new classification system, the project and the classification was renamed CoClass. This is an interesting and ongoing project that is providing a different perspective to classification systems and with many ambitions to improve the industry (Svensk Byggtjänst, 2016a).

The purpose with CoClass is digitalisation and to work with information that is in fact used to communicate. Sweden is trying to become the best in the world with the use of digitalisation. The impact and the help of the digital growth have changed the way we communicate. Also, changed the way people use information (Regeringskansliet, 2017)

According to the report from Svensk Byggtjänst (2016a), the newer and improved classification system CoClass is based on the previous classification system BSAB 96 and is also known as BSAB 2.0. From the perspective and studies done, it is shown that the lack of communication is making production more expensive. CoClass is intended to be implemented to improve the communication between different parts and thereby save the losses in production, to become more productive (Svensk Byggtjänst, 2016a).

The new classification system CoClass is viewed as a newer version that is an improved system. To fully understand CoClass, to explain how CoClass is intended to be used, it is divided into two headings *information* and *communication*. The intentions with CoClass is to reach all types of building environments and in time replace the current classifications system BSAB 96. The new classifications system is going to be adaptable with Building Information Modelling. With the implementation of BIM, it will provide a model of the layout together with information about different building parts, energy consumption, the effect on the environment and more. The implementation of CoClass will be helpful throughout the entire project lifecycle. It is intended to provide information regarding, for example, the cost estimation and information about the delivery of products. Maybe the most important aspect with the implementation of CoClass will be about managing information regarding changes (Svensk Byggtjänst, 2016a).

### 2.3.1 The implementation of CoClass

The implementation of CoClass is intended to be structured in a flexible way. To make the use and implementation of CoClass effective there is a need for the organisation to adapt it to their sector and around their own organisation. Trafikverket, which is one of the primary organisations around the implementation of CoClass, is advocating towards the new and more improved classification.

Trafikverket is showing the important aspects and steps with the implementation of CoClass and highlighting how to move forward and continue with the classification (Svensk Byggtjänst, 2016a).

With the help of reference ID, it is possible to describe the relations of the different building aspects. Also, it provides the option to provide the information of the position. Furthermore, what kind of demand is put on the product (different building parts) (Svensk Byggtjänst, 2016a).

### 2.3.2 Advantages that comes with CoClass

Who is benefiting and is able to use the classification? CoClass is intended to reach several different actors. Primarily beneficial with the classification is the software companies. Software companies such as CAD and calculation as examples. Also, contractors in construction and management is going to be beneficial with the implementations. Furthermore, architects and consultants together with builders and developers in both the public and private sector (Svensk Byggtjänst, 2016a).

From a general perspective, there are certainly several advantages with CoClass. For example, software companies will have a stable program that is developed and adapted for BIM. Owners and facility managers will receive structured information delivered with a common language and stored in an effective system. With these advantages in mind, it is safe to conclude that CoClass will have a positive impact on the construction sector (Svensk Byggtjänst, 2016a).

### 2.3.3 The future of CoClass

CoClass is supported by many organisations. Trafikverket is the organisations that have taken the lead with the new classification. However, it is important to point out and understand that CoClass is developing. The impact from international standards could lead to changes in the classification (Poormortezavy & Appring, 2017).

The changes and additions to the new classification system are going to be updated and adjusted the same way that was done with previous classification BSAB 96. The collaboration with construction sector where they has a say and have an impact will be an important factor. Also, to consider the responses of the management sector and they are able to help with the development. Another factor that needs to be considered is the cost. The use of the system should be cheap and justified to the result and the impact the system has (Smart built environment, 2017).

### 2.3.4 The principles of the structure

In the development of CoClass several principles have been considered as the aim to develop a complete classification system. *Clear principle of division* is one of them and it describes that for all physical objects the characteristics of function, form, or position is to be considered in the description and division of the classes. The characteristics can be used individually or in a combination. Another principle is *Univocal classes* which describes that each class is specified by the code and the class definition and not the designation. This means that the designation of the class can be adapted to the user and the context. *Few but stable classes* are a principle that specifies that the classes for all objects has to be stable during the entire project lifecycle. Meaning that a functional object retains the class even if the execution changes. The aspects of type, material, and other things are properties linked to the object that can be changed. The principle of *Easy to use* describes that synonyms for the class designations can be used to make it easier for everyone to navigate through the classification. The synonyms are not fixed and can be added if necessary. Another principle that makes CoClass easier to use is the *Flexibility*. The classification tables consist of main categories that are independent, univocal, and nonoverlapping. If it is necessary, the user can adapt a combination of the main categories for their organisational needs. The last principle is the *Internationally viable* which means that CoClass originates from several international standards, and also adapts and develops those for the Swedish conditions (Smart built environment, 2017).

### 2.3.5 International standards

As mentioned earlier in chapter 2.1.1, the International organisation for standardisation developed a standard called ISO 12006-2:2015. This standard is the cornerstone of CoClass and guided the development of the classification tables. However, it only provided examples for the categorisation of the tables and therefore two new standards are being developed to get a detailed guide for the categorisation. These new standards are named IEC 81346-26 and ISO 81346-12 and are applications of ISO 12006-2. The experiences and progress of the project BSAB 2.0 has been forwarded to the International organisation and helped the development of the two standards. The categorisation of the classification tables of CoClass will predominantly follow these standards but will also contain Swedish supplement (Smart built environment, 2017).

### 2.3.6 System structure

As the principles mentioned in chapter 2.3.4, the construction results in CoClass are primarily categorised and divided by the function. The most important is the class definition where the function is explained. Each class in the table has a class-code and this is used when referring to the class. In the classification, as per the principles, each class has its own suggested designation, but it can also be changed in regards of the context and the detailed technical solution. However, the foundation of the objects

must be the same and the designations linked to the suggested designation. Each class is constituted by its class-code and the class definition, the designation is not important. However, it is important that the technical solution is described in detail since it is needed for the construction or the cost calculation. There are several ways to specify the technical solution, firstly a *Type* can be linked to an object to develop a list of different object types, secondly, a *Product-Code* can be used, and thirdly the resources needed can be linked to the work result in a *Formula* for the object. In CoClass, the classes and the subclasses are related to each other by a hierarchical class definition. Whatever designation is used for a class must be included in the definition of the subclass. For example, the class *Storage object* has the subclass *Thermal energy storing object* which is defined as: Storage object for thermal energy (Svensk Byggtjänst, 2016a).

As mentioned above, the class-codes in the classification tables are connected to the designation and definition of the class. This means that the class-code alone is meaningless, and therefore same combination of codes can be found in the classification tables. To distinguish between the same codes, each classification table has its own code. See Table 2.5.

| **Table - Table Code** | **Table - Table Code** |
|---|---|
| Construction complex - BX | Built space - UT |
| Construction entity - BV | Work result - PR |
| Construction elements - BD | Maintenance activities - FA |
| Construction elements, Functional systems - FS | Property |
| Construction elements, Constructive systems - KS | |
| Construction elements, Components - KO | |

Table 2.5. Tables and table codes in CoClass (Svensk Byggtjänst, 2016a)

### 2.3.7 Built space

The international standard *ISO 12006-2* mentions that it is the operation that dictates the built space. Any space that has some sort of bounds against the surrounding can be called built space, for example, rooms, tunnels, and roads. The classification tables are divided into several main categories and consists of two types *Activity space* and *Built space*. An Activity space is defined as the space that is required for humans and equipment so that a certain activity can take place. A Built space is defined as a space that contains several activity spaces, for example, a room that contains eating-space, sleeping-space, and work-space. The classification tables are flexible in that the user

can choose whether a space is defined as built- or activity space (Svensk Byggtjänst, 2016a).

There are some classification tables in CoClass for Built space that are not derived from the international standard. Those tables are for the landscape spaces, for example, administrative areas, and land and water areas. The tables are coarsely classified and defined so that in the event a use of a space is changed, an alteration in the classification of the space is not required. The classes are based upon the proposals of the international standard *IEC/ISO 81346-2* and are classified in regards of user-activity or equipment, or a combination of the two. There are three levels of class-codes, and the second and the third are used for classification. The third level describes different types of material and can be excluded if necessary (Svensk Byggtjänst, 2016a). Some examples of the table are presented below in table 2.6.

| **Class** | **Designation** | **Example** | **Definition** |
|---|---|---|---|
| **D** | Space for technical systems | | Space designed for active technical equipment |
| DA | Installation space | | Space for technical systems which support the function of construction entities |
| DAA | Electric installation space | Battery room, generator room, high voltage room | Installation space for stationary electric equipment |
| **F** | Traffic space | | Space for the movement of vehicles, vessels, or persons |
| FA | Vehicle traffic space | | Traffic space for vehicles |
| FB | Active transportation space | | Traffic space for persons, animals, or bicycles |
| FC | Aircraft traffic space | | Traffic space for aircrafts |

Table 2.6 - Class for Built space of CoClass (Svensk Byggtjänst, 2018b)

### 2.3.8 Construction entity

A construction entity is seen as a single entity in the built environment that can be operated by an organisation for one or more functions or activities. Several Built spaces combined will result in a Construction entity and this is the reason why it should be classified by the dominated built space. In collaboration with the Swedish Planning and Building Act, the term *house* used in BSAB 96 has been changed to *building* in CoClass. There are two main types of construction entities: *building* and all that comes under the term, and *civil engineering work* which are entities that are not buildings. In CoClass, the construction entities are classified by the function, shape, and the user-activity. There are few classes in the classification which are planned to be stable for a long period of time. The Construction entity and the Built space classes are closely linked to each other. There are three levels of class-codes, and the second and the third are used for classification. The third level describes different types of material and can be excluded if necessary (Svensk Byggtjänst, 2016a). Some examples of the table are presented below in table 2.7.

| **Class** | **Designation** | **Example** | **Definition** |
|---|---|---|---|
| **A** | Building for human needs and human activity | | Construction entity designed for human dwelling and activity |
| AA | Residential building | | Building for human needs and human activity designed for permanent occupation |
| AAA | Single-family house | Detached house, holiday house, linked house | Residential building designed for one household |
| AAB | House for multiple occupation | Barrack, dormitory, multi-family dwelling | Residential building designed for several households with individual facilities |
| **B** | Technical facility | | Construction entity for active technical equipment |
| BA | Production plant | | Technical facility for production of energy or raw materials |
| BAA | Combined heat and power station | Combined power and heating plant, heating central | Production plant for energy extraction by combustion |
| BAC | Raw material plant | Sawmill, steel plant, sugar mill | Production plant for raw material |

Table 2.7 - Classes for Construction entity in CoClass (Svensk Byggtjänst, 2018b)

### 2.3.9 Construction complex

Several construction entities which are combined with a specific function or operation can be called a Construction complex. This can both be easy and hard to identify and classify depending on the scope used to specify the construction complex. This classification is flexible, and it is the user of the classification system that can specify the scope. In CoClass, a construction complex i classified in regards of the function, shape, and user-activity which makes this class also closely linked to Construction entity and Built space. There are three levels of class-codes, and the second and the third are used for classification. The third level describes different types of material and can be excluded if necessary (Svensk Byggtjänst, 2016a). Some examples of the table are presented below in table 2.8.

| **Class** | **Designation** | **Example** | **Definition** |
|---|---|---|---|
| **A** | Housing complex | | Construction complex for living |
| AA | Housing area | | Housing complex for living |
| AAA | Single or dual family house area | Detached house area, holiday home area | Housing area for single family houses |
| AAB | Apartment building area | Student housing area | Housing area for apartment buildings |
| **B** | Activity complex | | Construction complex for activities |
| BA | Hotel and restaurant area | | Activity complex for temporary living and eating |
| BB | Protection and defense area | | Activity complex for protection and defence |
| BBA | Prison | Correction facility, penitentiary | Protection and defence area for isolation of persons from other persons |

Table 2.8 - Classes for Construction complex in CoClass (Svensk Byggtjänst, 2018b)

### 2.3.10 Construction elements

A construction entity consists of built spaces that are needed for a certain operation to take place. The built spaces are in turn a system of construction elements. The classification tables in CoClass consists of construction elements that have a variety of different complexities for example, from entire wall constructions to a single brick. However, CoClass itself does not specify or explain how these elements are to be

used. Every construction element is described and detailed by its specific need for the structure (Svensk Byggtjänst, 2016a).

The tables for construction elements are categorised in regards of the *form*, *function*, or *position*, or a combination of these three. The categorisation by function have several benefits for the user for example, in the requirements for the construction in the early phase of a project or in the maintenance of the construction. The aspect of form describes the size and proportion of the construction element, but the main use of this aspect is to describe the construction technique with the use of types. The position of the construction element dictates the requirements on the construction form (Svensk Byggtjänst, 2016a).

A construction element can be a part of other construction elements depending on the level of details required for the project. Also, same construction element can be a part of several compound elements in a construction system. An example of this is a Pipe that has the designed function to lead high pressure material. This specific pipe can be part of a district-heating system and a compressed air system. These consequences have led to a division in the construction elements classification tables of CoClass. The class is divided into three independent tables: Functional systems, Constructive systems, and Components (Svensk Byggtjänst, 2016a).

This method of division in the construction elements tables provides a class where the objects are sequentially specified. Firstly, a construction element is specified by the use of function, which is the *functional system*. Secondly, the constructive solution is determined, meaning the *constructive system*. Thirdly, the detailed parts of the constructive system, the *components*, are specified. The tables in the functional system class is only categorised with one letter, the constructive system with two letters, and the components with two or three letters. These structures cannot be changed, and the types of each classes has to be categorised with numbers (Svensk Byggtjänst, 2016a).

The tables of functional systems are divided into three subcategories. *Space systems* which creates the construction form. *Installation systems* which distributes, transports, regulates, heat and cool. *Fit-out systems* which contributes with furnishing and equipment for the construction entity (Svensk Byggtjänst, 2016a). Some examples of the functional systems table are presented below in table 2.9.

| **Class** | **Designation** | **Example** | **Definition** |
|---|---|---|---|
| **1** | Space systems | | Functional systems creating space |
| A | Ground system | Ground, courtyard, road construction, railway construction | Space system on ground, or which terminates a construction entity downwards |

| | | | |
|---|---|---|---|
| B | Wall system | Wall, facade, facade system | Space system which forms and separates space vertically |
| **2** | Installation systems | | Functional systems providing services |
| E | Gas and air systems | Equipment for gas and air, gas, air | Installation system which supplies technical gases or technical air |
| K | Electrical system | Electricity production plant, power supply system | Installation system which supplies electrical energy |
| **3** | Fit-out system | | Functional system fitting out spaces |
| S | Arrangement system | Fitting out rooms, furnishing solution, ladders | Fit-out system which equips a construction entity and its spaces with fittings and equipment |

Table 2.9 - Classes for functional systems in CoClass (Svensk Byggtjänst, 2018b)

Constructive systems are a part of the functional systems in the sense that they provide the functional system with the constructive solution to build the construction element. In this system, the requirements and the detailed specifications of a construction entity can be conducted. The classes in the tables must be used in the second level category and the different types can be specified with two numbers (Svensk Byggtjänst, 2016a). Examples of the constructive system classes are presented below in table 2.10.

| **Class** | **Designation** | **Example** | **Definition** |
|---|---|---|---|
| **B_** | Structural system | | Technical system which forms structural construction |
| BB | Foundation structure | Foundation | Structural system connecting a construction entity with the underground |
| BB01 | Slab on ground structure | | Foundation structure in form of a stiff laying plane |
| BD | Wall structure | | Structural system in a vertical separation |
| BD01 | Solid wall structure | | Wall structure in form of a stiff standing plane |
| **J_** | Transporting system | | Technical system which brings something from |

| | | | |
|---|---|---|---|
| | | | one place to another |
| JK | Electrical power distribution system | Electrical distribution system, electrical system | Transporting system for electrical energy |
| JK03 | Electrical power distribution system for low voltage | | Electrical power distribution system for <1kV AC or 1.5 kV DC |

Table 2.10 - Classes for Constructive systems in CoClass (Svensk Byggtjänst, 2018b)

Components are parts of the constructive system, and they can be single or part of a compound. The level of detail in the components are different in the various stages of the project lifecycle. For example, a window can be one component in the planning and production phase, but later in the facility management phase, the window is seen as a system of components to make the maintenance easier and effective. The classes must be used in the second or the third level of the category (Svensk Byggtjänst, 2016a). Examples of the component classes are presented below in table 2.11.

| **Class** | **Designation** | **Example** | **Definition** |
|---|---|---|---|
| **B__** | Sensing object | | Object for picking up information and providing a representation |
| BA_ | Electric potential sensing object | | Sensing object for electric potential |
| BAA | Voltage relay | Measuring voltage relay, voltage relay | Electric potential sensing object, with Boolean output |
| **Q__** | Controlling object | | Object for controlling access or flow |
| QA_ | Electric controlling object | | Controlling object of electric current in an electric circuit |
| QAE | Switchboard | | |

Table 2.11 - Classes for Components in CoClass (Svensk Byggtjänst, 2018b)

### 2.3.11 Work result

The revised international standard ISO 12006-2:2015 mentioned in chapter 2.1.1, did not introduce changes to the work result classification tables compared to the older version. Therefore, the work result tables in BSAB 96 were imported to CoClass and no changes were made. In both classification systems, the work results describe the result of material and the work needed to build a part of or an entire construction entity. A concept which is introduced in CoClass is that in some cases where the designation of a construction element is related to the work result, then the work result can be put as a property for the element. For example, the construction element

*BD:RUB Wall* and work result *PR:FBB Stone wall* can be put in a combined code *BD:RUB (FBB)*. In chapter 2.3.6, it was mentioned that a formula can be used to specify the technical solution for a construction element. This a project-specific type which is made by compiling several work results to describe the construction element and how it is constructed. Then the type can be combined with the element-code instead of the work result (Svensk Byggtjänst, 2016a). For examples from the work result tables, see table 2.3 in chapter 2.2.6 Work result.

### 2.3.12 Properties

A property of an object is a proven characteristic that the object possesses. The characteristics can be subjective or objective, and also measurable with standardised methods (Svensk Byggtjänst, 2016a). As mentioned earlier in chapter 2.3.4, one principle of CoClass is to be flexible. This can be achieved with the help of properties in the sense that it can be linked to a class. An object can be classified with the class code and a property for the material. This is helpful in the maintenance phase since a change of material only requires change of property and not the class. Another use of properties is that the requirements for a project can be set by specifying the property. This can be done for all the phases in the project lifecycle. However, there are many different properties that can be linked to an object and it can take time to collect and classify properties for all objects. For now, Coclass has classified the properties that are most relevant for the entire project life cycle (Svensk Byggtjänst, 2018b). Some examples from the Property tables are presented below in table 2.12.

| **Designation** | **Example** | **Description** |
|---|---|---|
| **Cultural properties** | | Subjective claims which does not describe the object of material properties |
| Administrative properties | Name, address, price | |
| Symbolizing properties | Drawing, images, level of detail | How the object is documented or reported |
| Experiencial properties | Comfort class, character | How the object is perceived emotionally and visually |
| **Material properties** | | Objectively measurable and independent by a person's experience |
| Functional properties | Sound class, energy class, emission factor | How an object interacts with the environment, including side effects and environmental impact |
| Compositional properties | Quantity, density, material, finish | What an object consists of; how it's constructed, structured, composite |
| Temporal properties | Durability, maintenance interval, production phase | Time for manufacturing, usage, maintenance etc. |

Table 2.12 - Properties in CoClass (Svensk Byggtjänst, 2018b)

### 2.3.13 Maintenance activities

Maintenance activities are defined as actions that are performed to maintain a certain function. The aim of CoClass is to develop a classification for all common maintenance activities to make the facility management phase more effective since a common system will be used by the contractor and the facility manager. For example, it will be easier for organisations to perform the maintenance activities, and it will benefit them both practically and economically. The classification tables categorise all the different designations for the maintenance activities in all complexities, from the smallest component to the entire construction complex. The tables are categorised regarding the purpose of the activity. This classification is intended to be used by: the property owners, janitors, operation technicians, and real estate managers (Svensk Byggtjänst, 2016a). Some examples from the classification tables are presented below in table 2.13.

| **Class** | **Designation** | **Example** | **Definition** |
|---|---|---|---|
| **A** | Preparations | | Maintenance activity that provides documentation |
| AA | Inventory | | Preparation activity to list existing things |
| **B** | Control | | Maintenance activity that examines current status and provides documentation for decision for actions |
| BM | Status check | | Control activity to determine status and function of an object or a service |

Table 2.13 - Classes for Maintenance activities in CoClass (Svensk Byggtjänst, 2018b)

## 2.4 CoClass and BIM

The concept of BIM is a controversial topic since there are lots of different organisations who works with some parts or the entire concept. Many organisations think the modelling of the building or the layout is enough to call it, working with BIM. Nevertheless, it is shown that there is a need for more information about the construction and production than the modelling to be able to work with BIM. The information about different building parts is a vital aspect of the information sharing and the cost estimation is an important part of BIM (Trafikverket, 2017b).

The name Building Information Modeling consists of three different terms and definitions, mainly *Building*, *Information*, and *Modeling*. The term building is defined as a system, structure, project, or a space. The second term is information which is

defined as knowledge that are collected and obtained through communication regarding a specific topic. Modeling is defined as a representational description with relevant properties of a system or a design to provide detailed examination of the components (Weygant, 2011).

The aspect of *information* is the focus of any classification system and if the system is to be used with BIM, then it is essential that the information handling is standardised. Without standardisation, all the information put in a model will only be understandable by the user that made the model and embedded the information. Standardised information which is common and understandable by all can be beneficial when transferred between different actors in the sense that no information gets lost or misinterpreted. The transfer of the information between different actors in a project is dependent upon well-structured standards (Weygant, 2011)

### 2.4.1 How does CoClass support BIM?

As mentioned before, to build a digital information model in an effective way there is a need for a good structure and a common understanding. CoClass is intended to be that standardised classification that will support BIM and provide organisations with a more effective structure on how to build an information model (Svensk Byggtjänst, 2016a).

In the beginning of the earlier chapter 2.3 CoClass, it is mentioned that the classification system introduced the aspect of Reference-ID which consists of class-codes, product-code, type, and position. The classification codes in CoClass describe the function, form, and location. With the help of these different codes, CoClass can be implemented for objects in computer programs such as Revit and Solibri. During the planning phase of a project, any object that is designed can be specified with separate codes within the computer program (Carlsson, 2017).
The string of code can be built successively as the project continues and the different actors can add their information about an object to the reference ID. The level of detail in a reference ID can be beneficial for the constructor since it clearly explains where and what object is to be built. Also, the facility manager benefits from it even after decades of operation. Since the identification code together with a good information hub will make it easier for the facility manager to maintain, repair, or change an object efficiently (Svensk Byggtjänst, 2016b).

### 2.4.2 Reference ID

To avoid the possibility of misinterpretations, the different codes within the reference ID are specified with symbols that defines the code. The symbols are put before the code and can also work as separators to easily distinguish between them. These symbols are:

= which explains the function,

- which specifies the product,

+ which specifies the location and lastly

% which explains the type of the class.

To specify which system the string of code belongs to, a top node can be used which can be put before the code within two angle brackets (Svensk Byggtjänst, 2016b). An example of a reference ID is presented below.

**<House 1>+UT:DAA212=K.JK2.QAE12%JK03**

**<House 1>** Is the top node that describes that the object is located in House 1.

**+UT:DAA212** This describes the location which is the Built Space: DAA Electric installation space number 212

**=K.JK2.QAE12** This describes the function and the construction elements. Starting with the functional system: K Electrical system, then the constructive system: JK2 Electrical power distribution system number 2, and lastly the component: QAE12 Switchboard number 12.

**%JK03** This describes the type which is the project specific constructive system JK03 Electrical power distribution system for low voltage.

(Svensk Byggtjänst, 2016b)

# 3. METHODOLOGY

This report uses a qualitative research approach. To emphasize spoken discourse and written text instead of quantification when gathering data and conduct an analysis, is a strategy that represents a qualitative research. A qualitative research contains of 6 steps which the authors Bryman & Bell (2015) highlights in their book. We have with the help these steps conducted our research and written our report. (Bryman & Bell, 2015).

The first step is the *General research questions* which has been addressed in the beginning with an introduction where the topic is explained, and the background is described. Also, this section continues to explain the purpose of the work. This is followed up with project objectives and a few research questions. Furthermore, in the introduction part of the report, the method of work is described and the limitations of are recognized.

The second step is the *Conceptual and theoretical work* aspect which contributed to the framework of understanding. In this section, the two classification systems are defined and explained from a general perspective. Then, the Swedish classification system BSAB 96 is explained thoroughly following with the new classification system CoClass. Furthermore, the report describes BIM in general and investigates the implementation of CoClass regarding BIM.

The third and fourth step is *Selecting relevant sites and subjects* and *Collection of relevant data* which in this report has been considered in the chapter called empirical data. A project from the Swedish transport administration that is important regarding this topic, has been chosen as a case study. The project Centralen (Västlänken) is implementing CoClass and has been introduced and investigated. The empirical data is based on interviews with some professionals working in the construction industry and others working with the chosen project. The choice of interviewee persons was based on their knowledge in their respective areas. Recommendations from our supervisors (and from the interviewees) were also considered in the choice. The interview questions are similar in some ways; however, the questions differ in order to adapt to the interviewee's profession and area of expertise. The interview questions can be studied in the section Appendix.

The fifth step is the *Interpretation of the data* which means that when both classification systems, CoClass and BSAB 96, are introduced and explained, the report needs to highlight the differences between the two classifications. Under the chapter comparison, a comparison between the respective classifications can be found. This chapter is a systematic comparison done to develop the understanding between BSAB 96 and CoClass. Also, in this chapter, the framework of understanding data will be compared with relevant empirical data gathered from the interviews to see the real-world application of CoClass.

The sixth and last step is *Writing of findings and conclusions* which helped in this report to follow up with an analysis of the different perspectives. A discussion between the data from the framework of understanding compared with the empirical data is also included. The analysis and discussion will highlight the possible benefits of CoClass compared to the old classification and the implementation of CoClass in the case is analysed. The two classifications are also compared by the implementation with three-dimensional modeling. Finally, at the end of the report the results and findings of this project are concluded.

The ethical concern regarding research and development can be sometimes overlooked. Any project that is focusing on researching academic papers and literature must review and critically analyse them to gather the knowledge. The information that is gathered can then be compared and explained so that the author can describe where one literature is better than the other. In the ethics of academic writing, it is important that respect is shown towards the authors of the literature or the academic papers and the comparison is conducted impartially. The same thing is applied in the analysis of the project, here the author analyses the information regarding his/her own knowledge and understanding. The same level of respect has to be shown in the analysis towards the different authors. These aspects of ethics regarding research and development has been considered in our report and followed thoroughly.

Regarding the project, which includes supervision, interviews and case studies it is important to understand that the people contributing with information and guidance are providing it out of interest. The people might not expect anything in return other than a good report. Therefore, it is important that they are acknowledged and not take them for granted. In the aspect of interviews, it is important to consider the interviewee's position regarding anonymity in the report. If the persons names are to be mentioned, then their approval is needed. This report will not mention the interviewee's real names and instead use pseudonyms.

# 4. EMPIRICAL DATA

The base of the empirical part are interviews with different professionals who are knowledgeable of CoClass or are involved with the case study. Firstly, there will be an explanation of the case study, the project Västlänken. Secondly, the empirical part will continue with interviews about the classification, the project Västlänken, the sub-project Centralen and more. The last section is a follow up of the discussions and observations regarding these topics.

## 4.1 Case Study - Centralen

Centralen is a unique project in its nature of creating an underground subway with the implementation of CoClass. It is known as a starting point and primary project that will follow up and continue to create an underground subway through the city of Gothenburg. The sub-project stretches from Olskroken through the Central Station reaching Lilla Bommen. It is divided into two parts, the subway tunnel and the subway station at Centralstationen. The time schedule is estimated to be between six to seven years. The tunnel is planned to be built in sections that are made of concrete and sections that are drilled in the mountains. The total length is estimated to be 1800 meters long (Trafikverket, 2017a).

The subway station is planned to be built north of the Central Station in Gothenburg. The sub-project will consist of four railways with two platforms and the length of the platforms will be 250 meters long. The entrances to the station are planned to be built in connection with the existing public transportation. There will be three entrances were the first one is located in the Central Station, the second where today´s Göta Älv bridge is located, and the third is located in Gullbergsvass. The station will be 15 to 17 meters under the ground and will consist of several levels (Trafikverket, 2017a).

### 4.1.1 The subway project Västlänken

The construction of the underground railway project is divided into four stages. As mentioned before, the first stage starts in Centralstationen and continues with the second stage around the area Kvarnberget. The last two stages take place in Haga and Korsvägen, see figure 3.1. The aim of Västlänken is to develop a competitive rail bound public transportation system in the Western region of Sweden. However, the significance of this project is not only on a locally or regionally level, it is also important on a national level since this project will contribute to reduced commute time across the country (Göteborgs Stad, 2006).

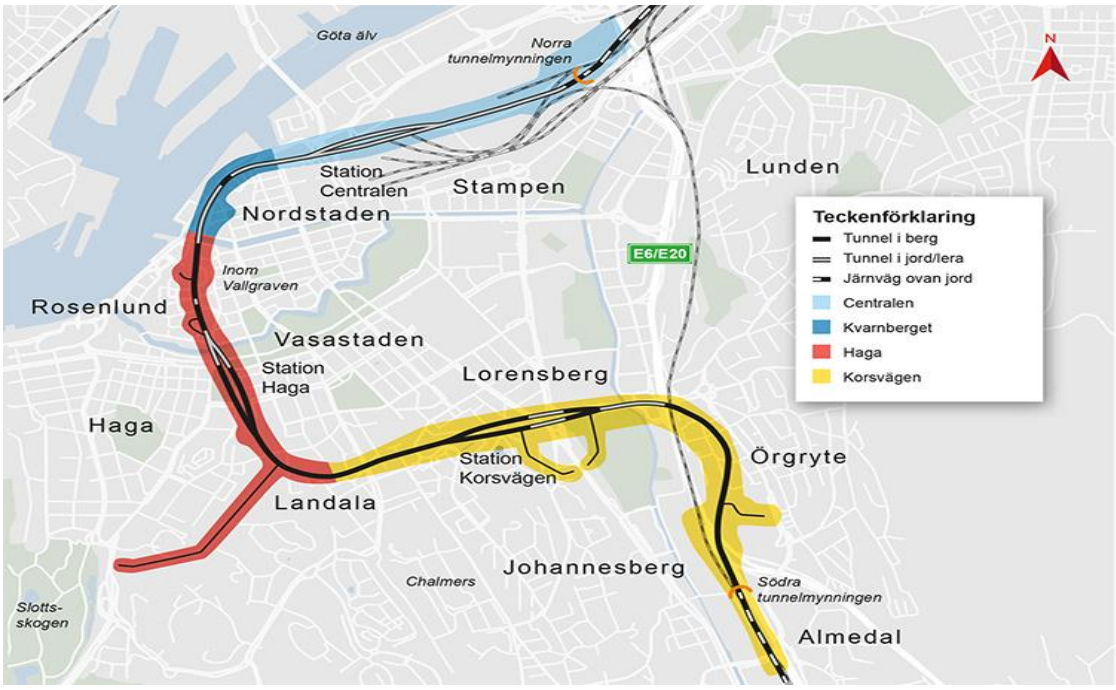

Figure 3.1 - Presentation of the project and its stages (Trafikverket, 2017c)

In a report by Göteborgs Stad in the year 2006, the average amount of people that would cross the municipality borders of Gothenburg on a weekday was estimated to be more than 650 000 by the year 2010. Only around 17% of these are commuting and using the public transportations. The regional and local authorities are striving to increase the use of public transportation and decrease the use of private car. Therefore, in the report, the main objective of Västlänken is defined as means to improve the railway-system and offer a good transportation that is also a sustainable development for the people, environment, and the society in a national and regional level (Göteborgs Stad, 2006).

### 4.1.2 The contractor

The construction company NCC is the responsible contractor for the sub-project Centralen. NCC as an organisation is well established and have a lot of knowledge with well-experienced workers. The cooperative contract form between Trafikverket and NCC for the sub-project is an Early Contractor Involvement (ECI). This contract form allows NCC to work closely with Trafikverket in the design and planning phase, and together optimize the cost calculations. The initial stage of the project involves heavy planning where the method and production solutions are chosen. In this stage, aspects such as work environment, organisation, sustainability, and economics are in focus (NCC, u.d.) Today the project is still in the initial stage and the project documents are being developed. Only recently, the project got the approval from the authorities to start the construction phase. There are over 170 people working with this project and most of the project organisation are working in the same office so that the work is more efficient (NCC, 2017).

## 4.2 Empirical findings

### 4.2.1 The implementation of CoClass

The interview with Karl starts with a brief explanation of how Trafikverket are working today. He follows up with the fact that there is hard to find a common approach to work collectively today. The implementation of CoClass is intended to have effect on the different actors and to be able work collectively. The interviewee continues to present the ambitions and goals that Trafikverket have. He talks about working collectively between the different actors. Trafikverket want to succeed in working collectively where everyone participated, and everyone are contributing. He continues to explain what actions need to take to reach the goals and ambitions of the organisation. Furthermore, he explains a vision of how it will look when everyone contributes. When every actor communicates well and participate to reach the goals of the projects and because of that able to save money and time on projects (Karl, 2018).

Jacob believes that the implementation of CoClass is important and necessary. He continues to describe that change is moving too slow especially for public organisations. He is currently working with CoClass as a classification and trying to identify and classify functions. Jacob explained during the interview that Trafikverket have had problems with the previously used classification BSAB 96 and the reason behind that is, there were own interpretations and completions. Since he mentioned that problems have occurred with previous classification for Trafikverket, the implementation of CoClass will improve the sector. Jacob continues the discussion about the limitations of CoClass. He mentions that a clear limitation is the fact that, when the whole industry is trying to become standardized it becomes a limitation for the organisations. Also, Jacob manages to highlight that Trafikverket are eager to implement CoClass because of the advantages that comes with new classification. Since Trafikverket were eager to implement CoClass he explained that the director just needed to give the order and Trafikverket implemented the classification. However, he follows up with an estimation around ten years for CoClass to be fully implemented in Trafikverket (Jacob, 2018).

The interviewee is positive regarding the implementation of CoClass. He mentions, for Trafikverket, that there are many flaws with the previous classification systems. The shortcomings that BSAB 96 have had has been throughout the projects and in classification tables. The interview continues with the statement that the implementation of CoClass is the right direction to go. However, he points out that it will definitely be some flaws and errors (Alex, 2018).

The best thing is to include and implement CoClass from the start of the project. Previously the contractor did not have the knowledge, technic and benefits of the digital model and was only interested in the drawings. Management organisations were also not mature enough for the digital and was pleased with a pdf-file. Both the contractor and managements can use the digital model to their benefits, thus, it

becomes valuable. Furthermore, the architect and the constructor need to understand that the thing that are put into the model will be beneficial for the coming 25 years. The interviewee believes this is the thought process needed in a project (Tom, 2018).

### 4.2.2 Västlänken - Centralen

The project Västlänken is viewed as a so-called pilot project. Pilot project is defined as a test project to try to implement CoClass. This project was specifically used for the reason being that it was fitting while CoClass as a system was completed in time of this project (Alex, 2018)

According to Victor (2018) he feels that it is good thing to use the same "naming system" (classification). He continues with the fact that he believes that in the long run the industry is a winner. Everyone will recognise what kind of project it is. Today, they are working with connect the database from Trafikverket with their BIM models from the project Centralen. They have named some systems and objects with the help of CoClass. To test the synchronization between the parameters and the objects and concludes that they have reached a few good results.

The whole project of Västlänken can be viewed as a pilot project for the implementation of CoClass. It showed to be fitting by time, when CoClass as a system was completed in time for this project. Västlänken is not only a railroad/railway project, but it contains more, for example different stations with many different building blocks and technical solutions. Therefore, there was a demand for something that could collect all information in a system and help in the management phase (Alex, 2018)

According to (Jon, 2018), to live up to the growing population in the city there needs to be an improvement of the transportation and with a city changing project such as Västlänken, it will provide a better public transportation.

### 4.2.3 NCC as a Contractor for project Västlänken

According to Alex (2018) the reason NCC was able to work with Trafikverket in this project is that NCC was the cheapest alternative. Also, NCC was able to live up to the demands of Trafikverket. In the start of the project, NCC was contracted as consultants. Thereafter, proceeded with an ECI contract. One major reason for NCC got the project is their organisation and thoughts regarding on how to perform the project. The interviewee continues to mention that the ECI contract form only affects sub-project Centralen and sub-project Olskroken. Other sub-projects have traditional contracts.

### 4.2.4 Advantages with CoClass

The advantages of CoClass are many. Most of the people interviewed agree upon the fact that CoClass needs to be implemented to improve the sectors. Some are more eager than others to implement the classification sooner than later. A common language is understandable for the actors involved. Tom (2018) defines CoClass as a more structured classification regarding function, form, and position. In the end it is all the same thing they are building and with CoClass they can get more detailed building part if it can be used correctly.

According to Jacob (2018), an improved aspect of CoClass is the better way of communicating and doing it in a concrete way. A recurring comment during the time of the interviews is the fact that CoClass is harder to follow and more complex. According to Alex (2018), it is easier to follow the tables and in general use BSAB 96.

The advantages with the new classifications system is that it is wide. CoClass is aimed primarily at the aspect of function and that makes it easier to use in the early stages, also to use over the whole life-cycle. Also, the interviewee continues with, there is a clear advantage in the fact that focus lies in introducing a collective system. Furthermore, he continues with the fact that the decision is from a level that cannot question the decision (Sean, 2018).

### 4.2.5 Disadvantages with CoClass

Victor (2018) discussed some disadvantages regarding CoClass. One aspect is time, time for all actors to really start using the system. If an organisation has worked in one way for the past years, then it can be hard to adapt and turn over to another classification.

There is a lack in explaining how to switch to templates for CoClass from BSAB 96. They have not even applied new systems to get new codes. Customers will wait to build. He thinks it is great that Trafikverket takes the initiative (Sean, 2018).

### 4.2.6 Contractors perspective of CoClass

From the perspective of the contractors, regarding the use of codes and reference ID, Jacob considers that it is easy for the contractors to adapt. However, he continues to follow up with the fact that there might be some problems with the project Centralen. Centralen is in an early stage and a lot of things can change therefore Jacob thinks problems can occur during the continuing timeline of the project. Regarding the appointed contractors NCC who is responsible for the project, Jacob believes that NCC can do the good work needed. Also, he points out that the if PEAB or Skanska would have been responsible for the project they would obviously be able to do a good job (Jacob, 2018).

### 4.2.7 The future of CoClass

The interviewee is estimating in ten years' time CoClass will be fully implemented. BSAB 96 will no longer be updated and only the work results tables from BSAB 96 will be updated because the same tables are used in CoClass. Trafikverket is first to implement the use of CoClass. There is also project in Stockholm that works with CoClass. Besides Västlänken and the project in Stockholm, the project called Ostlänken is using CoClass (Tom, 2018).

Regarding more organisations implementing Class besides Trafikverket, Sean mentions that some organisations have already started. Organisations that are sub-owners of CoClass, for example, special properties that manages prisons and security offices uses CoClass in administration. Everyone is not familiar with the classification yet, however, many want to implement it. If larger projects use CoClass shows to be successful, then, it will be easier to implement and that leads to more organisations willing to use CoClass. BSAB 96 will not be used and the development of the classification have stopped. The components in AMA that are from BSAB 96 will be adapted to CoClass. A new AMA will be available every 3 years; therefore, it will take 9 years to complete the series. It may take ten years before people fully stop using BSAB 96. There are however, many old documents and drawings from BSAB 96 and they will never be changed and in this instance BSAB 96 will live in many years (Tom, 2018).

Like the previous interviewee, Jacob predicts and estimates a similar time table around ten years' time for the implementation of CoClass (Jacob, 2018). According to Sean (2018) CoClass will be fully implemented in six to seven years and BSAB 96 will no longer be used. He continues with the fact that the patience will not allow the organisations not to use the new classifications system.

Regarding the future the interviewee is guessing around 4-10 years for the implementation of CoClass to fully be used and replace BSAB 96. Also, thereafter the system needs to be useful in the operating stage. However, he believes that firstly there needs to be some feedback from projects before you fully use the classification.

He continues to with his believes that the construction industry will follow with the train regarding the implementation of CoClass. For now, governmental constructors/clients are testing the implementation of CoClass. If it shows to become successful process, then more projects will be required to use CoClass and that means contractors will be forced to learn how to use it. When later the benefits with the use of CoClass will be shown then the private sector will follow. (Victor, 2018)

### 4.2.8 Projects currently working with CoClass

When asked if there are any projects that are using CoClass, Karl explains that the project Centralen is using the classification. Also, there is a bridge that PEAB is building and using CoClass. The interviewee mentions a project in Södertörn where Trafikverket is planning to build an interconnecting road. In this project, they are not using CoClass but rather a Trafikverket specialised system that has good connections with CoClass. Problems have occurred in the planning phase that has paused the project for now (Karl, 2018).

When asked if there are any projects that are using CoClass, Jacob continues to explain that the project Centralen is viewed as a pilot project. Furthermore, he continues to explain the fact that Trafikverket are first with the use of the classification (Jacob, 2018).

Project that use CoClass are the expansion of the subway expansion in Stockholm. Also, the project Östlänken. Karlstad's municipality use CoClass to classify their facilities and buildings in urban planning (Tom, 2018).

### 4.2.9 Reference ID

The Interviewee explains that CoClass reference ID is structured by several different parts. The first is a location code that describes the location of the object.
The next part explains the system the object belongs to and lastly what kind of object it is (Victor, 2018).

The interview with Karl goes in depth regarding how the Reference ID is used. The Reference ID is able to be understood by all actors involved in the project by looking at the codes. However, Karl continues to explain that Trafikverket has already started to make their own interpretations and completions to some aspect of CoClass (Karl, 2018).

The person interviewed is referring to himself as no coding expert. However, in his opinion it was easier to navigate through the old classification system. Also, easier to find a code or a value. Nevertheless, he states that CoClass is more abstract and tables are more complicated to follow. The function and the information in CoClass is

available for different building parts, still it is hard to search solely with the designation of the building parts (Alex, 2018).

In the plugin-program to Revit, NCC have created lists where the planners can choose where the object will be placed and is intended to be placed. What system the object belongs to and what object it is about will be mentioned in the reference ID. The CoClass codes in their regard paired with these lists to create the correct reference ID. This is a process created to facilitate the planners so that they do not have to look at the CoClass list and guess what system number and object- ID to choose (Victor,2018).

### 4.2.10 Software

The interviewee mentions that they are in contact with several software developers, AutoCAD, Revit, ArchiCAD, Tekla and these are the big developers for CAD: Other developers that works with cost calculations, Bidcon, MAP. Some have systems they have developed themselves, but CAD manufacturer are ready to implement CoClass as soon as their customers' demands it. The interviewee is convinced that this year most CAD programs will support CoClass (Tom, 2018).

NCC plan in the software program Revit where the objects are drawn in a 3D environment. In this phase, the parameters from objects are combined to Trafikverket's database Maximo. The plugin-program to Revit manages the synchronization to Maximo is adapted for this purpose and have been programmed on behalf of Trafikverket. This look like the current soft developer "Chaosfunc" that is developed to link AutoCad-files (DWG) with Maximo (Victor, 2018).

### 4.2.11 Education

Educating the people is also an important aspect. Many are not informed about CoClass. Also, the average builder might not understand the coding and definitions in the classifications therefore, it is important to educate and develop. Because if you do not improve then you deteriorate. There is also not a lot of information regarding CoClass since it is a developing and newer classification. Therefore, it becomes a crucial point to upload and make all information available for the stakeholders and people involved (Sean, 2018).

### 4.2.12 Communication Tools

Västlänken/Centralen is as mentioned a unique project. During the time of the work the project Centralen got the permission to start building. As scheduled as a starting year 2018. However, the communication remains the same type of methods of communication. Meetings are arranged and scheduled to have clear line of communication and understanding. Communication in the form Email and phone calls

to have the easy access to one and the other. Also, there is a project manual description in projects. Some people work in the same city and others live and work in another cities. Still, there are offices to meet at and have face to face conversations. So, the ability and opportunity to have a conversation with partners in the project is possible and available. Furthermore, not in just this project rather in all other projects it should be easy to reach and get in contact with other workers.

# 5. ANALYSIS

Based on the empirical data and discussion together with the observations, the authors can conclude that CoClass is an interesting subject. The construction industry needs an improved classification and it have been pointed out the advantages with CoClass. The implementation of CoClass will benefit all actors. This used as a background, we will furthermore analyse our results.

## 5.1 Centralen

According to Alex (2018) the reason being for the use of CoClass in this project is timing. Since it was fitting to use the classification because CoClass was completed in time of this project, the question remains, is it not better to test out the project into another smaller project and use that project as a pilot project?
Only after the project is finished is it possible to determine the choice of project. Furthermore, Centralen is a sub-project and how will it continue to affect the other sub-projects will be determined during the project and afterwards. However, one aspect is hugely positive regarding CoClass, the fact that CoClass is implemented into a project of this magnitude will increase the awareness regarding CoClass. Furthermore, will promote and make larger organisations aware of the possibility of working with projects using CoClass in the future. Therefore, learn how to use of the classification and have the advantage of knowing how to work with CoClass.

Västlänken is a big project and questions may arise regarding the implementation of CoClass in a project of this magnitude. However, it is obvious that Trafikverket believes in CoClass since they have been involved from the start and are Co-Owners. Another factor comes into place when the contractor is inexperienced and have not used CoClass in projects. Yet, as mentioned by interviewees it is easy for the contractor to use the system and follow the coding.

Västlänken/Centralen has a starting year 2018. With the construction work that is ongoing during this time it needs to be planned properly to not hinder the traffic flow and the ability to use the transportation to reach the destination. Eight years is a long time for a project and even though the purpose with this project is to improve the traffic and the transportation. It is still important to work collectively and create alternative roads to keep the Traffic flowing. This project is in the middle of the city and will hinder transportation. To not create alternative roads and plan properly will lead to traffic problems.

Today the projects Västlänken and Centralen is in an early stage and CoClass has not been fully implemented in the project. As it was mentioned in the interviews, only recently has the production phase started and the different actors has started to analyse CoClass to find the best solution for their needs. In this phase, it is important that all actors involved understands that every information that is classified with CoClass and

put in a system will benefit the project during the entirety of its life cycle. Therefore, good knowledge and education of CoClass is required so that the appropriate classifications are chosen. Since a project like Västlänken and Centralen has the lifespan of several decades, it is important that the actors' choice of classes is made with consideration of the facility management phase. There will be changes to the construction elements and objects during this phase and it is therefore important that a change in the classification is minimal.

## 5.2 CoClass

With the help of the new classification CoClass the users can speak a language where every actor in a project understands the information rather than the use of BSAB 96 where some organisations created their own interpretation of the information. Yet, the question if the construction sector and management sector need a new classification need to be answered. The opinion among the interviewees was that it is important to develop a new classification. The interviewees agree and explains that the implementation of CoClass is important. However, they mention that the change is taken too long, and the classification must be used more often in projects. Furthermore, if CoClass will be used more often and by larger organisations, the reactions and the consequences of the actions by the larger organisations will lead to a more established classification.

The contractor's perspective in projects is often time to adapt to the demands of the owner or the buyer. In the project of Centralen, the contractor needs to adapt to Trafikverket's demands and adapt to CoClass as a new classification. The contractor needs to understand what is demanded of them to be able to complete the different tasks and later complete the project. The magnitude of a big project such as Västlänken and Centralen comes with responsibilities. The demands and the pressure that follows a project such as this, there needs to be an organisation that have the resources and can live up to the demands. NCC as a contractor has taken up the challenges with the subprojects of Centralen and Korsvägen. NCC is more than capable and contain the resources in order to complete an underground subway under the city of Gothenburg. However, a failed project and not being able to complete the project will be devastating for the organisation.

The contract form of Early Contractor Involvement is crucial for this project. NCC´s input and contribution in the design and planning phase can make a huge difference. From the empirical data gathered during the time of the report, it can be concluded that the ECI contract form comes with a few advantages. A few interviewees agree upon the fact that when the contractor is involved in the early stage of the project, the organisations are able to save money. The contractors present their ideas and experience to work in a smarter and less expensive ways. Most of the time, the buyer is not knowledgeable in the construction and production phase and can therefore not make appropriate decisions in the planning phase. For example, in projects regarding

building bridges, the input from the contractor can differentiate between building on ground rather than on water. Also, the contractor knows the relevant technical solution and can give advice. In this instance, the project will save a lot of time and money. Furthermore, in these instances it is possible that the project reaches a better quality. Regarding the projects Västlänken and Centralen, the input from the contractor can be beneficial in the planning phase where the appropriate CoClass classification tables are to be chosen.

The construction industry is diverse. Jacob (2018) explains that today, every organisation has their own interpretation and completions of the classifications. Therefore, with the implementation of CoClass, every organisation will be able to communicate and understand each other. Furthermore, this will lead to a clear communication and understanding that saves both time and money. It is important that there are no misinterpretations of the information between the different actors and between the phases of a project so that it can efficiently progress and succeed.

According to Sean (2018) a factor that needs to be highlighted is education. To educate the workers and promote the classification is essential for an eventual implementation. Not only do the larger organisations need to start using the classification, they also need to educate their staff on how to use it to really understand the function and the purpose. One thing that was also brought up during the interview was that the implementation of CoClass might also be depending on the economic factor. Since many construction companies has different departments and workers, there can be a situation where some departments are using CoClass and some are not. This means that two or more different systems and base of knowledge has to be considered within the company. Therefore, the best economical solution will be to choose between the systems, and this will logically be CoClass.

## 5.3 COMPARISON

### 5.3.1 CoClass vs. BSAB 96

Based on the framework of understanding and the empirical data it can be concluded that CoClass is based on the currently used classification BSAB 96. When comparing BSAB 96 with CoClass, it is important to understand that CoClass is being implemented because of the current classification is not effective enough and to implement CoClass could lead to potential improvements in the industry. Furthermore, some parts of BSAB 96 have been directly implemented into CoClass. With this as a background, in this section a comparison between the two classifications will be made (Smart built environment, 2017).

BSAB 96 have been used as an information structure in the construction sector. CoClass is slowly replacing the former classification since the first version of CoClass was introduced in 2016. The interviewees mentioned that a common problem

regarding the use of BSAB 96 is that organizations make their own complementation and interpretation. Even though there is the possibility of making own interpretation in some parts of CoClass, the classification is trying to avoid that possibility so that everyone can communicate under one common "language". These possibilities are avoided by developing CoClass in detail and covering all aspects of a construction project under one classification system.

CoClass is intended for all building environments and will be a contributing factor during the whole life-cycle of a project. All actors, from the owners, contractors to planners can use CoClass (Svensk Byggtjänst, 2016a). However, CoClass is still being developed, changes will occur, and information and components will be added to the classification system in regards of the feedback from the users. Therefore, there will be updated and improved versions of the classification the same way BSAB 96 was updated and adjusted.

As it was mentioned in chapter 2.1, the authors Lou and Goulding (2008) argued that the most important aspect of a classification is its ability to be integrated easily and efficiently rather than the structure of the classifications. Comparing both BSAB 96 and CoClass with this statement, it can clearly be seen that CoClass is trying to be more efficient and easier to implement in the sense that is considers the function, form, and/or position of an object. CoClass can be used to classify an object with the help of these three aspects and therefore gives the user more flexibility. However, BSAB 96 is only using the function to classify objects and Ekholm (2016) describes the negative aspects of this method. He mentions that the structure or the composition of the objects must be considered since a function can be provided by several different objects. Without specifying the form or the position, the professionals who develops the technical solution will not be able to follow the classification. All these negative aspects described by Ekholm can be overcome with CoClass, since the composition and structure can be described by classifying an object by the form and position. CoClass also introduces different Types that can be linked to an object which will help the development of the technical solution.

The classification tables of BSAB 96 and CoClass are categorised differently and as described in the framework of understanding section, the tables of BSAB 96 only describes the object where the tables of CoClass gives designations, examples, and definitions to an object. The tables of BSAB 96 offers no flexibility and it must be used as it is, whereas CoClass allows for changes in the designation of an object so that it suits the user. Another aspect that makes CoClass more flexible is that there are more subcategories rather than many levels in the hierarchy. For example, the tables of BSAB 96 can be stretched down to five or six levels where the tables of CoClass only stretches down to three levels. This method makes CoClass easier to use since the subcategories are more detailed and prevents changes in classes if an object must be changed.

CoClass has divided the construction element classifications into three different categories, as described in chapter 2.3.10. There is a category for the functional system, for the constructive system, and for the components. With these three categories, a construction element can be described in detail. BSAB 96 lacks the level of detail in the classification for the construction element and the Swedish regulations AMA must be used in collaboration to develop the constructive technical solution. The method that CoClass is introducing allows for a common language to be used and another benefit with this method is that the constructive system classes can also be used as types for the object and make the classification more flexible. This means that if a component must be changed, then it will only affect the type and doesn't require a change of the functional classification table. For a company that uses CoClass, the different components and constructive systems can be saved as formulas to standardise their own construction element. Meaning that by determining the function, the company can easily derive a constructive system and components from earlier projects. This will benefit them in the calculations and also reduce the planning time.

As mentioned earlier, CoClass considers the function, form, and position of an object. Therefore, something new that the classification introduced is the implementation of a reference ID for an object. This reference ID, as mentioned in chapter 2.4, is a string of code that firstly describe the position, then the construction element, and lastly the type. This string of codes can be used due to the classification systems acknowledgement of the form and position in the categorisation. In BSAB 96, the only focus is on the function. Therefore, the form and position must be categorised with the help of other regulations or systems. A complete reference ID will describe the object from its position to its different type of component. This will benefit the facility management phase of the project since the operations manager can easily plan the maintenance and change a component more freely.

CoClass introduced two new tables, the maintenance activities and the properties, both of which was missing in BSAB 96. The framework of understanding chapter in this report explains the properties as proven characteristics that an object possesses. These characteristics can for example be the material used in the production. The other table that is new in CoClass is the maintenance activities, these classification tables describes the different actions that are needed to maintain a certain operation in the facility management phase. In BSAB 96, there were no specifications regarding the maintenance activities and properties. Other standards and systems such as FI2 and BIP-codes had to be used to specify the needed maintenance activities and properties. These systems are compatible with BSAB 96 but are not developed by the same organisation and are not part of BSAB 96.

### 5.3.2 CoClass in Centralen

From the interview with Karl, it was explained that there might be some conflicts of interest in the project of Central regarding the implementation of CoClass. The

interviewee gave the example of staircases, escalators, and elevators. For the contractor, the staircase is seen as part of the flooring system where the escalator and elevator are people-transporting systems. In the facility management phase, all three objects are seen as people-transporting systems. Trafikverket and the project Centralen focuses on the people-transporting systems and to provide the function of transportation. The conflict that arises in the functional systems is that different actors does not understand each other's needs. The interviewee mentions that when everyone understands the facility management phase and the needs, then these problems will be solved (Karl, 2018)

Regarding the conflict of interests, the interviewee Tom did not see it as a problem if an object had to change between different classification tables in the facility management phase. However, he mentioned that in the long-term perspective, it is better that a class is not changed. Therefore, the choice of classifying in levels should be made carefully. If the object is classified with the higher levels, then the code and classification definition will be broader (Tom, 2018).

In some of the interviews with the people working with CoClass, it was mentioned that the new classification can be a bit harder to use. The problem was that it was hard to find a specific class since the method of categorisation was different compared to BSAB 96. This is something that will be solved by education and experience. In the project of Centralen, the production phase has just begun, and they are analysing the classification tables to find the relevant tables for this project. Once CoClass is fully implemented and the users has gathered experience, the classification will become much easier. Also, from the experience of this project, both the users and the developers of CoClass can see where there is need for improvements.

# 6. DISCUSSION

Today, it is not hard to conclude that many companies have their own view and interpretation of BSAB 96. Some organisations are more eager than others to stop working with the previous classification and implement CoClass into their organisations. However, according to Jacob (2018) it will be easier for some organisations to implement it than others, depending on their level of experience with other systems that are classifying by codes.

CoClass is as mentioned still developing. To be able to improve the classification, it is important that the construction sector and management sector are involved. The development is a continuing process and the impact from different sectors could be vital. It is in our opinion that the construction management sector should have a role in the developments. Since the classification is aimed for organisations in the construction sector and management sector. Therefore, their voice needs to be heard and their opinions considered.

It is important to have a common language and to be able to communicate well and clearly. This will lead to an opportunity to save a lot of money and a better understanding of the intended information that is shared. Also, looking at BSAB 96, it is necessary to look at the disadvantages with the classification and from that aspect find a better solution. That solution can be implemented into the new classification. CoClass went under the name BSAB 2.0 as it was viewed as an improvement from the previous BSAB 96. Also, the impact of the international standards could lead to changes in the new and improved classification. Therefore, it is hard to consider CoClass a full developed classification yet.

Throughout the report the interviewees mentioned that BSAB 96 is an easier system to use. Since BSAB 96 is a part of CoClass and CoClass covers more of the project life-cycle. Then, CoClass is viewed as a more abstract system and harder to follow in the tables. Although, it might seem that BSAB 96 is easier to use it is important to mention that the reason might be that if a person have used a system for a certain time, that person will be accustomed to that specific way of working. It is important to get accustomed to the new system and work with it a few times (years) before making judgements.

From a general perspective it is hard to conclude when the new classifications system will be fully implemented and replace BSAB 96. Since Trafikverket just start implementing the system and it is only around two years old. However, it is a popular opinion among the interviewees that CoClass is the future and will be the new classification system. How long time it takes will be determined but in the competitive market everyone wants the head start so, to gain advantages, the sooner the implementation of CoClass is starting the better for the organisations.

According to the interview there are a limitation in the fact that CoClass have not reached a further point in their development (Sean, 2018). If the classification had reached a more developed staged there might have been more projects currently using CoClass. Because, it can be concluded from the interviews that the reason Västlänken is used as a pilot project is the reason of timing. The time schedule for the presented CoClass version was in line with the start of Västlänken.

According to Tom (2018) if larger projects use the classification then more will follow. Västlänken is a big project and a city changing project. Therefore, with the implementation of CoClass Trafikverket believes in a more complete classification. As mentioned before, CoClass is covering the whole life-cycle. It is interesting to analyse the benefits that these projects will have with the implementation of CoClass.

The authors of this report agree upon the fact that a city such as Gothenburg which is growing in population needs to have developments in the transportation. Because the demand is increasing and therefore needs to be adapted to. As we mentioned in the empirical chapter, the amount of people commuting in and out of the city are more than the roads can handle. This will only increase since most of the job offers are inside the big cities and people all around the municipality will travel into the city for work. With consideration of these factors, investments and developments in the transportation systems are necessary.

# 7. CONCLUSION

In the beginning of the report, this project research questions were presented. These questions have directed and guided the scope of this project to get the results and accomplish the goals. The questions are:
*-How is the new Swedish classification CoClass intended to be used in Västlänken and Centralen? How is CoClass going to be implemented in the projects?*
*-Is CoClass an improvement compared to BSAB 96? Is CoClass a new and improved classification system?*
*-How is CoClass used in collaboration with BIM and three-dimensional models?*

The project Västlänken is the first stage of the city-changing project across Gothenburg. With the implementation of CoClass the project should provide some good results. The project has only recently finished the design and planning process and got the permission to start building. The classification tables of CoClass are under analysis by the construction professionals and the first impression of using the classification is promising. The year 2026 is the estimated year the project will be finished. Therefore, it will be interesting to look at the progress and follow up with the project these coming years.

In this report the conclusion is that communication is a vital aspect of the role of the interoperability in construction projects. CoClass can clearly be seen as an improvement over BSAB 96 in almost any aspect regarding a classification, and a classification system is a vital aspect of communication within a construction project. CoClass covers more of the project lifecycle and have benefits for all actors involved. From the very start of the planning phase, any information that is implemented with CoClass can be built upon and serve all the other actors that need the information. If the project is using BIM, then all the information regarding the construct for example, the classification code or the properties, can be implemented directly in the computer program and serve as an information centre. The information can then easily be transferred between the different actors involved.

From the Interviewees perspective, it is clear that they believe in CoClass. The advantages with the new classification have been highlighted by the authors of this report and by the interviewees. However, there are still a lot of work to be done and developments need to be in order to reach the goals with the new classification.

Overall, it can be discussed the importance of a new classification. Yet, this report provides the benefits and necessary information for an implementation of CoClass. However, there needs to be more projects that implement CoClass and even though Trafikverket is first to implement it, other organisations need to follow the lead of Trafikverket. Practical experience with the system is important to see where there is need for improvement and the users has to come with ideas for improvements. Therefore, the classification system is going to be as good as the people using it.

## Future Studies

- To analyse the implementation of CoClass when the project Västlänken is finalized. To make a comparison between the theoretical implementation with the practical implementation of CoClass. To analyse a finalized project that have implemented CoClass.
- The construction sectors perspective of CoClass. Do organisations need to implement CoClass to get a head start over other organisations who are not using the new classification?
- When the project Västlänken and Centralen is finished. To analyse these projects and look at what did CoClass change and improve in these projects. Make a comparison between implementing CoClass rather than BSAB 96.

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# Appendix

## 1. Interview with Jacob

- *Vad har du för roll? Bakgrund och utbildning?*

Jacob arbetar på ett lokalt kontor i Karlstad, Trafikverket och är utbildad inom samhällsbyggnad. Han har inriktat sig inom infrastruktur och geografiskt. Jacob arbetar på en enhet kallad, väg och data. Jobbat på trafikverket i 15 år.

Jacob arbetar för närvarande med ANDA och använder CoClass för klassifikation och sätta en identitet för en funktion. Trafikverket har haft problem med BSAB för att de fanns egna tolkningar och kompletteringar. Det finns inte något utbytesformat (inga standarder finns än så länge).

- *Vad tycker du om CoClass? vad tycker du är fördelarna med CoClass jämfört med BSAB 96?*

Fördelarna med CoClass är att man vänder på funktionen och konstruktionen med CoClass vilket Jacob anser är en uppenbar fördel.

- *Vilka begränsningar och möjligheter finns i CoClass?*

CoClass har möjligheten och försöker standardisera hela industrin, detta är i sig själv en begränsning för organisationer. Fördelen ligger i faktum att man kan kommunicera på ett mer konkret och på ett bättre sätt än andra.

- *Hur implementeras CoClass i projekt?*

*Olika aktörer har möjlighet att göra sin egna tolkning och ge olika definitioner på CoClass? Vad tycker du om det? Det verkar som att det är i förvaltningsskedet det kan bli problem för slut-användaren gällande referens ID och koder då det kan bli olika tolkningar. **Karl** nämnde att det skulle hållas ett möte för att komma fram med en lösning. har du hört något om det. Har det kommit någon vart?*

Jacob tycker att det är viktigt att hålla isär vad man vill uppnå. CoClass presenterar underdelen konstruktivt. Referens ID presenterar ett generellt begrepp. Jacob fortsätter förklara faktum att diskussioner med Svensk Byggtjänst pågår. De är på väg att nå CoClass 2.0 och fler typer.

- *Vad var den första reaktionen till implementeringen av CoClass?*

Trafikverket behövde implementering av CoClass för att standardisera sig. Generaldirektören gav ordern och Trafikverket implementera. Jacob fortsatte förklara att arbetsgrupper samlades för att komma med en lösning till BSAB 2.0 (CoClass kallades BSAB 2.0). Det fanns olika delar av Trafikverket som kom med olika idéer med CoClass till exempel Referens ID har använts i installation i vägar men inte i järnvägen.

- *Any other projects that Trafikverket are implementing CoClass in?*

Nej, enligt Jacob är Centralen ett pilotprojekt som är allra först med att implementera CoClass. Trafikverket har haft problem med BSAB 96 och var tvungna att göra en egen tolkning av klassifikationen.

- *Vad tycker entreprenörerna om detta?*

De har använt koder och referens id sedan tidigare så för dem är det bara att anpassa sig till och Jacob anser att det är enklare. För Centralen kan det bli problem då det är i tidigare skede och saker kan ändras.

- *Hur lång tid tror du det tar innan CoClass är helt och hållet implementerad och vad händer med BSAB 96 då? Tycker du man ska ge upp BSAB 96 helt och hållet.*

Han räknar med att det kan ta upp emot ungefär 10 år för att trafikverket ska implementeras helt och hållet. Anledning är att det är många olika tekniker och anläggningar. För privata företag kan det gå snabbare.

- *NCC Centralen, vad tycker du om det? Om Peab eller Skanska till exempel fick projektet är de mer lämpade för att ta an ett projekt som detta.*

Jacob har ingen åsikt gällande om NCC är bästa organisationen för jobbet, tror att NCC kan säker göra ett bra jobb. Alla ovannämnda företag är väletablerade företag och alla har möjligheten att göra ett bra jobb.

- *Trafikverket första att implementera klassifikationen? Tror du fler organisationer kommer följa upp och implementera den? Vilka organisationer?*

Jacob nämner att CoClass används av andra organisationer för att strukturera information.

## 2.1 Interview with Karl

- *Vad har du för roll? Bakgrund?*

Karl is working as Bim coordinator for Trafikverket. He started his career as a consultant for Trafikverket. The interviewee started the interview with an introduction of the new classification and the perspective of the new classification. The interview continues with a brief explanation of how Trafikverket are working today. He follows up with the fact that there is hard to find a common approach to work collectively today. CoClass is intended to have effect on the different actors and to be able work collectively.

- *What do you think of CoClass? What are the intentions and ambitions with CoClass?*

The interviewee continues to present the ambitions and goals that Trafikverket have. He talks about working collectively between the different actors. Trafikverket want to succeed in working collectively where everyone participated, and everyone are contributing. Furthermore, he continues with what actions need to take to reach the goals and ambitions of the organisation. Furthermore, he explains a vision of how it will look when everyone contributes. When every actor communicates well and participate to reach the goals of the projects and because of that able to save money and time on projects.

Karl continues the interview with a longer explanation of CoClass. He goes in depth with the Reference ID. He explains the that the Reference ID is a combination of the code of the function added together with the code of position.

- *What kind of projects are using CoClass?*

When asked if there are any projects that are using CoClass, Karl explains that the project centralen is using the classification. Also, there is a bridge that PEAB is building and using CoClass.

- The interview continues with

Three aspects were explained as resources from the aspect of Trafikverket. Digitalisation of plant and building focus on LCA. Also, a structured focus on the perspective of the function where the deliveries of Trafikverket are reached. For example, focus should be put on safety, environment, time and usability.

## 2.2 Interview with Karl

Intervjun startar med rekommendationer av personer som möjligheten finns att kontakt gällande intervjun och följer upp med kommentarer från följande intervju/samtal. Möjliga kontakter som kan intervjuas och som är kunniga och kan tillföra med ett bra perspective gällande klassifikationen CoClass och projektet Västlänken.

Karl förklara att Trafikverket har använt deras egna speciella kodifiering system de senaste 15 år och att de är erfarna med att använda och arbeta med koder och klassifikationer. Detta tillåter dem att använda deras erfarenhet och kunskap för att utveckla och implementera CoClass. Emellertid, detta system är inte ett classification system och kan inte tillämpas av andra organisationer.

Karl nämner ett projekt i Södertorn, där Trafikverket planerar att bygga en sammankopplande väg. I det här projektet, används inte CoClass men Trafikverket specialiserade system har goda kontakter med CoClass. Problem har uppstått i planeringsfasen och har lett till att projektet är pausad för nu.

Personen som intervjuas fortsätter med att förklara olika komponent koder och vilka kompletteringar Trafikverket har haft. Han fortsätter att förklara listan över komponenterna. Därefter, har Västlänken (installationer) tas från listan. Är den färdig listan som talas om? Listan som talas om är färdig.

I ett möte gällande vad är det vi (Trafikverket) gör? I det här jobbet fokuserar vi att på implementera CoClass och fokus bör ligga på uppnå målen och ett resultat. CoClass är endast ett verktyg till att nå målen. Det blir begränsande att använda CoClass strikt.

*Det låter att som att Trafikverket har lagt till extra arbete för att anpassa sig till ert system? Extra utvecklingar?* Han svara med att : JA, det skulle jag säga, vi har inte har nått ut med behovet tillgångsförvaltning i branschen.

Han nämner att om enligt dagens CoClass kan man typa men enligt dagens CoClass när man bara har en nivå för funktionella system med rätten till egen typning då konstaterar han att Trafikverket följer CoClass. *Så det finns möjligheten för olika organisationer att göra sin egen tolkning?* JA,
Han fortsätter med att en entreprenör kommer behöva typa för till exempel för vänsterhängt fönster. Problematik finns i att det finns ett icke publicerat CoClass som kommer att komma ut.

På västlänken har det endast mappat för installationer. Problem i Stockholm angående ström från omformarstationer, (kablar) skickar ström på vägnätet. Problem ska diskuteras i Workshop.

Vi sortera som system, (pelar system eller bjälklag system) det är bro system. Saker som inte kan förklaras generellt, har visat att med dagens system när man mappar broar, inte kan förklaras med dagens system. Konkret problem med tunnlar och broar finns och Trafikverket har jobbat hårt med det och trafikverket har byggt om en hel del för att hitta en lösning. *Är det planlagt att det ska finna möjlighet ha egna tolkningar?* Komponenterna får absolut inte ha egna tolkningar ska vara gemensamt för alla.

- *Vad händer om man presenterar dessa specifikationer (modifikationer) för entreprenören, vad säger NCC till exempel? Gällande tillgång system ?*

Det har blivit många hörnor av en fjäder i den diskussionen. Det enda stället där det här kommer dyka upp det är, då en sådan här specialkod, det är i referens ID. Det enda sättet för NCC att skapa referens ID är från vårat Referens ID generator. Förvaltarna däremot kommer lära sig utantill för att det kan de redan idag. Sedan i det vanliga arbetet som NCC gör ska de klassificera allting och då klassificerar vi enligt CoClass. Då är det ett bjälklagssystem och då är det inga konstigheter. Jag tycker inte att det ska vara några som helst problem och alla förvaltare måste ha sitt egna någonstnat. Köra så mycket som möjligt i de befintliga systemen för då får man en synergi i framtagande av verktyg.

Om man tänker på anläggningsdatabas som kommer sättas upp kommer vara en bra stomme för alla andra förvaltare.

En grej som kommer dyka upp i centralen är ju trappor, rulltrappor och hissar. Där skulle ni kunna göra en koppling utan att gå in på det. Hissen och rulltrappan är persontransporterna system. Trappan är bjälklag. För förvaltaren är alla person transporterande system. Vi tillhandahåller funktioner att kunderna ska kunna ta sig från en nivå till en annan nivå i Centralen. X antal ska kunna ta sig i hissen/rulltrappan och det fokuserar Centralen på.

NCC vill verkligen använda CoClass och Trafikverkets avdelning vill sen upptäcktes att NCC ville titta på konstruktionerna mycket mera än och göra en indelning utifrån deras etapper.

Konflikt som uppstått i funktionella system är för att aktörer inte förstår varandras behov. När alla förstår tillgångsförvaltning och deras behov blir det en icke fråga. Bron som PEAB testar CoClass åt Trafikverket. Trafikverket la det inte på deras huvud att använda CoClass utan PEAB ville använda de som testpilot. Han konstaterar att även om man vill samarbeta så är det inte mycket man kan samarbeta med, det är reference ID och sedan får de hitta deras metoder.

## 3. Interview with Alex

- *Vem är han? Vad har han för roll i projektet?*

Alex jobbar som BIM-samordnare för Trafikverket, och nämner att dem är uppdelade i olika verksamhetsområden och han sitter på Stora Projekt. Dem är ansvariga för att planera och bygga riktigt stora infrastrukturprojekt i Sverige. Alex jobbar heltid med projektet Västlänken och han ansvarar för olika sorters informationshantering både digitalt och traditionellt dokumenthantering. I projektet Västlänken jobbar han övergripande med BIM och försöker få likformighet mellan dem olika delprojekten.

Alex nämner att Trafikverkets roll som beställare är att utföra kravdokument och handleda entreprenörerna så att kraven uppfylls. Det innebär att förklara och förtydliga sånt som entreprenörer tycker är oklara. Alla detaljer är inte klara än och kommer säkerligen ändras med hänsyn till synpunkter.

- *Vad är dina åsikter och tankar kring CoClass? både bra och dåliga jämfört med BSAB 96?*

Jag är positiv inställd till CoClass utifrån brister som BSAB 96 har haft i både klassifikation tabellerna och användbarheten under hela projektet. BSAB 96 användes endast under en liten fas av ett projekt och hade brister när det gällde drift och förvaltning.

- *Ser du några brister i CoClass? Något som inte funkar med verkligheten? Vilka begränsningar och möjligheter finns i CoClass?*

Inga brister direkt, men jag tror definitivt att det kommer att finnas luckor när man jobbar skarpt med det i projektet. Organisationer som arbetar med CoClass får ta höjd med att det finns en hel del fin putsning och revidering från Svensk Byggtjänst. Det är nästan omöjligt att ett sådant system är 100 procent direkt.

- *Vad var första reaktionerna på implementeringen av CoClass?*

Den gamla klassifikations tabellen var enklare att navigera sig runt. Till exempel var det lättare att hitta ett värde eller en kod. CoClass är mer abstrakt och tabellerna är lite mer komplicerade att följa. Funktion och information finns i CoClass för olika byggdelar men det är svårt att leta enbart med byggdels namn.

- *Hur har CoClass implementerats i projektet än så länge?*

Man har precis börjat gå igenom relevanta CoClass tabellera för att kunna projektera installations objekt. Trafikverkets interna IT-verktyg har kompletterats med ett matris

där man beskriver olika godkända kombinations former av CoClass tabeller. Det finns en viss flexibilitet i CoClass systemet med tanke på hur man kan använda tabellerna kopplad till varann.

- *Hur fick NCC dessa projekt och varför valde man just NCC?*

Helt enkelt för att NCC var billigast men det är också en kombination med att dem klarar Trafikverkets kravnivå. I början av projektet kontrakterades NCC som konsulter och det gick sedan vidare till ett ECI kontrakt. En stor anledning till att NCC fick projektet var deras organisation och tanke kring hur dem skulle utföra projektet. Alex nämner att det är endast delprojekt Centralen och delprojekt Olskroken som har ECI kontrakt. Andra delar av projektet har traditionella kontrakt.

- *Varför valdes just Centralen som pilotprojekt?*

Man kan se hela Västlänken som ett pilotprojekt för implementering av CoClass. Framför allt var det passande då CoClass färdigställdes som ett system i tid för det här projektet. Västlänken är inte bara ett järnvägsprojekt utan det innehåller mycket mer, som till exempel olika stationer med många byggdelar och tekniska lösningar. Därför behövdes något som kunde samla all information i ett system och hjälpa till i förvaltningsskedet.

- *Vet du om det finns det andra projekt som jobbar med CoClass och referens ID?*

Det har funnits projekt som är liknande och har använt komponentbeteckningar men inte exakt CoClass. Det är tunnelbaneprojekt Citybanan i Stockholm och Citytunneln i Malmö och dem använder ett äldre system som är lik CoClass. Än så länge är Västlänken den enda med att referens ID. Vi får se vilka projekt som följer efter.

- *Varför valdes ECI kontrakt formen?*

Det finns stora fördelar med att entreprenören är med och projekterar från början då dem har det lättare för att se bra och dåliga planer. Samt att dem vet direkt vart man behöver lägga fokus på och vad som är billigt att bygga respektive vad som är onödigt dyrt att bygga.

Svårigheten med ECI är att man som beställare måste ha bra insyn och kunna kontrollera kalkylerna för att när entreprenören väl presenterar sitt riktpris så ska man kunna veta att det är rimligt. Det krävs mycket förtroende då entreprenören är ensam med att ge ett offert och förhandlingarna kan ta längre tid. En annan utmaning är också att jobba mer integrerad med entreprenörer.

För delprojektet Centralen har nyligen en totalentreprenadkontrakt upprättats med hänsyn till ABT 06 och riktpriset har hamnat på cirka 4,7 miljarder SEK.

- *Vilka program använder ni er av?*

Trafikverket har utvecklat ett IT-verktyg med information om olika referens ID som sedan kopplas till entreprenörens projekteringsprogram Revit. Tanken är att man under projekteringen kopplar på referens ID på varje objekt som projekteras. Trafikverkets egen IT-verktyg tillhandahåller projektören referens ID för olika objekt och på så sätt kan Trafikverket kontrollera att allt stämmer.

- *Hur genereras en CoClass referens ID?*

En referens ID består av två delar. En del som beskriver vart i konstruktionen objektet är lokaliserad och en del som beskriver vilken funktion objektet erbjuder. Under projektering bestäms plats och funktion för objektet och referens ID skapas med hjälp av CoClass, även driftinformation knyts ihop till referens ID. Den här metoden medför även likformighet med tanke på referens ID för hela projektet Västlänken. Därefter överförs all information till Trafikverkets databas där allt är samlat för att underlätta förvaltning och drift.

- *Hur långt har projektet Centralen kommit än så länge?*

Trafikverket fick nyligen godkännande beslut för att börja bygga. Nästan samtliga entreprenader har börjat byggprocessen och dem är alla ny-kontrakterade.

## 4. Interview with Jon

- *Who are you? And what's your education and work background?*

I graduated from Addis Ababa University with a bachelor's degree in Civil engineering. I worked as an office engineer, site engineer and design engineer. I have three years of experience.

- *Tell us about your work in railroads. How is the work governed? Who controls the work so it will be finished?*

Work is usually done under the supervision of a consultant firm which in the FIDIC contract is called the Engineer. The contract type was a BOQ type which means the contractor is paid based on quantities of work executed on site as per the technical specifications. The engineer is responsible for approving of all the works done by the contractor. The contractor has signed time period within which he will finish all the works in the contract and penalties follow if the contract is not strictly followed without admissible reasons stipulated in the contract. The contractor has a defects liability responsibilities for three years after the completion of the road project but the federal government is usually the one who controls the work after its finished.

- *What kind of resources are used to aid the projects.*

The resources used to aid projects are usually experienced manpower and some technology tools to aid their work in managing the projects. The physical work is aided by machines and different types of construction materials with the assigned manpower.

- *What kind of Software programs are used?*

Software programs that were used in my project for management and reporting purposes was Microsoft Project and Excel.

- *Have you worked with BIM and how important do you think it was for the success of the project?*

BIM was not used in my project and all of the work depended on 2D drawings but since the personnel working were well versed with the drawings it wasn't a problem. I believe BIM is extremely important for Building projects and other complicated types of infrastructure construction works like Bridges, Dams and railways. BIM helps visualize the physical works and in addition contains information within the drawings that would otherwise had to be stipulated in tables and other complicated symbols and etc..

- What kind of rules and regulations are you dependent on when working?

There are several rules and regulations that the construction work will depend on, the first one will be the contract signed between the client and the contractor. The others would be different types of internationally recognized codes of operation and technical specifications that are usually mentioned within the contract

- What kind of standards or classifications are used in construction?

The standards i have used were ERA (Ethiopian Roads Authority) manuals for geometric design, pavement design, drainage structures design etc…

- What is your view of the communication in projects? Is there room for improvements? Is there a need for a change.

Communication in construction is usually full of misunderstandings in my experience and i would definitely say there is room for improvement/change. Many delays in my experience occured because of misunderstandings between the contractor and the engineer.

- What is your view of BIM from the perspective of communication?

Since all the design information is in the model itself i would say it greatly aids communication between the designers and contractors.

- How is BIM aiding the projects?

I haven’t worked with BIM but from what i know BIM is aiding contractors in visualizing and getting full design information from the model instead of going through a list of 2D drawings which could get tedious at times.

- Have you heard of the project Centralen? It's a underground subway station. The project centralen is using the ECI (early contractor involvement ) contract form what do you think of the choice of contract form ?

Yes I have heard of ongoing underground subway construction and stations around town. The choice of the contract form is actually appropriate for works of this nature since there could never be a 100% sure way of knowing what is under the ground therefore it allows the contractor to take the necessary precautions before engaging in full construction and it will help sharing of experience between the designers and the contractors. It is usually the contractor who knows how the work is done which could be a very positive input for designers.

- Do you think there are other contract forms that are better in this instance? Are there any other contract form you prefer and why?

I think ECI is appropriate for this work.

- What do you think of the project to build underground subways station?

Underground subway station projects will change the city for better this is usually seen after ten or fifteen years when it is fully finished and operational.

- What are the benefits of it?

It will handle the transportation demand for the growing population in the city.

## 5. Interview with Tom

- *Vem är han? Vad har han för roll i projektet?*

Intervjupersonen börjar med att nämna att hans akademiska bakgrund är landskapsarkitekt och han har både undervisat och forskat vid Sveriges lantbruksuniversitet. Han har under sin karriär jobbat mycket med IT och de senaste åren har han jobbat med klassifikationer. Utöver klassifikation har han även jobbat mycket med standarder för dokumentation inom SIS.

Intervjupersonen nämner att han började jobba med klassifikationer när Trafikverket gav honom i uppdrag att upprätta förfrågningsunderlag med hjälp av CAD-modeller för Förbifart Stockholm. Det här projektet krävde en utveckling av BSAB 96 men Svensk Byggtjänst bestämde sig istället att för att starta projektet BSAB 2.0 där man skulle utveckla ett helt nytt klassifikationssystem. I det här nya projektet samarbetade intervjupersonen med flera andra inom byggbranschen för att inventera klassifikationen som blev kallad CoClass. Han har även samarbetat med representanter från ISO och IEC. Med IEC standarden var han med och utveckla så att det passar både hus och infrastruktur. CoClass är grundat på de här två standarderna men har fler och mer utvecklade tabeller.

- *Vad tycker du är bra och dåliga skillnader med CoClass jämfört med BSAB 96?*

BSAB var framförallt tänkt för tekniska beskrivningar och tabellerna för Produktionsresultat som är baserad på AMA har flyttats över till CoClass. Däremot, BSAB tabellerna för byggdelar var tänkt för produktion och byggprocess till skillnad från CoClass tabeller som är neutrala klasser för funktionella objekt. Det är därför BSAB inte är lämplig för BIM där man helt enkelt vill identifiera ett objekt oberoende av produktion. CoClass är neutral till objekten och BSAB syftar till byggproduktion.

- *Ser du några brister i CoClass än så länge? Något som inte funkar med verkligheten?*

Nej faktiskt inte, vi har inte stött på något som vi inte har tänkt på. En utmaning kan vara att förstå att byggdelarna är helt neutrala funktioner eller ord som folk tycker är konstigt. Även att CoClass säger inget om hur man bygger utan man får själv koppla ihop funktionella system.

- *Vilka begränsningar och möjligheter finns i CoClass?*

Jag har svårt med att se några begränsningar, jag tycker vi täcker hela livscykeln och alla typer av objekt samt även natur och miljö. Möjligheten är att vi får ett gemensamt språk som täcker hela livscykeln, allt från planering till rivning. Än så länge ser jag bara möjligheter.

- *Hur tycker du att CoClass ska implementeras i olika projekt?*

Det bästa är att man har med det från början av projektet. Det svåra kan vara att få folk att tycka att det är värt att lära sig något nytt. Även användandet av det digitala är något nytt. Tidigare hade entreprenören inte tekniken, kunskapen, eller nyttan av den digitala modellen och ville endast ha ritningarna. Förvaltningsföretag var heller inte mogen för det digitala och nöjde sig med en pdf-fil. Både entreprenören och förvaltaren har nytta av den digitala modellen och på så sätt bli den värdefull. En arkitekt eller konstruktör behöver till exempel förstå att det som stoppas in i modellen då har nytta för någon om 25 år. Det här tankesättet ska finnas i ett projekt.

- *Har du märkt några projekt som har använt CoClass på fel sätt?*

Nej, det är ju inte så många projekt som använder CoClass så det är svårt att följa upp. Vi diskuterar fortfarande med Trafikverket angående hur de vill använda CoClass i förvaltningen. Alla måste anpassa CoClass så att det funkar för dem själva och det kan man göra på flera sätt.

- *På vilket sätt är CoClass bättre på att integreras med BIM jämfört med BSAB?*

CoClass ger neutrala beteckningar på ett objekt, BSAB tabellerna är tänkt för produktionen och byggandet. CoClass är även mer flexibelt.

- *Olika aktörer har möjlighet att göra sin egna tolkning och ge olika definitioner på CoClass? Vad tycker du om det?*

Ja det finns ju alltid en risk att man slarvar, men man måste förstå definitionerna och själva CoClass. Det är förstås olyckligt om man använder CoClass utan förståelse. I grunden är det samma saker som vi bygger och med CoClass kan man få ut detaljerade byggdelar om man kan använda det på rätt sätt.

- *Vi hade fått höra att det verkar som att det kan bli problem i förvaltningsskedet gällande referens ID och koder då det kan bli olika*

*tolkningar mellan entreprenören och förvaltningsföretaget, hur kommer det här att lösas?*

Jag ser det inte som något problem egentligen om man i förvaltningsskedet vill flytta över några objekt mellan olika koder. Om man ser det i ett långsiktigt perspektiv så är det bra om man aldrig någonsin behöver byta kod på något objekt man har lagt in i förvaltningssystemet. Därför gäller det att välja om man vill ha en, två, eller tre bokstäver när man redovisar koden. Ju färre bokstäver desto mer övergriplig blir koden.

- *Hur kopplar man CoClass med något som är äldre, som t ex. AMA och BH90?*

BH90 är mer rekommendationer för hur man gör handlingar så det säger inget om CoClass. Produktionsresultat (”AMA-koderna”) finns kvar i CoClass och man använder det när man vill bestämma material och utförande för ett objekt. Man kopplar byggdelskoden till ett eller flera produktionsresultatet. När man byter material så ändras endast produktionsresultaten och man behåller byggdelskoden.

- *Trafikverket är först med att implementera klassifikationen? Tror du fler organisationer kommer följa upp och implementera den? Vilka organisationer?*

En del organisationer har redan börjat. Dem som är delägare av CoClass, t.ex. Specialfastigheter som sköter fängelser och säkerhetspolisens lokaler använder CoClass i sin förvaltning. Alla känner inte till CoClass än, men många vill implementera och fler tillkommer. Om stora projekt som använder CoClass lyckas så blir det enklare att implementera och fler kommer att vara villiga.

- *Utöver Västlänken, är det något annat projekt som använder CoClass?*

Vissa delar av utbyggnaden av tunnelbanan i Stockholm använder CoClass samt även Östlänken. I förvaltning har vi Karlstad kommun som använder CoClass för att klassificera sina anläggningar och byggnader i sin förvaltning.

- *Hur lång tid tror du det tar innan CoClass är helt och hållet implementerad och vad händer med BSAB 96 då?*

BSAB kommer att försvinna och vi har slutat att utveckla det. Byggdelarna i AMA som är från BSAB kommer undan för undan anpassas till CoClass och ny AMA kommer var tredje år så det kommer ta 9 år tills den serien är klar. Det tar kanske 10 år innan folk har slutat tänka BSAB. Det finns många gamla dokument och ritningar som använder BSAB för namngivning och de kommer inte ändras så i det här fallet kommer båda systemen leva parallellt i många år.

- *Hur lång tid tror du det tar innan CoClass är helt komplett? Eller kommer det alltid komma uppdateringar?*

Ja det kommer alltid komma uppdateringar, framförallt synonymer för namn på objekt. Men på den grundläggande nivån, den funktionella objekten kommer det inte hända mycket. Olika typer av ett objekt kan tillkomma om branschen kräver det och produktionsresultat utvecklas hela tiden i takt med att man hittar nya sätt att bygga.

- *Vilka program kan man använda sig av och hur hjälper det implementering av CoClass?*

Vi har kontakt med flera programvarutillverkare, AutoCAD, Revit, ArchiCAD, Tekla, dessa är de stora tillverkarna för CAD. Andra tillverkare som jobbar med kostnadskalkylering, Bidcon, MAP. Vissa av dem har system som dem själva har utvecklat, men CAD-tillverkarna är redo att implementera CoClass så snart deras kunder vill ha det. Jag är övertygad om att i år kommer de flesta CAD programmen ha stöd för CoClass.

## 6. Interview with Sean

- *Vem är han? Vad har han för roll i projektet?*

Utbildning: Väg och vatten, Jobbat med större järnvägsprojekt sedan 90 talet i snart 30 år. Jobbat i stort sett hela processen från att vara med i projekteringsskede till uppförandeskede. I många fall driftsättning av projekt.
Exempel på projekt som han har jobbat med är: Öresundsförbindelsen, citytunnel i Malmö, citybanan i Stockholm. Driftansvarig för tunneln i Hallandsås. För närvarande arbetat med Västlänken i 3 år. I projekt västlänken i det här tidiga skedet så arbetar han primärt med anläggningsövervakning. De övervakningssystem som inte är signal. Systemet som är tågtrafik system utan tunnelsäkerhet system. Blir med den erfarenhet han har projekt samordning.

Frågan om CoClass kommer upp för att anläggningsövervakning behöver en motor för att driva kodifiering. Han har jobbat sedan tidigare kodifiering enligt CoClass. Det har varit begränsat de fastighetssystem som är kopplat till tunnel driften, ventilationsstyrning pumpar hissar etc. Det har alltid kommit så långt att järnvägssystem,elsystem, tele, jobba i samma kodiferingssystem som alla övriga anläggningar och där är CoClass unik. Första gången det skapar sån kraft där man kan samla alla olika i ett system och det är ett stort språng för västlänken att gå in och diskutera det vi på Trafikverket kallar reference id. Har vi (Trafikverket) tvingats ta fram och göra nationellt samtidigt. Det är då en styrka att vi för första gången kan se på alla delar av hela järnvägsinfrastruktur och det är första gången.

Den funktionella delen har varit i aktiv dialog med Svensk Byggtjänst som har inte har landat fullt ut förrän förra veckan. Projekt säger vi går med på tåget. Ett nervöst läge att satsa på ett nytt arbetssätt och ett nytt system.

- *Vad tycker du är bra och dåliga skillnader med CoClass jämfört med BSAB 96?*

Inte överdriva skillnader mellan BSAB och CoClass. I trafikverket har man kämpat med att hitta ett tillägg för järnvägssystem. Fördelen är att CoClass kommer vara bredare. CoClass går på funktion aspekten primärt så blir det mycket enklare att använda i tidigt skede och över hela livscykeln. Bsab 96 finns fortfarande som byggdelstabell och produktionsresultat i CoClass. Fördelen är att fokus på att införa ett och samma system. *Generaldirektören, beslutet?* Ett beslut togs även om man inte förstod vad det innebär. Det handlar om att vilja att agera i gemensam marknad för en gemensam sak.

- *Ser du några brister i CoClass än så länge? Något som inte funkar med verkligheten?*

TF har haft möjligheten att påverka, när hela registret inte funnits så har man lagt till det. Bsab 2.0 hade en bredare grupp, fler människor som har fallit av projektet Bsab 2.0 som han anser skulle behövas. Bristen ligger att branschen inte har haft uthålligheten. Behoven kommer vara olika för byggfirma A och Trafikverket. Inte sabotera någon annans möjlighet att använda ett öppet klassificeringssystem.

Finns en brist i att det inte förklarats hur övergång i mallar till CoClass från BSAB 96 ska ske. Inte hunnit tillämpa nya system för att få nya koder. Beställare kommer vänta med att byggar. Han anser att det är fint att Trafikverket tar initiativ.

- *Vilka begränsningar och möjligheter finns i CoClass?*

Inga direkt, det är förklarings mässigt, du ritar kartan. Begränsning är att de inte kommit så långt. Jobba på ett detaljerat sätt. Inte ha för många variabler utan säga det är så vi använder system med fasta metoder. Din egen begränsning är begränsningen. ABC är enkelt att nåt, DEF är svårt att nå. Koden och din funktion, Ren byggare vet inte hur man använder koder och måste utbildas. Utbildning behövs. Visa på många goda exempel. Från kommuner och landsting och flera företag ta an systemet. Successivt arbeta och bygga.

- *Finns det andra projekt som använder sig av och arbetar med CoClass? Any other projects that are working with CoClass in?*

Projekt som använder CoClass är: Västlänken, tvärförbindelsen Södertörn i Stockholm, Ostlänken är det sagt att de kommer jobba successivt med CoClass. Den bästa motorn är att man uttalar att alla framtida anläggningsprojekt ska använda CoClass. BIM kan vara allt och ingenting.

- *Trafikverket första att implementera klassifikationen? Tror du fler organisationer kommer följa upp och implementera den? Vilka organisationer?'*

Det kommer vara en konkurrensfördel och organisationer måste svara upp med krav och jobba på ett visst sätt. Sven anser att man inte ska överdriva gällande CoClass, systemet ska inte vara komplex utan ska vara effektiv och enkelt. Man går från differentiering till en likartad och detta ska ge effektivitet. Han fortsätter konstatera att alla företag som vill jobba effektivare. Detta stödjer ett effektivare arbetssätt.

- *Vad var den första reaktionen på CoClass, Trafikverkets, Entreprenörens sida?*

Det är ju fortfarande en lång väg till att man introducera fullt upp med entreprenörerna. Han fortsätter med att nämna, att han var en av personer som trycket på för att ändå ta arbetet med att gå in i processen. Det är 8 år kvar med Västlänken och det är långt tid. Därför är det ofantligt mycket arbetet tills man har de rätta tillämpningarna.

- *Varför fick NCC uppdraget Västlänken? Varför valdes ECI kontrakt formen?*

För några år sen var de enda upphandlade entreprenader. Centralen är ECI och NCC fanns för ett år sen när man diskutera införande av CoClass. Konstaterar att det fanns ingen annan att diskutera med. Därför fick NCC bli (ECI – Testpiloter) i begränsad skala. NCC har även ett fokus att bli bra på CoClass och det är en bra start tycker han. De var upphandlade tidigt för att de har den kontraktsformen (ECI).
CoClass ska tillämpas och saker och ting ska märkas. Därefter gå in med BIM arbete gällande byggarbete och CoClass.

- *Hur stor del av CoClass har implementerats?*

Det första kontraktet –HAGA och konkret upplägg och bygghandlingar. Värdet att placera en bra platschef är värd mycket. Gick på kompetens, haga och korsvägen gjort en teknisk lösning.

- *Hur lång tid tror du det tar innan CoClass är helt och hållet implementerad och vad händer med BSAB 96 då? Tycker du man ska ge upp Bsab 96 helt och hållet?*

Tittar man på trögheten i branschen så skulle jag säga att när man slutar underhålla BSAB. Då anser han kommer CoClass bli fullt ut implementerat cirka 6–7 år. Han fortsätter med att han inte tror att tåla moden kommer finnas. En annan faktor är vilka ekonomer som styr, sitter med olika kompetenser och licenser och fortsätter med att det kommer ta cirka 6–7 år sen.

## 7. Interview with Viktor

- *Vad är din arbetsbakgrund och utbildning? Vad jobbar du som?*

Jag började min karriär som CAD-konstruktör efter att ha läst en El- och Motor Teknisk linje. Därefter har jag jobbat mig fram i branschen som drifttekniker samt el- och styr konstruktör. Jag startade även upp eget efter några år men huvudsysslan har varit elkonstruktion. Idag sitter jag som handläggare på företaget Technology For Infrastructure Projects (TFIP).

- *Vad har du för roll i projektet Västlänken och Centralen?*

Jag har rollen som handläggare för el och styr.

- *Som en entreprenör i projektet, vad är dina åsikter och tankar kring CoClass? Något som inte funkar med verkligheten?*

Jag tycker det är bra att försöka få alla att använda samma ”benämningssystem”. Även om det är en övergångsperiod så tror jag branschen kommer vinna på det i längden då alla kommer känna igen sig vilket projekt det än handlar om.

- *Vilka fördelar eller nackdelar anser du finns i CoClass?*

Fördelarna är som nämns ovan. Nackdelarna är väl att det kan ta tid att få alla parter att verkligen börja använda systemet. Har man gjort på ett sätt i alla år så kan det vara svårt att ställa om sig.

- *Finns det några begränsningar?*

Jag har idag inte själv stött på några begränsningar. Men med tiden kommer det säkerligen fram något som gör att systemet kan utvecklas ytterligare.

- *Vet du vad andra entreprenörer tycker och tänker om CoClass?*

Nej inte specifikt. Men jag tror de flesta förstår vinsterna med att ha ett generellt benämningssystem för alla. Dock tror jag inte alla har tagit sig tiden att sätta sig in i CoClass och vad som behövs för att använda det fullt ut.

- *Hur har CoClass och BIM implementerats i projektet?*

Idag sitter vi och jobbar fram en arbetsmetod för hur det skulle kunna vara att koppla ihop Trafikverkets databas över objekt med våra BIM modeller som projekteras fram i Centralen. Vi har namngett några system och objekt med CoClass för att testköra synkroniseringen mellan objektens parametrar med databasen med gott resultat.

- *Vilka program använder ni er av och hur hjälper det implementering av CoClass?*

Vi projekterar i programvaran Revit där objekten ritas in i en 3D miljö. Här knyter man ihop skräddarsydda parametrar från objekten till Trafikverkets databas Maximo. Plugin-programvaran till Revit som sköter synkroniseringen till Maximo är specialanpassad för just detta och har programmerats på uppdrag av Trafikverket. Detta liknar den nuvarande programvaran ”Chaosfunc” som är utvecklat för att knyta ihop AutoCad-filer (DWG) med Maximo.

- *Hur genereras en CoClass referens ID?*

CoClass referens ID är uppbyggd av ett antal olika delar. Den första är en placeringskod som beskriver vart ett objekt befinner sig (Även i vilken typ av utrymme). Efterföljande del är vilket system objektet tillhör och sist vad för typ av objekt det handlar om.

I plugin-programmet till Revit så har vi skapat rullistor där projektörerna kan välja vart objektet är tänkt att placeras. Vilket system den tillhör samt vad för objekt det handlar om som ska delges ett referens ID. CoClass koderna är i sin tur ihopparade med dessa så att rätt referens ID skapas. Detta är gjort för att underlätta för projektörerna så att de inte behöver sitta själva i CoClass listan och gissa sig fram till vilket systemnummer eller objekt-ID som ska väljas.

- *På vilket sätt är CoClass bättre på att integreras med BIM jämfört med BSAB?*

CoClass är inte i sig bättre på att integreras med BIM jämfört med något annat benämningssystem. Men CoClass omfattar förutom placering även fler system och objekt vilket gör att man får ett större omfång som döps på ett liknande och systematiskt sätt.

- *Trafikverket/NCC är en av de första att implementera klassifikationen? Tror du fler organisationer kommer följa upp och implementera den? Vilka organisationer?*

Ja jag tror att de flesta i byggbranschen kommer att följa med tåget med CoClass. Nu testar statliga beställare att implementera CoClass. Lyckas man fullt ut med detta så kommer fler projekt kravställas att CoClass ska användas och entreprenörer blir tvingade till att lära sig använda det. När man sedan ser vinsterna det medför så kommer nog även den privata sektorn att följa efter.

- *Hur lång tid tror du det tar innan CoClass är helt och hållet implementerad och ersätter BSAB 96?*

Det är en väldigt svår fråga att svara på. Jag gissar på att det skulle vara möjligt någonstans mellan 4-10 år. Det beror dels på mitt svar i förra frågan. Sen ska systemet även vara användbart i driftskedet. Vill man i sin tur ha in feedback från de projekten innan man kör fullt ut så kan det ligga en bit in i framtiden.