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The Relation Between Contract Type, Biggest Defects, and Building Type

An Investigation of Swedish Building Construction Projects

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MASTER'S THESIS

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Abstract

Defects and disturbances are significant issues in the construction industry, that they can impact on the outcome of projects. Most of organizations endeavor continuously for improving their businesses and to be more successful compared to other competitors. The aim of the study is identification of the biggest defects in the Swedish construction industry and investigation of the relation between contract type and biggest defects for different building types. In this study, both qualitative and quantitative methods, beside abductive approach are used. A set of secondary data are used which are collected from 313 projects through survey based on 452 telephonic interviews carried out with client and site manager in different building projects whom oversee implementing these projects from client organization. A model was suggested by authors, based on understanding of construction context. Defects are grouped in several categories based on this model, such as external, input and process defects. Two types of contracts were investigated, which are design bid build and design build contract. Thirteen different type of buildings were investigated. Discussion was made to find the relation between the three variables of the main research question, including building type, contract type and defects. A set of the biggest defects was identified that includes 35 different defects. At the end as the study result, there is relation between building type and different contract type, based on defects. This relation shows that for each building type there is contract type which is more appropriate.

Keywords: Defects, Design Build, Design Bid Build, Swedish construction industry, contract type, building type.

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Preface

This thesis has been performed in fulfilment of the master's program in International Project Management & the master's program in Design and Construction Project Management at Chalmers University of Technology. The research have been conducted in the spring of 2018. This study shaped in this way because of the lack of knowledge about the relation between biggest defects, contract type, and building type in Swedish construction industry. The outcomes of the study can be used by organizations which work in this field.

We would sincerely as authors thank people which somehow cooperate to execute this study. Firstly, our thanks to the supervisor Christian Koch for his supporting and efforts to facilitate our study, and excellent resources which he has provided for the study, as well as deep points and comments which improved our way of thinking. We also want to thank Chalmers university of technology including the Department of Architecture and Civil Engineering, especially Matine Buser, for the excellent system and valuable support. Finally, to our family & friends, who with their help and support it could be possible to conduct this study.

Gothenburg, June 2018

Abbas Dehghani Tafti, Mohammed Almaswari

1-Introduction

The first part in the introduction is the background which talks about the environment in which defects occur. The problem formulation is the second part, how problem in this study is defined and perceived. Defining the purpose of study based on the formulated problem is the next part. To reach the goal it is necessary to answer the research questions, based on scope and delimitation of this study.

1-1 Background

Defects and disturbances are significant issues in the construction industry. They can affect on the outcome of project. The identification of the construction defects has consequences about, legal issues, improving the productivity and financial issues.

Based on Mosey (2009) the dominant view that is taken by the court, in USA, is that project actors such as professional advisors and design consultants have responsibility to inform their client probably about design defects. Besides that, the standard contracts are oriented "to make excuse" for performance and late project completion, delay acceptation, or improper cost management, this fact differs between countries which nowadays they are not accepted by client in construction industry Mosey (2009). These issues show necessity of identifying defects, and their causes in construction industry even in the legal point of view.

The Josephson (2013), is the report which is based on database that will use in this study. "This report presents productivity-related data for new construction projects, multi-family houses and office buildings, completed in 2012 and the beginning of 2013. It aims to stimulate and guide improvement efforts by clients, consultants, entrepreneurs and other actors that have a significant impact on the construction process in a more efficient and safe way" Josephson (2013).
Based on Josephson (2013), in the Swedish construction industry there are a lot of varieties and differences in projects, for instance, market and land situation, purpose, client and user`s project. For instance, Weather makes a difference for projects outcome. key stakeholders, such as politicians, clients, and managers, have some authority in the project that can impact it. For all these actor's profitability and interest have different meanings. For instance, Increasing productivity can affect stakeholders' interests.
By considering this issue, having higher productivity is possible by increasing the predictability of the project processes, to avoid some defects or failures, and for increasing the predictability it is necessary to find the trend of repeatability in projects. Factors such as standards, instruments, routines, and so on, should be compatible and repeatable in construction industry to have the possibility to compare and predict them.
Making a database, by repetitive data, from different projects, in different places in Sweden, from different actors perspective, can help to achieve a more consistent process in construction industry.
It is hard to measure productivity, because of stakeholder's different perception of productivity's definition, complexity of projects, difficulty to compare productivity in different projects.

According to Jaspal Singh & et all (2012), despite construction industry development, there are some challenging construction defects that are not easy to prevent, which are affecting on final cost of project and maintenance phase.

1-2 Problem Formulation

All organizations endeavor continuously for improving their businesses and to be more successful compared to other competitors. Increasing sales and profitability, building a reputable position in the market and being the leaders in their field industry are some of the ambitions that organization are looking to achieve. Construction industry are not an exempt from that, however, there are some specific characteristics that distinguish construction industry from other industries. Among these, there are the temporary nature of the construction projects and the relatively large number of actors which are involved in projects.

In Sweden there are construction projects with a considerable turnover with different features and difficulties, there is opportunity to design a road map for preventing the consequences that defects can occur in this environment. Design and implementing this road map is time consuming and should be step by step. As a first step, defects should be investigated and identified. For instance, there are a lot of defects in construction projects that effect on the outcome and consequently on the firm's profitability and productivity. These defects occur in all project phases including design, construction, and maintenance phase. Some of the key actors in projects are consultant, client, contractors and subcontractors, designers, and suppliers, which they are engaged in complex relationship network. (Josephson 2013)

To deal with this issue, first it is necessary to define the defects which by preventing and decreasing them it is possible to improve project performance, and firm's empirical knowledge by applying lesson learned. It is impossible to know about all defects but obviously it is possible to identify the biggest constructional defects and have an appropriate knowledge about their types and natures. There are variables which could relate to defects are possible to investigate, such as contract type and building type. Projects have different contract types that organize and define the relationships between actors and thereby affect on several features of the project such as quality, time, and cost. then it is worthful for investigate about contract types. On the other hand, every project has specific type of building. Each building type has features that can make difference with regard to defects. For instance, for investigating design`s defects for hospital projects and residential building projects, design complexity in both building type are different and the same for the requirements which cause different defects.
Accordingly, the problem can be defined as understanding the relation between these three variables, including building type, contract type and biggest defects.

1-3 Purpose & Audience

The aim of the study is identification of biggest defects in Swedish construction industry and investigation the relation between contract type and defects for different building type. For reaching to this aim, it is necessary to divide it in different objects. First it is necessary to identify the biggest defects in Swedish construction industry. The step after biggest defects identification is to determine and investigate the relation between contract type, and building type, and biggest defects.

The audience of this thesis firstly are private and public Swedish construction companies, beside their clients. Especially because they spend a lot of money for their project and they should know the possibility for preventing the defects cost. Secondly, other actors such as site manager, project managers, contractors, subcontractors, that they involve in the construction projects, and have the opportunity for contributing to prevent these kinds of defects. Thirdly, students that are interested in contract management, quality management, and project management. Finally, and in another level, decision makers that by understanding the importance of these problem, can influence on future projects to save huge amount of money for society.

1-4 Research Questions

Main Questions:

- What is the relation between project`s contract type and defects for different building types in Swedish construction industry?

Sub Research Question:

- What are the biggest defects in Swedish construction industry?
- How to suggest a categorization for the biggest defects?
- Who are the Key actors that are involved in?
- Weighing the impact of biggest defects on Swedish construction projects type?
- What are the contract type of Swedish construction projects?

1.5 Scope and delimitations

The scope of study will focus on defects, especially biggest defects in Swedish construction industry, It is including private and public sectors. On the other hand, based on using the secondary data, it is obvious that the scope of this study will be define in consistent with their borders.

The Christian Koch & M.L. (2018) as a resource which it used as empirical data in the study, categorize defects in several groups which including, client mistake, design mistake, contractor and subcontractor mistake, material supplier mistake, machine failure, weather disturbance, municipality related mistake, defects that are difficult to define, and finally other defects.
On the other hand, the aspect to face with defects are wide. In this thesis the investigation is about two actors point of view, site managers and clients.
Type of construction, that it investigated in this thesis including public buildings such as, Health, transport buildings, Service buildings; financial building such as Offices & Business offices, Workshops and storage, Hotels and restaurants; Industrial building, Sports and leisure buildings, Schools & Kindergarten construction, and electrical power constructions. These constructions made by different building methods, such as prefabricated, semi-fabricated, and built in site method. Which used for new building construction and renovation projects. Then some different contract type which used in this are Design Build, Design Bid Build, Trade and Partnering contracts, which just DB and DBB are the concern of the investigation. (Josephson 2013)

2- Methodology

This part start with the research approach which explain the selective approach of the study then methods used in analyzing are described later. The next part include the explanation of the data used in conducting the research finally the credibility of the research and ethics are mentioned in the last part.

Research Approach

The essential purpose of any research is to challenge and face the practice by using set of theories(Dubois & Gadde 2002)**.** There are different approaches to conduct researches that include deductive, inductive and abductive.

A deductive approach is triggered from theory by formulating specific hypotheses followed by collection of data that is used to test the theory whereas the inductive approach is different from deductive where it starts with data for the purpose of build a theory(Bryman & Bell 2015). The abductive approach which follow nonlinear movement between theory and empirical data where it relies on a continuous movement between theory and empirical data(Dubois & Gadde 2002). The Kovács & Spens (2005) established the following figure to describe the nonlinear process that the abductive approach take where it starts with theoretical framework used to derive observation then matching it with theory and evolving the empirical part again to reach the final conclusion .

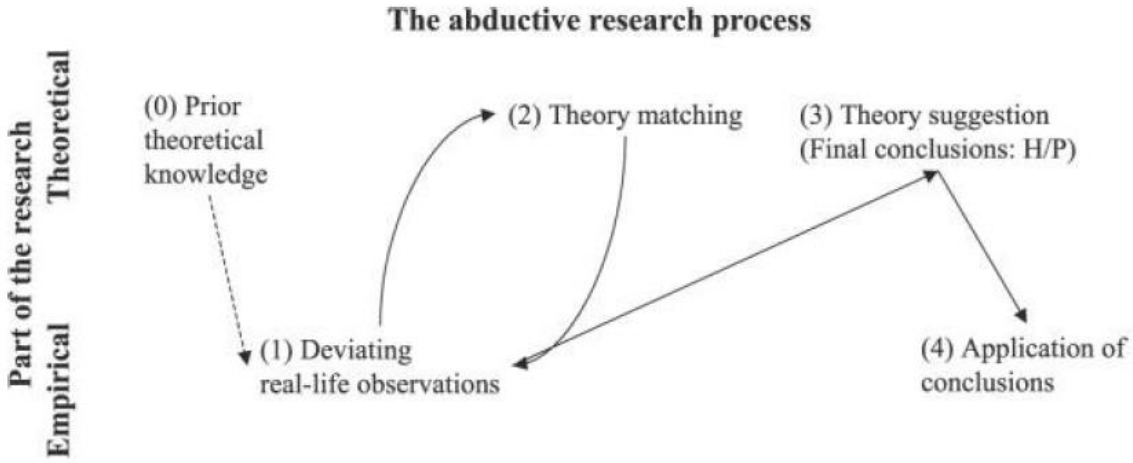

Figure (1) The abductive approach process (Kovács & Spens 2005)

The abductive approach will be selected. It will have started with analysis of the collected data which is used to develop a framework to analyze and discuss to get final conclusion. The research starts with database for identification of the biggest defects, that should be categorized and

analysis firstly. Then based on the analyzed data and theoretical part, the model is established which will then use and applied to facilitate the investigation of relationships between contract type and building type.

Quantitative & Qualitative

The meaning of research strategy is “a general orientation to the conduct of business research” (Bryman & Bell 2015a) P 26. In this study there are two different type of data or information. First there are numerical data, such as number of defects. The second type is description information such as defects explanation and interviews. For these two different orientation need different approaches. Answering the research questions needs an extensive and sufficient data about the disturbances which occur in different building projects.

A qualitative approach will be used to identify different types of defects and categorize this data into logical categorization that make it easy and useful to analysis it with respect to different variables. besides, building type and contract type are investigated by qualitative approach.

On the other hand, quantitative approach will be used in regard with the established figures and tables for weighing the contribution and the relation of every variables with different defects categories.

Secondary Data Analysis

Secondary analysis as It mentioned by Bryman & Bell (2015) express about the study or research which is carried out by researcher and mainly relied on data to other researchers or organizations for a purpose that differs from the original one which the data is collected for. Using of the secondary data is considered as an affordable approach when the time and financial resources are limited (Ibid).

For this research approach there are benefits and shortcomings. One of benefits that it provides a wide and dense information compared to other collection data methods (Bryman & Bell 2015). However, there are shortcomings in some cases in term of reliability and relativity of these data (Bryman & Bell 2015).

In this research the plan will include using of secondary data for the reasons that a large amount of data are required to achieve the research objectives which is can be done by performing interviews and telephone interview with number of companies. These process need considerable long time which is not available for us to do within short period of thesis time.

Three different sources of data are used in this research as followed:

The research relies on extensive data that are collected from number of telephone interviews carried out with client and site manager in different building construction projects whom are in charge of implementing these projects from client organization. The data that will be used represents 313 construction projects of different companies. This data was collected through telephone interviews with project managers and site managers who are in charge of these projects. The data include a lot of information about contract type, amount and duration and also include useful information about the performance of every project. Referring to the disturbances both of project managers and site managers were asked to mention only the biggest disturbances in projects . A set of figures and table will be established to represent the analyzed data in a useful

way that facilitate predicting and understanding the relationships between different variables. Interpretation and discussion then will have performed according the analyzed data and the theoretical framework. The data represent 18 different types of building project. Table (1) shows the number, type of building projects and the registered defects in every category.

No.	Project Category	Number of Projects	Number of Respondents
1	shops premises	44	55
2	preschools	58	87
3	hotels and restaurants	17	27
4	sport and recreational facilities	25	36
5	industrial facilities	17	22
6	office building	28	43
7	Power and lighting facilities	6	11
8	Public premises, churches, etc.	9	13
9	Communal facilities	17	22
10	service building	25	41
11	hospital and health cares facilities	12	18
12	schools	24	35
13	warehouses and workshops	31	42
	Total	313	452

Table (1), Summary of Collected Data (Abbas Tafti & Mohemmed Almaswari., 2018)

The registered defects then will be analyzed and grouped into main groups that include the similar type together.
After identification of biggest defects another analysis will be carried to understand how these defects relate with different building type. This include determine which category is dominant with respect to different type of building. The same will be done with respect to contract type also. All quantitative data comes from the Database which used as secondary data.
For this study, other material is used as secondary data. First of all, the (Christian Koch 2018) used as the basement for understanding the biggest defects, and categorization of them.

Another resource which used in this study is the Report (Josephson 2013). This report`s data is produced by Sverigebyggindustrier and Sverigebygger which is the construction industry's organization for research and development. Theirs's pursues toward improving the construction processes and environment through implementation different researches that could contribute to continuous and further development. More than 3000 company in Sweden are linked with this organization. Chalmers university also participated to make this job done.
This report includes 444 building construction projects, it is collected through several interviews with the client's project managers and site managers in (2012/2013). Several concepts are covered within this report (Josephson 2013), including productivity, actor's performance, and defects.

Credibility

According to Bryman & Bell (2015) credibility is one way that is used in evaluating the research where it deals with the degree of acceptability to research finding. Credibility is one important aspect that is used in both of quantitative and qualitative approach which denote the trustability of the content of the finding beside other aspects such as Transferability, Dependability, and Confirmability (Bryman & Bell 2015).
In addition to that, the credibility has an essential role with regard to both of the procedure that the research is implemented (Bryman & Bell 2015). At the end the main concern is the audience who is the receiver of the research result so they have to be capable of understanding in a good way (Bryman & Bell 2015). For instance some issues can affect on credibility such as values.
The database which the research are rely on are large which include 452 interview that represent wide strip of construction industry.so in this regard it support the finding of the research.

Influence on research

There are several factors that affect business research as shown in Figure (2), one of these factors is personal value.

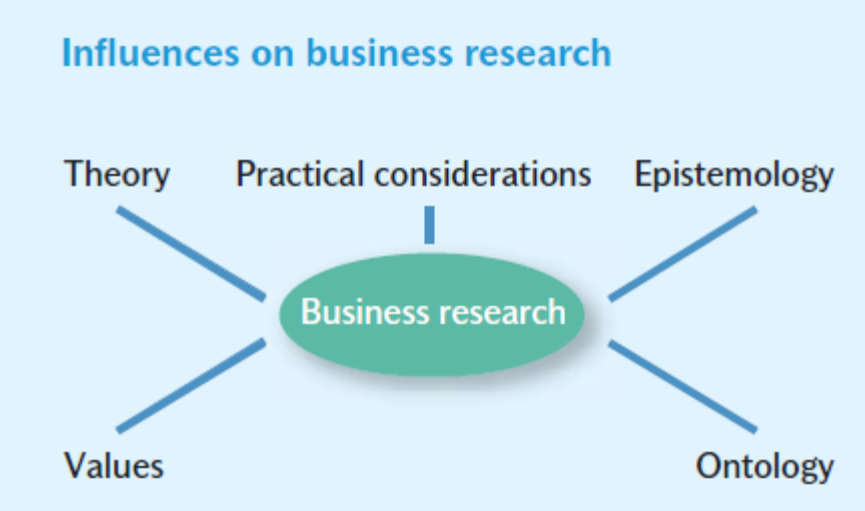

Figure (2): Influence on business research (Bryman & Bell 2015)

According to Bryman & Bell (2015) P 29, "Values reflect either the personal beliefs or the feelings of a researcher. On the face of it, we would expect that social scientists should be value free and objective in their research. After all, one might argue that research that simply reflected the personal biases of its practitioners could not be considered valid and scientific because it was bound up with the subjectivities of its practitioners".

Personal value of interviewee which are client and site manager, and personal value of authors can affect on credibility. For instance, interviewee mentioned that some projects are defects free, but that no means these projects are really 100% defects free. This idea maybe comes from long term experience in the industry which make some defects acceptable as the nature of project. For authors in addition to theoretical and empirical contexts, there are some model's analysis which is based on authors understanding and perception which could have effects on findings and outcomes. Consequently, all these mentioned issues have also impacts on the credibility as well.

Ethics

Based on Bryman & Bell (2015), for business researches there are specific ethical issues which are significant to take into consideration, these issues include preventing from "harm to participants, lack of informed consent, invasion of privacy, deception is involved".
In this study the used data are secondary data that belong to other organization which make it is necessary to deal with them with confidential way that assure preventing any harm for participant for instance, do not publishing their private data, then it is just used the general information that relate to the purpose of study. In addition to this with regarding to the privacy the analyzed data and provided results are presented in a way without mention additional information about the participants. Based on using the ethical principles it is more convenient to trust to data, process and outcome of the study.

3-Theoretical

In this section as a platform for the study, it is significant to have appropriate understanding about related issues to the study purpose. These issues including, the nature of constructional industry and related defects. In addition, the actors which play main role in this context, finally contract and different types of them.

3.1 Construction industry

Most of organization and firms struggle to be successful in implementing their construction projects. Kerzner (2017) refers to projects success in term of several factors which include adaptability with time, cost management, and quality. In addition, recently focused factors include customer satisfaction, low deviation of scope and maintaining the culture of the corporate (Kerzner 2017).

According to Burati et al. (1992) focusing on mitigating the occurrence of problems and improving the quality, enables companies to save 15% to 20% of its sales which is actually used to correct the mistakes. That will be an effective approach to increase the profitability beside sales increasing.

The same study concluded the relative high contribution to cost of design deviation with 9.5% of the total project costs. Where the design deviations represent approximately 78% of the total number of deviations and 79% of the total deviation costs, compared to construction deviation which are found to have 2.5% of the total project cost with 16% of total number of deviation which represent 17% of the total deviation costs (Burati et al. 1992).

According to (Josephson 1998) the cost of defects in building projects in production phase ranging from 2% to 6% of the cost of the project which represent valuable amount that should be not neglected. Additionally, based on Josephson(2013), biggest defects cost mostly is about 1% and in some cases about 5% of construction cost. But by including all defects cost this amount of money is remarkably going to a greater extent.

3-2 Defect Identification

At the beginning, the term of defects should be defined. According to Cambridge dictionary, there are two definitions about Defects, “a fault or problem in something or someone that spoils that thing or person or causes it, him or her not to work correctly “, which emphasis is on do not work correctly. Another meaning in Merriam Webster dictionary there is another definition that together with above definitions will complete the whole picture of this term, “a lack of something for completeness, adequacy or perfection”. On the other hand, according to Hoyle (2009) a defect is “nonconformity with a specified requirement”. This definition reveals that a defect is a term opposite to the term quality where defects express lack or absence of quality in doing something, this could relate with inputs, processes, and practices. According to Ahzahar et al. (2011) construction defects, include any type of failure in each type of construction and building that decrease the project value. There is different type of construction defects such as structural, electrical, ventilation, plumbing and heating systems defects and etc.

Love & Edwards (2005) argue that there is no clear differentiation between aspects related to reworks, several terms which are mentioned in literatures such as defects, changes, nonconformance, omissions, deviations, failure, errors and damaged are used reciprocally to refer to each other's which reveal the high degree of ambiguity in aspect definition. In (Burati et al. 1992) it used the term deviation to refer to nonconformance of designs and constructions processes with distinguishing between deviation and defects as the latter is more related to manufacturing industries. Besides, according to Burati et al. (1992) deviation imply full or partial noncompliance with the specified requirement that might or might not need to implement reworks.

According to Ahzahar et al. (2011) there is a mechanism for occurring defects. This mechanism as a distinguishable happening explain the procedure that lead to an special failure which is called failure mechanism. Defects can occur within project designs by architect, wrong production methods, installation problem, lack of alignment, material, contractor & subcontractor, or any other mixture of them. For instance, loading more than structural capacity is a cause of structural, failure or instability.

Constructional Defects

During the last decades the traditional thinking of organizations against defects was to keep them hidden from the customer and other because their thoughts about affecting the reputation of their business. But nowadays this way of thinking is changed where the organizations recognize the need of manifestation of defects and looking for the ways of preventing and improving based on these defect (Kerzner 2017).
Building construction projects vary from project to another in several aspects such as location, design, contract type and actors involved in the project. They include several actors and disciplines working together temporarily through a complicated network of relation for the purpose of implementation the project, actors include ; designers, client, consultants, contractors (Ahzahar et al. 2011), users, suppliers and subcontractors Josephson & Hammarlund (1999).

Ahzahar et al. (2011) refers to the defects in buildings as negative consequences on the value of building due to existence of undesired problems which could be resulted from any or both of the following; design mistakes, production flaws, using of defective materials and bad commitment of contractors to the design and specified requirements.

According to Ballesteros-Pérez et al. (2017) the weather has great consequences on the implementation of construction project which involves impacts on cost and duration in addition to increase contractual claims between project parties.

3-3 Actors

According to Josephson & Hammarlund (1999) defects causes mainly assigned to the individuals who form the core of implementing the construction projects through their interactions within the organization context.
Then it is obvious that the interaction between different actors in different phases should be taken into consideration. According to Project Management Institute (2013) projects team combination is different based on the organizational structure, culture, and projects location**.**

It is important to take into consideration of organizational roles of some key actors. According to Josephson (1998) the principal causes of defect were founded as due to lack of motivation which represent the highest percentage around 50%, lack of knowledge with 29 %, lack of information with 12 % and risk, stress with 6% and 3% respectively . However, individuals are included within the project organizational context, therefore project organizations circumstances and conditions has a large contribution with defects. Josephson (1998) mentioned some forms of organizational problems that lead to the uncertainty which is the main causes of most defects. Some of these problems include gaps in vertical relationships (for example between client and contractor, designer, supplier or between project manager and site); gaps in horizontal relationships such as between design teams or production teams and unstable organization.
Within project life cycle there are a lot of actors involved such as owner, the designers, contractors, suppliers, and subcontractors. They need to cooperate and communicate in an effective manner to ensure project success and complement Sha'ar et al. (2017).
They are all playing an important role in the project and through their performance the project is implemented, in that way The defects in building project could be assigned to one of these actors or to more than one actor Josephson & Hammarlund (1999) .

Client

Dictionary of construction (Gorse et al. 2012), define client in construction industry as "The person or organization that requires and pays for the building or works". The client has essential role and significant impact on construction project through providing the required support and information to the project (Verma 1995).

The client has different duties which are necessary for the successful and completeness of the project which include, identification of the project objectives, selection of designers and contractors, facilitating issues relating to the permissions and property acquiring, making required decisions for construction and design, and providing the financial support suitably for designers and contractors (American Society of Civil Engineers 2012).
But then, based on (Eriksson 2010) client, as owner or owners representative, is starting the project and make contract with actors which contributing the project. At the end, client is possession in the finished project by authority of economically make benefit from it.
Eriksson (2010) mentioned that for constructing the construction, client should get involved with a key stakeholders, experts, and different businesses in construction industry, and make deal in

a procurement process to make expansion or progression in construction industry. Traditional client themselves make decision about what is the outcome, who are key actors such as contractor and designer, and what is the contract issues.

Client sectors

For construction categorization Clough et al. (2015) mentioned, there is a different construction categorization, based on its diverse product nature. However generally accepted categorization includes “residential construction, commercial construction, heavy/civil/highway construction, and industrial construction”, that each of them can divide into sub categories to have better understanding and explain different situations. This categorization is helpful for contracting firm, because they need to specialize the job based on different resources that they need for each project, such as equipment, also different professions and methods that they use for construction. On the other hand, for better understanding the construction client, categorization of these type of client should be explained. Based on Eriksson(2010), the categorization including different parts such as public or private clients, local or national clients, belonging to service sector or industrial sector, which explained in Figure(3).

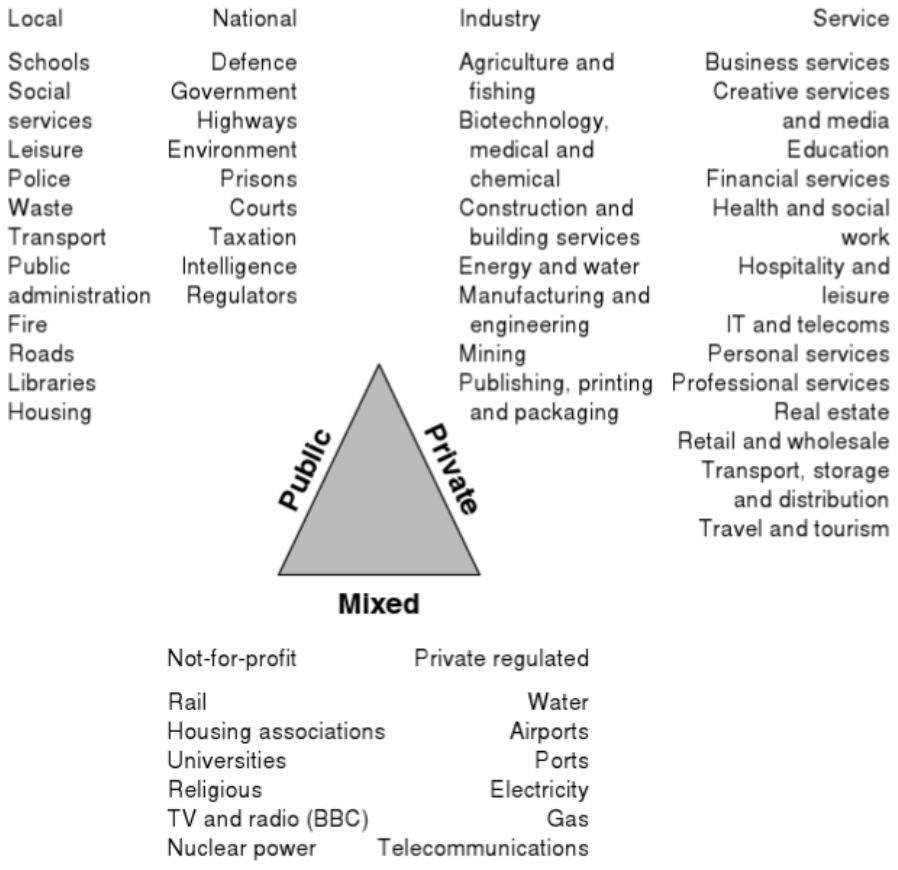

Figure (3): Categorization of construction client sector

(Eriksson 2010) P.8.

Client Defects

With regarding to the client there are defects related mainly to the client which include focusing on the lowest bidding price, unclear clients requirements and the high competition at tender that affect negatively on bid price (Schultz et al. 2014). on the other hand, Sha'ar et al. (2017) referred to delaying of payment and slow process in approving the executed works.

Contractors

According to American Society of Civil Engineers (2012) The role of contractors is to provide and manage the different resources required to implement the projects according schedule, drawing, standards and specification, these resources includes employee, materials, equipment, suppliers and subcontractors. So it is the contractor responsibility to plan and execute different construction activities, organize required resources, coordinate and communicate with other actors in the project such as client and designer, comply with different project requirements to achieve the required quality(American Society of Civil Engineers 2012)

However, there are a large set of defects that strongly related to the activities that are implemented by contractors. Sha'ar et al. (2017), referred to the contractors as the second main source of biggest defects after the designer. These causes include the lack of experiences for employees and the lack of skills in construction management.

Site manager

Based on Gorse et al. (2012), site manager in this industry define as "The main contractor's lead representative on-site, responsible for control of site-based operations and activities", Which also called site agent. In different countries there is differences for site managers responsibility and roles. For Swedish construction industry, Styhre (2011) mentioned this role is accepted as a father's role with necessity for working in long hours, by complete control of status and conditions, which have responsibility for the events that appear or it is not possible to predict them.

Based on Styhre & Josephson (2006), the site manager role in construction industry is similar as middle managers in other industries. Site managers are key actors in this industry which their proficiency and norms are necessary for the industry. Site managers need to have determined level of expertise to be eligible for this intricate role. In addition of being expert in technical issues, they should have the combination of different other proficiencies such as, operational and leadership skills, beside the ability to control and to plan projects procedures. For managing these extra task, it is necessary to train then, also they need more resources including time. It is not possible to be a high-level site manager without working in a long period to be able to combine ability and experiences.

Designer

To achieve client objectives in project, these objectives needed to be translated in to designs, plans, and other technical documents that facilitate execution of project to meet the client's

requirements. Therefore, designers use their skills and experiences to design the project details within reasonable budget and schedule in complying with codes, standards, and laws, communicate with other disciplines in project to clarify and resolve conflicts.
So, the role of designer in addition to technical tasks include also other tasks related to interpersonal and organizational issues (Al-Hammad et al. 1997).
According to Al-Hammad et al. (1997) the building research establishment in England, mentioned that the designs are one of the main cause of defects in building and more than 58% of defects are originated mainly from faults in designs.
Sha'ar et al. (2017), refers to that the designer has the highly ranking compared to the other actors in the building projects with respect to the defect causes, the identified defects include improper coordination between design team, unqualified and inexperienced employee in the design team, and unclear and fault drawing.
Hussain et al. (2018) in their study of identification of delay reasons, they refer to some causes of delay that are also could be considered as the causes of defects in the design process which include mistakes in designs documents, delay in delivering design in time. lack of investigation before design preparations, lack of skills for the design team, and Inability to meet the client's requirement.

3-4 Contract

Definition of contract based on Randolph Thomas & Ellis (2008) P.10 is, "A contract is a legally binding agreement between two or more parties to exchange something of value.", Which " A contract imposes both contractual and legal obligations on both parties that are difficult or impossible to change". In construction industry, money in replace of special service for different type of construction can be trade in.

Mosey (2009), mentioned about centralizing about pretext making, in field of performance, late delivery, disturbance, and overestimated budget, in contracts which make in standard types. But making pretext with contactor is not accepted for construction industry in this new age. The insufficiency of standard form of construction contract, can affect, in a negative way, on client profit and make them unsatisfied (Mosey 2009).
Randolph Thomas & Ellis (2008) explained that there are two steps for differing site condition in contracts. Firstly, the contractor immediately before changing the site condition should inform responsible of contract by written about issues such as, subsurface, other hidden or unknown physical conditions which are different from the contractual terms or generally accepted terms as nature of contract. In the second step, responsible of contract immediately after receiving notice should check site conditions. In the case of any differentiation which affect on time, cost, or performance of the contract, a fair modification should apply for contract in written appropriately.

3.4.1 Contract Type

Design Bid Build

First type of contract is, design-bid-build (DBB), that also called Traditional Contract. The Murdoch & Hughes (2008), refers to this type of contracts as general contract which involve a clear separation between the construction and design stages where the constructor is responsible only to implement what has been provided by designer who is appointed from client and due to the widespread using of this type of contract it is called as traditional.
Potts & Ankrah (2014), describe the processes within this method of contracting which normally start with client preparation of feasibility studies and then the client contract with designers group that include architects and consultant to prepare the preliminary and the detailed designs for the project and then provide required consultancy to the client in order to compile the contract documents that are necessary to the bidding process, then a contractor is selected among other competitive bids to implement the project which is mostly be selected based on the least price. In this system the client makes two contracts, one with the designer and the other with the constructors (Rumane 2017). Figure (4) depicts the organization of this contract type.

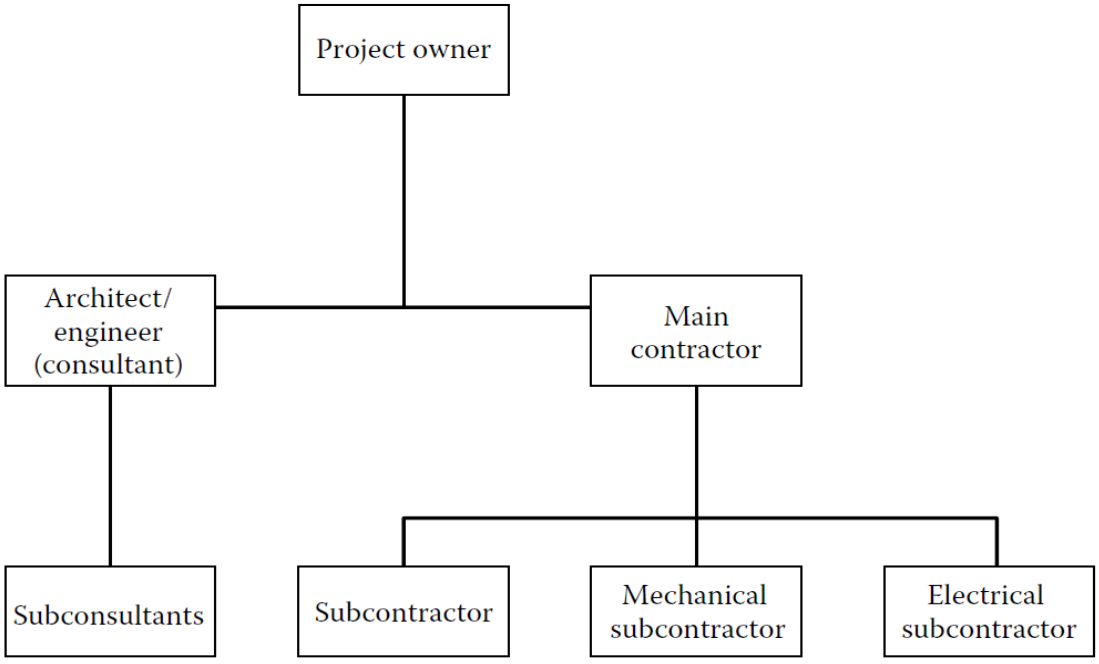

Figure (4) The organization of Design build contract in USA (Rumane 2017)

There are advantages and disadvantage for this type of contracts which are mentioned by (Potts & Ankrah 2014), here below some of them.

Advantages

1. • Less vulnerable for changes and claims due to either high degree of certainty or the clear state of accountability

2. • Provide opportunity to get lower price of contract
3. • Getting higher quality both in design and construction
4. • Provide more flexibility to the client in term of control the design and choosing of specific specialist
5. • Clear and well tested and practiced approach

Disadvantages

1. • Difficulties in managing the relationships between different actors
2. • Client possess weaker role with respect to its ability to communicate with contractors
3. • Relatively take longer period of time where the design must be executed before commencement of the project
4. •Low buildability because of inability of contractor to influence the designs
5. • Client is banded through several contracts with different parties which could increase the potential of defects occurring

Design Build

In this type of contract, the overall responsibility of design and construction process is transferred to the contractor. At the beginning of this process the client defines the scope and the outlined design that describe the general requirements and the desired specifications and then a set of contactors are invited to provide their tenders based on these inputs. The winning contractor then take a task of contract with other designers or architects in order to prepare the designs and start the construction process (Potts & Ankrah 2014).
The organization of this system is depicted in Figure (5).

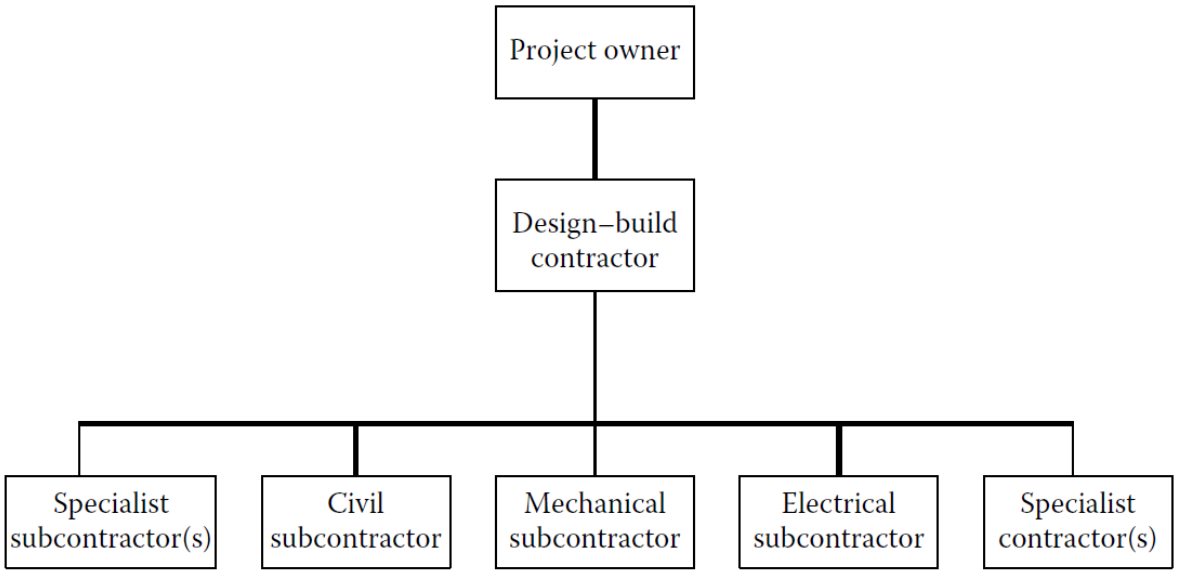

Figure (5) The organization of Design build contract in USA (Rumane 2017)

According to Murdoch & Hughes (2008) there are some main aspects which should be considered before deciding to choose design and build contracts which include:

- Experience of client
- Client priorities (time, cost, quality)
- Degree of complexity of the project
- Degree of requirement certainty
- Emergency of project start up

The above-mentioned factors determine whether the design build contract is more suitable or not. As long as the client has no experience in construction or has emergency with time and there is high level of uncertainty then the design build contract could be a better choice. However, if the client is more focus on the quality and design or the complexity of the project is high with related with design, in this case could not be the typical choices and other system could be better to choose.

Potts & Ankrah (2014), has referred to some weakness and strengths related to design build contract as following:

Advantages

1. • Shorter time required to project execution due to ability to overlap design and construction.
2. • Increasing in the constructability due to design construction integration
3. • Less variation as a result of early collaboration between different disciplines

• Clear responsibility lead to less conflicts.

Disadvantages

1. • For the client it is required a good briefing and description of project in order to meet his requirements.
2. • No control of the client over the design process
3. • Difficult to change the design where it becomes costlier for making changes
4. • The client loses control over quality in design

Partnering

It is mentioned in (Chan et al. 2006) the partnering definition which include a relationship between different organizations for intent of getting better outcomes and working effectively and efficiently by integrating of their capabilities and required resources and implementing an extraordinary level of collaboration between them based on trust and shared values.

Based on Project Management Institute (2013). the combination of project team is related to the structure of project organization for instance partnership-based project. Implementing the project can be as joint venture, partnership or etc. Between different organizations, based on the contract. Which one of them conduct and allocate someone as a project manager to harmonize relation between partners. Partnership project can help to decreasing the cost, but it is significant to have powerful communication plan and improvement controlling. It is good idea to establish industrial cooperation to invest in special case which one of them cannot tolerate it because of financial, strategic or other reasons.

It is argued by Murdoch & Hughes (2008) that there are some characteristics with regarding to partnership contract that distinguish it from other type of contracts. This includes a sufficient and large diversities of competences and resources, sharing the risk between parties, providing more potentiality to compete in new markets and provide good opportunity to embrace new technologies. Other benefits which are mentioned locally within the projects involves achieving more satisfaction for the client, increase the level of certainty, achieve more efficiency in design and develop the constructability.
For summary, in theoretical part, the construction industry in Sweden are mentioned in general then defects definition, occurrence, and types are mentioned in construction industry. Then defects are presented regarding actors in construction project these include client, contractors designer, as a main actor in construction projects. Finally, different types of construction contracts are mentioned besides discussing the advantages and disadvantages for every types regarding to several issues such as designs cost and duration.

3-5 Model

Based on the project process understanding, the construction project is an outcome which is produced from the integration of the site with different inputs through several processes which are implemented under different external conditions. This definition is the base for the model which shows in Figure (6), as the model that will use in this study. For more clarification it is significant to define models consisting parts.
Firstly, Input, which including, materials, designs, information, planning, equipment and human resources. Second concept is Process that refers to different activities which are necessary for project delivery such as planning, coordination, communication, decision taking and production.
Thirdly, External factor, which are emerged out of the project organization but affect the project directly or indirectly. These might include the weather impacts and organizational problems as examples. Finally, Site, consisting of issues such as Ground Conditions and Site Obstacles. Figure (6) show the model for construction project which can be used, as checklist, for classifying different types of defects into these main categories.

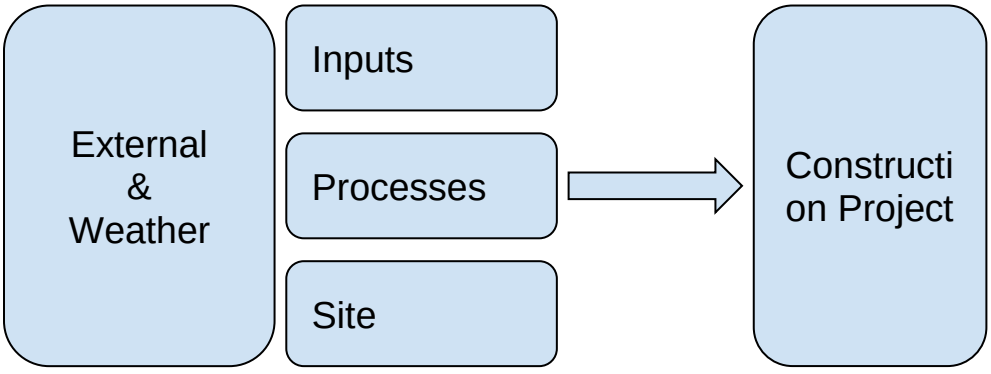

Figure (6) Building Project Context, (Abbas Tafti & Mohammed Almaswari 2018)

4- Empirical

In this part, based on database and resources mentioned before, information has been extracted and categorized based on different aspects as shown in the following sections. This information includes defects, actors, and contracts.

4-1 Defects

The total number of the registered defect is 333. By investigating these defects, some defects are repeated in different projects. So, similar defects have been grouped together. Table (2) shows the list of defects found in all projects. The shown defects are sorted according to the most repetitive one to the least one.

No.	Defect Detail	Number of Defects	% of Total Defect
1	Weather	70	21.0%
2	operational mistakes- production	19	5.7%
3	material delayed	18	5.4%
4	inadequate design	16	4.8%
5	unclear	15	4.5%
6	bad planning	14	4.2%
7	hard rock ground	14	4.2%
8	setting mistakes	12	3.6%
9	design mistakes	11	3.3%
10	others	10	3.0%
11	environmental issues	9	2.7%
12	bad ground conditions	9	2.7%
13	additional works	8	2.4%
14	incomplete design	8	2.4%
15	bankruptcy	7	2.1%
16	users	7	2.1%
17	utilities obstacles	7	2.1%
18	wrong geotechnical investigations	7	2.1%
19	contractual conflicts	6	1.8%
20	lack of coordination	6	1.8%
21	crowded workplace	6	1.8%
22	Internal organizational problems	5	1.5%
23	change of requirement	5	1.5%
24	design changes	5	1.5%
25	tight schedule	5	1.5%
26	bad consulting	5	1.5%
27	permissions	5	1.5%
28	lack of information	4	1.2%
29	change of scope	4	1.2%
30	delay in schedule	4	1.2%

31	wrong information	3	0.9%
32	bad decisions	3	0.9%
33	neighbors	2	0.6%
34	late information	2	0.6%
35	late decisions	2	0.6%
Total		333	100.0%

Table (2) List of Defects (Abbas Tafti & Mohammed Almaswari 2018)

Defects number in total is 333. Accordingly, all defects grouped in Table (3) based on their building types. Table (3) show the number of project and number of defects for each building category and number of projects which are free of defects.

Building Type	Number of Defects	Number of Defects Free	Number of Telephone interview	Total Projects
shops premises	36	19	55	44
preschools	66	21	87	58
hotels and restaurants	23	4	27	17
sport and recreational facilities	30	6	36	25
industrial facilities	17	5	22	17
office building	30	13	43	28
Power and lighting facilities	10	1	11	6
Public premises, churches, etc.	8	5	13	9
Communal facilities	18	4	22	17
service building	29	12	41	25
hospital and health cares facilities	15	3	18	12
schools	28	7	35	24
warehouses and workshops	23	19	42	31
	333	119	452	313

Table (3) Distribution of Defects based on Building Type (Abbas Tafti & Mohammed Almaswari 2018)

Based on Josephson (2013), it is not possible to have a completely defect-free projects, but some interviewee mentioned defects-free project. There are two reasons for this result. First, maybe the workflow is acceptable, without expensive and huge defects. Secondly, some site managers, have long term experience and they assume some defects as nature of their job and because of their full schedule they do not have sufficient resources to take this issue in consideration.

With regarding to the building types, there are difference in defect distribution for each type of building. Based on this fact, the percentage of defects for each type of building it shows in Figure (7)

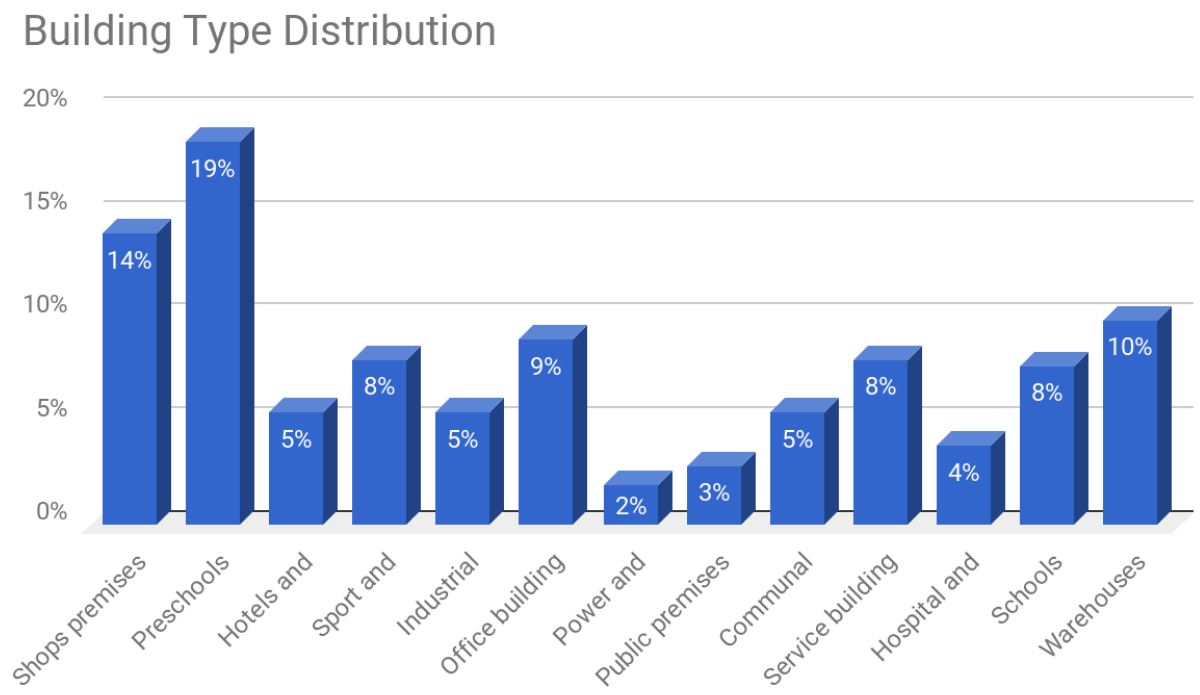

Figure (7) Building type distribution (Abbas Tafti & Mohammed Almaswari 2018)

Defects grouping

The defects list is introduced in table (2), that includes 35 different defects types. For this, it was necessary to investigate defects one by one in order to understand the nature of every defect which enable for classification of them into similar groups. Then similar defects were grouped into main and sub categories as it shown in Figure (8).

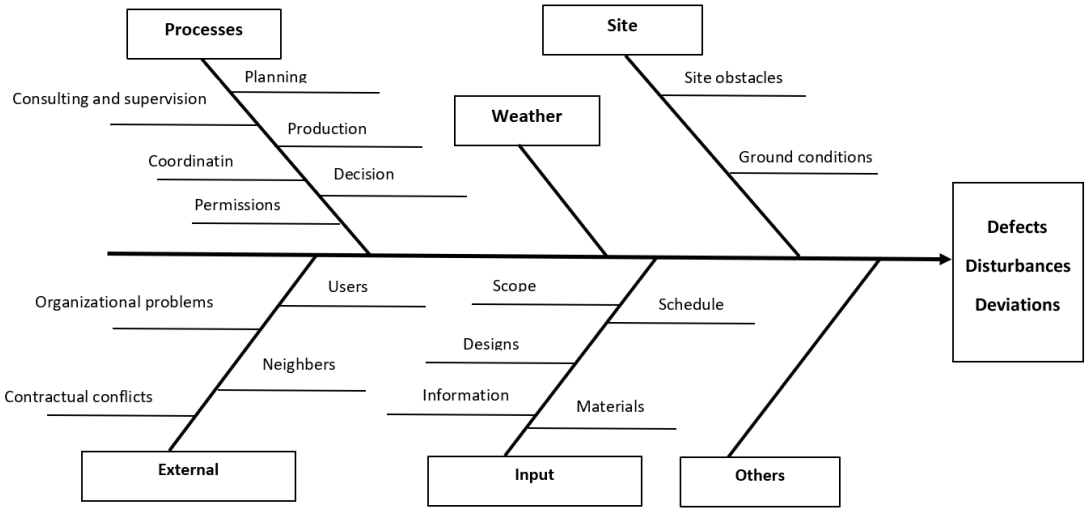

Figure (8) Distribution of Defects Categories, (Abbas Tafti & Mohammed Almaswari 2018)

The Figure (8) shows main classification without any special details. But for having better understanding of a bigger picture it is significant to have more details about each part of the model. General weighing for defects are depicted based on the model in Figure (9).

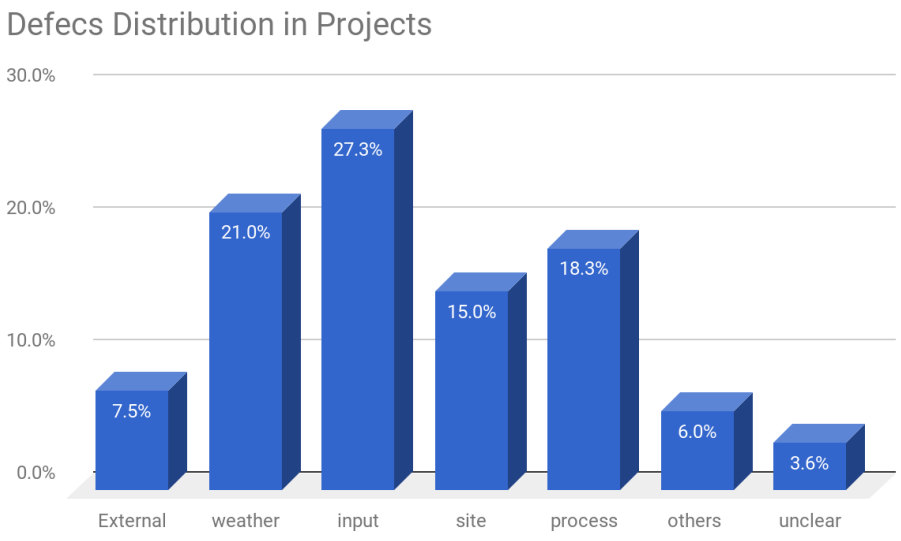

Figure (9) Defects Distribution in Project, (Abbas Tafti & Mohammed Almaswari 2018)

It is clear from the above chart that the defects related to input group constitutes the largest percentage of defects with 27.3% of total defects . Weather category has high contribution to the

registered defects with 21% which represents a significance percentage compared to the input. Process and site have 18.3 % and 15% respectively of the total defects and lastly the defect under external category has the lowest percentage of total defects with 7.5%.

The different defect categories then assigned for every building type according to the following figures. The distribution of defects differs from building to other building types. It is noteworthy to mention that there is a clear variation between the building type and percentage of registered defect.
Figure (10) shows that for instance, warehouses, public premises, and shops premises projects have registered the least percentage of defects compared to other building types. Whereas on the other hand power and lightning facilities has the highest percentage of defects.

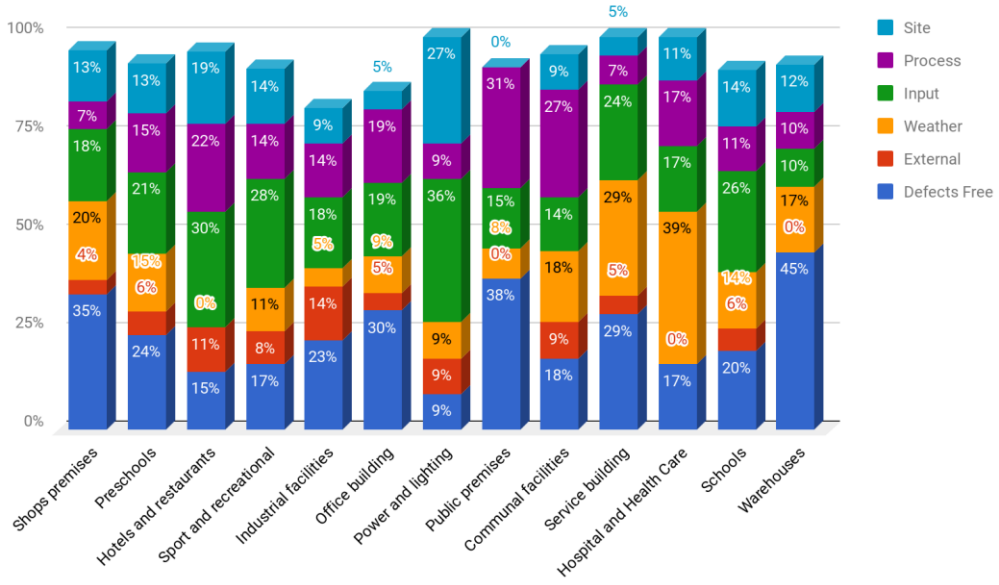

Figure (10) Building types & Defects Grouping, [(Abbas Tafti & Mohammed Almaswari 2018)]

Figure (10) expanding understanding of defects and their distribution, however, this information is incomplete. Other data, which are useful are represented in Table (4). These details include number and percentage of defects that occurred, within each defects category, beside defects details of each category.

It is noteworthy to mention that the weather which is involved in external part is shown separately because of the high percentage of this category. So, it is useful to represent it individually. The external category expresses about defects that occurs out of the project internal organization but at the same time has consequences on the project. These include for example bankruptcy, internal organization problems, users, and neighbors.

The input part refers to several entities that are needed to drive different process in the project. These include information, scope, design, materials, and schedule. For instance, designs are inputs that are necessary to start construction where there are not ready designs the construction could not be commenced so it is represented here as inputs.
The processes represent activities that are necessary to transform inputs into results, these include process of planning, production, coordinating, and decision making.
Site refers to the place that the project is built in, it involves a building area and the surrounding area that contains different facilities and utilities.
The term “Other” expresses about several other defects that are out of these above categories. The last category” unclear” refer to defects that are not goodly understood and identified.
It is obvious that these defects grouping which suggested, have the possibility to shape in another way. Different shaping has different process to lead to main goal which is identifying the relation between defects and contract type for their building type

Main Category	Defect Category	Number	%Defects	Defect/disturbance detail	Number
External	Organizational Problems	12	3.6%	Bankruptcy	7
				Internal organizational Problems	5
	Contractual conflicts	6	1.8%	Contractual conflicts	6
	Users	7	2.1%	Users	7
	Neighbors	2	0.6%	Neighbors	2
Total		27	8.1%		27
Weather	Weather	70	21.0%	Weather	70
Total		70	21.0%		70
Input	Information	9	2.7%	Wrong information	3
				Late information	2
				Lack of information	4
	Scope	17	5.1%	Additional works	8
				Change of scope	4
				Change of requirement	5
	Designs	40	12.0%	Design mistakes	11
				Incomplete design	8

				Inadequate design	16
				Design changes	5
	Material	18	5.4%	Material delayed	18
	Schedule	9	2.7%	Tight schedule	5
				Delay in schedule	4
Total		93	27.9%		93
Process	Consulting and supervision	5	1.5%	Bad consulting	5
	Coordination	6	1.8%	lack of coordination	6
	Decisions	5	1.5%	Bad decisions	3
				late decisions	2
	Permissions	5	1.5%	Permissions	5
	Planning	14	4.2%	Bad planning	14
	Production	31	9.3%	Operational mistakes	19
				Setting mistakes	12
Total		66	19.8%		66
Site	Site Obstacles	15	4.5%	Crowded workplace	6
				Utilities obstacles	7
	Ground Conditions	37	11.1%	Wrong geotechnical Investigations	7
				Hard rock ground	14
				Environmental issues	9
				Bad ground conditions	9
Total		52	15.6%		52
others	Others	10	3.0%	Others	10
unclear	Unclear	15	4.5%	Unclear	15
Total		333	100.0%		333

Table (4) Detailed Grouping of Defects, (Abbas Tafti & Mohammed Almaswari 2018)

External

Total percentage of this category including weather disturbance is about 29% of all occurred defects in all projects which is a considerable amount. This first part of model grouping, consisting of different defects categories such as users, Contractual conflicts and so on.

The largest percentage within external defects are belonging organizational problem that include for example bankruptcy and the internal organization problems. The other part such as Contractual conflicts, users and Neighbors come in the next step.

Weather

Although the defects related to this category could be considered within the external category, it has been grouped separately because of the high frequency of this portion in all building projects. The other reason is because weather is a disturbance rather than a defect. The registered defects related to weather were extremely high with 21% of the total defects as it is shown in Figure (9). All these defects happen in winter because of snow, heavy rains and wind which leads to work stoppage, difficulties in production and cause delay in projects.

Input

According to the data of defects which lay in these category, five types of defects have identified which are information, designs, scope, schedule and materials.

Designs defects

This category represents high percentage with 12% of the total defects. This can imply the essential role of designs on the success of any project. It includes different form of defects which are mistakes existence, incomplete design, inadequate design, and design changes.

The most dominant type of design defects is inadequacy of designs with 40% of the total design defects. This express about the low quality of designs with respect to buildability, functionality, safety and aesthetic aspects. It also involves the contradiction between design document and the ambiguity of designs.

Mistakes and incomplete designs have been found the second form of defects with amounts of 28% and, 20% respectively of the total designs defects. It encompasses mistakes in drawings, dimensions, calculations and other design document. The other aspect reveals lack in design documents when it is needed which could be a result of bad design management that should be adopted to ensure the delivering of design as required to begin the construction. It also includes the missing of designs for some element in the building.

The last category is design changes which represent 12% of the registered defects in the designs. Change in designs has emerged mainly from two sources the first one is client desires to change, add or cancel a component of the building so it is made to meet the new requirements of the client. The second reason could be come from inappropriateness of the old design which imply necessary changed have to be made to deal with constructability, functionality or even the existence technology required to implement the building.

Scope

Table (1) reveals that defects related to scope are the second part in input category after designs with 5.1% of total number of disturbances in the projects. These include changing in scope or specific requirements which could be according to the client desire based on his own circumstances and include the additional works which come as a result of bad defined scope or uncertainty.

Materials

The defects that correspond to this category represent a percentage of 5,4 % of the total defects. Most of defects mentioned under this category are referring mainly to the delay in delivering required material by suppliers which could imply the absence of good coordination between contractors and suppliers or logistic problems.

Schedule

Defects in schedule include two different levels. The dominant one denotes the inappropriateness of schedule to the size of implemented work. This could happen in the case of poor evaluation of the contract time which is determined by client. The other defects are schedule delay which occurs because of reasons belonging to clients such as delay in providing designs or delaying the commencing time of the project due to problems related to the client.

Information

The defects related to this category represent about 2.7 % of the total defects and it is distributed through three subcategories, including, wrong information, lack of information and late information. With absence of right information, defects become Inevitable which lead to more reworks and more cost incurred. Lack of information and delay of information could also lead to the same consequences. In addition, delay happened due to waiting to get the required information. With lack of information level of uncertainty increase which affect negatively on the overall project performance.

Processes

This category represents a considerable amount of the total defect it includes several processes which are related to different actors such as planning, production, coordination, production, consulting, permissions, and decision making.The highest percentage of defect lay within this category which refer to the mistakes which happen during the construction phase. There are two types of mistakes within this category. The first one includes mistakes represent operational mistakes.

Site

This category has a considerable amount of the total defects and it include two main classes the first one refers to issues that are related to the nature of the ground conditions of the site which are dominant. The other class represent the difficulties with respect to other facilities and utilities encountered in the site such as surrounding electricity and telecommunication services.

The rest belong to defects which are unclear or not fit to put in other categories, with not considerable number of total defects.

4-2 Contract

All the 313 projects have an agreement, including different types such as Design-Bid-Build, and Partnering. The distribution of contact type for projects is shown in Figure (11)

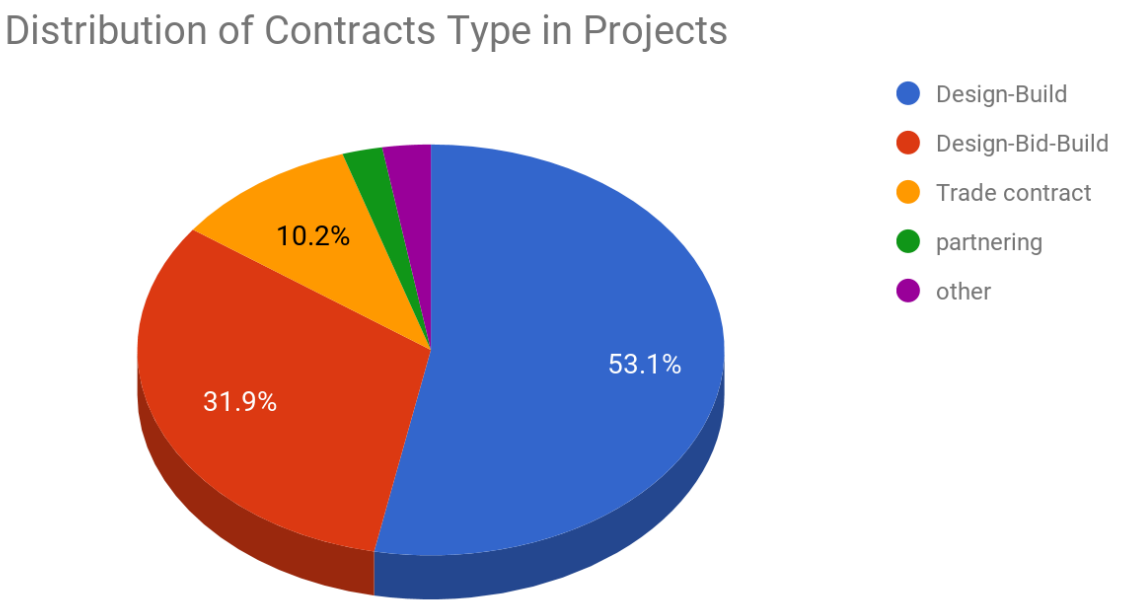

Figure (11) Distribution of Contract Type in Project, (Abbas Tafti & Mohammed Almaswari 2018)

All projects have different actors such as client and contractor which with contribution of them the project can implement. These actors are coordinating their relationship through contracts. These contracts have different types such as Design-Build, Design-Bid-Build. Mainly, four different types of contracts are found in all projects which investigated in this study. Different categories of defects have been distributed according contract types as shown in Figure (12).

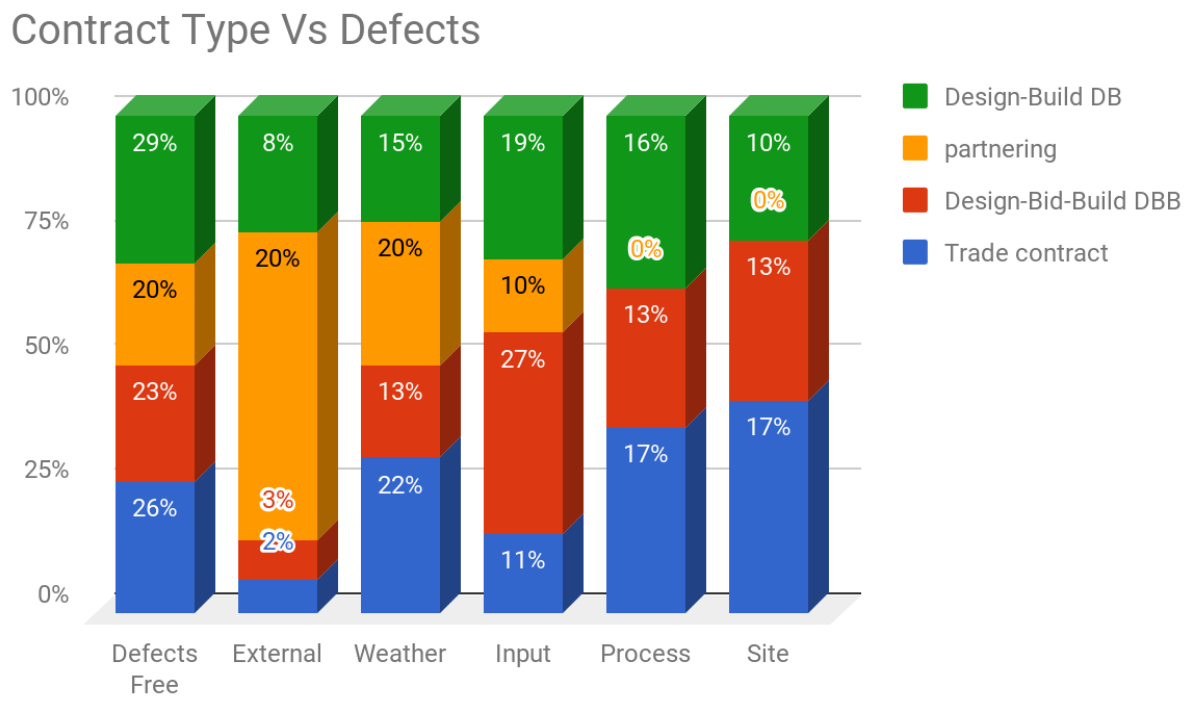

Figure (12) Contract Type Vs Defects Distribution, [(Abbas Tafti & Mohammed Almaswari 2018)]

Defects Distribution & Design-Bid-Build Contract

As it mentioned in empirical part, most projects have delivered by using both of the Design-Bid-Build contract and Design-Build contract, so the next two figures can help to compare Design-Bid-Build and Design-Build system in regard to different defects grouping. Figure (13) show that inputs have larger contribution compared to the other groups. On the other hand the external factors has the lowest percentage.

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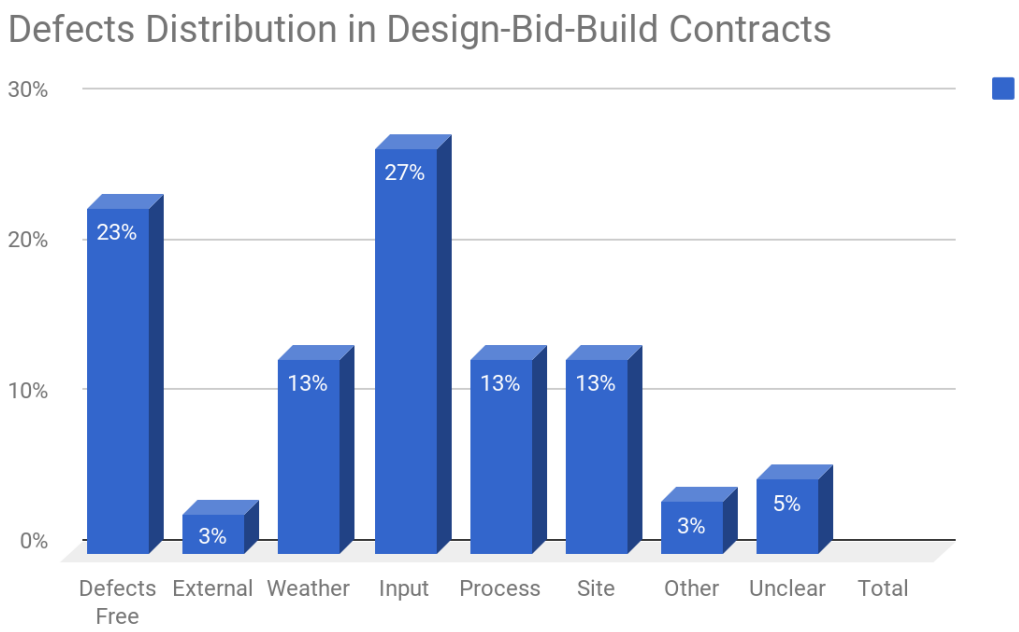

Figure (13) Defects Distribution in Design-Bid-Build Contract, [(Abbas Tafti & Mohammed Almaswari 2018)]

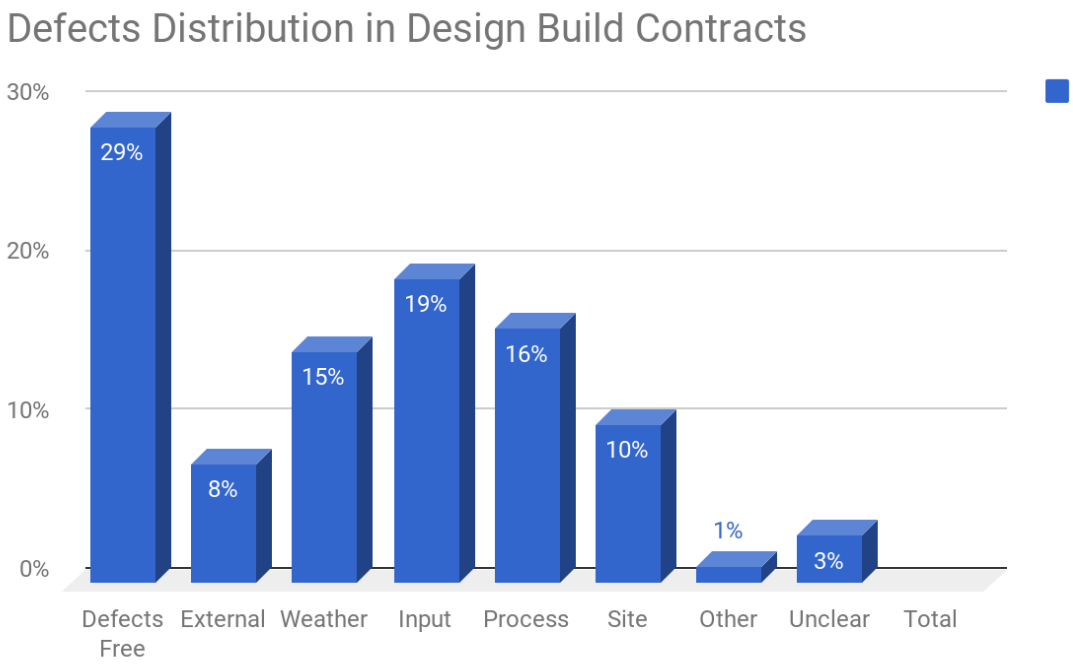

Figure (14) Defects Distribution in Build Contract, [(Abbas Tafti & Mohammed Almaswari 2018)]

4-3 Actors

Based on the report, two interviewee, site manager and client, mentioned some different thing as biggest defects. For instance, client mentioned firm bankruptcy as a biggest defect, and site manager mentioned lack of coordination between contractor and architects, as biggest defects in their project. This classification of defects shows in the Table (5).

Type of Defects	**Actor**
firm bankruptcy	Client
contractor mistakes in construction	Client
production management and deviations.	Client
geotechnical investigation delay project starting, building located near a river.	Client
improper coordination of subcontractors works	Client
improper construction planning	Client
incomplete action especially for electrical works	Client
lack of internal examination in production management, design responsibility was not taken seriously	Client
The municipality site restriction	Client
delay and incomplete actions	Client
Municipality changed land allocation during ongoing pre-planning	Site Manager
lack of planning and production management, forcing to work in small restricted area.	Site Manager

unsuitable client's selection method, work before completing all design which lead to reworks	Site Manager
inadequate site investigation, lack of skilled designers	Site Manager
raining during construction period	Site Manager
inadequate actions from consultants	Site Manager
contractor implement the items that he thinks beneficial to him, lack of communications	Site Manager
inadequate geotechnical investigation / late information from client	Site Manager
lack of coordination between contractor and architects.	Site Manager
subcontractor's construction mistakes	Site Manager

Table (5) Client & Site Manager`s Reported Defects,(Josephson 2013)

As it mentioned in (Josephson 2013) that the client role is significant because of the assignment which this role takes. Some of this duty are, creating a good template for actor's collaboration, project planning with high level of clarification, capability for decision making when it is necessary, providing appropriate information without lag when it is necessary. Site managers knows clients have strengths and weaknesses. Capability to making decision and interplay are their positive ability, but they are not good at planning the project and make an appropriate message. As another factor site managers have a better relationship with municipal in compare with private customers.

For more clarification of information which used in the Table (5), type of defects and actors, next table explain about defects details that related to the client. Client is important in this step because one side of contract is client. Then with more detail is possible to take more in consideration this issue to have bigger picture about the defects which related to clients.

Number	Defect Detail	Number	% of Total Defects
1	Hardrock ground	12	12%
2	Additional works	8	8%
3	Environmental issues	8	8%
4	Bad planning	7	7%
5	Wrong geotechnical investigations	7	7%
6	Bad ground conditions	7	7%
7	Utilities obstacles	6	6%
8	Change of requirement	5	5%
9	Change of scope	4	4%
10	Bad decisions	3	3%
11	Neighbor	2	2%
12	Users	2	2%
13	Wrong information	2	2%
14	Late information	2	2%
15	Tight schedule	2	2%
16	Lack of coordination	2	2%
17	Lack of information	1	1%
18	Inadequate design	1	1%
19	Design changes	1	1%
20	Material delayed	1	1%
21	Delay in schedule	1	1%
22	Late decisions	1	1%
30	Others	7	7%
31	Unclear	6	6%
	Total	98	100%

Table (6) Client`s Defects, (Abbas Tafti & Mohammed Almaswari 2018)

Then again, according to Josephson (2013), some other defects which related to the clients are "inadequate Geotechnical investigation, Inaccurate/insufficient information, unsuitable method selection, changes and unsuitable choice of materials". But some other actors such as contractors have some defects which mostly relate to them including, "Lack of planning, mistakes in execution, insufficient preparation of work, inappropriate material handling, inadequate geotechnical investigation", is possible to mention which not take into consideration in this study. As it clear from the table that the Design-Bid-Build contract and Design-Build contract, represent the dominant systems for project delivery with 32% and 53% respectively of among all projects.

5- Discussion

This section is including specific issues which relate to Swedish construction industry, then separately about the defects and contract. At the end for have better understanding discuss about combination of all aspects which are involve. Based on clarification of this combination it is possible to reach the result.
Construction defects cost could reach between 2% to 6% of whole projects cost. By investigating about defects and trying to prevent or decreasing amount of it, which is possible with features of Swedish construction industry such as opportunity for educating laborers and employees, the productivity can be increase and enables companies to save 15% to 20% their sales. A lot of different terms can affect on defects by their relationship with it. Every project has client and contractor which they should have an agreement for exchanging money and service that called contract. The contract has different type with specific features which can have related defects.

Defects

At the beginning based on the empirical data there are other concept beside defects, such as errors and disturbances when projects investigated. For instance, a considerable part of defects, about 21% of all defects, which interviewee mentioned about it come from weather, that is mostly disturbance not a real defect. But in this study, it is accepted as defect. As it mentioned In defects meaning has one term which refer “a lack of something for completeness, adequacy or perfection” which in this definition include some factors which can affect on other process and outcomes. In theory it is mentioned for weather that it has great consequences on the implementation of construction project which involves impacts on cost and duration in addition to increase contractual claims between project parties.
The question asked for interviewee was about what the biggest disturbances is they have in project however it is important here to mention that the answers for these questions was including some errors which defects are not disturbances. For instance, site obstacles and conditions could be considered as a disturbance but mistakes in designs, production and geotechnical investigation are clearly defects in their nature. This reveals that there is no clear distinguishing between both of defect and disturbance terms which confirm what was mentioned before about using of these terms interchangeably due to lack of definition.
Moreover, based on the definition of the construction defects which refers to any type of failure in each type of construction and building that decrease the project value, it is possible to extend the concept of disturbance to other failure. In this study all error, failure, and disturbance called Defect.

The used database in this study include wide range of information about projects such as project size and cost, based on the purpose of the study only the related data like, contract type and registered defects have been chosen to use. The number of defects is 333 then it should be introduced a simple proper classification as it shown in Table (2) where the defects number are classified into 35 defects category which it is more acceptable.

There are different ways for categorizing the defects, at first based on client sector and consequently, building type there is possibility to classify the defects. The result is including 13

different type of buildings and the number of defects which related to each type of building. For instance, for school building, there are 24 projects, which 28 defects occur in it, and 7 projects are defects free. This information is useful but there are not include the defects type. To have better understanding of relation of defects and other terms, there is necessity to analyze them based on appropriate grouping. Before talking about specific defects grouping it should explain about the school example. There are just 24 projects with 35 defects which means for some project there is more than one interviewee.
Based on need for appropriate grouping which emphasis on defects category it is essential to understand the project environment and its process. Referring to theoretical, Defects occur in an environment and by special mechanism. Then understanding the environment and its mechanism is the point which lead to clarifying this procedure with Model that it tries to include all actors and process which affecting or involving on project. Based the new trend in construction industry this model includes external defects which can include client as well. This model as shown in Figure (6) made based on new defects categorization in Table (4), which solve the previous problem with buildings type categorization. In addition, the model helps in providing possibility to interrelate the different building type and defect.
Based on Figure (10) it is notable to denote that there is different distribution of model categories along of each building type.

Project are different in features, location, actors, organizational structure, client sector and so on. One of these features is project location, which in this study is Sweden, with all specification that affecting on defects projects. In Swedish case because of labor permanent hiring there is possibility to educate them. As it mentioned one of the causes of defects is lack of knowledge with 29 %, that it can decrease in this way. But It is obvious that it is not possible to assign defects just to one actor or one specific reason. It is combination of different actors and reasons which make the defects to occur. But for simplifying the process of defects investigation it is possible to assume that the specific defect assigned to one actor or reason.

Besides, mostly defects in construction implementation occur with actors. Then identifying actors and the organizational structure which they are interacting in different phases can clarify environment that defects occur. In this study interview is held with site manager, and client. Site managers idea is important because of they are expert, skillful, with good understanding of work environment, and they spend long hours' time in the site. In addition, they have direct contacts with all problems that happens within the site. Based on Table (5), among of the biggest defects which site managers reported about it are raining during construction period, which means weather disturbance, or subcontractor's construction mistakes, which relate to production mistake in process category. Weather and process are the parts of the defects grouping which shown in Table (4).
The other actor is client. They are paying the project cost and as a key stakeholder, they have significant role in defining the project scope, deciding on the contract type and provide the required support. Clients has different sectors that each one has different building type. For instance, schools are one of the local sectors, building type. As it mentioned for site manager, table (5) explained the biggest defects which reported based on the client point of view, then it combined in Table (6). On the other hand, there are some defects which client are responsible for them as

it shown in Table (5). This information is important because client is one side of contract. By having this kind of information, and take them into consideration in the contract, there is opportunity to prevent some of them or at least with awareness of them have an appropriate plan for facing them. On the other hand, this information from Table (5) will be helpful for choosing the right contract type with suitable conditions, for increasing the client performance. As an example, among this defect in Table (6) the most dominant are related to hard rock ground and environmental issues that are related to the site category in Table (4). Site category represent 15.6% of all defects. But the perception of defects is different from client aspect and site manager, even for the same project.

The extent of defects depends mainly on several factors which are related to these actors for example bad planning or poor scope description of project with respect to client, mistakes in designs related to the designs, construction defects related to the contractor or subcontractor and late material delivery with respect to the supplier.
However, the defect could be a result from the bad coordination and cooperation among these actors.

As it mentioned before that every building type has its unique circumstances with regard to site, actors, degree of complexity of designs and level of details which make these variations occurs. For instance, the percentage of free defects observation in warehouses is relatively lower compared with other building types. But it is not only the above characteristics that make this differentiation. For instance, every building type has a different contract type which make it important to investigate this factor in more detail.

Contract

Base on contract definition, it is an agreement which organize legal obligations and identify several responsibilities for included parties for exchanging money between different actors in construction industry. Besides, as it discussed, defects can effect on profitability. Then there is necessity to understand the relation or relation of biggest defect in construction industry with contract types. On the other hand, as it mentioned, contract is a framework for legal obligations, but it was a trend for many contractors to use this framework for making excuse for project defects or disturbance. This is not acceptable today and contract is the frame for solve this issue not for making them.
Based on project delivery system in every project, there are different type of contact. Based the database which is used in this study, mostly 4 different contract types applied for investigated projects, Design-Build, Design-Bid-Build, partnering, and trade contract, as it shown in Figure (7). As it obvious in Figure (7), 53% of all contracts are design build, and 32% are design build bid. Accordingly, more than 85% of project are executed with these two types then the focus will be concentrated on them. As it mentioned in theoretical part DBB is more tested and practiced approach, then it should be the most repetitive contract type. But based on Figure (7), DB is dominant one. Which this fact shows one of differences between Swedish construction industry and the others.

It is mentioned that in Design Bid Build contract have main advantages that revolve mainly around concepts such as, design, changes, buildability and time.For instance within DBB there is more opportunity to affect on design, less expected change compared to DB. On the other hand, DB is better than DBB about it provides more constructability and save more time.

By Design Bid Build contract there is less vulnerable for change or claim. Which means in case of change it is easier to manage it. On the other hand, because of the fact which the bid will held after design phase, contractors have opportunity to compete for price and then it is possible to do the same project with a lower price. But DB has this advantage to finishing the project in a shorter time because of its nature which combining the design phase and constructional phase. On the other hand, in DBB, design and construction phase are different, then they do not have that opportunity which mentioned about DB, in this case, the quality of design and construction is higher. The reason can be two, first because design phase is done at first, without considering the executive problem which can be happen in construction phase, then based on this comprehensive design construction will start. Secondly. Client has more potential to influence on both the design and construction. But means more flexibility for client to choose best specialist. Beside in DB type early collaboration is higher and there is clear responsibility which make conflicts less, but in DBB type, designer and contractor can go through circle of blames. It is noteworthy to mention that in DB it is important for client to define the scope in an appropriate and clear way in order to assure achieving the desired requirements and at the same time to prevent need to change which will be costlier in this contract type.

Next step for investigating the relation between different contract type and defects is comparing percentage of each contract type based on the defects grouping as it defined in the model and shown in Figure (12). In Figure (11) contract project types weighted based on their percentage of all project, but Figure (12) shows the percentage of defects which belong to each project type. As an example, in Figure (11) it is mentioned that 10% of all project contract is Trade contract. But Figure (12) shows how this 10% divided between different defects group. On the other word, 17% of trade contract defects are related to the site. It should explain here, all percentage gathering together it can be less than 100% because “unclear” and the “other” defects are excluded.

To be more specific, in Figure (13) and Figure (14), it talked about Defects distribution in Design-Bid-Build, and Design-Build. It is notable the variation between these two figures with regard to different defects categories, for instance defects input in design bid build are clearly more frequent than design build contract.

6- Analysis

In the empirical part the different defects are identified and grouped into main categories. These categories will be used later here in the investigation of the relation between defects, contract type and building type.
For every contract type there are different building type, so it is necessary for have comprehensive understanding of relation which related to defects, investigate all variable which are contributed in the process. Main factors in this study which are combined, are, *Contract type, Building type,*

and Defects. In this section as final discussion part, all these three factors are combined and discuss at the same time. At the beginning, Table (7) shows the the whole picture that relates these three variables Contract type, building type and Defects, which it will explain later on separately in details. For instance, building type include 13 different building and contract type is expressed here as a percentage of design bid build contract to the total number of DBB and DB, and for defects five groups of defects are shown according to the suggested model.

building type	DBB	Defect Free	External	Weather	Input	Process	Site
Public premises	91%	38%	0%	8%	15%	31%	0%
Preschools	51%	24%	6%	15%	21%	15%	13%
Schools	50%	20%	6%	14%	26%	11%	14%
Sport and recreational	40%	17%	8%	11%	28%	14%	14%
Office building	35%	30%	5%	9%	19%	19%	5%
Service building	26%	29%	5%	29%	24%	7%	5%
Hospital and Health Care	25%	17%	0%	39%	17%	17%	11%
Hotels and restaurants	25%	15%	11%	0%	30%	22%	19%
Warehouses	21%	45%	0%	17%	10%	10%	12%
Communal facilities	15%	18%	9%	18%	14%	27%	9%
Shops premises	11%	35%	4%	20%	18%	7%	13%
Power and lighting facilities	0%	9%	9%	9%	36%	9%	27%
Industrial facilities	0%	23%	14%	5%	18%	14%	9%

Table (7) Combination of Defects Grouping & Building Type with DBB, (Abbas Tafti & Mohammed Almaswari 2018)

Based on Table (4) which explains defects distribution of model grouping, weather represents the largest percentage of defects in all projects which is 21% of total defects. However, Figure (10) relate weather for every building type and Figure (9) showed the percentage of every defects group based on model, such as weather and contract type. Merging relations between above factors are depicted in next figures.

In these coming figures, the above variable is represented, x axis represents different building type and the blue line refers to the percentage of DBB projects in every building type and the red line represent defects related grouping model.

DBB in these figures has some specifics. For instance, DBB is most repetitive contract type for public premises projects. On the other hand, DBB is less used contract type for industrial and

power facilities. For the other building types there are varieties in using of DBB. By investigating critical point for DBB and building types in coming figures, it is possible to find relation between them. The shown percentage of DBB express about the ratio between DBB and total of DBB and DB in percentage (DBB = DBB/(DBB+DB) *100%), the other type of contract and their projects (15% of all contracts) are excluded. As it obvious in Figure (15) the DBB percentage except public premises is less than 50%. Another word, 68% of all contract are DB.

Figure (15) is related to weather defects. The highest amount of weather defects belongs to hospital and healthcare facilities, and the lowest one belongs to hotels. Except hospital the other defects in other building types are less than 25%. For weather defects, and public premises project, 91% of all project have DBB type, and just 8% of defects belong to weather, then this type is appropriate for public premises project. For preschool and schools project 50% of contract are DBB, and around 15% of defects are related to weather. Another critical point appears in hospital and health care, which 75% of contract are DB, and at the same time around 40% of defects related to weather. This means DBB type is more appropriate for this kind of building. It possible to have almost same issue for service building. For hotel and restaurant, 75% of project are DB which is related to zero defects. It is same for industrial facilities, and power projects which 100% are DB. weather defects for industrial facilities is 5% and for power projects is 9%. For other type of building by considering the weather defects more than 60% of contract type are DB, at the same time less than 20% of defects related to weather.

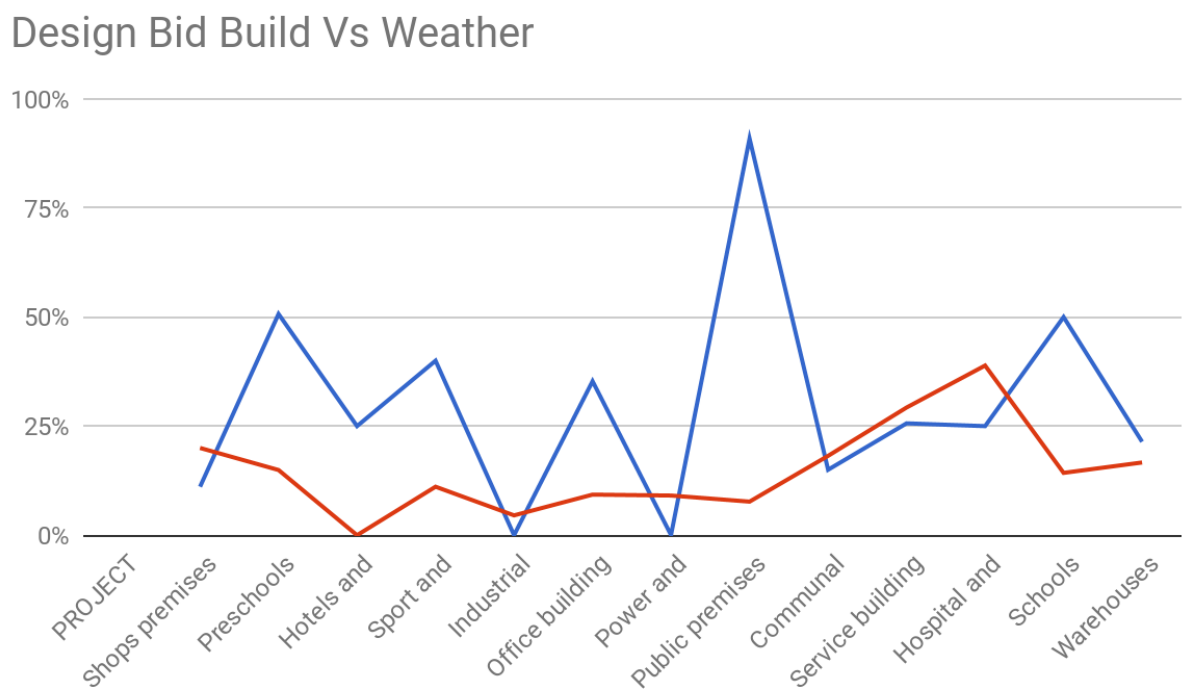

Figure (15) Design Bid Build Vs Weather, (Abbas Tafti & Mohammed Almaswari 2018)

Figure (16) is about input defects grouping and DBB contract type. The critical points in this figure are public premises projects, with 91% of DBB type, which 15% of all defects in this building type relate to input defects grouping. 15% almost is the low one in input defect type that means DBB type is appropriate for public premises buildings. The lowest input defect belongs to warehouses building type, with just 10% input defects. In this building type 80% of contracts are DB, which means DB type is more acceptable for this type of building. It is almost the same for communal facility, by applying DB type for them. The highest amount of input defects belongs to power building projects, with 100% DB contract type and 36% related input defects. That shows DB contract it is not good choice for this type of building. It can be same for hotel buildings, with 75% DB and 30% defects which related to input category. For industrial facilities, which 100% of contracts are DB, the input defects rate is 18%, which is in average.

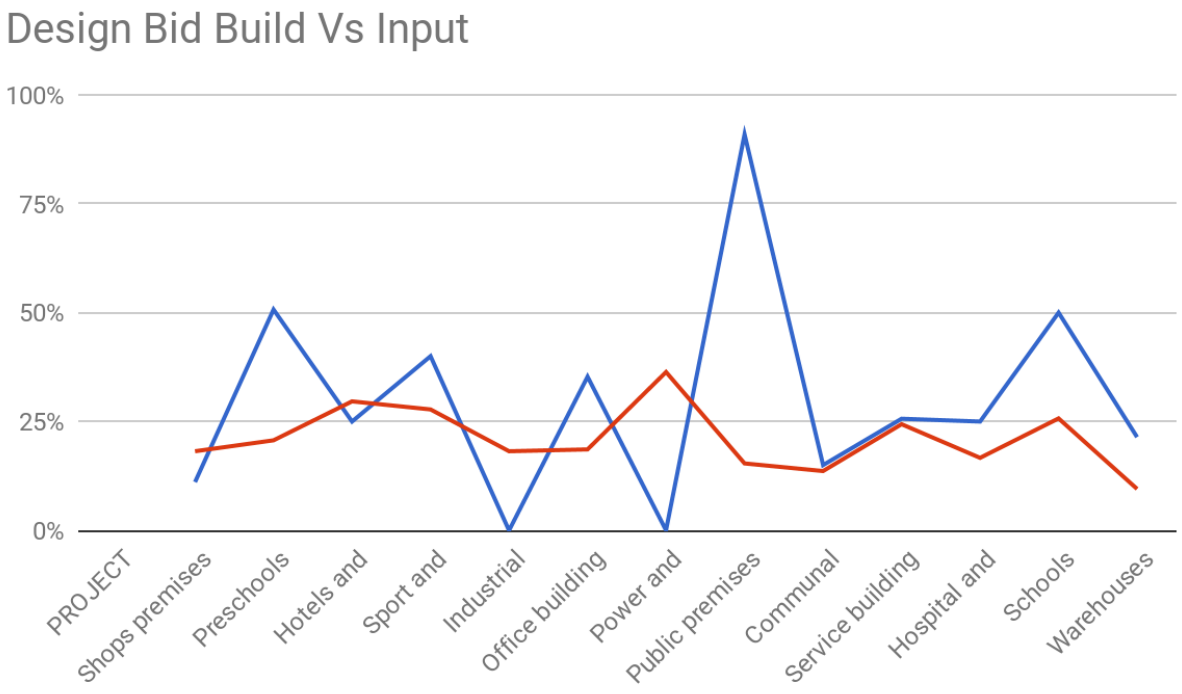

Figure (16) Design Bid Build Vs Input, (Abbas Tafti & Mohammed Almaswari 2018)

In the Figure (17) there is comparison for process and contract type. As it shows shops premises has 89% DB contract type, with 7% defects in processes. That make it good choice to use this kind of contract in shops buildings. By same result it is possible to talk about service building with 74% DB contract type and 7% process defects. But the best result here belongs to power and lightning project which 100% of them are DB and the related defects are just 9%. DB can be acceptable for warehouse project by 79% DB type and 10% process defects.
On the other hand, the biggest problem relates to public premises, which 91% of contract types are DBB and 31% of process defects (the highest one) occurred in this building type. That mean DBB is not appropriate for it. On the other hand, in Hotels and restaurants 75% of contract are DB with a 22% of related defects, which means DBB is a better choice for it. For the communal facilities with 85% of DB, the percentage of defects is 27% which means that DBB is better for this type.

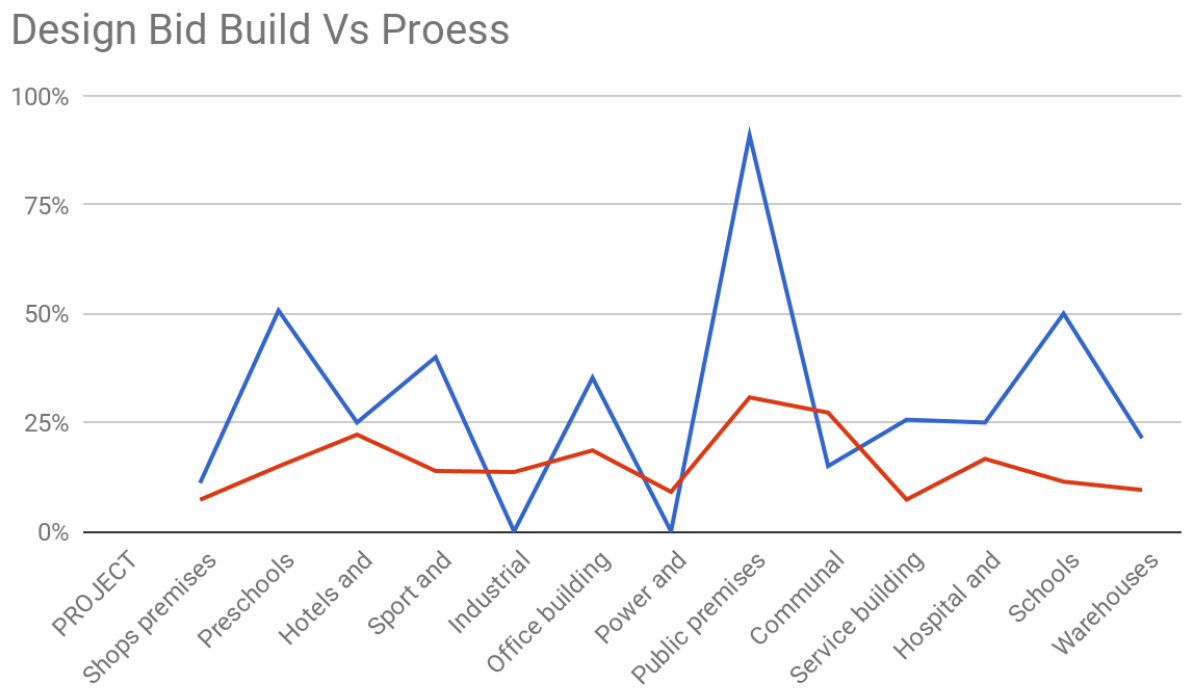

Figure (17) Design Bid Build Vs Process, (Abbas Tafti & Mohammed Almaswari 2018)

For Figure (18), the purpose is investigating the contract type and site defects. The best case in this figure belong to public premises with 91% of DBB contract and without any site defects. The worst case belongs to power and lightning facilities with 100% DB type which reached the highest site defects percentage. Additionally, 74% of service building have DB type which contributed to 5% of site defects. It is same for office building with more than 65% DB contract type and 5% defects in site. For industrial facility DB contract is appropriate choice, because of this reason that 100% of them having DB with just 9% site defects.

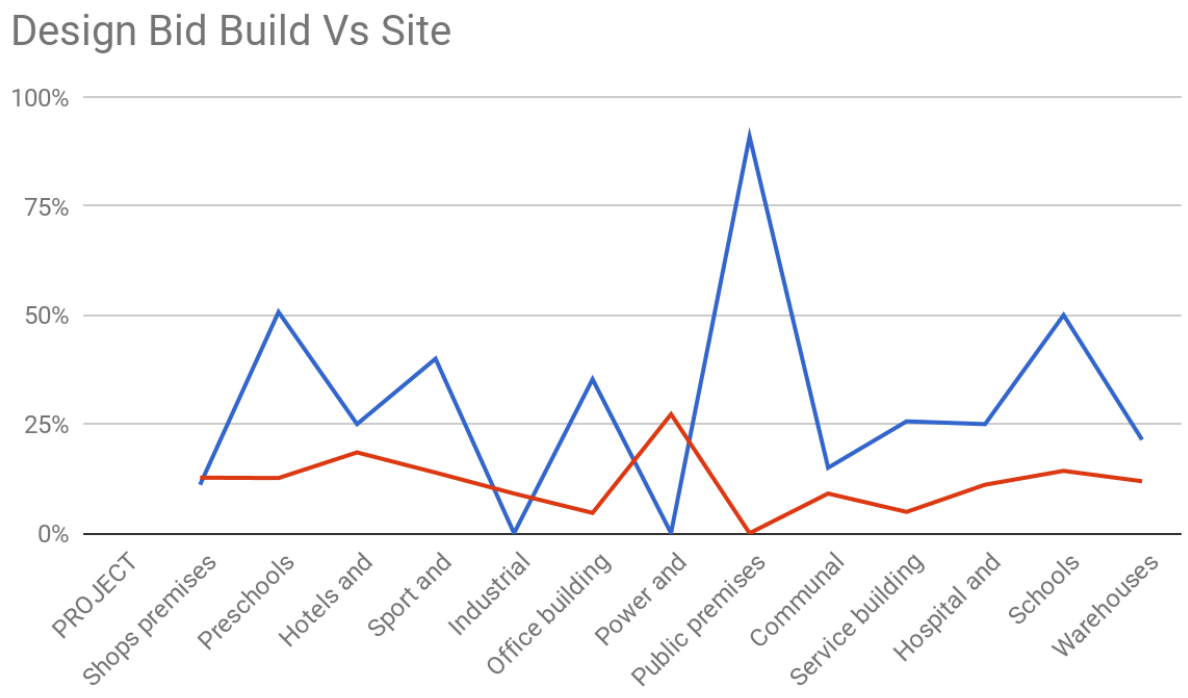

Figure (18) Design Bid Build Vs Site, (Abbas Tafti & Mohammed Almaswari 2018)

Figure (19), shows the relation between external defects and DBB type for different building type. As the first fact, 91% of public premises contracts are DBB, with 0% related defects which is acceptable result. On the other hand, for shop premises 89% of project are DB with only 4% defects that is imply DB is appropriate for this kind of buildings. For warehouse and, hospital facilities that have about 80% of DB contract the defects range is 0% which indicate that DB is more suitable for these two-building type. For industrial facilities with 100% DB, the worth case for defects by 14% which means DB is not good idea for this building type. Hotel and restaurant in compare to external have the 75% of the contract type is DB and the external defects is 11% which can recommend for DB type. On the other hand, communal facility has 85% DB contract type with 9% defects is high in compare to other building type so, in this case DBB is more suitable for this type of building.

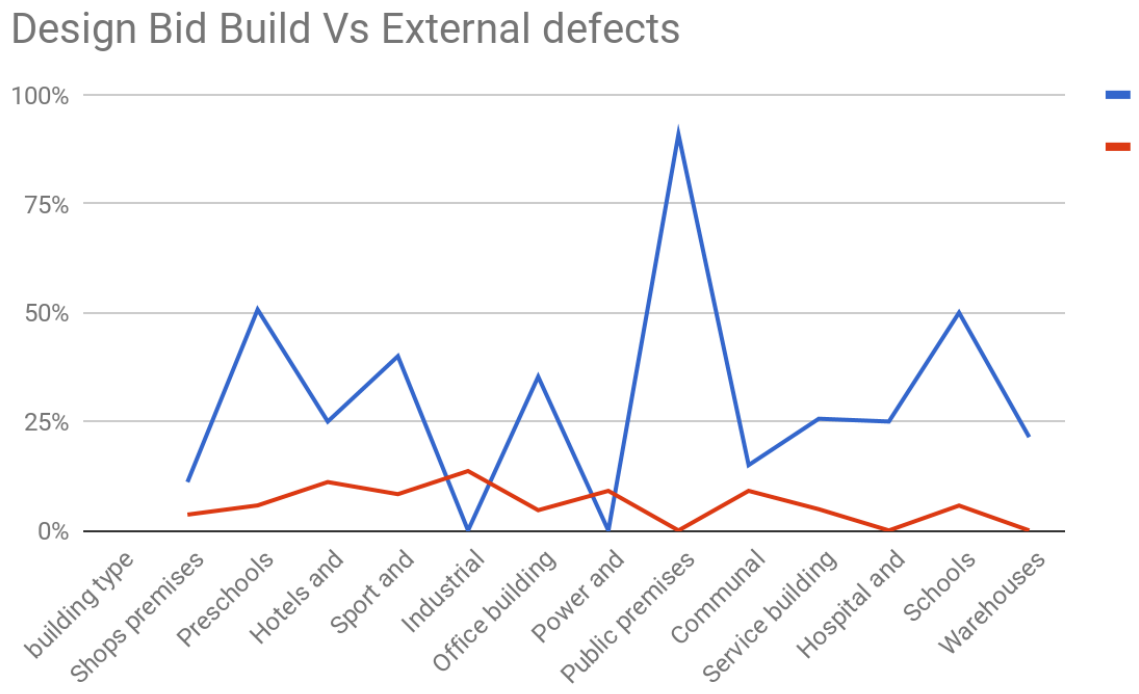

Figure (19) Design Bid Build Vs External Defects, (Abbas Tafti & Mohammed Almaswari 2018)

This part is different. During all projects some of them have defects which explained before. The others are projects which they are defects free. This category is more significant, because shows the relation of contact type and the projects which they considering by interviewee defect free. In Figure (20) which express about defects free projects and their construction type. First of all, 100% of Power and lighting facilities project are DB type, with 91% of defects, which is worst case in the study. On other side, for warehouses 45% of projects are defect free, corresponding to 79% of DB contract, that is one of the good choices. Another appropriated choice of DB is for shop premises projects, with 89% of this contract type and 35% of defects free projects. At the opposite, public premises which mostly, 91%, have DBB contract type, and high level of 38% defects free project, is one of the good choices for DBB.

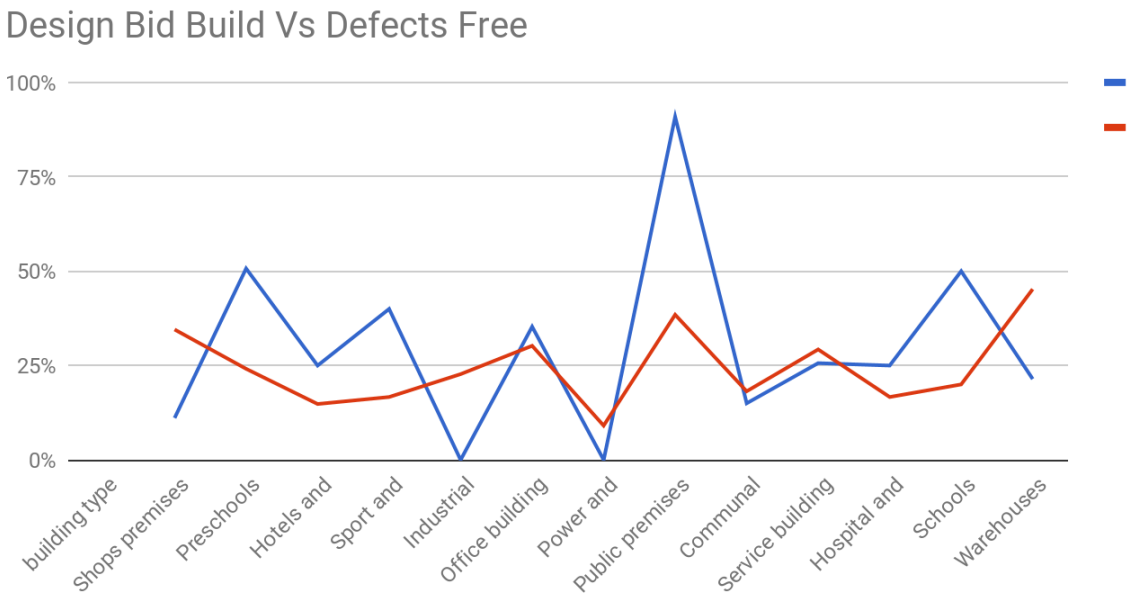

Figure (20) Design Bid Build Vs Free Defect, (Abbas Tafti & Mohammed Almaswari 2018)

Result

After analyzing empirical data based on theory and the suggested model in Figure (6), which grouped the biggest defects, as a next step each defects group was discussed based on DBB contract type and different building types (from Figure 15 up to Figure 18). Additionally, the discussion about the defects free project, as it is shown in Figure 20, was conducted in this combination of building type, contract type and group of defects. All above steps up to here lead to answering the issues which were discussed in problem formulation. All these issues are summarized in Table 8.

As it is shown in Table 8, for each group of defects the priority for suggested contract type was determined. This investigation shows that there are critical points for each building type and defects group. By investigating these critical points in the discussion chapter, outcomes present which type of contract is more appropriate for the combination of building type and defects group. These results are shown in Table 8. For instance, considering Public premises, one of the building types, for each defects group, it is obvious that except defects which are related to process, DBB is an appropriate choice for this type of building. Then it is possible to suggest DBB as an accepted choice for Public premises buildings.

As it is obvious in the table, some cells are empty. Theses empty cells refer to the fact that it is not possible to choose between DBB and DB. The reason is that they are not critical points and the information that we have is not sufficient to choose contract type. The criteria for deciding which is the suitable contract type for every building type is based on comparing each defects category with the percentage of DBB as an index.
For this reason, it is obvious that this decision cannot be made in case that there are closer percentage of both DBB and DB. The explanation of the empty cells for three building types including school, preschool and sport, shows that as it mentioned in Table 7, if the range of DBB and DB for these types of building is around 50% then information is not sufficient to decide the contract type. In other words, it is almost the same for these three types. One reason is because of the nature of the database, the percentage of DBB and DB used was almost the same for these building type.

It is noteworthy to denote that these findings are based on the developed model where the defects have been categorized. in the case of choosing another framework the results may differ.
There is the recommendation of Not DB in some part of the table which means in this cell all projects have DB contract type, but the percentage of defects are high, so DB is not recommended. But because all data is based on 100% DB contract, it is not possible to suggest DBB.

Building type	Defect Free	External	Weather	Input	Process	Site	Total
Public premises	DBB	DBB	DBB	DBB	DB	DBB	DBB
Office building						DB	DB
Service building			DB		DB	DB	DB
Industrial facilities		Not DB	DB			DB	DB
Communal facilities		DBB		DB	DBB		DB/DBB
Hospital and Health Care		DB	DBB				DBB
Warehouses	DB	DB		DB	DB		DB
Preschools							DB/DBB
Shops premises	DB	DB			DB		DB
Sport and recreational							DB/DBB
Schools							DB/DBB
Hotels and restaurants		DB	DB	DBB	DBB		DBB
Power and lighting facilities	Not DB		DB	Not DB	DB	Not DB	Not DB

Table (8) Summary of Result, (Abbas Tafti & Mohammed Almaswari 2018)

As another outcome of this research, it is possible to mention this example. For Hotels and restaurants building type there are two DB suggestions and two DBB suggestions, and in the first step it seems it is not possible to choose. If there is no problem prediction for hotel and restaurant, it is possible to weight them based on the percentage of total defects in each defect grouping. For instance, based on table 6, weather and external process together are 29.1% of total defects which suggest DB, but input and external together are 47.7% of total defects, and DBB is recommended for them. Then the total suggestion for hotel and restaurant is DBB. with the same procedure, it is possible to suggest a contract type according to building type and defects grouping.

But on the other hand, based on the specification of each project and its nature, one of the contract type can be chosen. For instance, based on Table 6, if the first issue for a company in a specific project is an internal organizational problem, according to investigated relation choosing DB is more appropriate for this case. Internal organizational problem is a subcategory of external defects grouping. But if the main problem can be happening in group of input defects, such as design problem, scope changing or information issues, then choosing DBB is more appropriate.

7- Conclusion

The aim of this study is the investigation of relation between three different variation including, biggest defects, contract type, and building type in Swedish construction industry. One of the significant issues to take into consideration in construction industry is biggest defects and identifying them to prevent. On the other hand, all projects need contracts and these contracts of different types have relation with projects defects. Despite high development in the construction industry, defects are still considered as a significant issue which has negative consequences on organizations` performances and profitability.

The biggest identified defects in construction industry which have more frequencies in projects are weather, production mistakes, design mistakes and material delayed which represent external, input and process categories. There is relation between different defects categories distribution and contract type with regard to design build and design bid build which was obvious in our result. There is variation between DBB and DB with respect to input, process, site and external defect. However, there is another factor which affect as part of this relation that is building type. It is preferably to take into consideration, building type when choosing contract type. Each building type has specific conditions which related to some issue for instance, design, complexity, requirements and actors which make some contract type is more appropriate for this type of building.

The outcomes that are discussed before in this study, can be used to suggest contract type based on specific building type. This outcome which is based on Swedish construction industry, can use for improving the efficiency in facing with biggest defect in this environment. On the other hand, the suggested contract type based on different defects grouping are identified. These three factors, building type, contract type, and biggest defects, in Swedish construction industry are explained as the result of the study.

8- Future Research

As a future study it is possible to suggest, with identified major defects, repetitive and highly cost, and their effect on the project cost, how it is possible to prevent them, maybe by improving the project management tools, techniques, and methods, such as, contract management tools.

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