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I needed and significantly contributed to my study. Their participation is greatly appreciated. Finally, I would like to thank my family for their support throughout all the year of my studying at the University College London.

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ABSTRACT

The construction industry has a consistently poor record with respect to the completion of projects in time, especially for traditional contracts. Delays are the most common and costly problem encountered in construction projects. Completing projects on time is an indicator of efficiency, but the construction process is subject to many controllable and uncontrollable variables. Slipping over the planned schedule, affects both client and contractor.

This study is aiming at providing a clear identification and classification of the main causes of delays involved in Greek construction projects, analyzing their effects based on the type of contractual agreement and provide pointers towards mitigating these types of delays. More specifically, this thesis will explain how the design construction coordination and the supply of specialized materials and components can cause time extensions in projects procured through traditional contracting.

The thesis is based on qualitative research, which is carried out by use of literature review, interviews and a case study approach of Alexandroupoli's airport in Greece. From the knowledge derived from the existing literature and the particular case study, it has been confirmed that Significant amount of time should be devoted in planning the project and estimating its time duration. Good design quality will only be assured if Design Construction Coordination is encouraged and implemented. This will help overcome various design-related constraints that would, otherwise, lead in reworks and loss of valuable time and revenue. The principles of Supply Chain Management should be carefully followed, so as to ensure reliable, long-lasting working relationships with competent professionals, which result in on time delivery and trustworthy arrangements. Finally, the choice of procurement affects the smoothness of a project's flow, but not because of the characteristics of each procurement system. It is the context of the project, the client's expectations and the size and complexity of the construction to be built that determine which procurement method is more suitable.

Keywords: Construction delays, Design Construction Coordination, Supply Chain Management, Procurement.

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1.0 INTRODUCTION

A. Research Aim/ Question

The construction industry has a consistently poor record with respect to the completion of projects in time, especially for traditional contracts. There are other contractual forms, apart from traditional procurement, which claim superior completion times, such as Design and Build and Project Management. However, despite these innovative systems, the traditional contracting is still the dominant procurement system in Greece and many other countries. Delays are the most common and costly problem encountered in construction projects. Completing projects on time is an indicator of efficiency, but the construction process is subject to many controllable and uncontrollable variables. In construction projects, the plans and specifications of the project do not specifically identify the individual steps to be taken, their order and the timing followed to achieve the end product. Slipping over the planned schedule, affects both client and contractor. To the contractor, delay could mean higher overhead costs, due to longer work period, higher material costs through inflation and due to labour cost increases. To the client, this might relate to loss of revenue through lack of production facilities and rentable space.

This study is aiming at providing a clear identification and classification of the main causes of delays involved in Greek construction projects, analyzing their effects based on the type of contractual agreement and provide pointers towards mitigating these types of delays. More specifically, this thesis will explain how the design construction coordination and the supply of specialized materials and components can cause time extensions in projects procured through traditional contracting.

The main research question is “What are the main factors that contributed to the delay of the construction of the airport in Alexandroupoli, in Greece, did the use of traditional contracting contributed to these delays? And, finally, how could these factors have been mitigated?”

B. Research Objectives

The objectives of this research are as follows:

1. Identify the most important causes and effects of delays in construction projects, as proposed by the existing literature.
2. Study the effects of delays on the client and the contractor, depending on the type of contractual agreement.
3. Assess, in particular, the significance of design construction coordination and supply of specialized materials and components, in terms of their impact on construction delays.
4. Examine whether the theoretical background applies to the research findings from the case study of the Greek construction project.
5. Provide pointers to appropriate strategies and measures that may be adopted to avoid or mitigate delays and/or minimize their effects.

The existing literature written on delays in Greek construction projects is most certainly limited. Not much research has been done on this field of construction and that is what this study aims to do. That is, identifying and clarifying the major contributors of delays in a Greek construction project, procured through traditional contracting. The academic value and contribution of the case study used in this thesis will be to give a more detailed insight of the Greek construction sector, aiming to determine whether the causes proposed by the existing literature can be applied to a typical Greek construction project. The problem owners of this case study are the Greek government, the construction firm and the airport authorities.

C. Structure of Dissertation and Chapter Summary

This study has placed its focus on identifying and investigating the core reasons that lead projects to time overruns. More specifically, the impact of problems caused by lack of design construction coordination and supply of specialized components and equipment have been thoroughly examined, including issues arising from the type of procurement method chosen. The effects of these types of delays and appropriate mitigating strategies to overcome the problem have also been analyzed.

In the introductory chapter, the research aim and objectives of the thesis are presented, so as to show the goals to be met. The research question developed, will be answered by the end of this research. Then, a brief description of the case study used in this thesis is made, so as to understand the complexity and size of the project and the reasons why it is used as a sample.

In the next chapter, that of literature review, an effort has been made to link theory to practice. Based on existing literature on the subject of construction delays, the major contributors are presented. Then, the focus is narrowed down to the significance of Design Construction Coordination. Furthermore, the study looks into the impact of Supply Chain Management regarding supply of specialized materials and components and explains why it is important to choose the right procurement method. Pointers towards avoiding or mitigating time extensions are provided.

In chapter three the research methodology is presented and all the methods used to collect data throughout the research are explained. There is a section in this chapter that ensures the credibility and quality of data, as well as presenting the problems that arose while conducting the research.

Chapter four is the analysis and interpretation of findings. All the data collected from fieldwork and interviews are presented and then analysed. Patterns are identified and then the theoretical framework is applied to the current findings, in order to test the initial research question.

Finally, the closing chapter is that of conclusion, where useful future lines of research are suggested and personal concluding thoughts are summarized.

The plan initially proposed by the government, was to renovate the existing terminal building and construct another one along the existing runway. The proposed new design where the whole existing building would be brought down and a new construction of 10.000m² would be built along it.

D. Brief description of case study: ATESE A.E. – Alexandroupoli's airport, Greece.

The project in question is undertaken by ATESE A.E. construction firm, who is well-established in the Greek Construction sector with annual turnover around €20m. Although the company has worked numerous times with the public sector in the past, the construction of the airport's terminal is the first so complex and specialized project they undertake. The project was procured through Design Bid and Build method. The initial estimated duration of the project was three years, however, it was delayed by one whole year, with a budget reaching €30m, which is €9m more than expected. The site is situated in the northern part of Greece, in the town of Alexandroupoli, just a few kilometres from the major city of Thessaloniki, with great transportation links, both bus and train.

Picture 1: Map of Greece, location of Alexandroupoli



Source: Google Maps

The plan initially proposed by the government, was to renovate the existing terminal of 3,000m² and construct another two wings adjacent to the existing building. However, the firm estimated that this would be neither economically efficient, nor constructible. Which is why, they proposed a new design, where the whole existing building would be brought down and a new construction of 10,000m² would take place (Picture 1).

Picture 2: Design of new construction of Alexandroupoli's Airport terminal.



(Source: official site of Alexandroupoli's airport <http://www.alxd.gr>)

Picture 3: Overview of the old airport



(Source: official site of Alexandroupoli's airport <http://www.alxd.gr>)

2.0 LITERATURE REVIEW

A. Factors Causing Delays in Construction Projects

Slipping over the planned schedule is the most common and costly problem encountered in construction projects. Completing projects on time is an indicator of efficiency. However, the construction process is subject to both controllable and uncontrollable variables (Assaf & Al-Hejji, 2006). Kumaraswamy & Chan (2006), in their effort to identify the sources of construction delays, they developed the *8 factor-category model*. According to the model, delays can originate from any of the following categories:

1. *Project-related* (eg. size and complexity of project, location, residential or commercial);
2. *Client-related* (eg. inability of client to finance project, previous working relationship with client, private or public project);
3. *Design team-related* (eg. omissions and errors in design documents, unclear details and specifications in drawings, lack of buildability of design, misunderstanding of clients requirements, changes to initial design);
4. *Contractor-related* (eg. lack of skills of site management team, inadequacy of subcontractors, unrealistic contract duration, communication/management problems);
5. *Material-related* (eg. shortage of supply, delays in time of delivery, inaccurate material estimation);
6. *Labour-related* (eg. slow productivity, lack of skilled workers);
7. *Plant/equipment-related* (eg. complicated machinery/installations required);
8. *External factors* (eg. unforeseen ground conditions, problem with legislation, bad weather conditions).

In the same study, the authors stress the importance of the 'multiplier effects', where problems arising in one category may also have an impact on another category and thus create an even greater delay on the project. The multiplier effect is frequently observed in circumstances where more than one of the aforementioned categories exist.

Ubaid (1991) supports that the major cause of construction delays is related to the contractor and his lack of experience, which leads to bad decision-making. Whereas

Kaming et al. (1997) points out another critical factor, that of the economic cycle of the building sector. Authors such as Noulmanee (1999), Al- Momani (2000) and Assaf & Al-Hejji (2006), all agree that the sources of time overruns include performance of parties, availability of resources, environmental conditions, contractual relations and design issues.

After having identified the broader range of factors causing scheduling problems, this study will narrow its focus on three major contributors to construction delays. The importance of design-construction coordination and of the efficient management of the supply chain will be thoroughly investigated. Moreover, emphasis will be placed on the importance of the type of contractual agreement used in projects. The main objective is to examine the extent at which they contribute to the excess of speed standards of projects and compare it, later, to the case study of Alexandroupoli's airport.

A.2.1 Impact of Design Construction Coordination

The successful completion of a construction project includes efficient implementation of two critical processes, among others, namely design and construction. Clearly, the nature of expertise required for these procedures, involves broadly one group performing the design and another group performing construction (Manavazhi & Xunzhi, 2001). Little interaction among design and construction teams can lead to design deficiencies, construction rework and therefore, severe delays of projects. Integrating design and construction is vital in order to avoid cost and time overruns, client dissatisfaction and 'waste'. *Design Construction Coordination* offers a great potential for improvement on traditional construction systems. It is during the design phase that the requirements of the client are identified and the constructive issues and standards of quality are determined through processes, drawings and technical specifications (Alarcon & Mardones, 1998). Failing to consider the way the design should be executed by a builder is the major contributor to scheduling problems, building constraints and delays during the construction process (Glavinich, 1995). These problems create a series of impacts in construction works, such as loss of labour, idle times, abnormal use of machinery and equipment, delays and reworks. The consequences of most design coordination problems are not discovered until during construction (Hegazy et al., 2001). The impacts of reworks and changes in design are rarely understood in terms of costs and schedule (Alarcon & Mardones, 1998).

The design process in a construction environment is extremely dynamic and complex. It is an evolutionary process that is multidisciplinary in nature (Krishnamurthy & Law, 1995). Through *Design Construction Coordination* those activities that add value to the design process are identified, value being 'the satisfaction of the requirements of the client'. Only the activities that can be converted to form valuable assets for the client are the ones that contribute to the value-adding process (Alarcon & Mardones, 1998). Redesign caused by errors, omissions and vagueness is also considered waste. Only a small part of the entire design cycle is used in value-adding activities, which is why even a small reduction of this value loss can offer great possibilities for improvement. There are several instances where value loss is created, for example in

cases where the requirements of the client are lost or errors in the quality of the design remain in the final product. In order to avoid this, design professionals should improve and optimize the design process through fast iterations among all the parties that distribute design and construction information at all stages of the project. Detailed analysis of the requirements of the clients and close collaboration with the client throughout the project is also strongly advised (Alarcon & Mardones, 1998). In order to achieve an improved integration, continuous and interdisciplinary sharing of data, knowledge and goals among all participants, is essential. Hierarchical representation of design data can be used to encode the design rationale, which is vital for *Design-Change Management* (Hegazy et al., 2001).

According to Alarcon & Mardones (1998), the problems associated with design are usually caused by three main reasons. First and most importantly, poor design quality due to incomplete or non-explicit drawings. Specifications, when hard to handle, are often overlooked. Design documents often lack clarity or have inconsistencies, errors or omissions. Second, lack of design standards or lack of suitability for the existing technology can lead to loss of efficiency. Third, lack of constructability which is mainly caused either because of incoherencies in design documentation or due to unforeseen conditions during construction. Constructability of the design refers to the “ease with which raw materials and components of the construction process can be brought together by a builder to complete the project in a timely and economic way” (Glavinich, 1995, p.72). The greater the complexity of projects, as for instance in Alexandroupoli’s airport, the greater the chance for significant amount of design errors (Alarcon & Mardones, 1998). Larger, complicated developments, which involve design innovation, require greater volume of flow of information and greater expertise in design and building. An excellent example of such complex, modern design would be the Opera House of Sydney. By ignoring constructability in design, the designer may burden the builder with conflicting requirements that could lead to out-of-sequence work, ineffective use of resources, structures and components difficult to be erected or constructed in-situ and, finally, the dissatisfaction of the client (Glavinich, 1995). Finally, factors such as changes introduced by the owner and designers with little construction knowledge can also be proved to be critical, as the builder may even initiate a lawsuit to recover damages. The details which are not underlined in the designs, become obstacles that have to be overcome by the contractor on site (Alarcon

& Mardones, 1998). A great example of complex project which was delayed by 3 years because of its extremely difficult design which required constant design changes, would be the construction of the Scottish Parliament building in Edinburgh. What design construction coordination does, is to incorporate construction personnel in the design stage, so as to help prevent problems before they arrive to the construction site. Adopting standards for design information will help avoid misinterpretations and loss of time in understanding design information.

Manavazhi & Xunzhi (2001), classifies the causes of design revisions into five categories. First, *owner-initiated changes* could consist of a change in the scale or standard of a building or its functional characteristics. Constraints of time, money and non-availability of experienced, in construction, designers usually augment the problem. Second, *designer's errors and omissions*, such as inconsistent details or impractical designs are another major source of delays and can be reduced through training and experience. Third, *contractor's errors and omissions* would relate to failure to execute the work according to the drawings and specifications. Such errors are usually detected through inspections, which is why regular visitations to the site are essential. Moreover, *changed site conditions* would occur as a result of substantial differences between the initial assumptions and the actual construction site conditions. Finally, if *changes in laws of regulatory agencies* occur before the design is completed, the design will most probably have to be revised. Such changes would be, earthquake and fire- resistance standards.

According to Love et al (2000, p. 567), 'rework is the unnecessary effort of re-doing a process or activity that was incorrectly implemented the first time'. In order to understand the source and nature of rework, modelling the design process is the key so as to prevent it by integrating design management with project management. The occurrence of design revisions is a function of both the project type and the environment in which it is carried out (Manavazhi & Xunzhi, 2001). The major source or reworks in construction, is the documentation, which consists of design changes, errors and omissions. Designers provide the graphic and written illustrations, which enable contractors and subcontractors to convert concepts and images into physical reality. How effective and accurate this transformation is, depends on the quality of the documentation and design. In an ideal world, the design and documentation available for the construction projects would be complete, accurate and explicit. In reality,

however, that is not the case. Tiley et al. (1997, p. 139) describe the design and documentation process as the 'ability to provide the contractor with all the information needed to enable construction to be carried out as required, efficiently and without hindrance.' Although the design itself has to be effective, it is equally important to be communicated successfully through the documentation. The documentation process, which is distinct from the creative process of design, is called *Design Management* (Love et al., 2000). Introducing a design change involves full understanding of the underlying principle behind the original design, which helps avoid violations of the requirements of the original design. That is the reason why, it is important to represent the evolution of design information (Hegazy et al., 2001). With the escalating complexity of building projects and the tighter restrictions on design time and cost, coordination-related errors increase in design documents (Hegazy et al., 2001). Tiley et al. (1997), propose a number of criteria which determine the quality of the design documentation; *accuracy* (free of errors and inconsistencies), *timeliness* (on schedule so as to avoid delays), *completeness* (all the information required is provided), *coordination* (among design disciplines), *conformance* (meeting performance standards and statutory regulations). Request For Information (*RFI*) process provides a better indicator of the total quality of design and documentation by quantifying the degree of deficiencies in the documents and their relative severity. This method, however, can also be inefficient if non-value adding delays occur due to the time wasted obtaining the necessary information (Tiley et al., 1997). As suggested by Alarcon & Mardones (1998), introducing continuous improvement in the design process and adopting standards for design information will help avoid repetition of design defects and prevent reworks. It is supported that a reduction in design errors and rework can enhance the profitability and competitiveness of a design firm and the performance of construction projects (Love et al., 2000).

Based on previous studies, there are a number of ways to reduce non-affordable delays, during construction, caused by design errors and inefficiencies. Alarcon & Mardones (1998), proposed a methodology to improve design quality. At this proposed methodology, four actions are underlined; *supervision* so as to eliminate the problems caused by lack of construction knowledge on the behalf of designers and provide experience in design solutions. *Coordination* of different specialties through a logic series of information transfer to prevent wrong assumptions and improve design

compatibility is also proposed. In addition, *standardization* of design information will help avoid omissions, repeated errors and continuous changes. Finally, *control* of the flow of information will result in preventing design defects from arriving to the construction site.

Another pointing strategy towards preventing delays and problems caused by design, is proposed by Glavinich (1995) and consists of two methods; *design-phase scheduling* and *in-house design-phase constructability review*. The former involves the development and successive revision of a construction schedule throughout the design process, which has to be updated regularly to depict the current status of the design, otherwise it is useless. Project scheduling is based on the availability of design resources and the requirements of the client. Planning and estimating design work is based mainly on experience and recorded data from previous projects of similar type (Manavazhi & Xunzhi, 2001). Whereas the latter, requires a detailed independent check of drawings and specifications prior to issuing them. The in-house review is more suitable for small projects and increases client goodwill by producing more efficient designs. As it offers greater design constructability, less labour hours and effort are required to solve problems.

Love et al. (2000) suggest the *Modelling approach* as a measure to avoid reworks. This method is composed of the following inter-related subsystems; *process of inducting/recruiting design personnel* (distinguishing between experienced and non-experienced personnel so as to avoid errors), *process of designing tasks* (depending on the error proneness of the designer), *error proneness during design* (determining a nominal value for committing error), *redesigning design tasks* (depending if the source of the error is the designer or the client). The modelling approach enables design and project managers to better comprehend the process of design documentation and identify the stage at which stage design errors occur and by whom. One could argue that it is an effective mechanism to examine several alternative scenarios in order to manage the design and documentation processes more efficiently.

To conclude, in a multidisciplinary environment such as the design process for building projects, changes are eminent, and managing these changes correctly is fundamental to controlling the project and ensuring a consistent and well-coordinated design. The designer must always bear in mind that the project plans are executed by

the builder at the owner's expense. Therefore, designers must produce a complete design that enables the contractors to use resources efficiently so as to provide the owner with an economical project. Clearly, a reduction in design errors will project a better professional image of the firm, lead to more effective design management, but most importantly, it will improve the profitability and the competitiveness of a design firm.

A.2.2 Impact of Supply Chain Management

A.2.2.i Demand for and Problems in Supplying Specialized Materials & Components in Complex Projects

The design and installation of building services and specialized materials and components is often precisely placed on the critical path of construction projects. This creates high expectations on the ability of the services team to deliver, so as to avoid extending projects' completion time. Regardless of the complexity and size of the installation, high-quality design, installation work and successful co-ordination are key to ensuring a lasting, effective operation of the asset. Despite that, most actors in the building sector will acknowledge that building services installations could sometimes be designed and built in a more efficient way (Rawlinson et al., 2007). Apart from quality, both availability of specialized materials and components and delivery on time play a major role in the time frame of the project.

It has been reported that lack of resource availability, changes in delivery dates and chaotic installation conditions are often the sources of costly delays (Vrijhoef & Koskela, 2000). In special, complex projects, with unique facilities, planning and managing, in advance, the design and installation of specialized materials and components helps reduce any problems that may arise regarding their availability or delivery time (Ballard & Howell, 1998). Delivery time constraints involve paying attention to managing stocks and transportation modes. Issues such as, the quantity of stock needed at each point, the form of shipment used, the use of different transportation routes or modes, checking inventory status at all sites and inspection of supplier delivery schedules are matters that need to be checked thoroughly and regularly so as to ensure on time delivery (Croom et al., 2000).

A.2.2.ii Challenges in the Management of Construction Supply Chains during supply of specialized components

According to Cox & Ireland (2002), sourcing from the supply chains that form the industry of construction involves a high level of difficulty, as construction supply chains have remained fragmented and adversarial due to the contradicting character of supply and demand. The fragmentation signifies that the supply market from which clients may source is diverse. The construction sector is said to contain countless construction supply chains, which display different structural properties that need to be clearly understood in order to conclude to the appropriate sourcing strategy. It is the considerable technological progress of construction products and services that has provided firms with a variety of sourcing possibilities. Construction companies increasingly resort to external suppliers for construction related activities, which were supplied internally in the past. This is the reason why, construction supply management is becoming more and more significant. There is a high degree of subcontracting within the building sector, with main contractors involving third parties in order to deliver products and services that can be integrated in the solution. As mentioned above, in complex projects, such as the construction of an airport, the highly specialized services required, can only be performed by competent professionals. As the range of possible supplier relationships varies from solely independent transactional, price-based dealings to highly interdependent relationships, the choice of the supplier is clearly a situation-based one (Cox & Ireland, 2002). What is it, however, that influences the supplier-contractor relationship? Croom et al. (2000), support that the most important factors are the degree of power and influence of each party, the length and complexity of the chain, the legal ties involved and the technological links. Buyers and sellers face complicated and hard choices on how to develop their relationships in cases of uncertainty, where motives of both sides are unknown. For that reason, it is very important to understand the criticality and significance of the product or service to be delivered. Firms must be fully aware of the products they buy and must understand the circumstances they are in. Understanding the structure of the supplying industries is fundamental. This can be achieved only by bringing different supply chain players together for each individual solution (Cox & Ireland, 2002).

A.2.2.iii The Role of Supply Chain Management

This brings us to the significance of *Supply Chain Management (SCM)* in the field of construction, since main contractors are becoming more and more dependent on other actors in the supply chain, such as subcontractors and suppliers. As defined by Christopher (2002), supply chain management is "the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer". What is special about this discipline is that rather than focusing on one part of the supply chain, it views the entire supply chain and aims at its coordination and control, by recognising its interdependency (Vrijhoef & Koskela, 2000). SCM strategies are mostly concerned with lasting partnerships, modular outsourcing of components, design for fitness for manufacture, flexible manufacturing technologies and evolution of the supply chain with the product life cycle (Lin & Shaw, 1998). According to Vrijhoef & Koskela (2000), opposed to the traditional way of managing the supply chain, which adopts a transformation view of production, SCM principle is based on a flow view of production. More specifically, in construction, it focuses on the impact of the supply chain on the on-site activities and aims at reducing cost and duration of site activities. It is particularly useful in complex projects where delays of specialized materials and components cannot be afforded. The key objectives are to avoid the disruption of the workflow and strengthen the relationship between the site and the direct suppliers. Understanding the actions of materials across a chain helps contractors choose the most suitable sourcing strategy (Croom et al., 2000).

A.2.2.iv Approaches Available to Overcome SCM Problems

An issue worth looking into, so as to avoid any supply-related delays, is that of involving suppliers in the early stages of the design process, this way working based on trust and securing order. Better coordination between all actors in the design process increases the chance of reaching to an optimum solution. The range of building products and components has expanded substantially in recent years and the fact that each of the firms in the chain is dependent upon another, without closely cooperating, makes the problem even greater. In order, for a contractor, to redefine his relationships with his suppliers, greater involvement of the supplier is required, so as to motivate him and keep him focused on the project. The distribution of a huge variety of building materials is complicated and a network of builders merchants has grown, who are key players in the construction supply chain. This has given room for partnerships to evolve between builders' merchants and construction companies developing long-term relationships. Partnerships are an alternative solution of ensuring that all participants are equally dedicated in achieving the client's expectations and avoiding any possible delays caused by supply of materials and components (Agapiou et al., 1998).

It is generally recognized that the construction supply chain includes a huge quantity of waste that is damaging to all parties involved within the sector. Furthermore, it has to be noted that, "construction is widely misunderstood by those procuring products and services" (Cox & Ireland, 2002, p. 410), which makes the selection between a single supplier who integrates supply chains and going directly to each of these markets, a critical decision for a project's completion on time. Furthermore, although SCM principles provide a directive for action, in construction, they have only had a limited impact on the sector and their application has been significantly slow (Vrijhoef & Ksokela, 2000). But it is through SCM that supply-related issues will be shielded from any occurrence of delays, on site-supplier relationships will ameliorate and flow of materials will be continuous. Planning and monitoring the availability of specialized materials and components and their delivery on time, rests on efficient supply chain management and plays a major role in reducing costly time delays.

A.2.3 Impact of Contractual Agreement

As construction projects have increased in scale and complexity, innovative possibilities of procurement have risen. Sharif and Morledge (1994) defined construction procurement as “the framework within which construction is brought about, acquired or obtained”. The contractual arrangement adopted establishes both the relationship of the numerous design, construction and advisory firms with the client and their relationship with each other. It determines at which stage each party should be involved, the lines of communication and responsibilities for information provision, coordination and control, especially when multiple tasks are involved (Nahapiet & Nahapiet, 1985). It is very important that clients choose the appropriate procurement strategy, as the opposite can lead to significant time and cost overruns for projects (Kumaraswamy & Dissanayaka, 1998). The three prevailing procurement methods are that of *Design-Bid-Build (DBB)* and *Design and Build (DB)* and *Project Management*. However, this study will place its focus on DBB and DB. The former is most commonly referred to as *traditional* or *lump sum contracting*, and it involves two separate groups designing and constructing the facility, respectively. Whereas, in the latter, the owner assigns both design and construction to a single organisation, usually a contractor, under a single DB contract (Janssens, 1991). As suggested by Rowlinson (1988), different procurement forms can be linked with different levels of performance. The performance of projects is multifaceted, which is why contractors must know the key variables they should control and focus on, so as to complete projects within schedule and achieve a high performance. It has to be noted that project size impacts performance. That is so because, in a larger structure there is an enlarged scope for parallel construction. The requirements of a building will also vary according to its function (Ling & Kerh, 2004). Most clients use the procurement method which they are most familiar with or base their choice on professional advice (Ling & Kerh, 2004). Based on predicted project performance, it is easier to decide whether DBB or DB procurement methods should be used in order to obtain the desired outcome (Ling at al., 2004).

Nahapiet & Nahapiet (1985) explain that traditional contract regards project delivery as a sequential procedure, with a large part of the design being completed before the selection of the contractors to whom specifications must be given. For traditionally

contracted projects, there are five variables which contribute in avoiding time extensions; contractors technical expertise, their time performance and quality in previous projects, the scale of change orders in their previous projects, the extent to which the contract period was allowed to vary during bid evaluation and finally, the flexibility of scope of works when the contractor is hired (Ling et al., 2004). A strong advantage of this contractual method is that it establishes a clear set of relationships at each stage of the project. Furthermore, it involves the client in less financial risk since contractors bid fixed prices on the basis of detailed plans. Although the method has survived throughout the years because of its familiarity to the participants and the clear lines of authority and liability, there are limitations. Vertical fragmentation, low productivity, little room for innovation and lack of single point responsibility are the problems of this method. The main reason behind the delays occurring during DBB contracts, is that contractors, after being awarded the DBB contract, start to identify any deficiencies or omissions in the design and ask for change orders to be issued and reworks to be done. This is not the case for other contractual arrangements, such as DB, Project Management, Management Contracting, since they appear to achieve higher speed standards, due to the greater emphasis they put on the interdependence of construction and design choices and the possibility they offer for “fast-tracking” (Nahapiet & Nahapiet, 1985).

In DB projects, on the other hand, the contractor is the one solely responsible for everything. According to Ling & Kerh (2004), this single point responsibility is the greatest strength. Owners have the benefit of effective and centralized accountability, which reduces disputes and misunderstandings. It is easy to start up and offers high process equipment quality and superior design. However, if the DB is construction led, design and construction cannot be fully integrated, thus creating design construction coordination problems (Glavinich. 1995). DB system is more suitable for innovative, complex projects (Ling, 2005). Despite the fact that DB has the advantage of the absence of the adversarial relationship between contractors and designers existing in DBB, it has a major disadvantage. Clients often feel that they have to bear more risks, which ultimately endangers the quality of the building. The method provides less price certainty, therefore, enhanced financial risk (Nahapiet & Nahapiet, 1985). In addition to that, DB contractors do not always take maintenance issues into account. According to Ling & Kerh (2004), regarding the subject of time duration of projects, DB projects

have 30% faster total delivery speed than DBB projects. They propose that if clients need to take possession of their facilities rapidly, then DB is the most recommended method.

When firms find themselves in a procurement path selection they should thoroughly examine the type, complexity and the size of the project. They should take into consideration the type of the client, the availability of information at the beginning of the project, the type and status of local construction, the availability of materials and components and the performance of available contractors (Kumaraswamy & Dissanayaka, 1998). The desired allocation of risks also plays a critical role.

Determining the strengths of a procurement system is a rather hard task. Relatively few professionals completely understand the differences in the various procurement systems, which makes it challenging to choose the right method (Ling & Kerh, 2004). Part of a chosen procurement method may end up being incompatible with some of the project's goals and priorities. When owners want high quality construction, they should not waste time debating whether to use DB or DBB. Based on the type of the project, the characteristics of the client and the time and cost constraints, clients should select the procurement system that is most suitably applied to their particular project priorities after including allowances for the appropriate condition of a particular scenario.

B. Consequences of Construction Delays

In an ideal world, each risk element should be assigned to the project participants that are best equipped to handle it. The choice of type of contract largely affects the allocation of liabilities and risks between the different parties involved in a project. For any project, it is critical that each party is fully aware of the risks undertaken and the possibility for unexpected problems (Kumaraswamy & Dissanayaka, 1998). A time extension may seem, at first, the simplest remedy for the contractor to recommend and the client to accept, however, the consequences are usually highly damaging to both parties (Glavinich, 1995).

B.2.1 For Client

To the client, delay is translated into loss of revenue. In large construction projects, such as the airport case study, where there is huge potential for revenue earning, delays can be very damaging (Assaf & Al-Hejji, 2006). In traditional contracting, any time extensions caused by design discrepancies will result in increased costs for the owner, which cannot be fully covered even by imposing liquidated damages on the contractor. In addition to increased construction costs, loss of customer goodwill is another delicate problem clients have to deal with. Furthermore, time extensions or extra compensation in order to minimize the effects of problems may result in the contractor initiating a lawsuit against the client in order to recover damages (Glavinich, 1995).

B.2.2 For Contractor

To the contractor, on the other hand, delay is related to an increase in overhead costs because of longer work period, higher material costs due to inflation and labour cost increases (Assaf & Al-Hejji, 2006). Time overruns usually lead to rework, as most probably there have been errors or omissions during the design or construction process (Alarcon & Mardones, 1998). Rework, for the contractor, means increased construction and operational costs. Finally, when projects are delayed, contractors make use of resources that could have been allocated in another project at that period of extension, thus making less profit.

C. Ways to mitigate Construction Delays

Analyzing construction delays has become a fundamental part of the construction life of a project (Alkass et. al, 1996). Improving productivity is a useful way of controlling delays (Kamaraswamy & Chan, 1998). Task execution needs resources to be deployed as efficiently as possible, for their maximum amount of their available time, so as to generate value and avoid delays (Winch, 2006).

In order to deal with the complexities arising from interdependent activities, which may cause delays, the *Critical Path Method* was developed by DuPont, which “arrays graphically all the different tasks in temporal sequence, forming a network of task dependencies” (Winch, 2006, p. 258). This method gives the opportunity to reschedule tasks off the critical path so as to attain resource utilisation. However, the technique is less reliable in cases where task objectives are vague, during, for instance, the design phase (Winch, 2006).

In the case of the design, the way to mitigate delays and avoid their costly consequences, as suggested by Alarcon & Mardones (1998), is to incorporate construction personnel in the design stage, establish standards for design information and bring in the principles of continuous improvement.

Problems regarding the supply of specialized materials and components and the choice of the right procurement method can also be minimized. Shoemith (1996) proposes that the procurement method must be suitable to the situation. The size and complexity of the project determines what kind of contractual agreement should be made. Factors such as good working relationships between designers, contractors and subcontractors, previous professional experience on the type of work and good administrative ability are all ways to avoid some extension of time.

Winch (2006) supports that the problem is that project managers spend remarkably little time on planning. It is common for a project manager to be engaged in more than one project at a time, thus not paying equal attention to all projects (Kog et al, 1999). This places managing the programme and planning thoroughly, at the core of construction projects. It is suggested that any technique is best employed at the time

when the delaying event is occurring and should be performed jointly by the contractor and the client (Bordoli & Baldwin, 1998).

3.0 RESEARCH METHODOLOGY

A. Research Techniques and Data Collection

This study aims at gathering an in-depth understanding of the major reasons lying beneath time overruns occurring in construction projects and more specifically, the main contributors for the delay of the construction of Alexandroupoli's airport in Greece. It is based on qualitative research, which is carried out by use of literature review, interviews and a case study approach. Qualitative research in the context of this research is both exploratory and explanatory, as its main objective is to test a hypothesis developed from existing literature and use of fieldwork and case study data to test the assumptions. Qualitative research enabled me to reasonably assess the situation in the particular project and investigate the critical factors of delays by direct observation, in depth interviews, participation in the setting and analysis of existing materials and documents.

The main hypothesis of this study was that the existing literature identifies many critical reasons for delays in construction projects (see Literature Review). Especially in projects procured through traditional contracting, design construction coordination and supply of specialized materials and components are critical to delays. This is applicable to the case study used in this thesis.

Through qualitative research, the need for smaller and more focused samples is created. These samples are in the form of case studies. Saunders et al. (2003) define a case study as "a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context, using multiple sources of evidence." They also argue that, information collected through case studies is more accurate and detailed, therefore, leading to a more objective picture. The reason the particular case study was chosen is because it is a perfect example of a large, complex project, where design deficiencies, supply of specialized equipment and the procurement method used, create problems in completing the construction within the anticipated schedule. It is a project which was initially planned to finish within 2 years, however, it was delayed by one

whole year. Moreover, it was ideal as both traditional and D&B procurement methods were used, due to the necessary design changes.

An interview is a purposeful discussion, which helps one gather valid and reliable data relevant to one's research (Saunders et. al, 2003). In this study, six semi-structured interviews were conducted, with the use of both open-ended and, at a later stage, closed-ended questions with the key players involved in the project. These included two architects, the site manager, the main contractor from ATESE A.E., one subcontractor and one supplier of specialized materials and components. Semi-structured interviews were chosen in order to understand the relationships between critical variables, while interviewees explain and build on their responses. Personal contact established in interviews, made the conversation more direct and gave a better understanding of the situation. The themes of the interview were designed in order to make the interviewee feel comfortable and then narrow the conversation down to the area of interest. Some of the themes turned out not to be of great relevance to the research and were later removed.

Secondary data were used to help me expand my knowledge on the field of construction delays and gain extra relevant information for my study. These include textbooks, articles from magazines and newspapers and the Internet. They were used as a foundation to support the theoretical framework presented in the literature review section, by analyzing the literature needed in order to test theory.

The issues of credibility and data quality were not a major problem for this research, as both primary and secondary data come from reliable sources. However, there is always some possibility for interviewee or response bias, when conducting interviews. In this case, this possibility is stronger since the perspective of the client is eliminated and all the focus is placed on the perspective of the contractor due to the denial on behalf of the client for interview. Moreover, there was no noticeable divergence in responses of interviewees, as they all mainly agreed to the major reasons behind the delayed project.

B. Limitations

The greater limitation was the difficulty of getting in touch with the client in this project. Since the construction of an airport is investigated and the client is the public sector, it was very hard to reach them and impossible to arrange an interview. The Greek government did not prove to be very helpful. This limited the scope of the study and did not allow for the client's point of view, to be presented which could have possibly changed the final outcome of the research. Furthermore, the availability of interviewees during the time period I was interested in, was limited. The employees of ATESE A.E. were engaged in a very demanding project and only six of them were able to provide me with interviews. In addition, the issue of time proved to be a great restraint, as with a more flexible time frame, more detailed research could have been done.

4.0 ANALYSIS OF RESEARCH FINDINGS

A. Presentation and Discussion of Research Findings

For the purpose of collecting reliable and precise data, so as to evaluate the causes behind the delayed project, six semi-structured interviews were conducted. More specifically, information was gathered from the main contractor of the project, the two architects of ATESE A.E. involved in the revised design of the terminal, the site manager, two suppliers of specialized equipment such as x-ray screening systems, airport monitoring systems and optical sensors and, finally, the subcontractor involved in the specialized installations of baggage conveyors.

They were questioned on six specific topics; the first was of a broader nature, whereas the rest were case-specific:

1. Construction delays in general.
2. Impact of design in the reconstruction of the airport.
3. Importance of supply of specialized equipment and components for the airport.
4. Impact of contractual arrangements.
5. Consequences and effects of time overruns.
6. Mitigation and avoidance strategies.

A.4.1 Construction Delays in General

As a technique to understand and assess the general understanding and opinion of the interviewees on the subject of time extensions, they were, initially, asked to rate the significance of Kumaraswamy & Chan's (2006) *8 factor-category model*. They were then asked, based on their experience, to apply and assess the model on previous construction projects they were involved. Five out of six interviewees rated the design-team related factors as the most significant (Figure 1). This 83.3 % consisted of the two architects involved, the site manager, the main contractor of the project and the supplier of specialized components. The subcontractor ranked as the main contributor of delays, the impact of supply of specialized equipment and components, combining the material and plant/equipment-related categories. Surprisingly, the category in which contractual agreement was in, that

of client-related was not considered by any of the interviewees the major contributor and was ranked third. Contractor-related issues and external factors were ranked fourth and fifth respectively (Table 1).

Figure 1. Percentage of significance of most important contributor to delays

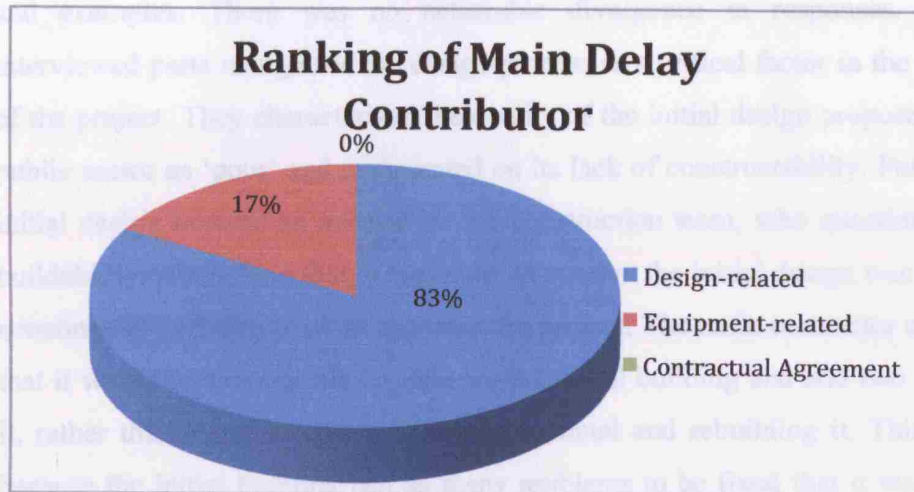


Table 1. Ranking of Significance of Factors causing Construction Delays

1. Design-related eg. Omissions and errors in design documents, unclear details and specifications in drawings, lack of buildability of design, change in initial design.
2. Material/Equipment-related eg. Shortage of supply, delays in time of delivery, inaccurate material estimation, complicated machinery/installations required.
3. Client-related eg. Inability of client to finance project, public or private, contractual agreement.
4. Contractor-related eg. Lack of skills of site management team, inadequacy of subcontractors, unrealistic contract duration, communication/management problems/
5. External Factors eg. Bad weather conditions, unforeseen ground conditions.
6. Project-related eg. Size and complexity of project, location.
7. Labour-related eg. Slow productivity, lack of skilled workers.

A.4.2 Impact of Design in Reconstruction of Airport

In this section, interviewees were, mainly, asked about the significance of the design problems in the case study, the root of these problems and specific details and examples. There was no noticeable divergence in responses. All the interviewed parts recognized the design process as a critical factor in the duration of the project. They characterized the quality of the initial design proposed by the public sector as 'poor' and commented on its lack of constructability. Parts of the initial design became an obstacle to the construction team, who questioned their buildability. Apart from that, it was pointed out that the initial design was the least economically efficient way to approach the project. The main contractor estimated that it would be more costly to preserve the initial building and add two wings to it, rather than bringing down the whole terminal and rebuilding it. This was so because the initial building had so many problems to be fixed that it would raise the budget. When asked whether the problems might have been created due to lack of construction knowledge from the behalf of the design team of the public sector, the interviewees all claimed that their knowledge was adequate, as they had undertaken such projects in the past. However, it was suggested that more time, thought and planning should have been invested in the design process. The interaction between design and construction teams, during the design process had characterized as 'average' from the two architects involved, whereas the main contractor described it as 'weak'. All participants were familiar with the concepts Design Construction Coordination and Design Change Management, however, it was claimed that it was not applied correctly in the particular project. The public sector design team did not work in cooperation with the main contractor. Instead, the design was delivered to them to be constructed and later the setbacks were identified by the construction team. If collaboration had begun at an earlier stage, this would have been avoided. It was stated that the complexity and size of the project did play a role in these problems and the aforementioned techniques would have made a great difference. When asked about the consequences of design related problems, the participants answered that they were proven to be very costly in terms both of time and money. In monetary terms it increased the budget of the project from €21m to €30m. The design documentation lacked clarity in the

specifications and a significant amount of changes were made throughout the process. For example, it was initially planned for a shelter to be constructed under the terminal for security reasons in case of attacks and crisis. However, the client decided at a later stage to move the shelter and build it under the control tower; a project undertaken by another contractor. Moreover, it took three months for the public sector to approve the revised design made by the architects of ATESE A.E.

A.4.3 Importance of Supply of Specialized Equipment and Components for Airport

This section was mainly interested in the difficulty obtaining specialized components required in such complex projects and the reasons behind any delays caused because of their supply. Furthermore, the additional aim was to assess the difference Supply Chain Management can make in the process. All participants claimed that a great amount of the time extension originated from the delay of obtaining the specialized equipment needed. The subcontractor of specialized installations placed this factor as number one contributor to the delay of the project. The reason behind this delay, was said to be the lack of availability, due to the fact that the majority of components was imported from abroad. 46 firms were involved in supplying specialized components and equipment for the airport, such as baggage conveyors, x-ray screening systems, light-emitting message signs, airport operational database, security barriers and monitoring systems and they were all supplied externally. All the interviewees agreed to the fact that construction supply chains in Greece are fragmented and these incidents are not unusual in Greek construction projects. The delay of materials and equipment of special use, in complex projects, are most common. Stock of materials arrived late on site, exceeding the delay schedule by weeks, however, when asked whether this could have been caused by inefficient transportation modes, the answer was unanimously negative. 32 subcontractors were involved in this project, however, no major disagreements took place, as the majority of them had a previous working relationship with the subcontractor. In the subject of Supply Chain Management, with which they were all familiar, interdependency was the concept mostly stressed. Croom et al. (2000), support that the most important factors influencing interdependency are the degree of power and influence of each party, the length and complexity of the chain, the legal ties involved and the technological links. Lasting working relationships, trust and efficient coordination and control were all recognized as crucial factors. Bad communication and abuse of trust were the most claimed reasons for the costly delays. Furthermore, another fact mentioned was the lack of finance from the public sector's part, which sometimes prevented the contractor from ordering stock on time.

A.4.4 Impact of Contractual Arrangements

Contractual agreement was ranked unanimously third in terms of significance in construction delays. It was claimed that the method of procurement does play a role but not as significant as the aforementioned categories. According to the information gathered from the interviews the project was procured through Design Bid and Build but due to the design difficulties, which required the drawing of an entirely new design by the construction firm involved, the contractual agreement automatically became, at a later stage, D&B. The main contractor suggested that the significance of the choice of contract depends on the context and type of the project and varies in every situation. Based on his experience, though, traditionally procured projects last more than the expected time frame. Although lump sum contracts are the ones with which contractors are more familiar and find them to be a more clear and straight-forward method, all the participants apart from the supplier of specialized components, who gave no answer, suggested that D&B method is quicker. Another comment made, was that D&B is better in terms of design quality and therefore, construction ease, since it encourages design construction coordination. The majority of constructions in Greece are traditionally procured. D&B method is more popular in residential construction. The criteria for selection of right procurement method were found to be the cost, the experience and knowledge of the participants involved and the potential of the contract. When asked in a future project of similar size and complexity, which method they would use, the main contractor answered traditional because of the familiarity of the process, and both architects chose D&B as it gives them greater flexibility and helps avoid misunderstandings. Greek firms, when engaging to public projects, are afraid of the uncertainty and the unknown behind D&B, which the reason why they choose the familiar way. The rest claimed that although the difference is not great, they would prefer D&B due to the effective and centralized responsibility which helps carry out the project in a faster pace.

A.4.5 Consequences and Effects

Regarding the consequences of the delays the participants were asked to categorize them into client-related and contractor related. The project was delayed by one year and cost €9m more than expected. The response relating the client was great loss of revenue due to loss of potential earning from the operation of the airport. Furthermore, interviewees commented on the customer dissatisfaction, due to poor customer service, as not enough capital and human resources were devoted in the operation of a part of the terminal, which functioned as a temporary solution, until the construction was finished. For the contractor, both construction and labour costs increased, since labour was being occupied and paid without producing what was supposed to be produced. The losses for the client were not recoverable, as the public sector was the one that initiated the delay by producing a poor quality design. As suggested in the data gathered, no litigations or submissions for arbitration took place.

A.4.6 Mitigation and Avoidance Strategies

Interviewees responded that the Critical Path Method was used, however, the site manager commented that it was altered so frequently, that no attention was paid to it after a certain stage. They all suggested that they should have stayed focused on revisiting the Critical Path, thus estimating time durations more accurately and having a precise time estimate. Existing literature describes bar chart methods as a strong communication tool regarding scheduling information and despite that being a difficult task, interviewees claimed that the best mitigation strategy would have been to maintain accurate schedules by quickly and regularly updating the status of the airport construction. Although management techniques were said to be of high quality, the essence for continuous improvement was recognized, especially by the main contractor, who underlined its importance. All interviewed parts agreed that methods such as, Design-Construction Coordination, Supply Chain Management and other delay analysis techniques would have been great mitigation strategies. Finally, it was collectively stated that errors and problems caused from the behalf of the public sector, could not have been controlled by ATESE A.E.

B. Theoretical Framework related to Current Findings

Based on the research findings derived from the interviews and fieldwork conducted, there was no considerable divergence in the way participants perceive construction delays and the factors to which they attribute these time overruns. A relation of the theoretical framework developed in the literature review chapter to the current findings is necessary, so as to test the hypothesis of this thesis.

Regarding delays occurring due to the design process, findings have confirmed the importance of Design Construction Coordination, as proposed by the existing literature. It has been found that problems in the case study, did actually originate from lack of integration between design and construction processes, which could have been avoided if the two teams had collaborated closely and shared their knowledge and experience. Another factor mentioned in the literature is that of lack of clarity in specifications of design documentation, which reportedly created a series of setbacks. Weak design quality and lack of buildability due to incoherencies, errors and omissions complicated the ease with which the components of the project were brought together to complete the project. An additional factor brought up by researchers, is that of lack of construction experience of the design team, which, in this project, was not a source of design related delay.

As for the supply of specialized equipment and components, the major cause was that of lack of availability, which as proposed by the literature, is common in projects of such complexity and could have been avoided by planning and managing in advance and selecting competent professionals and the appropriate sourcing strategy. Although the main contractor had worked with suppliers and subcontractors in the past, it was claimed that there was an abuse of trust due to the degree of dependency and lack of alternative sources of supply because of the specialized nature of equipment required.

The majority of the interviewed parts found no major difference between the two major procurement systems of DBB and D&B. As proposed by the existing theoretical framework, the major reason behind choosing traditional contracting is that of familiarity due to frequent use of the method. The main contractor confirmed that this arrangement is the one most known to him, however, he did recognize the positive impact of D&B in terms of design quality. Theory was verified by interviewees suggesting, based on their experience, that D&B does offer the benefits of effective and centralized responsibility.

Interviewees agreed that methods suggested as pointing strategies in the chapter of Literature Review, such as Design Construction Coordination, Supply Chain Management and Critical Path methods would have indeed improved the situation and limited the time frame of the project. Not all of the techniques proposed were applied, and those that were, were not applied at their full extent and potential.

5.0 CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUDING THOUGHTS

This study has investigated the core reasons lying behind time overruns in construction projects. The focus of the research has been placed on the importance of Design Construction Coordination and the impact of supply of specialized equipment and components in complex projects, especially under traditional contracting. In an effort to examine every possible angle and investigate all likely explanations behind the phenomenon of construction delays, a case study of the construction of a Greek airport was chosen as a sample. The fieldwork and research done on the case study helped answer the research question posed in the beginning of this thesis. Research objectives have been met, through the use of existing literature on the subject of construction delays and a series of reliable qualitative data obtained by close observation of the progress of the project and interviews with the parties involved.

The complexity of the conditions within which the clients of the construction sector are placed, makes them require the highest standards in terms of performance, cost and time required from conception of the project to occupation. Existing theoretical framework suggests that construction industry is fragmented and adversarial, which makes on time completion of projects an unattainable goal. A major contributor to this situation, which is widely recognized by experts on the subject, is that of the design process. Problems occurring during that stage have proven to be detrimental regarding the time frame of projects, something that has been confirmed by the case study as well. Concluding from the research findings, lack in integrating construction teams during the design process can lead to a series of setbacks. Designs of poor quality, characterized by lack of constructability can result in costly reworks, increased budget and exceeding the anticipated schedule. In the construction of Alexandroupoli's airport lack of Design Construction Coordination lead, necessarily, to costly design changes. The initial design proposed by the client lacked of clarity in specifications of design documentation, which came as a result of bad communication and cooperation between the design and construction specialists. This confirms the theoretical belief proposed in the literature review, that most extensive design-related delays are caused by poor quality designs with errors and omissions in the design documentation. From the data

gathered while conducting interviews, it was shown that this was not attributed to the lack of construction knowledge or competence of the design team, as suggested by existing literature. It was a result of bad-decision making and more time and effort should have been invested so as to avoid revisiting the design and recreating it.

Another issue that arose from the research was that of the criticality of obtaining the necessary specialized components and equipment needed, on time. This problem has been previously identified and investigated by researchers, who characterize the construction supply chains as 'fragmented'. Once again, fieldwork agrees with literature. The sample case study suffered extensively from lack of availability of specialized components and delays in delivery of stock, which was attributed to the complexity of the project and the amount of stock needed. Specialized materials and components were imported from abroad and lack of strong Supply Chain Management created unaffordable delays both in terms of time and money. The principle of Supply Chain Management is based on trust, which on this project was abused and the high degree of dependency of the contractor on the supplier worsened the situation. Sourcing from other alternatives was not an option due to the specialized nature of the project. These were the keys issues identified in the literature review too.

The aforementioned factors tend to worsen under traditional contract forms, as suggested by the theoretical framework. It has been proposed that although the traditional method is the most familiar method of procurement, it leads to greater time extensions. D&B is known for better design quality and performance, as well as greater speed standards, since the control and supervision of the whole process is under single responsibility. The particular project started as a traditional contract, however, due to the necessary design changes lead to a D&B contract. It is interesting, though, that reality contradicts the literature. Although the method of procurement became D&B, the project's speed was still very low, which leads to the conclusion that there is no major difference between the two contract forms. It is the context of each particular project that determines the right choice of contract and defines its time limits.

Regarding mitigation strategies, the methods proposed by the theoretical framework were not followed precisely in this project. As a result of which, coordination and management of the duration of activities got out of control. Planning was weak in this project and this cost both the client and the contractor. For the client, especially,

damages were not recoverable, as the design changes were initiated by the public sector.

B. USEFUL FUTURE LINES OF RESEARCH

Literature written on delayed projects in the Greek construction sector is most certainly limited and this thesis is an effort to provide pointers in order to avoid repeating mistakes made in the past. From the knowledge derived from the particular case study, there are some important points to be considered so as to prevent extensive delays in similar projects in the future. Significant amount of time should be devoted in planning the project and estimating its time duration. Special focus should be placed on scheduling of critical activities, so as to create room for unanticipated setbacks that may arise during the construction of the process. Construction professionals should be integrated in the design procedure and knowledge should be shared, if design errors and omissions are to be avoided. Good design quality will only be assured if Design Construction Coordination is encouraged and implemented. This will help overcome various design-related constraints that would, otherwise, lead in reworks and loss of valuable time and revenue. The principles of Supply Chain Management should be carefully followed, so as to ensure reliable, long-lasting working relationships with competent professionals, which result in on time delivery and trustworthy arrangements. Finally, the choice of procurement does, indeed, affect the smoothness of a project's flow, but not because of the characteristics of each procurement system. It is the context of the project, the client's expectations and the size and complexity of the construction to be built that determine which procurement method is more suitable.

If is the collective power of the factors mentioned in this study that will ensure an uninterrupted project with good quality in terms of both, time and performance. If everything examined and explained above is taken into account, this thesis should provide good pointers to eliminating the phenomenon of construction delays.

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APPENDICES

Covering Letter for Interview Questions

Dear Sir/Madam,

My name is Eleftheria Athanasopoulou and I am a MSc student in Construction Economics and Management at University College London. I am inviting you to participate in my research project regarding Construction Delays and more specifically, the construction of Alexandroupoli's airport in Greece.

Please find attached a series of questions, which will be part of the interview I wish to conduct. If you choose to agree to have an interview, please be assured that all the information provided will be treated with absolute confidence and used solely for the purposes of this research project.

Your contribution is significant in helping me to see a clear, true picture of the situation and reach a conclusion in my research. Your co-operation and help are greatly appreciated. This project has been approved by the Department of Construction and Project Management at University College London, UK.

If you need any clarifications or have any concerns regarding the interview questions, please do not hesitate to contact me at (+44) 777 4507 622 or email me at eleftheria_ath@hotmail.com. I am looking forward to your response and hopefully, arranging a meeting.

Yours sincerely,

Eleftheria Athanasopoulou

SECTION A: INTRODUCTION – Personal Profile

- A.1 What is your position within the company and what was your role in the project of Alexandroupoli's airport?
- A.2 Please describe briefly the activities you conducted.

SECTION B: CONSTRUCTION DELAYS

- B.1 What are, based on your experience, the most common reasons behind delays in construction projects?
- B.2 Please rate the significance of the following factor- related categories;
- B.3 What are the most common impacts on both the client and the contractor?

SECTION C: CASE STUDY. ALEXANROUPOLI'S AIRPORT. GREECE

- C.1 What were the main factors that caused the particular project to be delayed by one year?
- C.2 Can you provide me with some examples of such delays?

Design Construction Coordination

- C.3 How were these delays related to the design process and how significant was the role of design?
 - C.3.i. Would you say the initial design of the airport terminal had poor design quality?
 - C.3.ii Would you say that the design provided by the public sector suffered from lack of constructability?
 - C.3.iii Do you believe the time extensions may have been caused due to lack of construction knowledge of the design team?

- C.3.iv How would you characterise the interaction between the design and construction teams, during the design stages (pre-construction) and after construction work had started?
- C.3.v Were there any omissions, errors or lack of clarity in the specifications of the design documentation? If yes, how significantly did this affect the time frame? Please give some examples of such deficiencies.
- C.3.vi Were there any reworks because of design deficiencies during construction? If yes, please give some examples. How costly were these?
- C.3.vii Are you familiar with the concepts Design Construction Coordination and Design Change Management? If yes, to what extent, do you believe, these could have helped avoid some of the time overruns?
- C.3.viii Is there another strategy that could have prevented exceeding the expected time schedule because of design problems?
- C.3.ix What consequences did these particular design-related problems have on the project?
- C.3.x Would you say these problems could be attributed to the complexity and size of the project?
- C.3.xi Did the designers have experience on similar projects in the past?

Supply of Specialized Materials and Components and Supply Chain Management

- C.4 Do you believe these delays were critically affected by the supply of specialized materials?
- C.4.i Were the problems augmented due to lack of availability of specialized materials and components?
- C.4.ii How many firms were involved in supplying specialized components and equipment?
- C.4.iii Can you please give me some examples of the most important specialized components and equipment?

- C.4.iv Do you believe that construction supply chains are fragmented?
- C.4.v Were there any delays caused by stock of materials and components arriving on site delayed, exceeding the supplier delivery schedule?
- C.4.vi Were there any delays caused by inefficient transportation modes or forms of shipment used?
- C.4.v How many subcontractors were involved? How was the relationship between main contractor and subcontractor?
- C.4.vi Were there any design errors, incomplete designs, poor documentation, etc during installation? If yes, what were the causes?
- C.4.vii Would you say that the management and communication the subcontractors was poor?
- C.4.viii Which of the three factors mentioned below do you find to have had greater impact on the problem; power and influence of each party, length and complexity of chain and/or technological links?
- C.4.ix Is the complexity of the project a factor that contributed in the problems regarding the installation work?
- C.4.x Are you familiar with the concept of Supply Chain Management? Do you find its application useful and significant?
- C.4.xi From your experience, how else could these problems have been mitigated?
- C.4.xii What was the effect of these particular problems on the project?

Contractual Agreement

- C.5 Could the time overruns have been intrinsically generated by the chosen method of procurement? If yes, to what extent and how did this happen?
- C.5.i Could you explain the different type of procurement contracts used for different parts of the works? Why were these chosen?
- C.5.ii From your experience, do you believe that there are greater time extensions in projects traditionally contracted?

- C.5.iii Which do you find to be the advantages and disadvantages of DBB?
- C.5.iv Could these delays have been avoided if another type of contractual agreement was used?
- C.5.v Assuming a mix of DBB and DB contracts or subcontracts were used for this project, please compare two methods in terms of design quality, construction ease, time and cost overruns and performance. Give your reasons for the differences you noticed.
- C.5.vi Are there any projects in Greece that are procured by D&B or are they all traditionally procured?
- C.5.vii Are you familiar with any other forms of procurement, such as Project Management and Management Contracting? Which method do you find to be best in terms of time constraints?
- C.5.viii What do you think should be the criteria for the selection of the right procurement method?
- C.5.ix In a future project of similar scope and size, what type of procurement will you prefer?

Consequences and Effects

- C.6 What consequences did these delays have on the contractor? And how significant were they?
- C.6.i What consequences did these delays have on the client? And how significant were they?
- C.6.ii What percentage of the losses to the client was recoverable?
- C.6.iii How did the contractor and subcontractors fare in financial terms?
- C.6.iv Would you say there a lot of litigation, disputes or submissions for arbitration? What were the main issues of contention and were these in any way attributable to the DBB or DB type of contracts?

Mitigation Strategies

C.7 How could these delays have been avoided or mitigated in each situation? Please comment with respect to design construction coordination, supply of special components and equipment for airport and procurement methods.

C.7.i Are you familiar with the Critical Path Method? If yes, would you find its application valuable?

C.7.ii Do you think that continuous improvement in managerial techniques would be an effective strategy to avoid these kinds of problems?

DESIGN OF AIRPORT

Provided by ATESE A.E.

(Part1-4 from left to right)

