# The relationship of influential factors on material management effectiveness in building construction projects: Case study in Vietnam

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# ความสัมพันธ์ของปัจจัยที่มีอิทธิพลต่อประสิทธิภาพของการบริหารวัสดุในโครงการก่อสร้าง: กรณีศึกษาในประเทศเวียดนาม

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
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เบา แวน แฟม : ความสัมพันธ์ของปัจจัยที่มีอิทธิพลต่อประสิทธิภาพของการบริหารวัสดุในโครงการก่อสร้าง: กรณีศึกษาในประเทศเวียดนาม. ( The relationship of influential factors on material management effectiveness in building construction projects: Case study in Vietnam) อ.ที่ปรึกษาหลัก : ผศ.ดร.วัชระ เพียรสุภาพ

การปรับปรุงกระบวนการจัดการในการก่อสร้างเป็นหนึ่งในปัจจัยสำคัญที่จะนำไปสู่ความสำเร็จของโครงการก่อสร้าง ซึ่งควรมีการพิจารณาการจัดการวัสดุอย่างเหมาะสม แม้ว่างานวิจัยที่ผ่านมาจำนวนมากพยายามค้นหาองค์ประกอบของการจัดการวัสดุก่อสร้าง แต่ความสัมพันธ์ของปัจจัยที่มีอิทธิพลต่อประสิทธิภาพของการจัดการวัสดุยังขาดการค้นหา การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อระบุปัจจัยที่มีอิทธิพลต่อประสิทธิภาพในการจัดการวัสดุ และการพัฒนาแบบจำลองเพื่ออธิบายความสัมพันธ์ระหว่างปัจจัยเหล่านี้กับการตรวจสอบประสิทธิผลของการจัดการวัสดุก่อสร้างในโครงการจริง โดยวิธีการวิจัยได้รวบรวมความคิดเห็นของผู้รับเหมาในโครงการก่อสร้าง รวมทั้งประเมินปัจจัยและรายการของประสิทธิภาพในการจัดการวัสดุซึ่งได้รับการทบทวนและจัดเรียงเป็นกลุ่มต่าง ๆ จากบทความวารสารและเอกสารการประชุม จากการสำรวจความคิดเห็นในช่วงเดือนตุลาคมและพฤศจิกายนพ.ศ 2561 ในประเทศเวียดนามมีผู้ตอบแบบสอบถามทั้งสิ้น 223 คน แต่มีเพียง 200 แบบสอบถามที่ถูกตัดสินว่าถูกต้องสำหรับการวิเคราะห์ปัจจัยและการสร้างแบบจำลองสมการโครงสร้าง (SEM)

ผลลัพธ์ทางสถิติและการวิเคราะห์พบ 9 ปัจจัยหลักที่มีผลต่อประสิทธิภาพของการจัดการวัสดุด้วยค่าสัมประสิทธิ์มาตรฐาน ผลการศึกษานี้ทำให้เข้าใจถึงปัจจัยที่มีอิทธิพลต่อประสิทธิภาพการจัดการวัสดุก่อสร้าง โดยจะช่วยให้ผู้ที่มีส่วนเกี่ยวข้องในงานก่อสร้างหลีกเลี่ยงปัญหาที่อาจการเกิดขึ้นจริงในทางปฏิบัติ รวมถึงลดผลกระทบด้านลบที่จะส่งผลต่อประสิทธิภาพโดยรวมของโครงการก่อสร้าง ท้ายที่สุดนี้แบบจำลองเชิงปฏิบัตินี้สามารถนำมาช่วยในการประเมินประสิทธิภาพของการจัดการวัสดุสำหรับผู้รับเหมาในอนาคต



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The improvement of management processes in construction could be seen as one of the important keys to project success in which material management should be appropriately taken into consideration. Although many previous research studies have examined the components of construction material management, the relationship of factors influencing material management effectiveness has not been explored. This study was carried out to identify influential factors on material management effectiveness and develop a model to explain the relationships between these factors and the effectiveness of material management based on practical projects. The research method included the collection of contractors' opinions in building projects regarding the evaluation of factors and items in material management effectiveness, which have been reviewed and sorted into different groups from journal articles and conference papers. The survey questionnaire was gathered within two months during October and November 2018 in Vietnam. Lastly, 223 respondents were gathered in which only 200 samples were judged as valid for factor analysis and structural equation modeling (SEM).

The statistical results from confirmatory factor analysis presented nine major groups of factors affecting the effectiveness of material management with their standardized coefficients. The findings of this study enable a greater understanding of influential factors on material management effectiveness in particular, hence it will help construction players to avoid their occurrence in real practice as well as minimize their negative impacts on the overall performance of construction projects in general. On the other hand, the constitution of this practical model could be used for evaluating the effectiveness of material management for contractors in the future.



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|---|---|
| CT1 | Material price stipulation |
| CT2 | Payment and inspection conditions |
| CT3 | Adjustment of material specification during construction |
| IE1 | Material status as arriving to the site |
| IE2 | Label, source, quality certification of material |
| IE3 | Availability of material in market |
| IE4 | Adjustment about material demand |
| IE5 | Adjustment about material price |
| PI1 | Material budget management |
| PI10 | Co-ordination in construction sites |
| PI11 | Experience and qualification of staff |
| PI12 | Timing in decision making |
| PI2 | Material quantity takeoff |
| PI3 | Awareness of material types |
| PI4 | Material supervision and control capacity |
| PI5 | Progress of material procurement |
| PI6 | Progress in forwarding information on sizes of materials to be used |
| PI7 | Paperwork preparation for material requisition |
| PI8 | Documentation storage and organization |
| PI9 | Co-ordination between main office and site office |
| PL1 | Construction schedule |
| PL2 | Material supply plan |
| PL3 | Material protection during construction |
| PL4 | Material handling on site |
| PL5 | Equipment selection for unloading |
| PL6 | Readiness of design documents |
| QC1 | Certificate of material origin and quality (CO/CQ) |
| QC2 | Regulations about material procurement |
| QC3 | Regulations about material using and installation |
| SE1 | Contract with security company |
| SE2 | Site security system |
| SI1 | Storage location for transportation, loading/unloading |
| SI2 | Area for material storage space |
| SI3 | Material receiving and placement condition on site |
| SI4 | Checking, reception of material quality on site |
| SI5 | Checking, reception of material quantity on site |
| SI6 | Weather conditions |
| SU1 | Supplier/manufacturer selection |
| SU2 | Delivery plan/schedule of manufacturer |
| SU3 | Product quality of manufacturer |

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| TR1 | Delivery of materials to site and install on site |
| TR2 | Delivery date estimation |
| CT | Contractual issues |
| IE | Industrial environments |
| PI | Procurement issues |
| PL | Planning and handling on site |
| QC | Quality control |
| SE | Security on site |
| SI | Site conditions |
| SU | Suppliers and manufacturers' issues |
| TR | Transportation in and out site |
| T1 | Material supply plan |
| T2 | Contract signing plan for material procurement |
| T3 | Material receiving plan |
| T4 | Material payment plan |
| T5 | Material installation plan |
| T6 | Material inspection and handover plan |
| C7 | Material unit price comparing to budget |
| C8 | Construction material quantity comparing to loss ratio of project |
| C9 | Commitment contract to keep material price according to construction progress |
| C10 | Cost control system of material management process |
| Q11 | Inspection of material specifications compliant to the quality and standard of project |
| Q12 | Evaluation and control system of material quality from procurement till using |
| S13 | Transportation, loading/unloading of material comply with safety and health regulations |
| S14 | Security on site related to material storage |
| S15 | Work safety procedures regarding material installation |

# Chapter 1
# Introduction of Research

## 1.1 Significance of research

In recent years, the Vietnamese construction industry in general and building construction projects in particular have been increasingly developed. Both local and foreign construction companies have always found the solution to advance their working performance to compete in the market. Owing to economic recovery, coupled with government investment in infrastructure and residential construction, and the increased issuance of building permits; the Vietnamese construction industry has achieved the highest revenue in the past 10 years with continuous increase in sales from US $1.2 billion in 2007 to US $12.8 billion in 2017 (FDI news, 2018). It is expected to expand over the next few years, according to experts and businesses. That is to say, some projects in Vietnam could have a partial impact on the growth rate of construction sector.

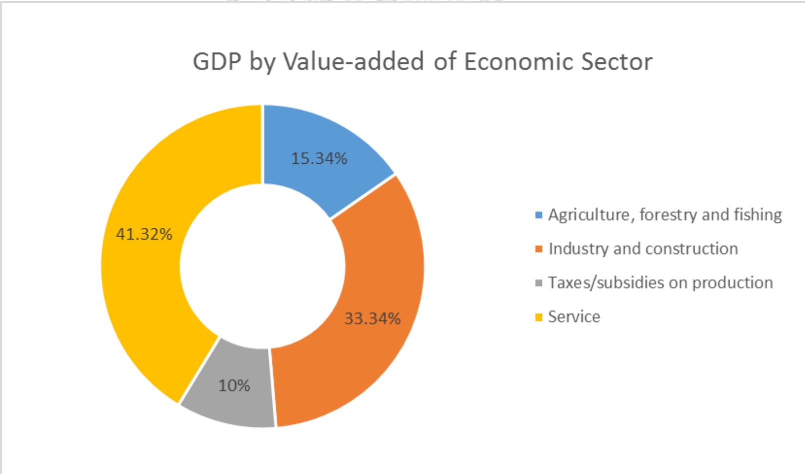


**Figure 1.1** Vietnam's economic structure 2017

*Source:* Online Newspaper of the Government (VGP News, 2017)

The management of construction projects could be seen as the essential element to ensure the project success. A construction project depends upon having the right people with right skills and equipment that are able to deliver the project on time and on budget. Having the right materials in the right place at the right time is equally important, and having the cash flow and capital to procure the labour and materials is also important. In other words, some main management processes included in any construction projects are related to labour, material, equipment and cost. It is noteworthy that the materials on a project can represent anything from 30% to 70% of the project cost (Patel and Vyas, 2011) and have been identified as one of the more prominent areas where significant improvements and savings can be made (Vorster and Lucko, 2002); however, material management has received less attention from researchers (Donyavi and Flanagan, 2009). Hence, the improvement of management processes is one of the important keys to success of construction projects in which the material management should be appropriately taken into consideration.

The term of material management has been designed by previous researches that refer to many procedures. For instance, Donyavi and Flanagan (2009) divided material management into five categories namely, measurement and specification; procurement and purchasing process where the order is transmitted to the supplier; delivery to site and logistics of checking the order, offloading, and storing on site; administrative and financial process of payment; using the materials in production on the job site and removing the waste. In addition, Kanimozhi and Latha (2014) defined material management as a process for planning, executing and controlling field and office activities in construction. Zeb et al. (2015) also defined management as a procedure for executing, planning, and controlling site activities in the construction project(s). Consequently, material management in this research is basically characterized as a process including planning, procurement, transportation, storing and material installation.

The material management could affect construction project performance in some aspects, such as quality, schedule and cost. The availability and quality of materials delivered to site are identified as one of the most critical factors that have an impact on quality in building construction projects (Oyedele et al., 2015). Besides, Durdyev et al. (2017) revealed that the shortage of materials on site and late delivery of material which are main causes of project delays should be reduced. In addition, other studies again indicated shortage of materials or unavailable materials when needed is among the most significant factors contributing to delays of construction projects (Rivas et al., 2010; Doloi et al., 2012; Safa et al., 2014). Moreover, lack of material management or poor material management can also result in large and avoidable costs during construction. For example, if materials are purchased early; capital may be tied up and interest charges incurred on the excess inventory of materials, materials may even deteriorate during storage or be stolen unless special care is taken (Formoso et al., 2002). Also, delays and extra expenses may be incurred if materials required for particular activities are not available (Rahman et al., 2017). Thus, the management of construction material to ensure a timely flow is a substantial concern of project managers to make the project management become successful although the components in this process are quite complicated.

In summary, material management is recognized as extremely crucial to project performance; in other words, ineffective material management could affect schedule, cost, quality and safety of entire construction projects. Additionally, many researches have been carried out to explore the methods for increasing the efficiency of material management in construction site. However, there are still many issues occuring everyday in every country regarding material management, it means that the future study of material management is still needed. Therefore, it is important and urgent to improve the effectiveness of material management as well as mitigate its negative impacts on construction sites in case projects are not well-managed. Furthermore, investigation into problems in practice should be done in order to help the project managers completely understand how their current work situation is and where to be improved or enhanced in the process of material management as well as projects.

### 1.2 Research problems

In the past, the issue of project performance and material management in construction have been discussed by previous authors. They are possibly categorized into applied, descriptive or quantitative researches. Each of these research types has its own strengths as well as limitations and all aim to get expected outcomes.

Firstly, with reference to other studies, the issue of project performance – a primary concern in construction projects, has been reviewed to seek for approaches to minimize. To be more precise, using a large number of performance indicators related to various dimensions (groups) such as time, cost, quality, client satisfaction, client changes, business performance, health and safety that could be used to measure and evaluate project performance as well as project success (Cheung et al., 2004). However, time, cost and quality are the 3 predominant dimensions for performance evaluation. Besides, Pheng and Chuan (2006) proposed another interesting way of evaluating project performance through 2 common sets of indicators. The first set includes the owner, users, stakeholders, and the general public who will look at project performance from the macro viewpoint. The other will look at project performance from the micro viewpoint that comprises the developer and the contractor.



It is obvious that performance dimensions could have one or more indicators, and could be influenced by different characteristics. For example, the appropriateness of project time management can be seen as a relevant indicator that could be used to assess contractors' effectiveness and capability to succeed on the completion of a project as well as to evaluate contractors' performance (Solis et al., 2009). According to Long et al. (2007), poor site management and supervision, poor project management assistance, financial difficulties of owner, financial difficulties of contractor and design changes are found as major causes of delay and cost overruns in Vietnam large construction projects. In addition, Dissanayaka and Kumaraswamy (1999) concluded that project time and cost performances get influenced by project characteristics, procurement system, project team performance, client representation's characteristics, contractor characteristics, design team characteristics, and external conditions. More interestingly, Love et al. (2005) examined project time-cost performance relationship, and their results indicated that cost is a poor predictor of time performance. On the other hand, Iyer and Jha (2005) identified critical success factors on project quality performance including project manager's competence; top management's support; monitoring and feedback by project participants; interaction among project participants; and owners' competence. Durdyev et al. (2017) found five key factors affecting construction safety performance in developing countries; namely, management and organisation, resources, site management, cosmetic and workforce. Moreover, a performance evaluation model for construction companies was also introduced in order to provide a proper tool for the company's owners, shareholders and funding agencies to evaluate the performance of construction companies in Egypt (Elyamany et al., 2007). In general, the above examples demonstrate that there is a comprehensive list of factors with the potential to affect the different dimensions of project performance among different countries.

Secondly, there have also been some studies accomplished to figure out some problems associated with material management process in construction projects. In particular, the most severe problem militating against material management on building projects in Ondo-State, Nigeria was lack of proper work planning and scheduling while other problems included inadequate cash flow to contractors due to delayed payments, burglary, theft and vandalism (Arijeloye and Akinradewo, 2016). Besides, Donyavi and Flanagan (2009) observed that common problems associated with material management on construction site included failure to order on time, delivery at the wrong time, over ordering, wrong materials or errors in direction of materials, theft and double handling of materials. In addition, general problems arising in material management of Maldives construction industry were unavailability of local construction materials, few suppliers in market and lack of storage space (Zaha, 2017). Generally, problems found in the process of material management become popular and again different among the countries owing to the distinct characteristics of each construction industry.



Moreover, in technical perspective, a number of other researches that tried to establish or propose methods to improve some specific stages in the process of material management. Beginning with material procurement, Hadikusumo et al. (2005) developed a decentralized database system equipped with electronic agents to assist human purchasers to carry out solicitation in identifying suppliers, searching materials, and preparing purchase orders. The material procurement for short-term project dynamic schedule was paid more attention to the e-commerce environment, which is used to support lean material delivery for lean construction, and an agent-based multi-issue automated negotiation framework was also given to improve negotiation efficiency and effectiveness, where a contractor negotiates with many suppliers individually in a bilateral fashion (Zhong et al., 2007). Based on the idea of lean construction, Sun and Zhang (2013) analyzed the advantages of construction procurement outsourcing, categorized the items to be procured, elaborated on the items suitable for procurement outsourcing and proposed the operation mode for the cooperation between customer and supplier. With regard to material logistics, Mao and Cheng (2010) proposed a shipment tracking-based approach based on lean construction to provide inventory transparency and a pro-active delivery approach for efficient material deliveries. Besides, a new lean model for construction on-site material logistics is proposed by Seppanen and Peltokorpi (2016): from local optimization of logistics towards global optimization of on-site production system, which is valuable for academics with research interests in construction logistics or productivity areas and for practitioners seeking productivity improvements. Yu et al. (2016) presented the development of a BIM-based dynamic model for site material supply management that is capable of identifying optimal dynamic scheme for the solution of problems – what (material), how many, when, and where. In addition, a structural equation model was used to identify best practice relating to the effective material logistics in an urban, confined construction site (Spillane and Oyedele, 2017). On the whole, the majority of these research works seem to concentrate on a typical phase of material management to suggest techniques for solving the problems that are being independently encountered. Meanwhile, the process of material management includes various elements, so its improvement should start from being thoroughly familiar with the theory of the most common influential issues.

To summarise, many past studies have tried to search for factors affecting project performance while others have attempted to find out problems that possibly occur in material management or develop approaches that can improve some typical stages in the process of material management, such as procurement and logistics. From that point, it can be concluded that the output of that research works is still quite general and distinct. Additionally, the factors affecting the material management are mostly determined in a discrete way with different results from previous research works, but still have been lacking of detailed discussion about assessing how the extent of their influence on the effectiveness of material management is in real projects. A study of Jusoh and Kasim (2017) further indicated that material management could affect five criteria of project performance namely; time, cost, quality, productivity and waste. Thus, the issue of synthesizing and verifying the relationship of these influential factors has become more important than ever, especially in the construction environment which exists many challenges and potential risks as in Vietnam. Moreover, it has been so hard to find any studies that use the SEM technique to explain the relationship between these factors and material management effectiveness most comprehensively although this application has been proven to be quite successful in elucidating research issues of such similar nature.

Based on the above discussion, adequate consideration about material management effectiveness must be given to Vietnamese construction projects so that some proposed solutions for situations arising could be appropriately applied then. In order to gain a greater understanding of this issue, it is definitely essential to search for details or a development model of influential factors on material management effectiveness. Referring to that proposed analysis model, managers are able to know the main groups of factors along with their significance level on different dimensions of material management effectiveness, from which priorities for activities in their plan have to be examined to suitably adjust. Accordingly, the question now arises as to what factors and how they affect material management effectiveness of construction projects in Vietnam.

## 1.3 Research objectives

From the above research problems, following research objectives will be then addressed:

Identify factors affecting material management effectiveness in construction projects.

Establish a model for explaining the relationship between these factors and material management effectiveness in construction projects.

## 1.4 Scope of research

The research will be implemented in the construction phase of building projects in Ho Chi Minh City, Vietnam.

The target participants who involved in this survey research used to have working experience relating to material management process.

The material management process has the main life cycle from planning, procurement, transportation, stock control and material installation.

## 1.5 Research methodology

The research approach involving the quantitative and qualitative methodology will be adopted in this research. This research has the advantage of obtaining a stronger research design and achieving more valid and reliable findings. As such, a questionnaire survey and literature reviews will be the methodologies conducted to meet the objectives of the research. Accordingly, it is believed that a deeper and more detailed quality of information can be obtained with interviews opted as the methodology instrument whereas questionnaire survey can cover a broad range of the study in fulfilling other objectives.

## 1.6 Research output

Critical factors affecting material management effectiveness of building construction projects in Vietnam.

# Chapter 2

# Literature Review

This chapter aims to provide a comprehensive literature review and relevant theories of some important studies that have conducted on material management process and effectiveness measurement in construction field. First of all, it describes the definition of material management and the process of material management. Next, it gives a current overview of management practice in Vietnam and the influence of material management on project performance. After that, consideration about factors affecting material management effectiveness in construction projects is also implemented and some previous researches related to effectiveness measurement are then discussed. The last section will present a framework for this research.

## 2.1 Material management process

This section defines material management and reviews material management process in construction projects.

### 2.1.1 Definition of material management

There are different definitions that are provided by different researchers for material management throughout the years. According to Bell and Stukhart (1986), material management is considered as activities that include *"material requirement planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory, and material distribution"*. Pellicer et al. (2013) stated that material management involves storage, identification, retrieval, transport and construction methods. Bailey and Farmer (2009) define material management as a concept concerned with the management of materials until the materials have been used and converted into the final product; and activities include cooperation with designers, purchasing, receiving, storage, quality control, inventory control, and material control. Besides, material management is also defined as a process to ensure the right quality and quantity of materials and installed equipment are appropriately specified in a timely manner, obtained at reasonable cost and are available when needed (Donyavi and Flanagan, 2009).

Basically, material management is concerned with the planning, identification, procuring, storage, receiving and distribution of materials. The purpose of material management is to assure that the right materials are in the right place, in the right quantities when needed. The responsibility of one department (i.e. material management department) for the flow of materials from the time the materials are ordered, received, and stored until they are used is the basis of material management.

### 2.1.2 Material management in construction projects

Material management becomes one of critical concerns due to the nature of construction projects. Clough et al. (2000) indicated that construction is the process of physically erecting the project and putting construction equipment, materials, supplies, supervision, and management necessary to accomplish the work. Also, it is obvious to say that construction projects are quite complex with many organisations involved, such as clients or owners, architects, engineers, contractors, suppliers and vendors. Material management is especially problematic for large and complicated projects where sophisticated tools and techniques are necessary to ensure materials are delivered on time, stock levels are well-managed, the construction schedule is not compromised and the wastage is minimised (Narimah, 2008). It can be concluded the management of materials in construction projects needs adequate consideration owing to the various elements involved and the significant contribution to the success of projects.

Material management is an important function from the design stage to the construction stage of projects as poor management of construction materials can have a major effect on the overall performance of construction projects in terms of time, budget (cost), quality and productivity. The result of inappropriate managing materials on site during construction process will influence the total project cost, time and quality (Che Wan Putra et al.,1999). Dey (2000) stated delays in material supply have been found to be a major cause of time overrun. The improper management of materials in construction sites has the potential to severely hamper project performance, in other words, it is regarded as one of the key reasons for project delays (Ogunlana et al., 1996). In addition, Dey (2001) indicated that almost 60% of the total working capital of any industrial organisation consists of material costs. The wastage of materials also should be minimized during construction in order to avoid loss of profit for construction companies (Kasim et al., 2005). John and Itodo (2013) observed that the relevance of material management to the total production operation cannot be overestimated; material management activities actually start before the production begins by providing optimum materials required for production and its supply at the various production stages. Therefore, an effective material management is required in order to avoid unexpected problems in construction projects. To be more precise, some issues which contribute to poor material management in construction projects will be discussed in the following sections.

### 2.1.3 The process of material management

The components associated with the process of material management have been proposed by some former authors. Each study has shown different perspectives in material management. According to Patil and Pataskar (2013), for example, material management comprises a series of processes that need to be integrated, coordinated and synchronized well to ensure that the materials are available at the time they want. It begins with the need generated from site, then this information will be conveyed to the store department to establish an order and the indent is created later. The next step is vender selection carried out for choosing the best items from the approved list. Materials are lastly inspected and received at the store department. This process can be described by the flow chart below:

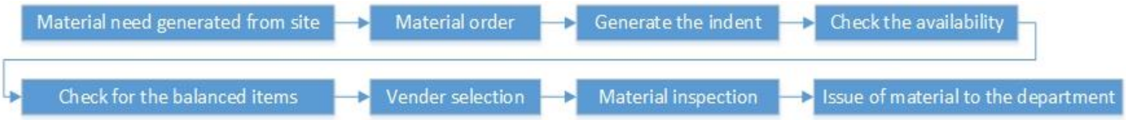


**Figure 2.1** Material management process (Patil and Pataskar, 2013)

Daniel and Ronald (1998) stated the material life cycle is depicted with four main phases including order, approval process, fabrication and delivery process and installation process. Material management practice in building projects is categorized into five stages, including planning, purchasing, transportation, handling and waste control (Gulghane and Khandve, 2015). By synthesizing from some prior researches, material management process generally involves the planning, testing, procurement, logistics, handling and stock control surrounding materials in construction projects. A good material management environment enables proper material handling in construction sites. To be more specific, each of stage in material management process will be discussed below.


**Figure 2.2** Vietnam's general steps in material management process

**2.1.3.1 Planning**

Construction companies may consist of two major levels in planning that are micro and macro level. Time, cost, material and labor are four major types of planning undertaken on sites. The planning should be revised as frequently as possible in order to monitor whether the work is on progress. During the time for price planning, detailing the project in terms of its outcome, team members' responsibilities, schedules, resources, scope and costs is needed. At the end of this phase, a project management plan is produced as a document that details how your project will be executed, monitored and closed.

In case of materials, there is a need for an appropriate planning, which must be done concurrently with engineering, construction, and other project plans. Material planning is known as an initial step that needs to be carried out accurately so as to provide guides for all the subsequent activities and possibly have a great impact on the project plan. According to Gulghane and Khandve (2015), material planning includes quantifying, ordering and scheduling. The material planning process covers the set up and maintenance of records, determines the target inventory levels and delivery frequency. Adopting a good material management plan can increase the productivity and profit of the company, and facilitate the timely completion of construction projects. Hence, it can give a better service and increase the success of project delivery (Kasim, et al., 2005).

**2.1.3.2 Testing**

Quality is a main factor to measure the performance of a project. Quality assurance of building materials is vital in order to create strong durable and cost-effective structures (Savitha, n.d.). Each construction project has a different set of specifications and requirements. The contractors are required to select and procure suitable construction materials so that they can meet the contract specification. Unless a specific brand and model number is stated, it is advisable to conduct thorough study and analysis of the different material properties to check for its compatibility in different zones of the building. The materials are only ordered after receiving an approval (Low and Ong, 2014). The proper assessment of various materials is so important to ensure the quality and durability of the final product.

**2.1.3.3 Procurement**

The procurement function is so critical to material management. Activities included in the procurement process range from purchasing of equipment, materials, labour and services required for construction and implementation of a project (Kasim, et al., 2005). Procurement is not only about appointing contractors and preparing contract but is also a remarkable starting point in the process of delivery (Mead and Gruneberg, 2013). Another author has defined procurement as identifying and analysing user requirements and type of purchase, selecting suppliers, negotiating contracts, acting as a liaison between the supplier and the user, and evaluating and forging strategic alliances with suppliers.



Purchasing materials from the best source, at the right price and with timely delivery are challenges of many construction companies. Therefore, a control strategy is needed during material procurement to achieve the targeted objectives. All requests for quotations and purchases must be initiated through a properly authorised requisitioning procedure normally controlled by a project manager to ensure that the purchasing of materials follows the standard requirement, time and quality. Many authors have suggested that choosing the best option of procurement can help to reduce the impact of uncertainties such as late deliveries, substandard raw material qualities, resource constraints and so on (Morris and Pinto, 2007). They also mention that for many organizations, materials and components purchased from outside vendors represent a substantial portion of the cost of the end product, and hence effective procurement can significantly enhance the competitive advantage of a project. To successfully deliver a project, it is not about adopting a procurement system with the best practice tactic to fix all problems, but to embrace an approach that has the best-fit tactic that gets the job done most efficiently (Keith, et al., 2016).

### 2.1.3.4 Logistics

Logistic is defined as a concept that includes movement and encompasses planning, implementing and controlling the flow and storage of all goods from raw materials to the finished product to meet customer requirements (Kasim, et al., 2005). Good logistics involved the use of a minimum of materials on site awaiting assembly, as well as being good for cash flow, this makes it easier to keep the site clean and tidy and reduces opportunities for slips trips and falls, an effective logistics team will also pay attention to the maintenance of plant and equipment. The primary focus of the logistics concept in construction projects is to improve coordination and communication between project participants during the design and construction phases, particularly in the material flow control process (Agapiou et al., 1998).

The routing of materials is one of the main causes which affect cost and time during construction project. For smoothly handling the materials, space needs to be carefully allocated for material handling equipment, access roads, warehouses, workshop, and lay down materials in construction site (Pellicer, et al., 2013). Planning these tasks precisely can help to formulate an efficient construction site layout that can provide an easy access and routing of materials within the construction site. Besides, the wall or fence setup can be also considered as a requirement for the construction site to control access and increase the security of the site. Optimum forecasting for material movement (Mahdjoubi and Yang, 2001) and planning of access and routing of materials within construction site (Olusegun et al., 1998) are factors that need to be taken consideration during the logistics process for effective material management.



### 2.1.3.5 Handling

Various materials have different features and properties which makes the handling of materials critical. Effective material handling involves handling, storing and controlling of construction material (Kasim, et al., 2005). Therefore, materials handling provides movement to ensure that materials are located and that a systematic approach is required in designing the system. Handling of materials is the flow component that provides for their movement and placement. The importance of appropriate handling of materials is highlighted by the fact that they are expensive and related to critical decisions. Due to the frequency of handling materials, there are quality considerations when designing a material handling system. Chan (2002) asserts that the selection of material handling equipment is an important function since it can enhance the production process, provide effective utilization of manpower, increase production and improve system flexibility.

**2.1.3.6 Stock control**

The European Construction Institute's Total Productivity Management report (ECI, 1994) states that "materials delivery to site is a critical, productivity-related aspect which demands the introduction of a carefully developed system of monitoring and control as early as possible". It is of great importance that the bulk of construction materials delivery requires proper management of stock control. Stock control is classified as a technique devised to cover and ensure all items are available when required. Stock control can include raw materials, processed materials, and components for assembly, consumable stores, general stores, maintenance materials and spares, work in progress and finished products (Prabu and Baker, 1986).

Proper protection during storage is often ignored which possibly results in poor material quality or even material deterioration. Moreover, the storage area needs to be enclosed, clean and dry with good air circulation and some kinds of materials need to be stacked on pallets, not exceed a certain safe height to prevent dampness and so on (Low and Ong, 2014). By adopting proper material storage, it will help to keep the material intact and in good quality. And the loss of profit, therefore, will be reduced due to theft, damage and wastage as well as running out of stock (Kasim, et al., 2005). As a result, the requirements of storing space should be taken into consideration from the initial stage of the construction process.

However, in order to gain an easy understanding, material management of construction projects in this study will consist of integrated processes and functions that are project planning, procurement, transportation, stock control and installation.


**Figure 2.3** Main processes in material management (Daniel and Ronald, 1998)

**2.2 Current practice of material management in Vietnam**

Vietnam is gradually integrating into the international market in many aspects; therefore, in terms of material management in particular, the local contractors are trying to find development strategies applied to compete with foreign contractors. According to Luan and Van (2011), some unique characteristics of the construction industry which can affect the management of materials can be described such as: (1) the work is mostly performed outdoor and strongly influenced by weather and other natural factors; (2) the numerous transportation (including material and semi-finished products); (3) most of the construction enterprises are small and medium; (4) construction products are diverse and complex, but normally single units; (5) the most influential and consequential factor from other characteristics is the inequality of inputs (manpower, material, equipment) while it needs more labors, expensive equipment, which constitutes hard and challenging problems.

In this study, a pilot company will be investigated to understand the process of material management in construction. For the sake of some specific characteristics compared to other forms of manufacturing industry, the management of materials on site in Vietnam is also quite distinct. The material sources of company may be provided by suppliers, manufacturers or domestic and foreign partners. Materials in the construction company are provided with the norms of each item of small or large projects. Besides, the construction company has to manage a variety of materials such as concrete, brick, sand, stone, cement, iron, steel, tole, formwork, purlins, etc. The basic activities of the material management include putting materials in the warehouse, supplying materials for the items in the norm sheet, reporting the amount of output and inventory monthly. Moreover, the management of materials in the construction company is a clear hierarchy, in which the material management department has a responsibility for the material import and export involving domestic material, foreign material, procurement and storekeeper. The structure of this department is figured as follows:

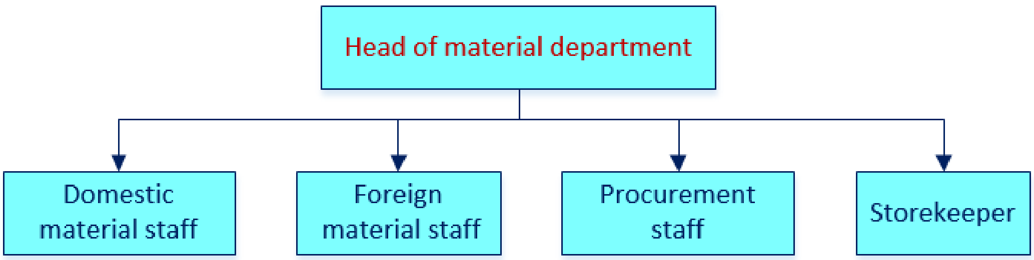


**Figure 2.4** The structure of material management department (Luan and Van, 2011)

The fundamental function of the material department is to ensure the timely material supply with competitive prices and appropriate quality, specifically as:

- Strategy and planning administration;
- Tender;
- Supplying materials, equipment and services;
- Project management and implementation;
- Risk management;
- Accountant;
- Human resource management;
- Administrative services;
- Management of internal information and media systems;
- Legislation;
- Quality management;

The loss of materials and the person for who is responsible can be easily detected thanks to the obvious assignment. In addition, the material carried in the construction site must abide by some elementary processes that the company has set to make sure that materials are provided on schedule, meet the requirements without deficiency and supplies from the owner are properly controlled at that time. However, some problems found from that management system resulting in delays on construction projects are naturally unavoidable and still going on. To better understand, the procedures most of the major contractors in Vietnam are currently using for the material management on the site are likely depicted below.

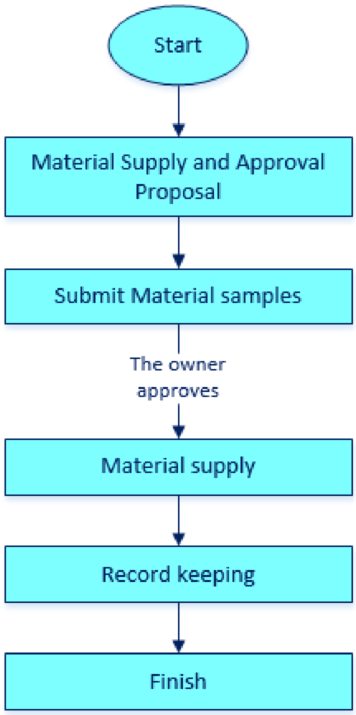


**Figure 2.5** General flowchart for material management process

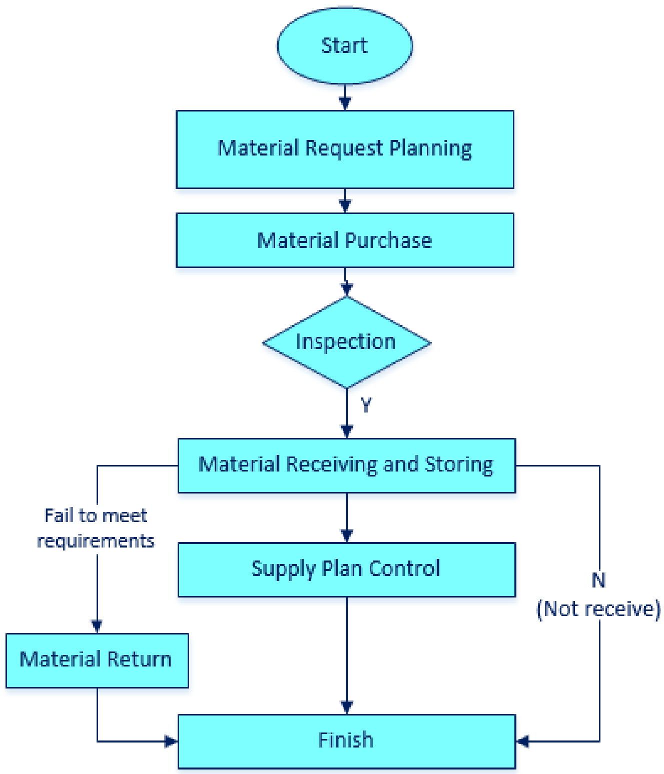


**Figure 2.6** Flowchart for material supply

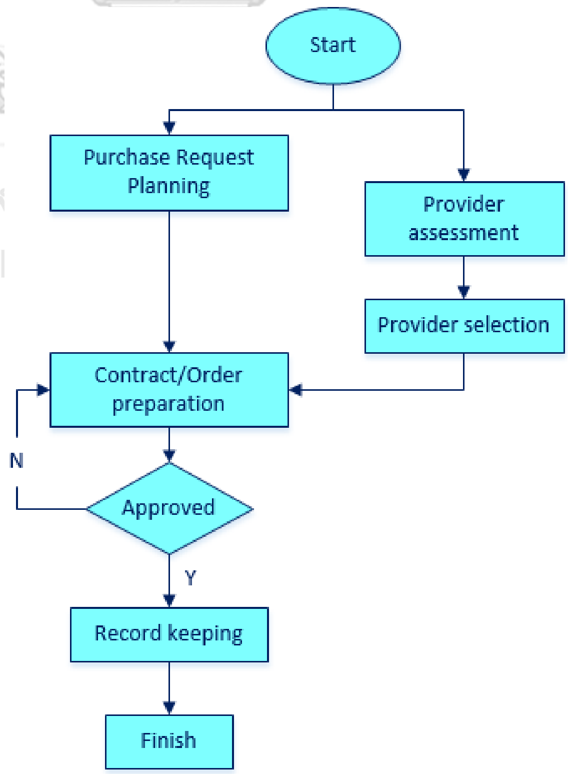


**Figure 2.7** Flowchart for material purchasing

## 2.3 Material management affecting project performance

As many previous papers mentioned, ineffective material management could be seen as one of the key causes that result in negative effects on project performance such as time, cost, quality or safety.

Ameh and Osegbo (2011) recommended proper management of material resources could guarantee to save projects from time overrun. Gulghane and Khandve (2015) stated that one of the major problems in delaying construction projects is poor material management. The management of procuring materials is critical as any material surpluses or shortages will delay the project and put it at risk. Similarly, a review of construction materials management on major capital projects demonstrates that the absence of materials on-site is one of the most commonly experienced causes of delays (Safa et al., 2014; Enshassi et al., 2009).

Applying the right material handling methodology in construction projects would result in real savings in the project time and cost (Alanjari et al., 2014; Ren et al., 2011). Project activities are usually interrelated, shortage of material availability for a particular activity could affect other project activities, for example, cost overrun and time delays are recognized as a result of material shortages (Hughes and Thorpe, 2014). In like manner, ineffective material management could influence completion time and cost of construction projects (Patil and Pataskar, 2013; Meng, 2012; Sardroud, 2012; Thomas et al., 2005).

Next, the overall schedule, cost and quality of construction projects could be impacted by late material deliverables (Barry et al., 2014); reliable and precise materials-locating process (Kasim and Ern, 2010; Caldas et al., 2014). Besides, Rustom and Amer (2003) identified availability of construction materials is one of the most significant factors affecting quality in building construction projects in Gaza strip. In addition, Kumar et al. (2015) also asserted that the major cause of accidents at construction sites is in terms of material handling equipment. Lack of protection in material transportation could have an effect on construction safety performance according to Durdyev et al. (2017).

## 2.4 Factors affecting material management effectiveness

In order to improve the performance of construction projects, it is necessary to identify the factors influencing material management effectiveness. There is no doubt that several former authors have identified the effect factors under numerous topics. There are many problems that contribute to poor material management in construction projects, for example, a study carried out by Dey (2001) emphasized that the common issues regarding material management are as follows:

- Receiving materials before they are required which may increase inventory cost and may increase the chance of deterioration in quality;
- Not receiving materials during the time of requirement causing to decrease motivation as well as productivity;

- Incorrect materials take-off from design and drawing documents;
- Constant design changes;
- Theft or loss of item;
- Choice of type of contract for specific material procurement;
- Vendor evaluation criteria;
- Piling up of inventory and controlling of the same; and
- Management of surplus material.

Besides, Donyavi and Flanagan (2009) stated the common issues in material management are as follows:

- Failure to order on time which may cause delay in the projects;
- Delivery at the wrong time which may interrupt the work schedule;
- Over ordering;
- Wrong materials or wrong in direction of materials requiring re-work;
- Theft of materials from delivery into production;
- Double handling of materials because of inadequate material.

A study done in Australia by Hughes and Thorpe (2014) revealed factors that contributed to lack of materials were shortage of funds, inadequate planning, excessive paperwork, improper material usage with respect to specifications, fluctuation in material availability, waste due to negligence/sabotage, improper materials storage, poor delivery of materials to site, on-site transportation difficulties, and material handling on site. Similarly, the factors associated with adverse material management conditions in Turkey were fluctuations in material prices, extensive multiple-handling of materials, improperly sorted or marked materials which made them difficult to define, wrong/damaged materials from the specification, poor quality because of production errors, unsystematic flow of materials, improper material planning and usage, design change leaving management with little time to order the necessary materials, on-site transportation and congested site (Kazaz et al., 2008).

Overall, to specifically understand the popular factors relating to the effectiveness of material management process, the important data (influential factors) were summarized from previous studies and shown in the **Table 2.1** below. All the factors must relate to the process and function of material management, i.e. planning, procurement, transportation, stock and installation.

**Table 2.1** Factors affecting material management effectiveness

| Label | Factors | References |
|---|---|---|
| 1 | Budget management | [1][2][50][72][123] |
| 2 | Material quantity takeoff | [89][122] |
| 3 | The adequacy of material planning | [38][50][55][57][73][83][88][89][109][123][136] |
| 4 | Manufacturing status | [1][11][84] |
| 5 | Availability of competent suppliers | [84] |
| 6 | Loss prevention of material | [10][50][57][73][79][82][89][93] |
| 7 | Awareness of material types | [38][50][57][79][83][88][89][136] |
| 8 | Supervision capacity | [89] |
| 9 | Quality of material | [40][57][79][83][84][98][109][128] |
| 10 | Material status during transportation | [11][38][88] |
| 11 | Protection during unloading | [89][128] |
| 12 | Area of material storage | [35][38][40][50][52][55][79][82][83][86][88][93][123][136] |
| 13 | Suitability of site storage | [82][89][122][128] |
| 14 | Storing methods | [89] |
| 15 | The adequacy of material specification | [2] |
| 16 | Weather conditions | [10][50][73][79][89][93] |
| 17 | Checking the accuracy of order | [38][79][82][88][89][122] |
| 18 | Progress of material procurement | [11][33][82][109] |
| 19 | Progress in forwarding information of materials to be used | [88][89] |
| 20 | Availability of material in market | [11][40][50][52] |
| 21 | Paperwork preparation for material requisition | [50][55][105][136] |
| 22 | Experience and qualification of staff | [1][72][73][123] |
| 23 | Documentation preparation | [2][73] |

**Table 2.1** Factors affecting material management effectiveness (Cont.)

| Label | Factors | References |
|---|---|---|
| 24 | Material labelling | [57] |
| 25 | Demand fluctuation | [2][73] |
| 26 | Changes of material specification during construction | [11][35][37] |
| 27 | Effectiveness in delivery of materials to site | [2][50][52][73][79][82][98][105] |
| 28 | Distance between working area and material storage | [89] |
| 29 | Attitude of suppliers | [40][79][89] |
| 30 | Custom clearance for imported materials | [73] |
| 31 | Communication between main office and site office | [73][82][86] |
| 32 | Co-ordination between main office and site office | [72][82][86][128] |
| 33 | Communication in construction sites | [82][123] |
| 34 | Control of material usage | [89] |
| 35 | Material price fluctuation | [35][52][57][79][83][109] |
| 36 | On-site transportation conditions | [50][55][57][82][89][105][136] |
| 37 | Material handling on-site | [40][50][57][79][82][89][93][122][128][136] |
| 38 | Equipment consideration for unloading | [2][79][89][128] |
| 39 | Regulations and procedure in procurement of materials | [136] |
| 40 | Timing in decision making | [2][52][82][98] |
| 41 | Design documents readiness | [55][57][89] |
| 42 | Delivery date estimation | [10][73][79][82][89][93] |

## 2.5 The issue of effectiveness measurement in construction sector

According to Rose (1995), performance measurement is defined as a process of evaluating performance relative to a defined goal. It provides a sense of where we are and, more importantly, where we are going. Rose also stated that measurement can guide steady advancement toward established goals and identify shortfalls or stagnation. Afterthat, the importance of measuring performance continued to be asserted by Willis (1996) because it will indicate status and direction of a project.

In terms of project scale, project performance can be defined as the project characteristics that interest stakeholders such as owners/clients, contractors and project managers. These characteristics are usually indicated by different factors, measures or indicators. To begin with, it is widely accepted view that, at a minimum, performance measures of a project are based on time, cost and quality (Barkley and Saylor, 1994). Next, Atkinson (1999) noted that these three components of project performance as the “iron triangle”. Nonetheless, Kumaraswamy and Thorpe (1999) indicated measuring a project could be associated with a variety of criteria which are meeting budget, schedule, the quality of workmanship, stakeholder’s satisfaction, transfer of technology, and health and safety. Chan and Tam (2000) subsequently noted that other key components are also used for project performance measurement such as health and safety, environmental performance, user expectation/satisfaction, actor’s satisfaction and commercial value. Overall, different construction projects may use different factors to measure performance, for example, cost, time, quality, safety, client satisfaction, environment, profitability, communication and so on (Chan and Chan, 2004; Luu et al., 2008; Skibniewski and Ghosh, 2009; Dawood, 2010; Toor and Ogunlana, 2010; Cha and Kim, 2011; Almahmoud et al., 2012; Ikediashi et al., 2012; Yeung et al., 2009, 2013). These factors help stakeholders measure the performance level of the project for improvement, which is often related to project objectives or three most suggested factors such as time, cost and quality. It is noticeable these factors vary from country to country; from project to project; furthermore, there is no consensus on how to measure the performance of mega projects (Toor and Ogunlana, 2010).

Comparing with construction project performance, measuring material management effectiveness in this study, therefore, has been likely indicated by four criteria: time, cost, quality, and safety. This proposition renders another basis for developing the conceptual SEM.

### 2.5.1 Time aspect

It is very important for construction projects to be completed on time, as the clients, users, stakeholders and the general public usually looks at project success from the macro view where their first criterion for project success appeared to be the completion time (Lim and Mohamed, 2000). Salter and Torbett (2003) and Odeh and Battaineh (2002) mentioned that time variance is one of the techniques for assessing project performance in construction projects. The element of time could indicate to project managers that the project was not running as smoothly as scheduled. Furthermore, Latham Report in 1994 suggested that ensuring timely delivery of projects is one of the important needs of clients of the construction industry. Hence, construction time can be regarded as the elapsed period from the commencement of site works to the completion and handover of a building to the client. The construction time of a building is usually specified before the commencement of construction and it is an essence of a construction contract. Construction time can also be deduced from the client's brief or derived by the construction planner from available project information.

### 2.5.2 Cost aspect

Cost is one of the major consideration in entire cycle of construction projects. Cost is defined as the degree to which the general conditions promote the completion of a project within the estimated budget (Bubshait and Almohawis, 1994). Salter and Torbett (2003) indicated that cost variance was the most common technique used to measure design performance. It is not only confined to the tender sum, but the overall cost that a project incurs from inception to completion, which includes any costs arise from variations, modification during period and the cost arising from the legal claims, such as litigation and arbitration. Cost can be measured in terms of unit cost, percentage of net variation over final cost (Chan and Tam, 2000). Cost variance is a very important factor in measuring project performance because it indicates how much the project is over or under budget. Typically, Andi and Minato (2003) used cost variance to measure project performance caused by defective design in Japan's construction industry. Afterwards, Georgy et al. (2005) suggested the element of cost to measure the performance of engineering projects.

### 2.5.3 Quality aspect

Quality is another critical measure. However, the assessment of quality is rather subjective. In the construction industry, quality is defined as the totality of features required by a product or services to satisfy a given need, or fitness for purpose (Parfitt and Sanvido, 1993). In other words, the emphasis of quality in construction industry is on the ability to conform to established requirements. Requirements are the established characteristics of a product, process or service as specified in the contractual agreement and a characteristic is any specification or property that defines the nature of those products, processes or services, which are determined initially by the client. In order to achieve a completed project that meets the owner’s quality expectations, all parties to a project must acquire an understanding of those expectations, incorporate them into the contract price and other contract documents to the extend possible, and commit in good faith to carry them out (Ganaway, 2006).

### 2.5.4 Safety aspect

Safety is another criterion that is repeatedly cited by previous researchers. Health and safety are defined as the degrees to which the general conditions promote the completion of a project without major accidents or injuries (Bubshait and Almohawis, 1994). The measurement of safety is mainly focused on the construction period as most accidents occur during this stage. Throughout the world, construction industry is known as one of the most hazardous activities. Construction workers worldwide have three times more chances of dying and two times of getting injured than any worker of other economic activity (Sousa and Teixeira, 2004). Traditionally, the safety aspect is measured through injury statistic. The main purpose of measuring safety criterion is to provide information on the progress and current status of the strategies, processes and activities employed to control safety risks. Effective measurement not only provides information on what the levels are but also why they are at this level, so that corrective action can be taken.

## 2.6 Proposed model

From previous literature review, the material management should be increasingly improved at construction site. Although several research studies mentioned about the importance of material management, few research studies focused on factors influencing material management effectiveness. So, this research aims to develop models to explain the relationships between factors influencing material management effectiveness based on their own perception and practice. A proposed model of factors affecting material management effectiveness is developed base on literature review and shown in **Figure 2.8** below.

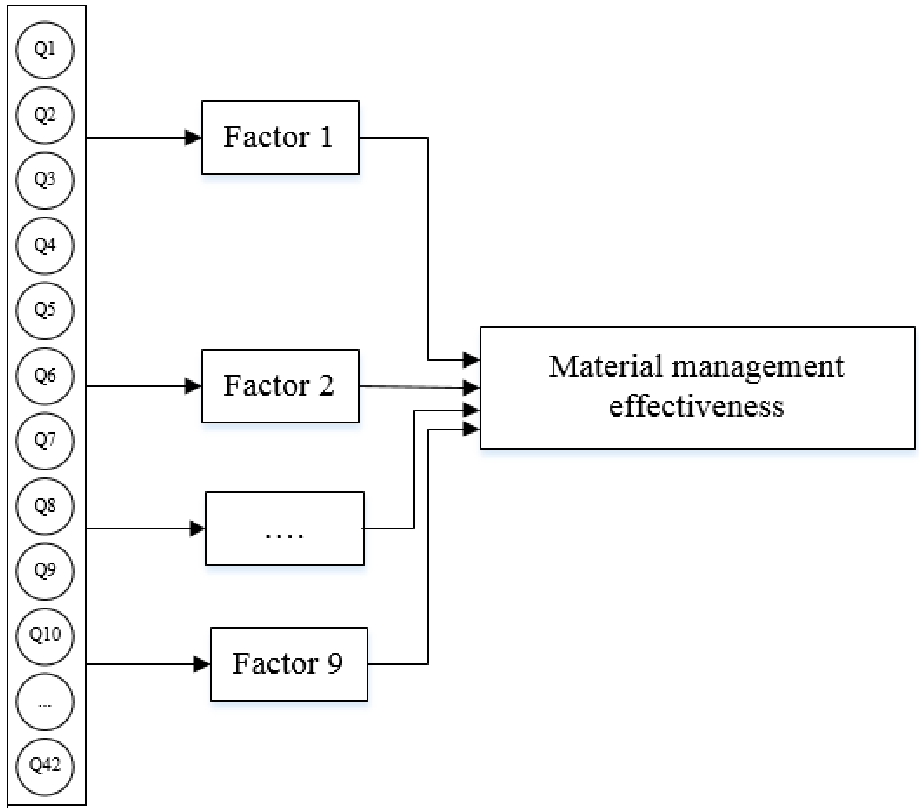


**Figure 2.8** Proposed model of factors influencing material management effectiveness

# Chapter 3
# Research Methodology

This chapter describes the research methodology adopted throughout the research project. Each step in the research consists of a main purpose, the research technique and the research process. It starts with research types, research design and then justifies the selection of the research methodology. Finally, it explains the preliminary stages to collect and analyze data. As mentioned in Chapter 1, the literature review and questionnaire survey were adopted as the two main tools used to identify factors affecting material management effectiveness in Vietnamese construction projects.

## 3.1 Research Types

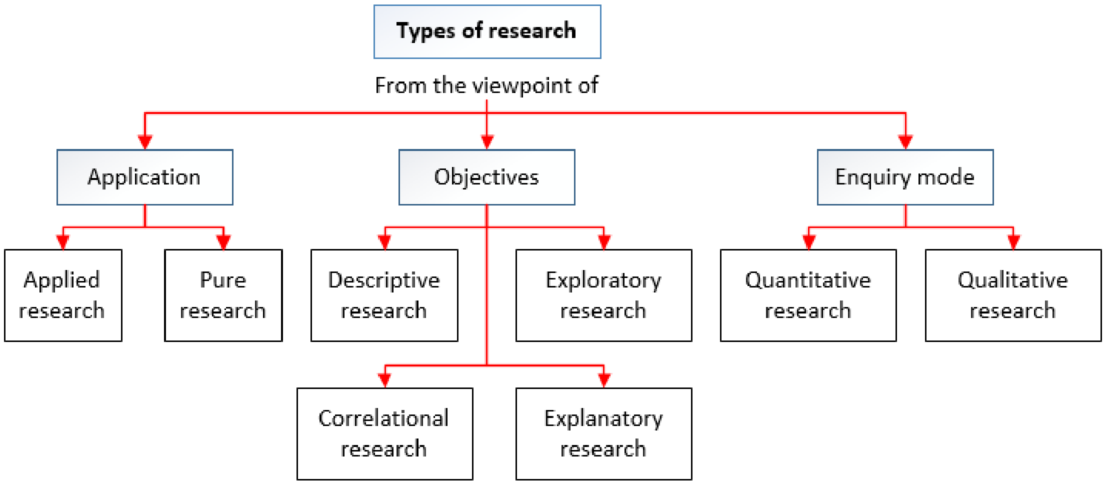


**Figure 3.1** Types of research

Types of research can be looked at from three different perspectives (Kumar, 2011) that are shown in **Figure 3.1**:

1. applications of the findings of the research study;
2. objectives of the study;
3. mode of enquiry used in conducting the study.

The classification of the types of a study on the basis of these perspectives is not mutually exclusive: that is, a research study classified from the viewpoint of 'application' can also be classified from the perspectives of 'objectives' and 'enquiry mode' employed. For example, a research project may be classified as pure or applied research (from the perspective of application), as descriptive, correlational, explanatory or exploratory (from the perspective of objectives) and as qualitative or quantitative (from the perspective of the enquiry mode employed).

### 3.1.1 Application perspective

To examine a research endeavour from the perspective of its application, there are two broad categories: *pure research* and *applied research*.

Pure research or otherwise called as basic or fundamental research, is one that focuses on advancing scientific knowledge for the complete understanding of a topic or certain natural phenomenon, primarily in natural sciences. In a nutshell, when knowledge is acquired for the sake of knowledge it is called basic research. Pure research is completely theoretical, that focuses on basic principles and testing theories. It tends to understand the basic law. Pure research deals with generalization and formulation of theory about human behaviour. It is aligned towards collecting information that has universal applicability. Therefore, pure research helps in adding new knowledge to the already existing knowledge.

Applied research can be defined as research that encompasses real life application of the natural science. It is directed towards providing a solution to the specific practical problems and develop innovative technology. In other words, it is the research that can be applied to real-life situations. It studies a particular set of circumstances, so as to relate the results to its corresponding circumstances. Applied research includes research that focuses on certain conclusions experiencing a business problem. Moreover, research that is aligned towards ascertaining social, economic or political trends are also termed as applied research.

**Table 3.1** Comparison chart (Surbhi S, 2017)

| **Basis for comparison** | **Pure research** | **Applied research** |
|---|---|---|
| Meaning | Pure research refers to the study that is aimed at expanding the existing base of scientific knowledge. | Applied research is the research that is designed to solve specific practical problems or answer certain questions. |
| Nature | Theoretical | Practical |
| Utility | Universal | Limited |
| Concerned with | Developing scientific knowledge and predictions | Development of technology and technique |
| Goal | To add some knowledge to the existing one. | To find out solution for the problem at hand. |



### 3.1.2 Objectives perspective

In order to examine a research study from the perspective of its objectives, broadly a research endeavour can be classified as *descriptive*, *correlational*, *explanatory* or *exploratory*.

**3.1.2.1 Descriptive research**

A research study classified as a descriptive study attempts to describe various aspects of the phenomenon. In its popular format, descriptive research is used to describe characteristics and/or behaviour of sample population. An important characteristic of descriptive research relates to the fact that while descriptive research can employ a number of variables, only one variable is required to conduct a descriptive study. Three main purposes of descriptive studies can be explained as describing, explaining and validating research findings. Descriptive studies are closely associated with observational studies, but they are not limited with observation data collection method. Case studies and surveys can also be specified as popular data collection methods used with descriptive studies.

Advantages of descriptive research:

The people individual studied are unaware so they act naturally or as they usually do in everyday situation;

It is less expensive and time consuming than quantitative experiments;

Collects a large amount of notes for detailed studying;

As it is used to describe and not make any conclusions it is to start the research with it.

Disadvantages of descriptive research:

Descriptive research requires more skills;

Does not identify cause behind a phenomenon;

Response rate is low in this research;

Results of this research can change over the period of time.

**3.1.2.2 Correlational research**

The main emphasis in a correlational study refers to the systematic investigation or statistical study of relationships among two or more variables without necessarily determining cause and effect. It seeks to discover or establish a relationship/association/interdependence between two or more variables that do not readily lend themselves to experimental manipulation.

Advantages of correlational research:

Can collect much information from many subjects at one time;

Can study a wide range of variables and their interrelations;

Study variables that are not easily produced in the laboratory.

Disadvantages of correlational research:

Correlation does not indicate causation (cause and effect);

Problems with self-report method.

### 3.1.2.3 Explanatory research

Explanatory research, also known as causal research is conducted in order to identify the extent and nature of cause-and-effect relationships. Causal research can be conducted in order to assess impacts of specific changes on existing norms, various processes etc. Causal studies focus on an analysis of a situation or a specific problem to explain the patterns of relationships between variables. Experiments are the most popular primary data collection methods in studies with causal research design.

Advantages of explanatory research:

May play an instrumental role in terms of identifying reasons behind a wide range of processes, as well as, assessing the impacts of changes on existing norms, processes etc.;

Usually offer the advantages of replication if necessity arises;

Associated with greater levels of internal validity due to systematic selection of subjects.

Disadvantages of explanatory research:

Coincidences in events may be perceived as cause-and-effect relationships;

It can be difficult to reach appropriate conclusions on the basis of causal research findings. This is due to the impact of a wide range of factors and variables in social environment. In other words, while casualty can be inferred, it cannot be proved with a high level of certainty;

In certain cases, while correlation between two variables can be effectively established; identifying which variable is a cause and which one is the impact can be a difficult task to accomplish.

### 3.1.2.4 Exploratory research

Exploratory research is a type of research conducted for a problem that has not been clearly defined. Exploratory research helps determine the best research design, data collection method and selection of subjects. The results of exploratory research are not usually useful for decision-making by themselves, but they can provide significant insight into a given situation. Exploratory research is not typically generalizable to the population at large. Exploratory research can be quite informal, relying on secondary research such as reviewing available literature and/or data, or qualitative approaches such as informal discussions with consumers, employees, management or competitors, and more formal approaches through in-depth interviews, focus groups, projective methods, case studies or pilot studies.

Advantages of exploratory research:

Flexibility and adaptability to change;

Effective in laying the groundwork that will lead to future studies;

Can potentially save time and other resources by determining at the earlier stages the types of research that are worth pursuing.

Disadvantages of exploratory research:

Generate qualitative information and interpretation of such type of information is subject to bias;

Usually make use of a modest number of samples that may not adequately represent the target population. Accordingly, findings of exploratory research cannot be generalized to a wider population.

Findings of these studies are not usually useful in decision making in a practical level.

### 3.1.3 Mode of enquiry perspective

On mode of enquiry perspective, all researches can be classified into two groups: *qualitative* and *quantitative* research.

Qualitative research is one which provides insights and understanding of the problem setting. It is an unstructured, exploratory research method that studies highly complex phenomena that are impossible to elucidate with the quantitative research. Although, it generates ideas or hypothesis for later quantitative research. Qualitative research is used to gain an in-depth understanding of human behaviour, experience, attitudes, intentions, and motivations, on the basis of observation and interpretation, to find out the way people think and feel. It is a form of research in which the researcher gives more weight to the views of the participants. Case study, grounded theory, ethnography, historical and phenomenology are the types of qualitative research.

Quantitative research is a form of research that relies on the methods of natural sciences, which produces numerical data and hard facts. It aims at establishing cause and effect relationship between two variables by using mathematical, computational and statistical methods. The research is also known as empirical research as it can be accurately and precisely measured. The data collected by the researcher can be divided into categories or put into rank, or it can be measured in terms of units of measurement. Graphs and tables of raw data can be constructed with the help quantitative research, making it easier for the researcher to analyse the results.

**Table 3.2** Comparison chart (Surbhi S, 2016)

| Basis for comparison | Qualitative research | Quantitative research |
|---|---|---|
| Meaning | Qualitative research is a method of inquiry that develops understanding on human and social sciences, to find the way people think and feel. | Quantitative research is a research method that is used to generate numerical data and hard facts, by employing statistical, logical and mathematical technique. |
| Nature | Holistic | Particularistic |
| Approach | Subjective | Objective |
| Research type | Exploratory | Conclusive |
| Reasoning | Inductive | Deductive |
| Sampling | Purposive | Random |
| Data | Verbal | Measurable |
| Inquiry | Process-oriented | Result-oriented |
| Hypothesis | Generated | Tested |
| Elements of analysis | Words, pictures and objects | Numerical data |
| Objective | To explore and discover ideas used in the ongoing processes. | To examine cause and effect relationship between variables. |
| Methods | Non-structured techniques like In-depth interviews, group discussions etc. | Structured techniques such as surveys, questionnaires and observations. |
| Result | Develops initial understanding | Recommends final course of action |

As mentioned in the first chapter, the main objective of this research are to identify factors affecting material management effectiveness in Vietnamese construction projects, then explain the relationship between these factors and effectiveness of material management. Afterthat, a case study with problems in real practice will be elucidated. Therefore, from the application perspective, our research will be categorized into an applied research, an exploratory research in terms of objectives, and combination of quantitative and qualitative research based on mode of enquiry aspect.

### 3.2 Research Design

The research process was designed to pursue the aim of this research, which is to have a profound understanding about the relationship of influential factors on material management effectiveness in Vietnamese construction projects. In order to achieve the purpose of this research, the overall research process was developed as illustrated in **Figure 3.2**.

First of all, a literature search was made to fully review preliminary factors affecting material management that can be detected in different stages of material management process in construction projects. Next, a questionnaire design was framed thanks to using previous researches that were performed in literature review so as to achieve the research objective. It would be completed after a pilot survey. The most critical step in this research design was data collection that was employed after questionnaires were sent to targeted respondents to get the results. Subsequently, the data were analyzed to obtain main issues in which the first phase is to compare respondents' perception and the actual practice of material management through descriptive analysis, the following phase is to verify the structure of factors influencing the effectiveness of material management through undertaking confirmatory factor analysis and the third one is to explain the model with SEM technique. Finally, the conclusion were made to show the useful findings of this study and some limitations were also shown afterwards.

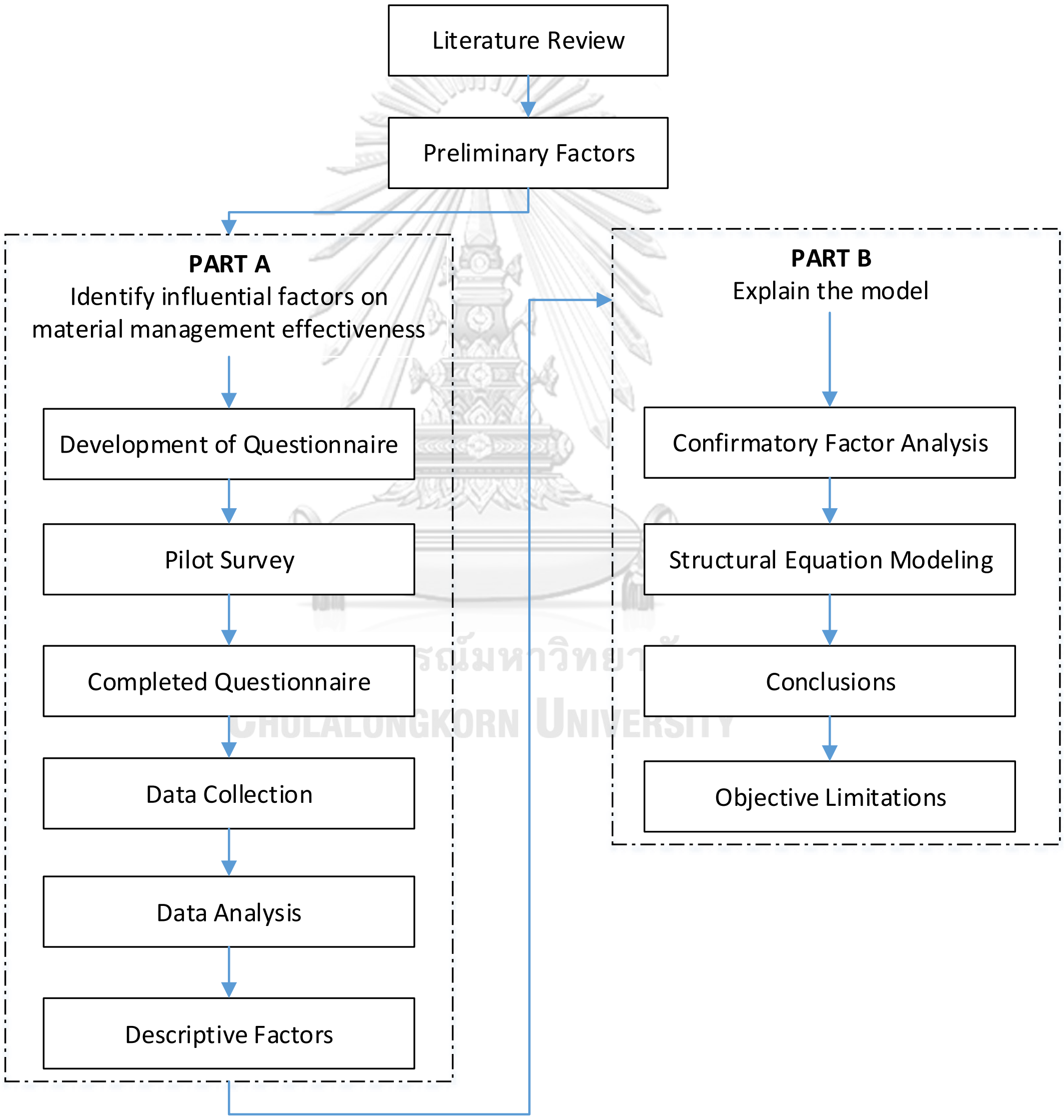


**Figure 3.2** Overall research process

The research methodology process in **Figure 3.2** is a master plan of procedures that we should follow to achieve the research objectives.

Brief descriptions of the research methodology used in this research were presented in the first chapter, and the following sections will provide further details of these procedures.

### 3.2.1 Review Literature

The aim of the literature review is to examine previous researches and identify the gaps in current knowledge. This review determined the context of the research study and positioned this work relative to previous studies. It also assisted in the conceptualisation of the research areas sufficiently to develop the main focus of the research, influence the research design and generate specific hypotheses to be tested.

It was particularly shown in chapter 2 with some activities included in this stage are:

Develop a clear understanding of the research problem being studied;

Consolidate and extract information from a preliminary literature review for the main areas of investigation including factors affecting material management in construction projects;

Formulate and create a description of the research questions and objectives identified. The sources of information for collection of data for this activity are from journal publications, books and magazine articles;

Develop the methodology for the research.

### 3.2.2 Questionnaire Design

Questionnaire is an efficient instrument for data collection. It contains a list of questions related to the research objectives that requires respondents to provide their answers. A great deal of care is necessary to write the best question for a survey, researchers have to know exactly what their purposes of each question and the scale to measure the variables. With an efficient questionnaire, researcher can achieve their research objective faster and cheaper that other mechanism. However, it is not easy to get a good questionnaire.

There are three steps in designing a questionnaire, namely:

Constructing questions to ask includes defining the research objectives and question wording.

Responses to questions contents categorized, scaled and coded responses for analyzing after collected.

Finalizing the questionnaire includes formatting the questionnaire and refining questions for more attractive and professional.

The main aim of this research is to analyze the relationship of influential factors on material management effectiveness in Vietnamese construction projects. To begin with, different factors affecting material management effectiveness identified in other countries were gathered in the literature review. With 42 factors that were synthesized from 28 reference journals in the extensive literature review, asking for experts' consultation was then carried out to reveal the existing practice in Vietnam. A group of professionals who got wide experience in material management was invited to consider, select the appropriate factors from the preliminary list and likely give supplementary ideas about other factors as their practical knowledge. The list of influential factors might be revised from then on.

Thereafter, a questionnaire survey was designed based on refined factors and used as a main tool to collect data. It was certain that structured questions might help to minimize flexibility and variation while standardization was maximized with the limitation of the short span of time for this research (Punch, 2014); hence, series of pre-established questions with pre-set response categories were carefully formulated. The structure of questionnaire was basically divided into 4 parts that helped to meet the objective of study. The first part was established to collect the respondents' background information. The second section consisted of questions to assess the importance level of factors that may influence material management effectiveness. The third section or the main content will evaluate factors affecting material management effectiveness in practice. The final one was developed to measure the effectiveness of material management.

**Section 1:** Background Information – this part is designed to obtain data involving target respondents' general information.

**Section 2:** Factors affecting material management effectiveness

Through the questionnaire, respondents were asked to express their perception with statements in which they had been directly involved. They will indicate the strength of importance according to a five-point Likert scale (1 = Not at all; 2 = Low; 3 = Moderate; 4 = High; and 5 = Very high).

**Section 3:** Evaluating factors affecting material management effectiveness (actual practice) – For each statement, respondents were required to evaluate the influential factors according to scale description from 1 to 5. It would represent different levels depending on each question.

**Section 4:** Measurement of material management effectiveness

The research questions were developed with the intent of evaluating material management effectiveness at construction sites. The effectiveness of material management could be measured through four criteria: time, cost, quality and safety (Samee and Pongpeng, 2015). In each of criteria, there will be some indicators used to describe the effectiveness. The measurement scale is rated from 0 to 10 which represents for different levels, starting from "*unacceptable*" to "*exceptional*" (Performance evaluation procedure – Northumberland County, 2017).

**Table 3.3** Indicators for measurement of material management effectiveness

| Factors | References |
|---|---|
| Regarding *time* criterion: | |
| On time delivery | Sjøbakk et al. (2015) |
| Procurement lead time | Sjøbakk et al. (2015) |
| Bid/Evaluate/Commit (BEC) lead time | Sjøbakk et al. (2015) |
| Purchase order to material receipt duration | Sjøbakk et al. (2015) |
| Payment processing time | Procurement Performance Indicators Guide (2013) |
| Regarding *cost* criterion: | |
| Workforce cost for material management | Samee and Pongpeng (2015) |
| Compliance with original contract price | Performance evaluation procedure – Northumberland County (2017) |
| Complete and correct volume/quantity | Supplier performance scorecard – Government of Victoria |
| Freight cost percent | Plemmons et al. (1995) |
| Cost control system | Enshassi et al. (2009) |
| Regarding *quality* criterion: | |
| Compliant to specification | Supplier performance scorecard – Government of Victoria |
| Fit for purpose | Supplier performance scorecard – Government of Victoria |
| Secure/No damage | Supplier performance scorecard – Government of Victoria |
| Quality assessment system | Enshassi et al. (2009) |
| Regarding *safety* criterion: | |
| Adherence to health and safety act | Performance evaluation procedure – Northumberland County (2017) |
| Number of accidents | Samee and Pongpeng (2015) |
| Number of injuries and casualties | Samee and Pongpeng (2015) |
| Cost of accidents | Samee and Pongpeng (2015) |
| Time loss from accidents | Samee and Pongpeng (2015) |

It should be noted that before collecting project data, a pilot study was conducted with professionals to solicit comments on the readability, comprehensiveness, and accuracy of the questionnaire. As a result, it could help to minimize or exclude the possibility of missing any information necessary for this study.

### 3.2.3 Data collection

The weight and authenticity of the research rely greatly on the validity and reliability of the collected data. Data are often thought as "the facts" – the things that are known to be true; however, the truth is that data are social products. "The records created are not reality itself; rather they are a result of researchers", which attempts to observe or measure traces or evidence of phenomena situated within a complex system" (Byrne, 2002).

**Pilot survey**

Collection of data through questionnaires was the main method of this study. Before using this method, a "pilot study" (pilot survey) was implemented in order to ensure that the data constructed enabled the researcher to address the objectives of which the research was undertaken. The pilot survey was conducted in Vietnam where the questionnaire was distributed to experts (about 10 people) in material management in Ho Chi Minh city. Subsequently, it intended to get feedbacks that could help the researcher improve the data collection strategy, measure the time required to complete all questions and identify any other problematic issues with the survey's format. From that point, the questionnaire is easily comprehensible to the respondents and accordingly get better responses from them.

**Population/Sampling**

The participants who were purposely selected to engage in this survey used to have working experience or skills relating to material management process in civil and industrial projects in Ho Chi Minh city, Vietnam. This could help to provide fruitful information and insight for this research. The target population expected to give the responses were project managers, site managers, site/office senior engineers (QS), warehouse managers. The sampling frame comprised about 30 building projects that could be classified into different types of projects such as residential/housing, hospital, office, and hotel.

There are two main techniques of sampling from a target population: probability sampling and non-probability sampling (Cozby, 2007; Hair, Black et al., 2010). In probability sampling, each member of the population has a specifiable probability of being chosen. In other words, the list member of population is determined before sampling. In non-probability sampling, we don't know the probability of any particular member of the population. Non-probability sampling technique is quite arbitrary, difficult to ensure that the sample accurately represents the population. However, it is cheap and convenient comparing with probability sampling. Hence, it is quite common and useful in many circumstances. In this study, the sampling units are mostly managers who are currently working at construction sites, so it is difficult to get a complete list of target population. Besides, contacting and entering construction sites to interview managers are very complex without personal relations. In addition, this research is performed in a limited time and budget. From these reasons, purposive sampling – a technique of non-probability sampling is selected as a suitable tool for this research. A number of available construction sites at Ho Chi Minh city are listed and contacted for interview permission before conducting the survey.

**Receiving data**

The questionnaires consisted of a number of questions typed in a definite order on a form. They were then emailed to target respondents who are expected to read and understand the questions and write down the reply in the space meant for the purpose in the questionnaire itself. After filling the form, the finished questionnaires were returned to the researchers via email. Also, for the ease of the respondents, the questionnaires were transformed into a Google form where they can fill in the form directly. At the same time, the data were conveniently gathered in a Google spreadsheet, so they needed not to send the email back. Moreover, in-person meetings were also arranged in accordance with the respondents' convenience. Providing this flexibility for the respondents made the procedure of data collection become effortless for both parties. Only questionnaires that were fully completed were accepted while the partially filled once were discarded.

### 3.2.4 Data Analysis

A series of statistical test and analytical study was carried out to find the relationship of influential factors on material management effectiveness in construction projects.

The data collected from the questionnaire surveys will be analysed by using an array of descriptive and inferential statistical analyses, facilitated by Microsoft Excel, Amos Version 20. The analysis includes: descriptive analysis, confirmatory factor analysis and structural equation modeling (SEM).

Descriptive statistics is the first technique applied. It is used to describe the characteristics of respondent sample, check variables for any violation of the assumptions underlying the statistical techniques that will be performed and address specific research questions (Pallant, 2004). Descriptive statistics can be obtained a number of different ways, using Frequencies, Descriptive or Explore. Different procedures depended on categorical or continuous variables.

Confirmatory factor analysis (CFA) is the second technique applied. It is a multivariate statistical procedure that is used to test how well the measured (observed) variables represent the number of constructs (Statistics Solutions, 2013). In confirmatory factor analysis (CFA), researchers can specify the number of factors required in the data and which measured variable is related to which latent construct (factor). In this study, Amos – a statistical software is used for confirmatory factor analysis. The objective of research is to identify factors influencing material management effectiveness, so this factor analysis will be carried out at the first step. Initial 42 items may influence material management will be grouped in a smaller set of factors before further analyzing.

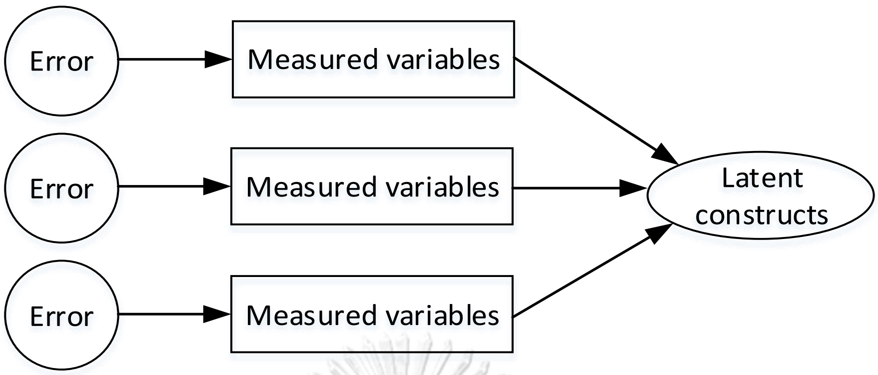


**Figure 3.3** Description about CFA structure

Besides, prior to conducting an analysis based on the results obtained from the questionnaire, Cronbach analysis will be carried out to ascertain the internal consistency of the questions using the Likert scale.

**Cronbach's alpha test**

According to Mohsen and Reg (2011), Cronbach's alpha, α (or *coefficient alpha*), developed by Lee Cronbach in 1951, measures reliability, or internal consistency. "Reliability" is how well a test measures what it should. Cronbach's alpha tests to see if multiple-question Likert scale surveys are reliable. These questions measure latent variables – hidden or unobservable variables that are very difficult to perform in real life. Cronbach's alpha will tell us if the test we have designed is accurately measuring the variable of interest.

Cronbach's alpha can be written as a function of the number of test items and the average inter-correlation among the items. The formula for the standardized Cronbach's alpha is:

$$\alpha = \frac{N\bar{c}}{\bar{v} + (N-1)\bar{c}}$$

Where:
N = the number of items.
$\bar{c}$ = the average covariance between item-pairs.
$\bar{v}$ = the average variance.

One can see from this formula that if we increase the number of items, Cronbach's alpha will be increased. Additionally, if the average inter-item correlation is low, alpha will be low. As the average inter-item correlation increases, Cronbach's alpha increases as well (holding the number of items constant). A rule of thumb for interpreting alpha for Likert scale questions is:

**Table 3.4** Rule of thumb about cronbach's alpha coefficient sizes

| **Cronbach's alpha** | **Internal consistency** |
|---|---|
| $\alpha \geq 0.9$ | Excellent |
| $0.9 > \alpha \geq 0.8$ | Good |
| $0.8 > \alpha \geq 0.7$ | Acceptable |
| $0.7 > \alpha \geq 0.6$ | Questionable |
| $0.6 > \alpha \geq 0.5$ | Poor |
| $0.5 > \alpha$ | Unacceptable |

In general, a score of more than 0.7 is acceptable.

Structural equation model (SEM) was alternative technique for exploring the interrelationship among factors in multiple layers of linkages between variables. SEM proves effective statistical technique in develop the causal model for explaining a dependent variable with a high quality information (Tabachnick and Fidell, 2006; Hair, Black et al., 2010). Therefore, SEM is selected in developing models for explaining material management effectiveness.

After getting the result in connection with important factors, interviews with experts will be again conducted to focus on problems that may occur in current practice of material management. From then, material management effectiveness could be well-improved.

### 3.2.5 Conclusion

This chapter has discussed the research methods adopted and used in this study. It presented a guideline or a research design that highlighted research approaches and techniques. Quantitative and qualitative research were also discussed. The selection of research methodology was considered through main sections: literature review, survey questionnaire and face-to-face interviews.

# Chapter 4
# Identification of factors influencing material management effectiveness

This chapter aims to explore influential factors that have already appeared or could happen in construction projects done in Vietnam. The list of 42 factors that was collected from 28 previous research works. To begin with, each of factor is verified by a pilot expert group in section 4.1 and aggregated data for large scale study is then given in section 4.2. Subsequently, section 4.3 will show the general survey data that may be used to analyze for the next chapter. Next, the characteristics of participants and independent samples t-test are also presented in section 4.4 and 4.5 respectively. The significant influential factors on material management effectiveness are illustrated in section 4.6. Last but not least, section 4.7 will demonstrate the effectiveness of material management through evaluation criteria of projects.

## 4.1 Pilot study

A pilot study is conducted to review the test responses to the survey, looking for any inconsistencies or unexpected answers for improving afterwards. It is done with a small sample similar to target population as designed before. The questionnaire is assessed in aspects of question objectives, wording and format to make sure its simplicity, clarity and understandability for respondents.

### 4.1.1 Questionnaire and Sampling

In pilot study, each participant is interviewed face-to-face carefully and required to answer questionnaire. Interviews not only focus on the meaning of the responses but also gather their suggestions for each component of questionnaire and their difficulties as answering questionnaire. The subject in this study was managers working on construction site at Ho Chi Minh city. The pilot study was undertaken in September 2018. It is conducted to collect data from 51 people who are currently working at thirteen construction sites (48 managers from twelve construction sites described as 4 persons per site – project manager, site manager, senior engineers/QS, warehouse manager and 3 office managers). The duration for each interview is approximately from 30 minutes to 45 minutes, depending on the amount of information that respondents want to provide and cooperate.

The questionnaire survey for pilot testing issued to the respondents is shown in Appendix A2 in Vietnamese version. The questionnaire survey contained four sections. The first section examined general information of respondents, such as, their working place and position, years of experience in civil field and so on. This section was included to ensure that information was received from valid sources. The second section required respondents provide their perception about the importance level of factors affecting material management effectiveness. From five-point Likert scale, forty-two existing factors were checked whether they are influential factors or not. In addition, respondents were asked to add more factors that may cause influence. The third and the fourth section were pretested about the appropriateness of scale measure, clarity, understandability and simplicity which could be answered by respondents. It should be noted that the questionnaire was translated into Vietnamese to ensure that all questionnaire items would be properly understood.

### 4.1.2 Results

First of all, the pretest survey is carried out with 10 managers who are currently involving in nine construction sites (8 site managers, 1 project manager) and one company office (1 department manger of material). It is expected to correct wording as well as contents used for delivering questionnaires later.

And then a pilot study is conducted to collect data from 51 people who are currently working in thirteen construction sites. However, there are 30 respondents (1 project manager, 8 site managers, 10 senior engineers/QS, 9 warehouse managers and 2 office managers) who are willing to participate in this survey and sufficiently complete, producing a usable response rate of 59 % for the pilot study. Of these participants, all of them were male (100%), have been working for large contractors in Vietnam and had experience in material management in construction site from 6 to 15 years.

The pilot study helped to test the appropriateness of data collection in preparation for the large scale study. It is also crucial to test whether the study instrument(s), is asking the intended questions, whether the format is comprehensible and whether the selected validated tool is appropriate for the target population. The primary concern is to obtain preliminary data for the primary outcome measure, in order to calculate a required sample size. From the results of pilot study, some conclusions are discussed below.

For the first section in questionnaire, the questions were commented clear and easy to understand. However, some questions should be associated with available choices to take less time for respondents. Besides, the question related to the age was flexibly combined with question talking about respondent's experience. Detail of revised questionnaire is shown in Appendix A1 and A2 for both English and Vietnamese.

For the second section in questionnaire, the majority of respondents agreed the importance of forty-two existing factors influencing material management effectiveness. **Table 4.1** will show the mean value of them which were higher than 3. Additionally, five-point Likert scale was reliable for these questions providing Cronbach's alpha was 0.966, higher than 0.6 – the threshold value. From respondents, all forty-two questions in this section are quite clear and easy-to-understand. However, they also gave some suggestions about reducing as well as adding some items that may affect material management effectiveness in their perception. To be more specific, eleven factors were reduced as follow:

- Manufacturing status
- Availability of competent suppliers
- Storing methods
- The adequacy of material specification
- Checking the accuracy of order
- Distance between working area and material storage
- Attitude of suppliers
- Custom clearance for imported materials
- Communication between main office and site office
- Control of material usage
- On-site transportation conditions

Instead, eleven additional items were included:

- Construction schedule
- Supplier/manufacturer selection
- Delivery plan/schedule of manufacturer
- Material price stipulation
- Payment and inspection conditions
- Material receiving and placement condition on site
- Checking, reception of material quality on site
- Checking, reception of material quantity on site
- Certificate of material origin and quality (CO/CQ)
- Regulations about material using and installation
- Contract with security company

Besides, some factors were also recommended to change into contents matching with questions' context. To illustrate this point, "The adequacy of material planning" was changed to "Material supply plan". Similarly, "Loss prevention of material" was renamed "Site security system". "Supervision capacity" became "Material supervision and control capacity". "Material status during transportation" was replaced by "Material status as arriving to the site". "Protection during unloading" was turned to "Material protection plan during construction". In the same way, "Suitability of site storage" was known as "Storage location for transportation, loading/unloading". Next, "Material labelling" was changed to "Label, source, quality certification of material". Likewise, "Demand fluctuation" was replaced by "Adjustment about material demand", "Material price fluctuation" was renamed "Adjustment about material price" and "Quality of material" became "Product quality of manufacturer". "Changes of material specification during construction" was turned to "Adjustment of material specification during construction" and "Effectiveness in delivery of materials to site" became "Delivery of materials to site and install on site". Lastly, "Communication in construction sites" was renamed "Co-ordination in construction sites", "Progress in forwarding information of materials to be used" was specified with "Progress in forwarding information on sizes of materials to be used" and "Documentation preparation" was changed to "Documentation storage and organization".

For the third section in questionnaire, it was suggested that the measuring scale should be converted into the same description to support respondents in easily evaluating factors affecting material management effectiveness. To be more precise, all of answers were designed based on five-point Likert scale (1 = Poor; 2 = Fair; 3 = Good; 4 = Very good; 5 = Excellent) except some answers related to frequency (1 = Hardly ever; 2 = Occasionally; 3 = Sometimes; 4 = Frequently; 5 = Always).

For the fourth section in questionnaire, most of previous researches applied the percentage scale to measure material management effectiveness through each specific item of activities which should be collected at the time projects finish. In this study, the indicators for evaluation were designed based on general stages of material management process with the satisfaction scale in which the projects used for data collection are on construction phase. All of interviewee agreed that four criteria including Time – Cost – Quality – Safety were a good representative to measure the effectiveness of material management. Some of them said that "material management should be evaluated through these main items to know exactly what they should improve to reinforce its effectiveness afterwards"; however, they also mentioned "performing all of them is quite difficult and subjective because of limited observation in some aspects". As a result, the elements in evaluation criteria were then modified to simple statements proposed by respondents' advices. For example, some indicators were used to evaluate "Time" criterion included:

- Material supply plan
- Contract signing plan for material procurement
- Material receiving plan
- Material payment plan
- Material installation plan
- Material inspection and handover plan

For "Cost" criterion, it encompassed some items as follow:

- Material unit price comparing to budget
- Construction material quantity comparing to loss ratio of project
- Commitment contract to keep material price according to construction progress
- Cost control system of material management process

Regarding "Quality" criterion, two indicators observed from suggestions were:

- Inspection of material specifications compliant to the quality and standard of project
- Evaluation and control system of material quality from procurement till using

Concerning "Safety" criterion, it is worth noting to three following items:

- Transportation, loading/unloading of material comply with safety and health regulations
- Security on site related to material storage
- Work safety procedures regarding material installation

In terms of rating scale, it is hard for respondents to think about "Excellent" and "Good" level; therefore, the score rating in this part was changed from six classes to five main classes described as: (0-2)/ Unacceptable; (3-4)/ Not Satisfactory; (5-6)/ Cautionary; (7-8)/ Satisfactory; (9-10)/ Good.

The last revised questionnaire which was used for large scale study is shown in Appendix A1 in English version and A2 in Vietnamese version.

**Table 4.1** Descriptive of factors influencing material management effectiveness (Pilot Study, N = 30)

| Item | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| PL1 | 30 | 2 | 5 | 4.07 | 0.740 |
| PL2 | 30 | 3 | 5 | 4.23 | 0.679 |
| PL3 | 30 | 3 | 5 | 3.77 | 0.679 |
| PL4 | 30 | 3 | 5 | 3.80 | 0.610 |
| PL5 | 30 | 2 | 5 | 3.37 | 0.765 |
| PL6 | 30 | 2 | 5 | 3.83 | 0.791 |
| PI1 | 30 | 3 | 5 | 3.87 | 0.629 |
| PI2 | 30 | 2 | 5 | 3.73 | 0.740 |
| PI3 | 30 | 2 | 5 | 3.50 | 0.731 |
| PI4 | 30 | 2 | 5 | 3.83 | 0.834 |
| PI5 | 30 | 3 | 5 | 3.77 | 0.728 |
| PI6 | 30 | 2 | 5 | 3.43 | 0.817 |
| PI7 | 30 | 2 | 5 | 3.47 | 0.860 |
| PI8 | 30 | 2 | 5 | 3.23 | 0.817 |
| PI9 | 30 | 3 | 5 | 3.83 | 0.747 |
| PI10 | 30 | 2 | 5 | 3.87 | 0.819 |
| PI11 | 30 | 2 | 5 | 3.73 | 0.740 |
| PI12 | 30 | 1 | 5 | 3.73 | 0.944 |
| IE1 | 30 | 2 | 5 | 3.90 | 0.803 |
| IE2 | 30 | 3 | 5 | 4.07 | 0.691 |
| IE3 | 30 | 2 | 5 | 3.83 | 0.699 |
| IE4 | 30 | 2 | 5 | 3.53 | 0.776 |
| IE5 | 30 | 3 | 5 | 3.67 | 0.711 |
| TR1 | 30 | 2 | 5 | 3.50 | 0.731 |
| TR2 | 30 | 2 | 5 | 3.70 | 0.837 |
| SU1 | 30 | 2 | 5 | 3.80 | 0.761 |
| SU2 | 30 | 2 | 5 | 3.93 | 0.740 |
| SU3 | 30 | 3 | 5 | 4.03 | 0.615 |

| Item | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| CT1 | 30 | 2 | 5 | 3.87 | 0.860 |
| CT2 | 30 | 2 | 5 | 3.93 | 0.785 |
| CT3 | 30 | 2 | 5 | 3.63 | 0.850 |
| SI1 | 30 | 2 | 5 | 3.50 | 0.820 |
| SI2 | 30 | 2 | 5 | 3.40 | 0.724 |
| SI3 | 30 | 2 | 5 | 3.37 | 0.718 |
| SI4 | 30 | 2 | 5 | 3.63 | 0.850 |
| SI5 | 30 | 2 | 5 | 3.73 | 0.785 |
| SI6 | 30 | 2 | 5 | 3.40 | 0.968 |
| QC1 | 30 | 3 | 5 | 4.10 | 0.712 |
| QC2 | 30 | 2 | 5 | 3.70 | 0.837 |
| QC3 | 30 | 2 | 5 | 3.63 | 0.890 |
| SE1 | 30 | 2 | 5 | 3.57 | 0.935 |
| SE2 | 30 | 2 | 5 | 3.57 | 0.898 |
| Valid N (listwise) | 30 | | | | |

## 4.2 Large scale study

The objective of this part was to collect enough valid and reliability data to achieve research goals.

### 4.2.1 Questionnaire for large scale study

The questionnaire in this section was developed based on literature review, lessons from the pilot study and consultation with experts specializing in material management. In particular, the pilot study helped to modify and refine the questionnaire layout, plan for data collection and gain an initial idea about the validity and reliability of modelling influential factors.

The large scale study questionnaire comprises four main sections. Section 1 included 15 questions related to respondents' background. In this section, they were required to state about their position, experience, information of projects they have been working and so forth. Section 2 consisted of 42 questions asking about respondents' perception associated with importance level of influential factors on material management effectiveness – five point Likert scale. Likewise, section 3 encompassed 42 questions used for evaluating factors affecting material management effectiveness in practice. The answers were mostly designed in accordance with five-point Likert scale starting from "Poor" to "Excellent". Section 4 included 4 main criteria with 15 indicators used to measure the effectiveness of material management. Participants were asked to rate each item according to scoring scale from 0 to 10. It is noted that all questionnaires used for large scale study are shown in Appendix A1 in English version and A2 in Vietnamese version.

### 4.2.2 Sampling Technique and Sample Size

During October – November 2018, data collection for this study was undertaken with construction professionals at Ho Chi Minh city in Vietnamese construction sites. One of the main objectives in this research was to explore factors influencing the effectiveness of material management. As we know, material management is a specific study, so it is difficult to convince construction company to participate in an investigation. Also, due to lack of cooperation between construction companies and researchers and some special rules in costruction site, they rarely allow people to conduct survey without individual relationship. To overcome that obstacles, a certain number of construction sites have shown their contacts to readily access. As a result, convenience sampling is selected as a suitable tool for this research. A number of available construction sites at Ho Chi Minh city are listed first and then contacted to get permission before conducting the survey.

The sample size will depend on the accuracy required and the likely variation of population characteristics investigated as well as the type of analysis conducted on the data. The larger a sample size becomes, the smaller the impact on accuracy is, so there is a cut-off point beyond which the increased costs are not justified by the (small) improvement in accuracy; typically, a sample size of 1,000 is often referred as a cut-off point beyond which the rate of improvement in accuracy slows. This study will use factor analysis to explore factors influencing material management effectiveness and structural equation modeling (SEM) to develop model for explaining influential factors, so with 42 independent variables, the sample size has to exceed 630 for this study. From the recommendation of SEM technique, the ratio should reach at least 15 samples for each independent variable (Bacon, 2001).

On principles, the necessary actual sample is calculated by dividing the determined sample size (630) by the acceptable response rate (50%); or in other words, the total sample should be 1260. However, for the sake of selective respondents, time and budget limitation; questionnaires were just issued to 500 respondents.

Within 500 questionnaires distributed, only 223 respondents were collected with 45% in the response rate. Other 277 questionnaires were not finished yet because they refused to provide information. There were many underlying causes making them declined to cooperate, the common reason could be explained they are too busy in their work to perform the questionnaire survey or the material management at construction site has been still normal, so they need not to care about it and so forth.

For the large scale survey, it is observed that 223 questionnaires fulfilled with highly cooperation from 36 construction projects (180 managers from construction sites, averaging 5 persons per site; and other 43 managers at the company office).

## 4.3 Descriptive Survey Data

### 4.3.1 General Survey Details

The research questions were developed with the intent of achieving research objectives. The questionnaire comprised four main sections as discussed above, respondents were asked to complete at the same time. It took about 2 months to collect data at Ho Chi Minh city, one of the most developing cities in Vietnam. Each respondent was interviewed in person or via email to complete questionnaire. After distributing 500 questionnaires to managers who have been working at 36 construction sites and office, there were only 223 responses supposed to be finished.

Data were then screened using the complete sample (N = 223) prior to main analyses to examine the accuracy of entry data, missing values as well as fit between distributions and assumptions of appropriate analytical tools. After removing unusable cases, only 200 responses out of 223 were counted valid for prospective analysis.

### 4.3.2 Data Screening

Before using the usable sample (N = 200) for analyses, it is so necessary to check for mistake initially. Hence, data were examined for the accuracy of entry data and missing values. The screening process involves a number of steps including checking for the error first, then finding the error in the data file and correcting them lastly. The accuracy of the data file was checked by proofreading a random sample of 100 of the original data against a computerized list. Additionally, the Frequencies and Descriptive Statistic command in SPSS Version 22 was used to detect any out of range values. Finally, it was informed “None were found”.

## 4.4 Respondent Profile



### 4.4.1 Company

The prestige of contractors may reflect some extent related to the quality of construction projects. In this study, most of respondents were from various construction enterprises including top contractors in Vietnam such as COTECCONS, HOA BINH, COFICO, CC1 and so forth. Here are some overviews about these large companies.

- **COTECCONS** (COTECCONS CONSTRUCTION JOINT STOCK COMPANY):

Coteccons is Vietnam’s leading private contractor in the construction of high-rises, commercial complexes, high-tech factories, hotels, and resorts. It has managed to overcome the slump in Vietnam’s real estate industry thanks to its healthy balance sheet (cash and equivalents making up about 31% of total assets; no interest-bearing debt). Coteccons is constructing Landmark 81, which will rank among the world’s eight tallest buildings when complete; this project also makes Coteccons the first Vietnamese contractor to develop a building higher than 60 stories. As of 2017, Coteccons’ backlog stood at around 44 million VND, promising strong growth in both revenue and profit.

- **HOA BINH** (HOA BINH CONSTRUCTION & REAL ESTATE CORPORATION)

Hoa Binh is well known in Vietnam for its young, professional and highly-skilled management team that is constantly challenging itself to do better. The company’s junior and senior management team includes young people who have professional qualifications, passion for their career and many experiences at different positions before being promoted to the roles of project managers and department heads. In business for 30 years, the company has more than 6,000 employees and 20,000 subcontractors working at more than 70 projects in the country. The firm has won numerous awards and is the only contractor in the country honoured by the government organised Vietnam Value, which highlights the country’s strongest brands. Additionally, the UK’s Brand Finance Consulting Company voted the firm as one of Vietnam’s top 50 brands (2015). Ambition, mission, and a forward-thinking business philosophy are just a few of the qualities that make Hoa Binh the Best Construction Company Vietnam at the Dot Property Vietnam Awards 2017. These traits can be seen in all of the firm’s projects as well as its industry-leading business practises.

- **COFICO** (CONSTRUCTION JOINT STOCK COMPANY NO. 1)

With the history of over 35 years of establishment and development, COFICO has been successfully collaborated with strategic local and international partners to develop various projects marking COFICO’s signature in different development milestones of the country. Its official transformation recently to a joint stock company is a convincing evidence of its strategic development and professional competence. The equalization will help the company to make the best of all of its available resources, to seize new opportunities and to integrate into the development trends of the market.



- **CC1** (CONSTRUCTION JOINT STOCK COMPANY NO. 1)

In its development strategy, executing the construction works is CC1’s traditional business line as well as strong point. Initially working purely as a construction contractor, over the past 39 years of construction and development, now CC1 is always the first choice for major projects of national importance in all forms of being main contractor, EPC Contractor, BOT, BT, BOO. CC1 has undertaken construction works of civil, industrial, transport infrastructure and energy infrastructure sectors nationwide. Using suitable construction technology and equipment and a highly skilled workforce, CC1 has participated with an accurate execution schedule in the successful implementation of key national construction projects, while producing a high quality construction outcome. Thus, CC1 has recently become an investor in major projects, proving itself a strong brand in the construction market of Vietnam.

In this study, the data were collected with total 15 contractor companies. The results are shown in **Table 4.2** and **Figure 4.1**. The data illustrated that 30 people, accounted for 15% of the total respondents were from COTECCONS, similarly, 27 people or 13.5% have worked for COFICO, 25 people or 12.5% from HOA BINH, 22 people from CC1 and 96 others from other contractors. Notably, almost all construction companies surveyed have large investment, so they could be chosen to collect data for measuring material management effectiveness.

**Table 4.2** Respondents' surveyed contruction companies (N=200)

| Construction company | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| COTECCONS | 30 | 15.0 | 15.0 |
| HOA BINH | 25 | 12.5 | 27.5 |
| COFICO | 27 | 13.5 | 41.0 |
| CC1 | 22 | 11.0 | 52.0 |
| AN PHONG | 18 | 9.0 | 61.0 |
| THUAN VIET | 19 | 9.5 | 70.5 |
| HA DO | 8 | 4.0 | 74.5 |
| CONINCO | 6 | 3.0 | 77.5 |
| VIET NHAT | 16 | 8.0 | 85.5 |
| HUNG LONG PHAT | 6 | 3.0 | 88.5 |
| HANDONG | 4 | 2.0 | 90.5 |
| CAT LINH | 5 | 2.5 | 93.0 |
| PHU MY HUNG | 5 | 2.5 | 95.5 |
| TAY HO | 4 | 2.0 | 97.5 |
| KHAI HOAN LAND | 5 | 2.5 | 100.0 |
| Total | 200 | 100.0 | |

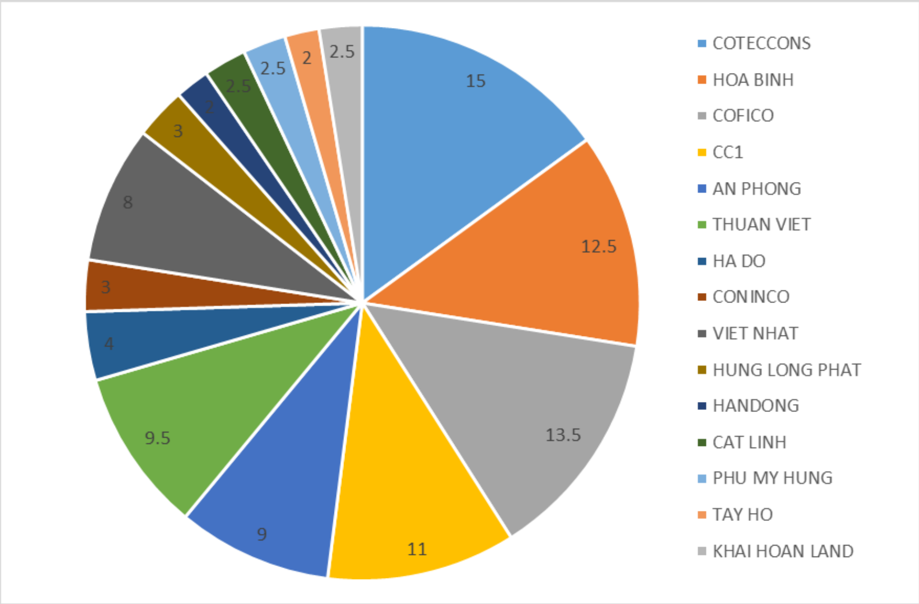


**Figure 4.1** Respondents' surveyed contruction companies (N=200)

### 4.4.2 Current working position

In fact, construction area involves in different specific fields in which material management is an example. Therefore, it is necessary to know as well as select appropriate people for data collection so that they could give the best comments. In this section, the participants observed have been working for eleven major positions. The results are shown in **Table 4.3** and **Figure 4.2**.

**Table 4.3** Respondents' working position (N=200)

| Construction company | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Project manager | 5 | 2.5 | 2.5 |
| Deputy project manager | 5 | 2.5 | 5.0 |
| Site manager | 20 | 10.0 | 15.0 |
| Deputy site manager | 20 | 10.0 | 25.0 |
| Senior engineer (QS) | 25 | 12.5 | 37.5 |
| Cost control specialist | 22 | 11.0 | 48.5 |
| QA/QC manager | 24 | 12.0 | 60.5 |
| Warehouse manager | 18 | 9.0 | 69.5 |
| Chief supervisor | 18 | 9.0 | 78.5 |
| Material manager (Office) | 21 | 10.5 | 89.0 |
| Manager for project coordination (Office) | 22 | 11.0 | 100.0 |
| Total | 200 | 100.0 | |

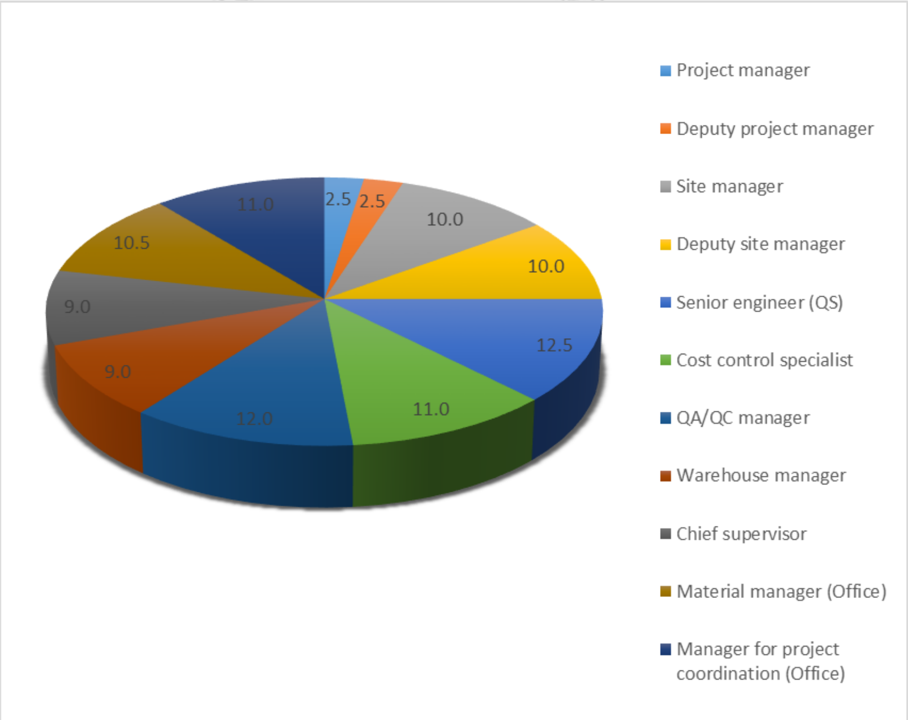


**Figure 4.2** Respondents' working position (N=200)

As we could see from the chart, the respondents aimed in this reseacrh have been mainly working as site manager, deputy site manager, senior engineer (QS), cost control specialist, QA/QC manager, material manager (office), manager for project, coordination (office); all are greater or equal 10% (20 persons). Next are chief supervisor and warehouse manager accounting for 9% each or 18 persons. The remaining 5% or 5 people is collected from project manager and deputy project manager who are always busy to arrange an appointment.

### 4.4.3 Type of building project

Types of construction projects could be sorted into many categories, but there are four primary groups (based on purpose of use) which correspond to another four main groups (based on number of stories) gathered in this survey. The results are shown in **Table 4.4** and **Figure 4.3**.

**Table 4.4** Building project type (N=200)

| Type | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Residential/Housing | 107 | 53.5 | 53.5 |
| Hospital | 45 | 22.5 | 76 |
| Office | 21 | 10.5 | 86.5 |
| Commercial, service | 27 | 13.5 | 100 |
| Total | 200 | 100.0 | |

| Type | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| 9 – 16 floors | 79 | 39.5 | 39.5 |
| 17 – 25 floors | 48 | 24 | 63.5 |
| 26 – 40 floors | 66 | 33 | 96.5 |
| > 40 floors | 7 | 3.5 | 100 |
| Total | 200 | 100.0 | |

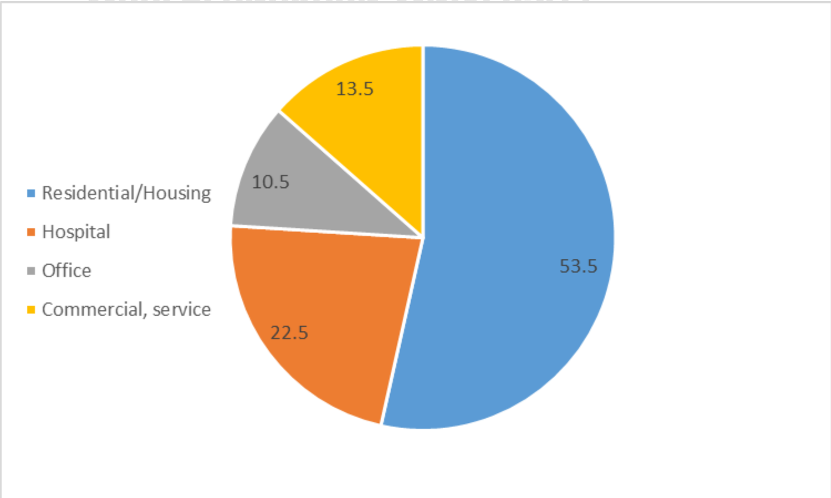


**Figure 4.3** Building project type (N=200)

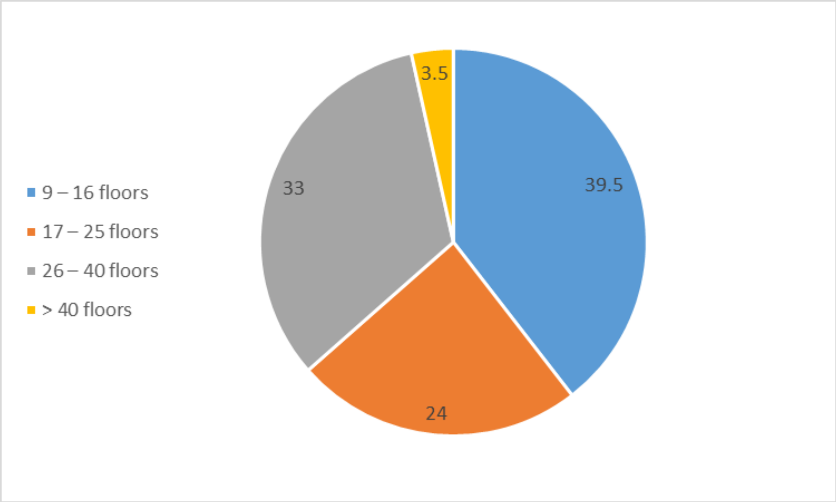


**Figure 4.3** Building project type (N=200) (Cont.)

According to purpose of use, 53.5% responses are noted as resiential/housing, 22.5% responses are mentioned as hospital, 13.5% for commercial, service and the remaining 10.5% for office. Regarding to number of stories, the majorty observed are projects with 9 – 16 floors accounting for 39.5%, then are projects with 26 – 40 floors making up about 33%, 24% for projects with 17 – 25 floors and the other 3.5% for projects with more than 40 floors.

### 4.4.3 Project duration and cost of project

Project completion time is classified to four major milestones starting from under 2 years until over 5 years. Besides, cost of project is similarly divided into five imperative levels starting from under 50 billion VND till more than 1000 billion VND. The results are shown in **Table 4.5** and **Figure 4.4**.

**Table 4.5** Project duration and cost of project (N=200)

| Project duration | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| < 2 years | 86 | 43 | 43 |
| 2 – 3 years | 103 | 51.5 | 94.5 |
| 4 – 5 years | 8 | 4 | 98.5 |
| > 5 years | 3 | 1.5 | 100 |
| Total | 200 | 100.0 | |

| Cost of project | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| < 50 billion | 10 | 5 | 5 |
| 50 – under 100 billion | 14 | 7 | 12 |
| 100 – under 500 billion | 38 | 19 | 31 |
| 500 – 1000 billion | 38 | 19 | 50 |
| > 1000 billion | 100 | 50 | 100 |
| Total | 200 | 100.0 | |

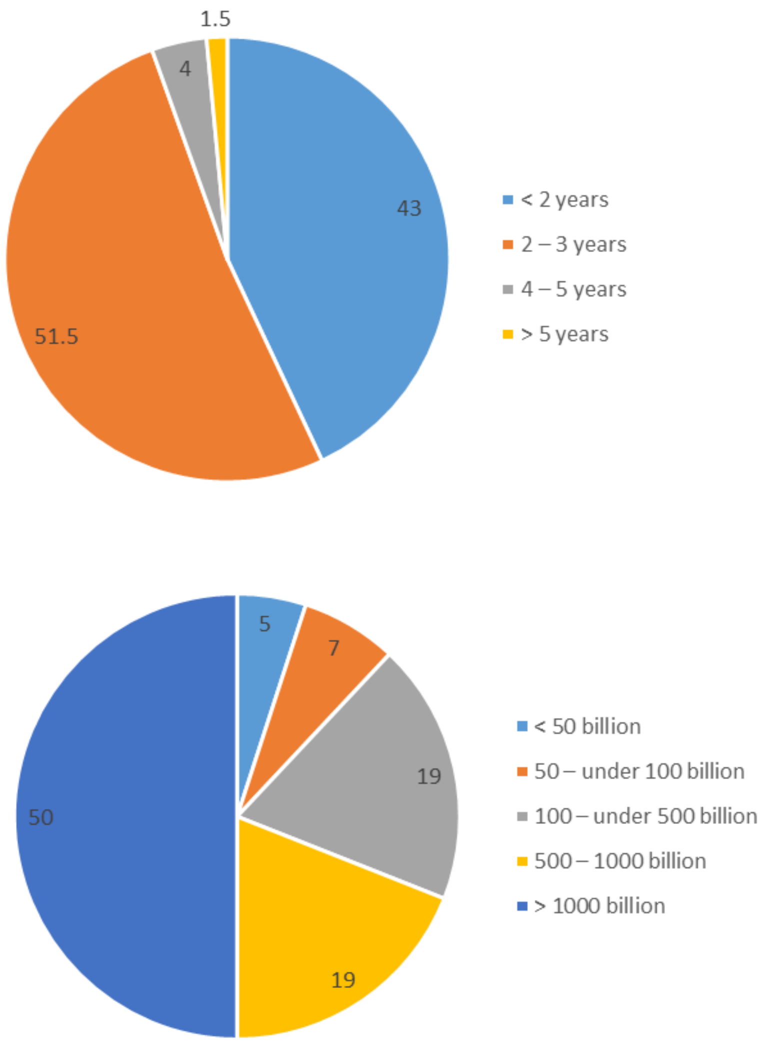


**Figure 4.4** Project duration and cost of project (N=200)



Regarding to project duration, 51.5% number of projects are constructed within 2 – 3 years, 43% less than 2 years, 4% and 1.5% in turn are summarized as 4 – 5 years and more than 5 years. Meanwhile, projects invested more than 1000 billion account for 50% in total, next are 100 – under 500 billion and 500 – 1000 billion with 19% each, projects cost under 50 billion and 50 – under 100 billion holding roughly 5% and 7% in turn.

### 4.4.4 Working experience

Working experience is one of important factors that may influence the effectiveness of material management. Personal experiences generally will help us understand about our workplace in which we are working to avoid any problems happening. To clearly understand about respondent's profile, this section will discuss in both sides including working experience in civil field and in material management on site. In this research, the answers are organized into five main groups and shown in **Table 4.6** and **Figure 4.5**.

Related to civil engineering field, 39.5% of respondents has from 1 to 5 years of working experience, next making up 33% is from 6 to 10 years of working experience while the number of respondents has from 11 to 15 years of working experience, accounting for 14%, 5% is from 16 to 20 years of working experience and the remaining 8.5% belongs to people having more than 20 years of working experience. In area of material management, similarly 67% of respondents has from 1 to 5 years of working experience, next making up 17% is from 6 to 10 years of working experience while the number of respondents has from 11 to 15 years of working experience, accounting for only 5%, 7% is from 16 to 20 years of working experience and the remaining 4% belongs to people having more than 20 years of working experience. In general, working experience may present the population of respondents at construction site. Therefore, sampling data is available for further analysis.

**Table 4.6** Working experience in civil field and material management (N=200)

| Civil Field | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| 1 – 5 years | 79 | 39.5 | 39.5 |
| 6 – 10 years | 66 | 33 | 72.5 |
| 11 – 15 years | 28 | 14 | 86.5 |
| 16 – 20 years | 10 | 5 | 91.5 |
| > 20 years | 17 | 8.5 | 100 |
| Total | 200 | 100.0 | |

| Material management | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| 1 – 5 years | 134 | 67 | 67 |
| 6 – 10 years | 34 | 17 | 84 |
| 11 – 15 years | 10 | 5 | 89 |
| 16 – 20 years | 14 | 7 | 96 |
| > 20 years | 8 | 4 | 100 |
| Total | 200 | 100.0 | |

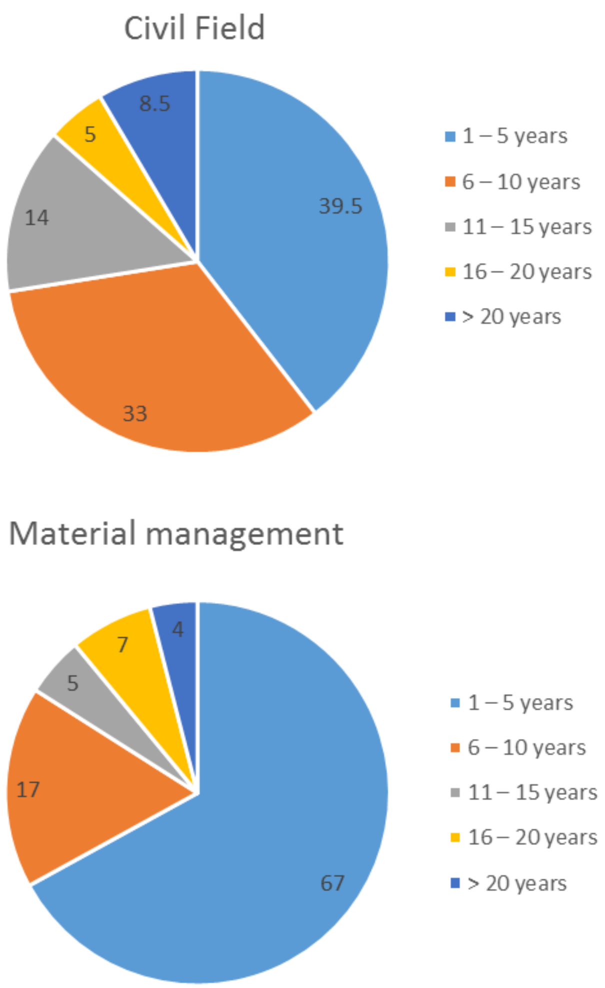


**Figure 4.5** Working experience in civil field and material management (N=200)



### 4.4.5 Other relevant information

In this part, some questions were designed to investigate some information involving material management at construction site.

To begin with, type of material are mostly bought in respondents' project, most of them indicated that iron & steel are always crucial accounting for 21.3%, next was cement at the second rank with 19.2%, then was sand & brick making up 17.9% each, following is stone with 17.0% and the remaining 6.8% were other materials such as ME materials, finishing materials and so on. The data all are shown in **Table 4.7** and **Figure 4.6**.

**Table 4.7** Type of material are mostly bought (N=200)

| Material type | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Iron and steel | 172 | 21.3 | 21.3 |
| Cement | 155 | 19.2 | 40.4 |
| Sand | 145 | 17.9 | 58.3 |
| Brick | 145 | 17.9 | 76.2 |
| Stone | 138 | 17.0 | 93.2 |
| Others | 55 | 6.8 | 100.0 |
| Total | 810 | 100.0 | |

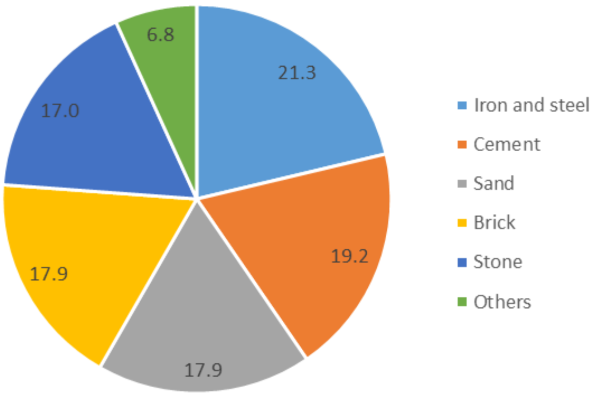


**Figure 4.6** Type of material are mostly bought (N=200)

Next are questions that asked about ordering material, it was said that materials in their project were mainly ordered through company office, making up about 73.1% of respondents, 26.9% of them answered materials were directly ordered at construction site. The data are shown in **Table 4.8** and **Figure 4.7**.

**Table 4.8** Material ordering (N=200)

| Material Ordering from | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Company office | 169 | 73.1 | 73.1 |
| Construction site | 62 | 26.9 | 100.0 |
| Total | 231 | 100.0 | |

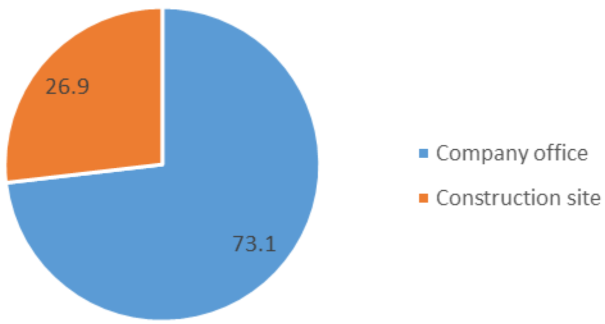


**Figure 4.7** Material ordering (N=200)

In the same way, regarding material transportation, the majority of materials were transported by suppliers with a very high response rate – 87.6%, hiring from company sometimes happens with the rate 12.4%. The data are shown in **Table 4.9** and **Figure 4.8**.

**Table 4.9** Material transportation (N=200)

| Material Transport by | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Supplier | 197 | 87.6 | 87.6 |
| Hiring from company | 28 | 12.4 | 100.0 |
| Total | 225 | 100.0 | |

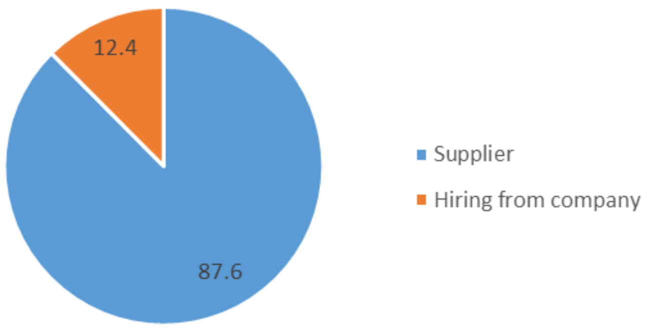


**Figure 4.8** Material transportation (N=200)

Besides, there were about 162 interviewee in 200 describing that their company has been had material control system to support their work, accounting for 81%; the others with 19% corresponding to 38 people said no. Also, 121 respondents in 200 answered that there were additional storages besides the storage at site, making up about 60.5% while the others with 39.5% in proportion to 79 people said no.

Moreover, when asked about how many percent the materials commonly cover the project cost, approximately two-thirds of participants said that materials may represent from 30 – 70% of the project cost and the others commented it depends on types of projects. It proves that the survey data gave the number being pretty much the same with reference papers. On the other hand, working in material procurement department, most of respondents provided that it needs only from 1 to 2 staffs on construction site while about 4 or 5 staffs in office are enough.

### 4.5 Independent Samples T Test

The independent-samples t-test (or independent t-test, in short) compares the means between two unrelated groups on the same continuous, dependent variable. In this study, it was found that there are 43 surveyed participants working at company office and 157 remaining people working at construction sites. Thus, an independent t-test was conducted to determine whether there is a difference in respondents' answers based on their work place (i.e., the dependent variable would be "answers (items)" and the independent variable would be "work place", which has two groups: "construction site" and "company office").

In sum, after analyzing the differences among the answers of both groups in three sections of questionnaire, it was found that there are two cases considered to be various in rating the effectiveness of material management among respondents who work in two separated places in the fourth part of questionnaire, namely C8 – “Construction material quantity comparing to loss ratio of project” and C10 – “Cost control system of material management process”. To be more precise, pertaining to the item C8, there was a significant difference in the scores for construction site (M=3.73, SD=0.756) and company office (M=4.02, SD=0.636) groups; t(77.719) = -2.602, p = 0.011. Similarly, participants from company office group (M=4.14, SD=0.639) scored higher on the item C10 than others from construction site (M=3.83, SD=0.732); t(198) = -2.484, p = 0.014. The data for these two cases are also shown in **Table 4.10**. These results might prove that managers in company office performed quite well with their jobs regarding the cost aspect of material management effectiveness.

**Table 4.10** Independent Samples T Test – item C8 and C10

**Group Statistics**

| | Workplace | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| **C8** | Construction site | 157 | 3.73 | .756 | .060 |
| | Company office | 43 | 4.02 | .636 | .097 |
| **C10** | Construction site | 157 | 3.83 | .732 | .058 |
| | Company office | 43 | 4.14 | .639 | .097 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| **C8** | Equal variances assumed | 6.504 | .012 | -2.357 | 198 | .019 | -.297 | .126 | -.546 | -.049 |
| | Equal variances not assumed | | | -2.602 | 77.719 | .011 | -.297 | .114 | -.525 | -.070 |
| **C10** | Equal variances assumed | .613 | .435 | -2.484 | 198 | .014 | -.305 | .123 | -.547 | -.063 |
| | Equal variances not assumed | | | -2.684 | 75.024 | .009 | -.305 | .114 | -.532 | -.079 |

## 4.6 Influential factors on material management effectiveness

### 4.6.1 Data preparation

This section aims to identify influential factors on material management effectiveness based on respondents' perception which were illustrated from the second part of questionnaire in the survey. It consisted of questions to indicate the strength of importance according to a five-point Likert scale (1 = not at all; 2 = low; 3 = moderate; 4 = high; and 5 = very high). Then, the third part was also built to evaluate the influential factors in actual practice according to a scale description from 1 to 5 (poor; fair; good; very good; excellent) or (hardly ever; occasionally; sometimes; frequently; always). From this point, it could be seen the difference between thoughts and practical situations.

Questionnaires were distributed and then completed by 223 respondents. Some were excluded due to negligent and inappropriate data. After processing data cleaning, the sample size was dropped down to 200. This number was used to represent and analyze the effectiveness of material management, producing a usable response rate of 40% of total distributed questionnaires. It was a low ratio because some respondents thought that any questions related to their projects were private, they felt afraid to answer them. Furthermore, four sections of questionnaire all were implemented at the same time, thus it easily made respondents be tired and lazy to fulfil carefully. Therefore, 200 valid responses which were carefully completed with high cooperation would be employed in this part.

Of these 200 respondents, all of them were male (100%) and had worked as managers in material management starting from less than 5 until more than 20 years of working experience, 6.08 years of working experience in average. The data showed that 77% of the respondents were site manager, deputy site manager, senior engineer (QS), cost control specialist, QA/QC manager, material manager (office), manager for project, coordination (office), 18% were chief supervisor and warehouse manager and only 5% were project manager and deputy project manager. The characteristics of respondents met all conditions as expected, so they could afford to evaluate for the designed questions.

### 4.6.2 Descriptive Factors

To ensure that criteria contain items with reliable scales, Cronbach's alpha coefficient of internal consistency was calculated for scale. Comparing with the acceptable value of Cronbach alpha of 0.60, the result was considered as reliable with the Cronbach alpha value of 0.824 (see in Appendix B).

The various factors together with their means and standard deviations were shown in **Table 4.11** below, then it was also briefly described in **Figure 4.9**. These descriptive statistics were calculated using SPSS Version 22. The importance level of 42 factors were all measured using a 5-point scale. All of mean responses to these factors were quite high, exceeding 3.0. It suggested that they all have considerable impact on the effectiveness of material management. However, the variance was high for all of these factors, above 0.70, showing that the number of respondents either agree or disagree was in the same portion. The highest responses pertained to the third and eighth factor, “Industrial environments” and “Quality control”, asserted that all of managers remarked the strong influence from these factors on their material management. Mean responses of seven remaining factors were not too high but above threshold of average 3.0. It proved that these seven factors also affected material management effectiveness from their opinions. Besides, the importance level of each item in each factor corresponding with its actual practice was also presented in **Table 4.11**.

**Table 4.11** Description about the importance level of factors (N=200)

| Factor | | Perception | | Actual Practice | |
|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Mean | Std. Deviation |
| **PL** | **Planning and handling on site** | **3.797** | **0.875** | **3.735** | **1.041** |
| PL1 | Construction schedule | 4.035 | 0.792 | 3.745 | 0.992 |
| PL2 | Material supply plan | 4.080 | 0.785 | 3.745 | 1.012 |
| PL3 | Material protection during construction | 3.875 | 0.770 | 3.955 | 0.968 |
| PL4 | Material handling on site | 3.925 | 0.783 | 3.750 | 1.031 |
| PL5 | Equipment selection for unloading | 3.340 | 1.044 | 3.445 | 1.210 |
| PL6 | Readiness of design documents | 3.525 | 1.075 | 3.770 | 1.031 |
| **PI** | **Procurement issues** | **3.803** | **0.918** | **3.674** | **1.094** |
| PI1 | Material budget management | 3.970 | 0.789 | 3.690 | 1.034 |
| PI2 | Material quantity takeoff | 3.985 | 0.830 | 3.700 | 1.047 |
| PI3 | Awareness of material types | 3.755 | 1.010 | 3.650 | 1.151 |
| PI4 | Material supervision and control capacity | 4.080 | 0.792 | 3.685 | 1.087 |
| PI5 | Progress of material procurement | 3.985 | 0.836 | 3.675 | 1.056 |
| PI6 | Progress in forwarding information on sizes of materials to be used | 3.635 | 1.052 | 3.640 | 1.112 |
| PI7 | Paperwork preparation for material requisition | 3.465 | 1.060 | 3.690 | 1.049 |
| PI8 | Documentation storage and organization | 3.445 | 1.050 | 3.470 | 1.207 |
| PI9 | Co-ordination between main office and site office | 4.010 | 0.814 | 3.715 | 1.095 |
| PI10 | Co-ordination in construction sites | 3.500 | 1.070 | 3.760 | 1.033 |
| PI11 | Experience and qualification of staff | 3.885 | 0.834 | 3.635 | 1.229 |
| PI12 | Timing in decision making | 3.915 | 0.878 | 3.780 | 1.033 |
| **IE** | **Industrial environments** | **3.985** | **0.796** | **3.700** | **1.066** |
| IE1 | Material status as arriving to the site | 4.060 | 0.787 | 3.675 | 1.102 |
| IE2 | Label, source, quality certification of material | 3.970 | 0.769 | 3.770 | 1.040 |
| IE3 | Availability of material in market | 3.975 | 0.817 | 3.675 | 1.051 |
| IE4 | Adjustment about material demand | 3.935 | 0.821 | 3.665 | 1.048 |
| IE5 | Adjustment about material price | 3.985 | 0.786 | 3.715 | 1.086 |
| **TR** | **Transportation in and out site** | **3.840** | **0.815** | **3.805** | **0.993** |
| TR1 | Delivery of materials to site and install on site | 3.790 | 0.799 | 3.795 | 0.958 |
| TR2 | Delivery date estimation | 3.890 | 0.831 | 3.815 | 1.028 |

**Table 4.11** Description about the importance level of factors (N=200) (Cont.)

| Factor | | Perception | | Actual Practice | |
|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Mean | Std. Deviation |
| **SU** | **Suppliers and manufacturers' issues** | **3.953** | **0.789** | **3.765** | **0.981** |
| SU1 | Supplier/manufacturer selection | 3.865 | 0.806 | 3.720 | 0.962 |
| SU2 | Delivery plan/schedule of manufacturer | 3.985 | 0.811 | 3.750 | 0.965 |
| SU3 | Product quality of manufacturer | 4.010 | 0.750 | 3.825 | 1.015 |
| **CT** | **Contractual issues** | **3.773** | **0.977** | **3.738** | **1.019** |
| CT1 | Material price stipulation | 3.605 | 1.107 | 3.720 | 1.018 |
| CT2 | Payment and inspection conditions | 4.065 | 0.783 | 3.820 | 1.016 |
| CT3 | Adjustment of material specification during construction | 3.650 | 1.041 | 3.675 | 1.022 |
| **SI** | **Site conditions** | **3.824** | **0.888** | **3.668** | **1.058** |
| SI1 | Storage location for transportation, loading/unloading | 3.840 | 0.847 | 3.675 | 1.027 |
| SI2 | Area for material storage space | 3.830 | 0.839 | 3.755 | 1.054 |
| SI3 | Material receiving and placement condition on site | 3.980 | 0.844 | 3.745 | 0.987 |
| SI4 | Checking, reception of material quality on site | 3.875 | 0.850 | 3.695 | 1.008 |
| SI5 | Checking, reception of material quantity on site | 3.915 | 0.837 | 3.700 | 1.066 |
| SI6 | Weather conditions | 3.505 | 1.112 | 3.440 | 1.206 |
| **QC** | **Quality control** | **3.970** | **0.818** | **3.618** | **1.037** |
| QC1 | Certificate of material origin and quality (CO/CQ) | 4.050 | 0.807 | 3.515 | 1.051 |
| QC2 | Regulations about material procurement | 3.955 | 0.822 | 3.680 | 1.026 |
| QC3 | Regulations about material using and installation | 3.905 | 0.824 | 3.660 | 1.034 |
| **SE** | **Security on site** | **3.883** | **0.832** | **3.740** | **1.026** |
| SE1 | Contract with security company | 3.895 | 0.823 | 3.710 | 1.015 |
| SE2 | Site security system | 3.870 | 0.841 | 3.770 | 1.036 |

In the first four groups of influential factors, it was found that "Planning and handling on site" and "Transportation in and out site" were thought as fairly significant and the result in practice was quite the same in which the item PL5 – Equipment selection for unloading should be raised awareness of more importance. Besides, we could see that "Procurement issues" and "Industrial environments" were considered as highly significant while there was a disproportion in their real evaluation. This indicated that some practical approaches need to be additionally improved.



Regarding the last five groups of influential factors, it was clearly seen that only "Contractual issues" was nearly similar in both cases whereas there was a significant disparity between respondents' thinking and practical results with the others, such as "Suppliers and manufacturers' issues", "Site conditions", "Quality control" and "Security on site". It also implied that there have been still some gaps in relation with material management in construction projects.

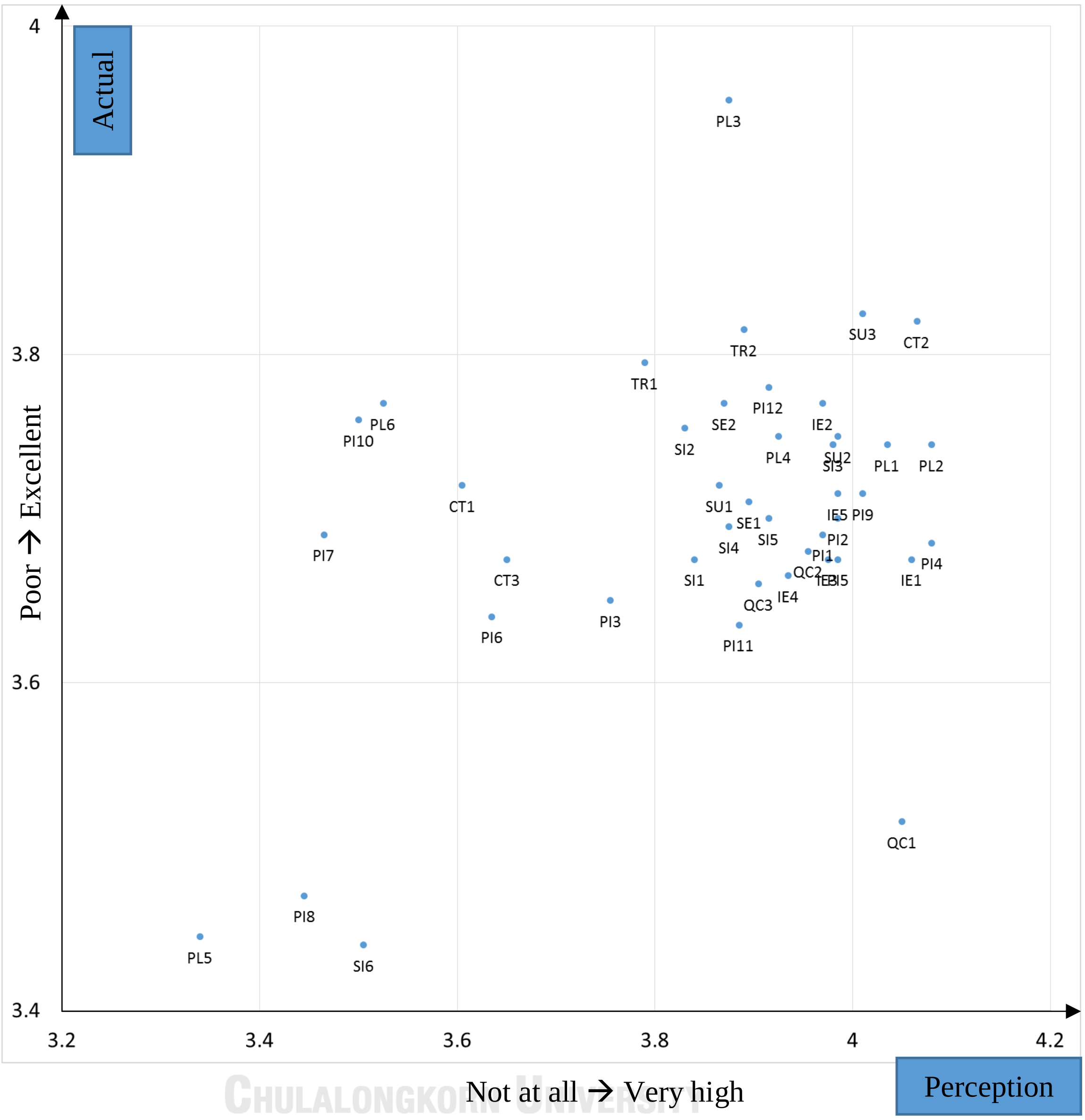




**Figure 4.9** Descriptive factors between perception and actual practice (mean values)

From the figure shown above, it was quite interesting when influential factors were differently considered between respondents' perception and practice. Obviously, a group of three factors PL5 – Equipment selection for unloading, PI8 – Documentation storage and organization and SI6 – Weather conditions, was thought as moderately important and the real practice was well controlled. In addition, the factor QC1 – Certificate of material origin and quality (CO/CQ) was assumed as highly important while the result of practice was just at good level, so it needs to be further deliberate in management. On the other hand, it was observed that other factors, such as IE2 – Label, source, quality certification of material, IE5 – Adjustment about material price, SU2 – Delivery plan/schedule of manufacturer, SI3 – Material receiving and placement condition on site and so on, were highly important while their real status did not reach at excellent level. Thus, there were still some works that need to be more improved.

### 4.7 Analysis of measurement of material management effectiveness

This section depicts the process of data preparation for measuring the effectiveness of material management which could be seen from the fourth section of questionnaire in the survey. As discussed before, material management effectiveness is measured by scoring the items from 0 to 10 in four main criteria of projects such as time, cost, quality and safety. Through respondents' evaluation, we could understand how the effectiveness of material management in their projects was.

#### 4.7.1 Reliability Analysis of Scale

**Table 4.12** Cronbach's alpha for scale of material management effectiveness (N= 200)

| Cronbach's Alpha = 0.731<br>N of Items = 15 | Cronbach's Alpha if Item Deleted |
|---|---|
| Material supply plan | 0.713 |
| Contract signing plan for material procurement | 0.710 |
| Material receiving plan | 0.714 |
| Material payment plan | 0.725 |
| Material installation plan | 0.720 |
| Material inspection and handover plan | 0.713 |
| Material unit price comparing to budget | 0.722 |
| Construction material quantity comparing to loss ratio of project | 0.718 |
| Commitment contract to keep material price according to construction progress | 0.721 |
| Cost control system of material management process | 0.717 |
| Inspection of material specifications compliant to the quality and standard of project | 0.713 |
| Evaluation and control system of material quality from procurement till using | 0.719 |
| Transportation, loading/unloading of material comply with safety and health regulations | 0.728 |
| Security on site related to material storage | 0.707 |
| Work safety procedures regarding material installation | 0.721 |

Again, the fourth section of questionnaire was developed with the intent of measuring the effectiveness of material management. And the measurment criteria were illustrated by four primary items including time, cost, quality and safety. To ensure that criteria contain items with reliable scales, Cronbach's alpha coefficient of internal consistency was calculated for each scale. The results were shown in **Table 4.12** above. Comparing with the acceptable value of Cronbach alpha of 0.60 (Hair, Black et al., 2010), this scale was considered as reliable with the Cronbach alpha value of 0.731. Referring to the column "Alpha if item deleted" in **Table 4.12**, it was suggested that all of these 15 items provided the most reliable scale for measuring material management effectiveness of projects. So we would not remove any items of this scale for further analysis.

### 4.7.2 Material management effectiveness

In this case, respondents were asked to evaluate the effectiveness of material management by using the rating scale (from 0 to 10 points). For each measurement element in each criterion, the numbers selected were scores of material management effectiveness. The average score of each item was demontrated in **Table 4.13**. The total score of all items would indicate the effectiveness of material management in construction projects. Results of descriptive analysis are shown in detail below and the mean score was categorized into intervals as follows: (0.00 – 2.99) Unacceptable; (3.00 – 4.99) Not Satisfactory; (5.00 – 6.99) Cautionary; (7.00 – 8.99) Satisfactory; (9.00 – 10.00) Good.

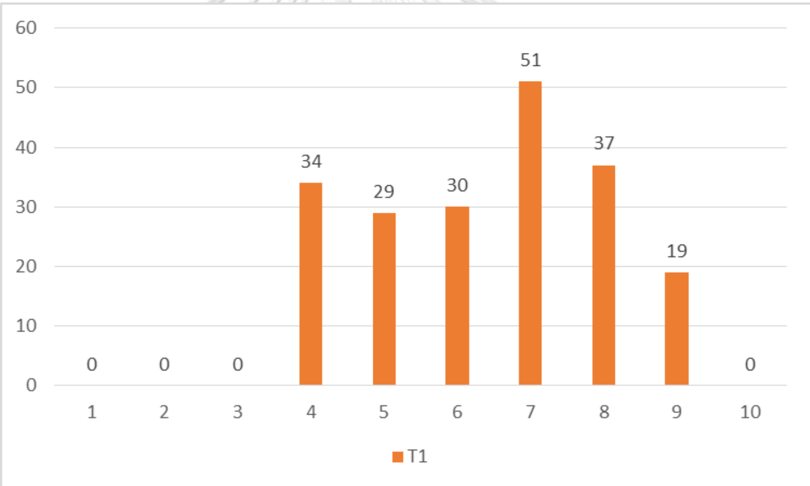


**Figure 4.10** Frequency of Material supply plan, item #1

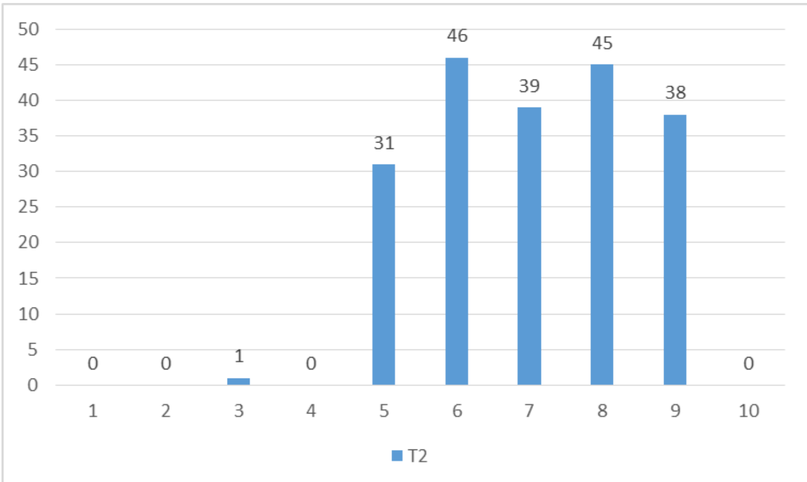


**Figure 4.11** Frequency of Contract signing plan for material procurement, item #2

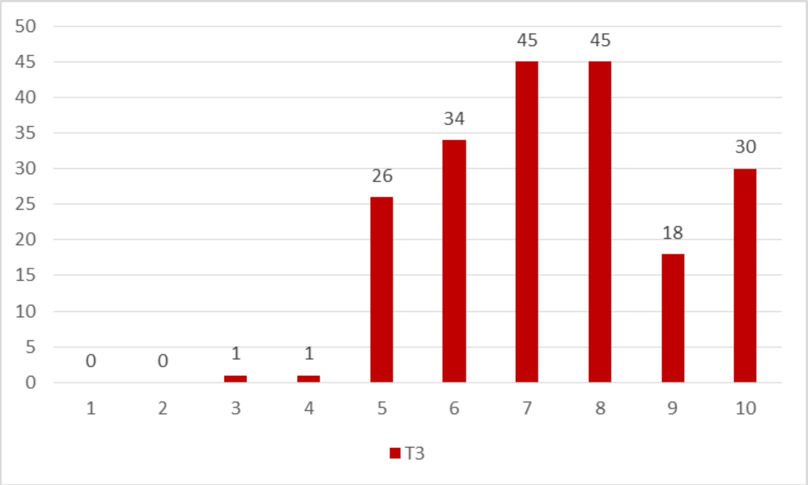


**Figure 4.12** Frequency of Material receiving plan, item #3

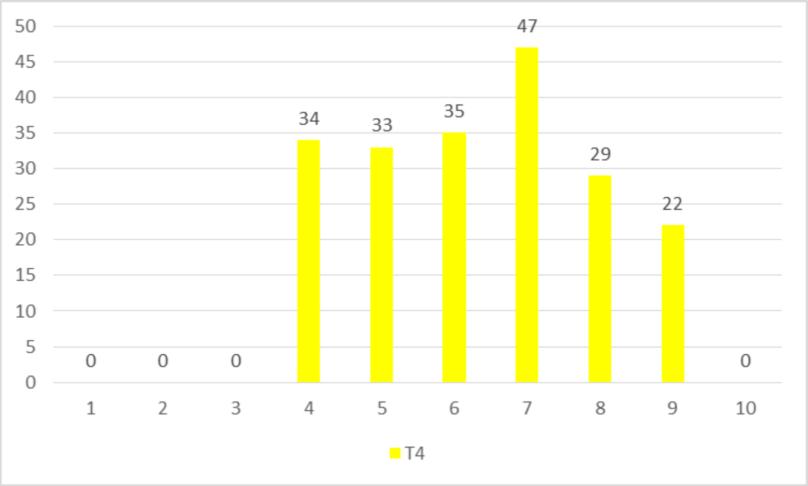


**Figure 4.13** Frequency of Material payment plan, item #4

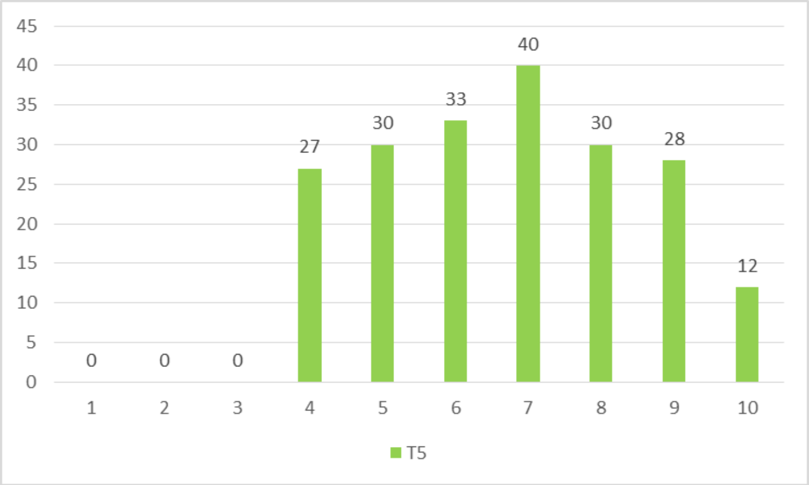


**Figure 4.14** Frequency of Material installation plan, item #5

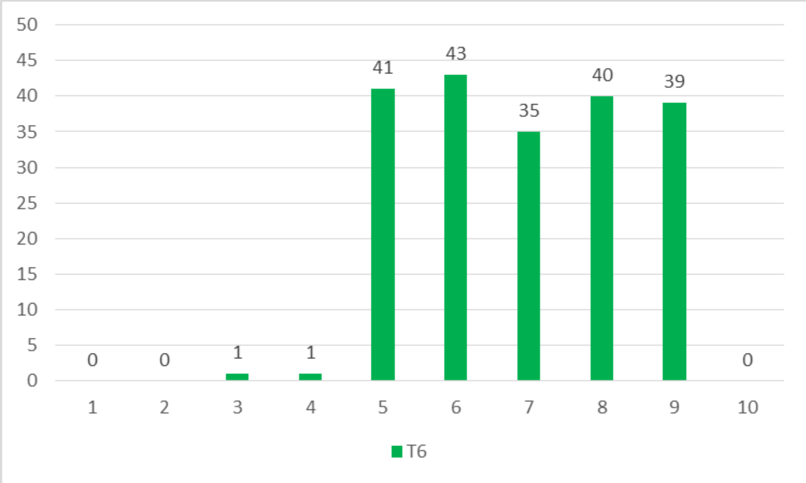


**Figure 4.15** Frequency of Material inspection and handover plan, item #6

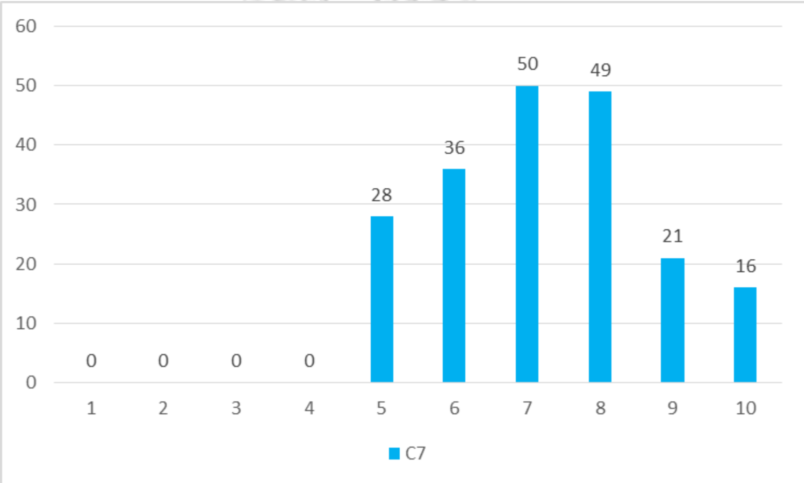


**Figure 4.16** Frequency of Material unit price comparing to budget, item #7

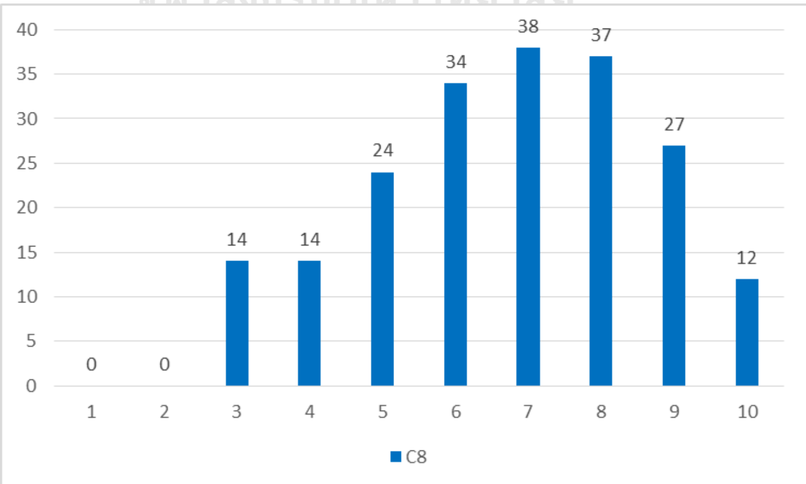


**Figure 4.17** Frequency of Construction material quantity comparing to loss ratio of project, item #8

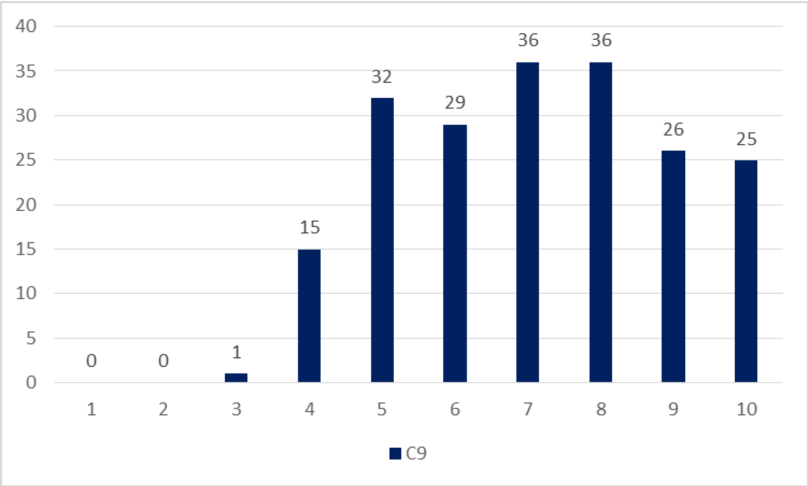


**Figure 4.18** Frequency of Commitment contract to keep material price according to construction progress, item #9

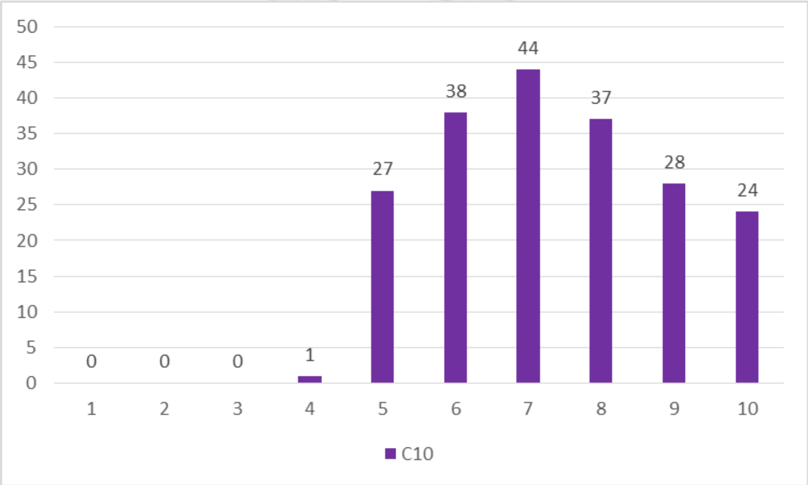


**Figure 4.19** Frequency of Cost control system of material management process, item #10



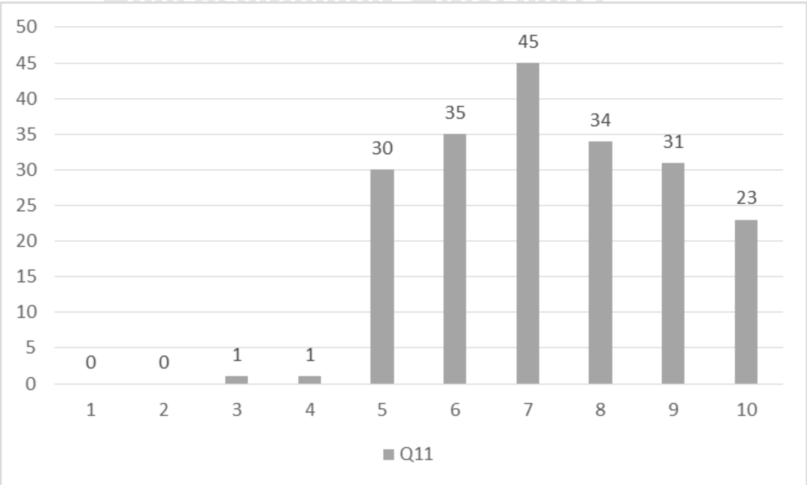


**Figure 4.20** Frequency of Inspection of material specifications compliant to the quality and standard of project, item #11

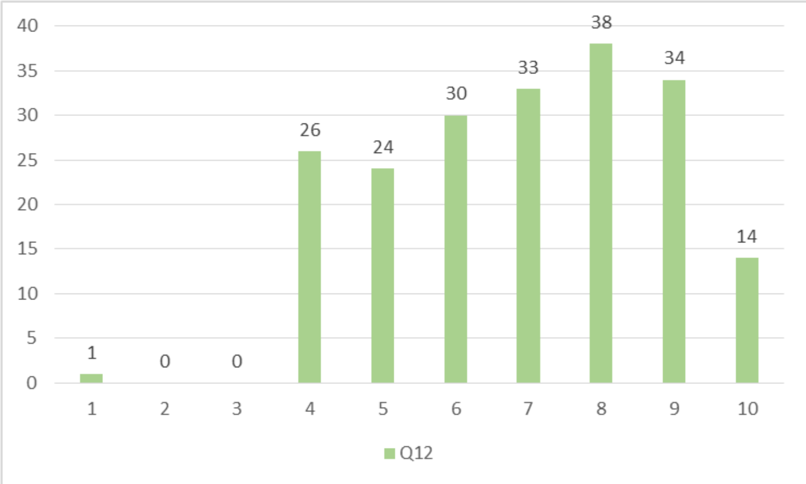


**Figure 4.21** Frequency of Evaluation and control system of material quality from procurement till using, item #12

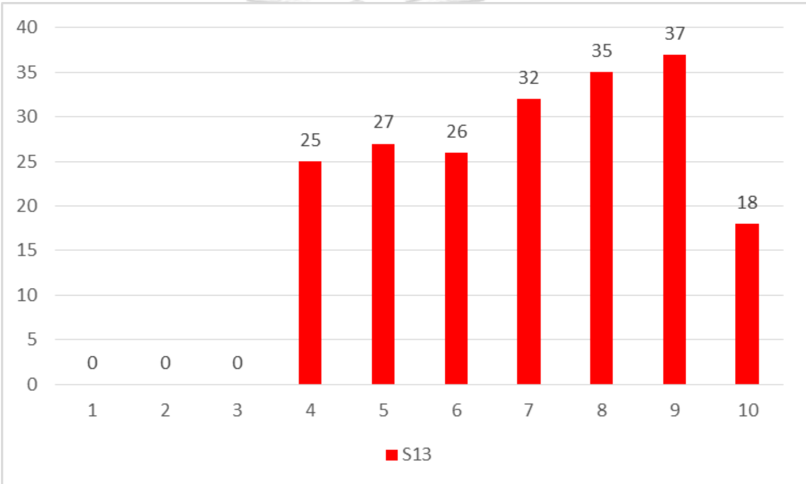


**Figure 4.22** Frequency of Transportation, loading/unloading of material comply with safety and health regulations, item #13

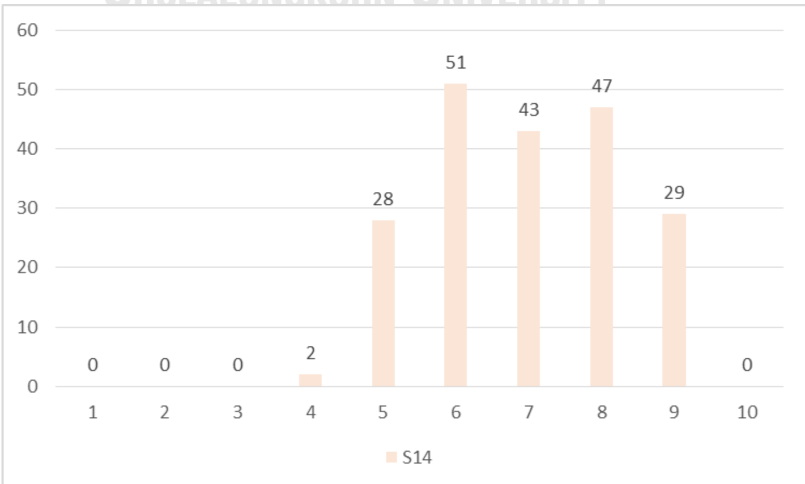


**Figure 4.23** Frequency of Security on site related to material storage, item #14

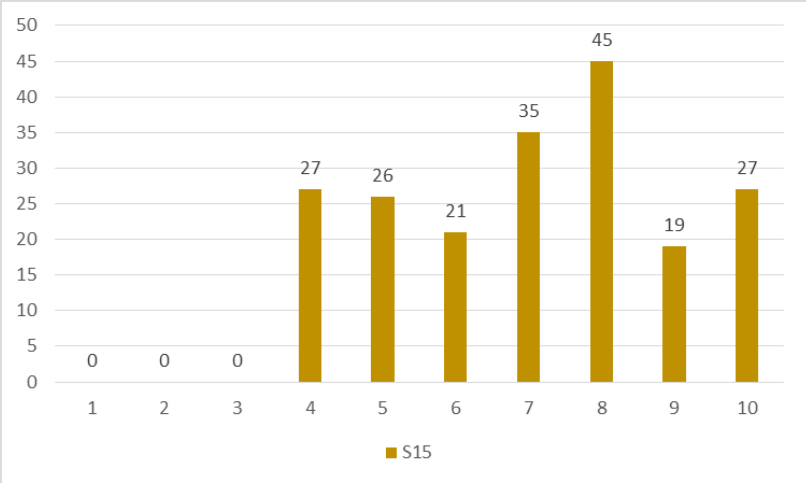


**Figure 4.24** Frequency of Work safety procedures regarding material installation, item #15

According to descriptive results in **Table 4.13**, the analysis of material management effectiveness can be grouped into four groups. In general, they all are around the average level and the average score of each item ranges from 6.35 to 7.39, indicating the effectiveness of material management as well. In addition, the standard deviation among them also dispersed widely (SD=1.314 – 1.917).

The first group includes evaluation criteria related to time of project. It could be seen that some items such as T1 – Material supply plan, T4 – Material payment plan, T5 – Material installation plan, T6 – Material inspection and handover plan were at cautionary level as their mean scores were less than 7.0. In case of T2 – Contract signing plan for material procurement and T3 – Material receiving plan with more than 7.0 in mean scores in which T3 had the highest score observed from total 15 items. So, they got a better trend which showed that these issues were evaluated as satisfactory. Next, the second group is known as evaluation criteria related to cost of project. This group achieved quite good results because three-fourth of them were considered as satisfactory in which 7.11 was the lowest mean score. They were C9 – Commitment contract to keep material price according to construction progress, C7 – Material unit price comparing to budget and C10 – Cost control system of material management process in turn. So, the only remaining item named C8 – Construction material quantity comparing to loss ratio of project should be paid more attention due to its low mean score. Regarding evaluation criteria of quality of project or the third group, their results are obviously divided into two directions. To be more precise, Q11 – Inspection of material specifications compliant to the quality and standard of project was rated with a high mean score of 7.32 or at satisfactory level while the other Q12 – Evaluation and control system of material quality from procurement till using was a bit less than the value of 7.0, it meant that it was still categorized into cautionary level. The last group similarly consists of evaluation criteria related to project safety. It was found that the most cautionary item we should care about was S14 – Security on site related to material storage though its mean score was approximately 7.0. In other words, this might tell that the security problem should be always the first priority on site. Equally important, two remaining issues were S13 – Transportation, loading/ unloading of material comply with safety and health regulations and S15 – Work safety procedures regarding material installation, with mean scores of 7.04 and 7.05 respectively, so they also needed to be developed for further projects.

**Table 4.13** Average score of each item related to material management effectiveness (N=200)

| Item | Minimum | Maximum | Mean | SD. | Rating |
|---|---|---|---|---|---|
| **Time** | | | | | |
| T1 | 4 | 9 | 6.43 | 1.583 | Cautionary |
| T2 | 3 | 9 | 7.05 | 1.387 | Satisfactory |
| T3 | 3 | 10 | 7.39 | 1.616 | Satisfactory |
| T4 | 4 | 9 | 6.35 | 1.594 | Cautionary |
| T5 | 4 | 10 | 6.74 | 1.783 | Cautionary |
| T6 | 3 | 9 | 6.93 | 1.465 | Cautionary |
| **Cost** | | | | | |
| C7 | 5 | 10 | 7.24 | 1.442 | Satisfactory |
| C8 | 3 | 10 | 6.74 | 1.901 | Cautionary |
| C9 | 3 | 10 | 7.11 | 1.836 | Satisfactory |
| C10 | 0 | 10 | 7.32 | 1.661 | Satisfactory |
| **Quality** | | | | | |
| Q11 | 3 | 10 | 7.32 | 1.624 | Satisfactory |
| Q12 | 1 | 10 | 6.93 | 1.869 | Cautionary |
| **Safety** | | | | | |
| S13 | 4 | 10 | 7.04 | 1.880 | Satisfactory |
| S14 | 4 | 9 | 6.96 | 1.314 | Cautionary |
| S15 | 4 | 10 | 7.05 | 1.917 | Satisfactory |



### 4.8 Summary

This chapter has discussed about data collection in detail together with description of respondent profile. The result of pilot study and preparation for large scale study have been firstly given. Then they all were screened to check the appropriateness of proposed analysis tool. Afterthat, the illustration turned to descriptive statistics regarding influential factors on material management effectiveness of construction projects. The outcome indicated some important items in evaluation criteria which need more attention or should be more developed. Typically, the worst issue of effectiveness fell into time for making a payment plan while other items such as time for contract signing plan; transportation, loading/unloading of material comply with safety and health regulations and work safety procedures regarding material installation had to be gradually improved to achieve better ratings.

# Chapter 5

# Explaining model for influential factors on material management effectiveness

This chapter explains the statistical analysis of data which were obtained from targeted participants' survey. Also, it aims to explore groups of factors influencing material management effectiveness of construction projects. To begin with, section 5.1 intend to give an overview of data collected and employed for this chapter. Next will be the process of factor analysis to verify influential factors on material management effectiveness which is explained in detail in section 5.2. Section 5.3 will ultimately establish a model to explain how these factors influence material management effectiveness by using structural equation modeling. It is quite necessary to emphasize that all of information conducted in this chapter are based on respondents' evaluation with their own experience about practical issues as well as indexes of material management.

## 5.1 Descriptive Statistics for Factor Analysis

### 5.1.1 General Survey Details

The research questions were developed with the intent of exploring influential factors on material management effectiveness. The list of variables was presented in the second section among four sections of questionnaire (see in Appendix A). It comprised forty-two statements, which are considered as factors that affect material management effectiveness.

Data were then screened using the complete sample (N = 223) prior to main analyses to examine the accuracy of entry data, missing values as well as fit between distributions and assumptions of appropriate analytical tools. After deleting unusable cases, only 200 responses out of 223 were used for factor analysis. The reliability analysis (Cronbach's alpha) was primarily done on the items to test the internal consistency of the scales. Following that, confirmatory factor analysis would be employed to examine the construct validity of questionnaire.

### 5.1.2 Data Screening

Prior to using the usable sample (N = 200) for analyses, it is so necessary to check for mistake first. So, data were examined for the accuracy of entry data and missing values. The screening process involves a number of steps including checking for the error initially, then finding the error in the data file and correcting them lastly. The accuracy of the data file was checked by proofreading a random sample of 100 of the original data against a computerized list. In addition, the Frequencies and Descriptive Statistic command in SPSS Version 22 was used to detect any out of range values. Finally, it was informed "None were found".

### 5.1.3 Respondent Profile

The details of respondent profile were clearly featured in section 4.4 Respondent Profile of Chapter 4. In summary, of those targeted participants, they all are 100% male and have experience as engineers or managers in the field of material management starting from 1 to more than 20 years of working experience, average 6.08 years of working experience. The data illustrated that 77% of them have been working as site manager, deputy site manager, senior engineer (QS), cost control specialist, QA/QC manager, material manager (office), manager for project, coordination (office); 18% are chief supervisor and warehouse manager; and the remaining 5% are project manager and deputy project manager. The characteristics of respondents possibly meet all conditions as expected, so they are capable of giving the answers that are in harmony with study's goals.

## 5.2 Factor Analysis

As an early step in data analysis, all received responses had to be checked to ensure completeness and readability before processing the data by using the Statistical Package for the Social Sciences (SPSS) version 22. The questionnaire (Appendix A) encompassed 42 variables dealing with influential factors on material management effectiveness. The data were gathered for factor analysis in order to examine the interrelationships among 42 variables and confirm the number of these original variables into a smaller set of factors. It is important to inform this factor analysis is based on actual conditions of construction projects.

The construct validity of scales in the sample (N = 200) was investigated by confirmatory factor analysis of items using Amos program. Though structural equation modeling would be later used, factor analysis was implemented to help refine the measurement model.



### 5.2.1 Overview

Factor analysis, a multivariate statistical technique, involves grouping similar variables into dimensions. This process is used to identify latent variables or constructs. The application of this technique is to reduce many individual items into a fewer number of dimensions or even create new variables as replacements for the original variables while still retaining their original characteristics (Pallant, 2004).

### 5.2.2 Reliability Analysis

Internal consistency reliability is typically estimated using a statistic called Cronbach's alpha, which is the average correlation among all possible pairs of items, adjusting for the number of items. It varies between zero and one. The closer alpha is to one, the greater the internal consistency of the items in the questionnaire.

**Table 5.1** Cronbach's Alpha for each factor scale (N = 200)

| Label | Items of Scale | Cronbach's Alpha | Corrected Item-Total Correlation | Cronbach 's Alpha if Item Deleted |
|---|---|---|---|---|
| **PL** | **Planning and handling on site** | **0.718** | | |
| PL1 | Construction schedule | | 0.573 | 0.643 |
| PL2 | Material supply plan | | 0.575 | 0.642 |
| PL3 | Material protection during construction | | 0.221 | 0.741 |
| PL4 | Material handling on site | | 0.519 | 0.659 |
| PL5 | Equipment selection for unloading | | 0.282 | 0.739 |
| PL6 | Readiness of design documents | | 0.592 | 0.635 |
| **PI** | **Procurement issues** | **0.881** | | |
| PI1 | Material budget management | | 0.591 | 0.871 |
| PI2 | Material quantity takeoff | | 0.697 | 0.865 |
| PI3 | Awareness of material types | | 0.256 | 0.891 |
| PI4 | Material supervision and control capacity | | 0.651 | 0.868 |
| PI5 | Progress of material procurement | | 0.669 | 0.867 |
| PI6 | Progress in forwarding information on sizes of materials to be used | | 0.693 | 0.865 |
| PI7 | Paperwork preparation for material requisition | | 0.653 | 0.868 |
| PI8 | Documentation storage and organization | | 0.298 | 0.889 |
| PI9 | Co-ordination between main office and site office | | 0.658 | 0.867 |
| PI10 | Co-ordination in construction sites | | 0.587 | 0.871 |
| PI11 | Experience and qualification of staff | | 0.662 | 0.867 |
| PI12 | Timing in decision making | | 0.603 | 0.871 |
| **IE** | **Industrial environments** | **0.778** | | |
| IE1 | Material status as arriving to the site | | 0.311 | 0.816 |
| IE2 | Label, source, quality certification of material | | 0.603 | 0.720 |
| IE3 | Availability of material in market | | 0.634 | 0.709 |
| IE4 | Adjustment about material demand | | 0.620 | 0.714 |
| IE5 | Adjustment about material price | | 0.620 | 0.713 |
| **TR** | **Transportation in and out site** | **0.841** | | |
| TR1 | Delivery of materials to site and install on site | | 0.727 | - |
| TR2 | Delivery date estimation | | 0.727 | - |

**Table 5.1** Cronbach's Alpha for each factor scale (N = 200) (Cont.)

| Label | Items of Scale | Cronbach's Alpha | Corrected Item-Total Correlation | Cronbach 's Alpha if Item Deleted |
|---|---|---|---|---|
| **SU** | **Suppliers and manufacturers' issues** | **0.723** | | |
| SU1 | Supplier/manufacturer selection | | 0.550 | 0.628 |
| SU2 | Delivery plan/schedule of manufacturer | | 0.553 | 0.624 |
| SU3 | Product quality of manufacturer | | 0.529 | 0.655 |
| **CT** | **Contractual issues** | **0.868** | | |
| CT1 | Material price stipulation | | 0.759 | 0.805 |
| CT2 | Payment and inspection conditions | | 0.808 | 0.760 |
| CT3 | Adjustment of material specification during construction | | 0.682 | 0.874 |
| **SI** | **Site conditions** | **0.786** | | |
| SI1 | Storage location for transportation, loading/unloading | | 0.560 | 0.748 |
| SI2 | Area for material storage space | | 0.606 | 0.737 |
| SI3 | Material receiving and placement condition on site | | 0.585 | 0.743 |
| SI4 | Checking, reception of material quality on site | | 0.632 | 0.732 |
| SI5 | Checking, reception of material quantity on site | | 0.608 | 0.736 |
| SI6 | Weather conditions | | 0.285 | 0.821 |
| **QC** | **Quality control** | **0.730** | | |
| QC1 | Certificate of material origin and quality (CO/CQ) | | 0.530 | 0.669 |
| QC2 | Regulations about material procurement | | 0.529 | 0.670 |
| QC3 | Regulations about material using and installation | | 0.599 | 0.586 |
| **SE** | **Security on site** | **0.844** | | |
| SE1 | Contract with security company | | 0.730 | - |
| SE2 | Site security system | | 0.730 | - |

As we can see from **Table 5.1** above, the Cronbach's alpha coefficient ranged from 0.718 to 0.881, which are higher than the ideal value of 0.70, indicating adequate internal consistency or the questionnaire is reliable (Pallant, 2004; Hair, Black et al., 2010). In addition, we also should take a look at two last columns to know any items need to be removed.

First, the values in the column labelled *Corrected Item - Total Correlation* tell us how much each item correlates with the overall questionnaire score. So, we are looking for items that do not correlate with the overall score from the scale: if any of these values are less than around 0.30, it indicates that a particular item may not belong on the scale. Items with low correlations may have to be dropped (Andy Field, 2006). Considering this criterion, all of items have item-total correlations approximately 0.30, which is encouraging.

Second, and more importantly, we are interested in the final column in the table *Cronbach's Alpha if Item Deleted*. As the name suggests, this column reflect the change in Cronbach's alpha that would be seen if a particular item were deleted. In other words, they give us the Cronbach's alpha score we would get if we removed each item from the questionnaire (Andy Field, 2006). For example, deleting the item PL3 would increase our Cronbach's alpha score to $\alpha = 0.741$; however, this increase is not dramatic which is similar to other cases. Hence, all of items would be retained.

Finally, a reliability analysis was carried out on the perceived task values scale comprising 42 items. Cronbach's alpha showed the questionnaire to reach acceptable reliability was almost above 0.70. They all appeared to be worthy of retention.

### 5.2.3 Prerequisites for Factor Analysis

Collected data are required to check whether it suits with performing factor analysis. Data testing includes three primary steps involving in checking the adequacy of sample size, assessing the factorability of the correlation matrix, and examining the anti-image correlation matrix (see Appendix B).

To start with checking the adequacy of sample size, factor analysis prefers sample size larger than 100 and at least five times of observations (Hair, Black et al., 2010). In this study, the sample size of observed respondents is 200, with the ratio of 4.76 cases to 1 variable (approximately 5.0) and for the sake of time constraints, it could be acceptable according to the specified limit.

The next phase is assessing the factorability of observations via the correlation matrix of survey. It is suggested the values of correlations should be greater than 0.30 in factor analysis (Hair, Black et al., 2010). Results from the correlation matrix among 42 observations in this research point out more than 20 percent of correlations are higher than 0.30 at a significance level of 0.01.

The last step is known as examining the anti-image correlation matrix. It is said that the diagonals on that specific matrix should have an overall Measure of Sampling Adequacy (MSA) of 0.50 or above (Hair, Black et al., 2010). Besides, the same criterion of MSA applies to the values of individual variables, which should be considered for elimination from further analysis if they are low on this measure (Hair, Black et al., 2010). After excluding the above variables, the MSA test is conducted again to check the revised values for overall and individual MSA. The set of variables gave satisfactory values above 0.50 and were therefore deemed fit for further analysis. Besides, the test of sphericity also reached at statistical significance with Chi-square 1068.692, degree of freedom 783 and a significance level of 0.000. Accordingly, factor analysis was supposed to be relevant.

### 5.2.4 Confirmatory Factor Analysis Process

As a first step, it is necessary to explain the structure of factors conceived from previous researches before carrying out CFA. There are nine groups of factors together with the number of items loaded on each factor that need to be examined and verified here. It was shown with more details in **Figure 5.1** and **Table 5.2** below.

**Component 1:** including variables PI1, PI2, PI3, PI4, PI5, PI6, PI7, PI8, PI9, PI10, PI11 and PI12 → known as "Procurement issues"

**Component 2:** including variables CT1, CT2 and CT3 → known as "Contractual issues"

**Component 3:** including variables IE1, IE2, IE3, IE4 and IE5 → known as "Industrial environments"

**Component 4:** including variables TR1 and TR2 → known as "Transportation in and out site"

**Component 5:** including variables SI1, SI2, SI3, SI4, SI5 and SI6 → known as "Site conditions"

**Component 6:** including variables SE1 and SE2 → known as "Security on site"

**Component 7:** including variables QC1, QC2 and QC3 → known as "Quality control"

**Component 8:** including variables PL1, PL2, PL3, PL4, PL5 and PL6 → known as "Planning and handling on site"

**Component 9:** including variables SU1, SU2 and SU3 → known as "Suppliers and manufacturers' issues"

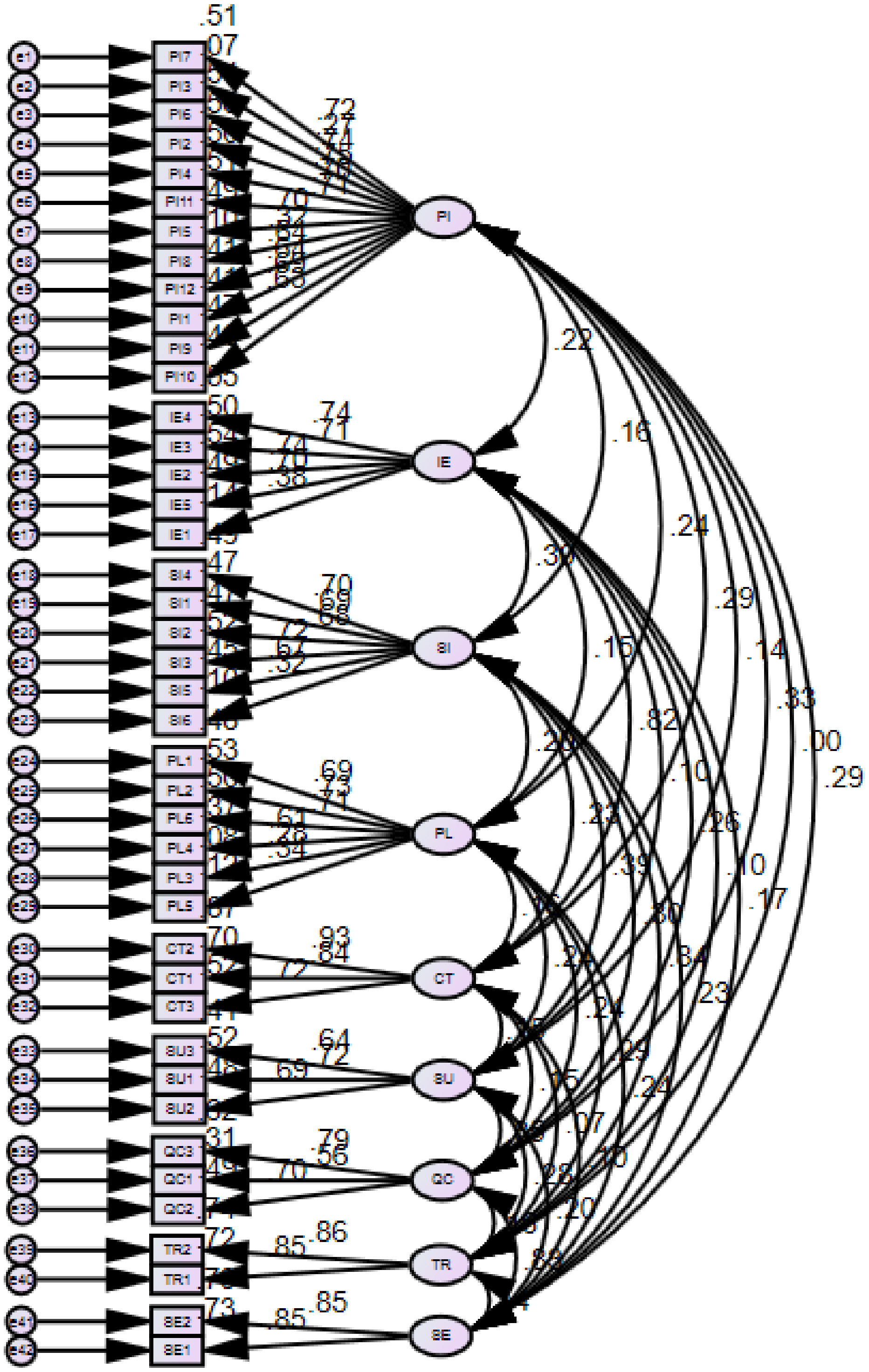


**Figure 5.1** Structure of influential factors on material management effectiveness – Preliminary result

**Table 5.2** Standardized Regression Weights explained for factors influencing material management effectiveness (N =200) – Preliminary result

| Item | PI | SI | PL | IE | CT | QC | SU | TR | SE |
|---|---|---|---|---|---|---|---|---|---|
| PI2 | 0.746 | | | | | | | | |
| PI6 | 0.737 | | | | | | | | |
| PI7 | 0.721 | | | | | | | | |
| PI11 | 0.717 | | | | | | | | |
| PI4 | 0.707 | | | | | | | | |
| PI5 | 0.701 | | | | | | | | |
| PI9 | 0.680 | | | | | | | | |
| PI1 | 0.644 | | | | | | | | |
| PI12 | 0.639 | | | | | | | | |
| PI10 | 0.629 | | | | | | | | |
| SI3 | | 0.721 | | | | | | | |
| SI4 | | 0.694 | | | | | | | |
| SI1 | | 0.693 | | | | | | | |
| SI2 | | 0.684 | | | | | | | |
| SI5 | | 0.663 | | | | | | | |
| PL2 | | | 0.745 | | | | | | |
| PL6 | | | 0.710 | | | | | | |
| PL1 | | | 0.690 | | | | | | |
| PL4 | | | 0.594 | | | | | | |
| IE4 | | | | 0.743 | | | | | |
| IE2 | | | | 0.747 | | | | | |
| IE3 | | | | 0.707 | | | | | |
| IE5 | | | | 0.702 | | | | | |
| CT2 | | | | | 0.932 | | | | |
| CT1 | | | | | 0.835 | | | | |
| CT3 | | | | | 0.723 | | | | |
| QC3 | | | | | | 0.787 | | | |
| QC2 | | | | | | 0.701 | | | |
| QC1 | | | | | | 0.555 | | | |
| SU1 | | | | | | | 0.719 | | |
| SU2 | | | | | | | 0.690 | | |
| SU3 | | | | | | | 0.638 | | |
| TR2 | | | | | | | | 0.863 | |
| TR1 | | | | | | | | 0.843 | |
| SE2 | | | | | | | | | 0.854 |
| SE1 | | | | | | | | | 0.854 |

In addition, it is necessary to find out criteria to cut off some items due to inappropriate factor loadings in factor analysis. Factor loadings are part of the outcome from factor analysis, which serves as a data reduction method designed to explain the correlations between observed variables using a smaller number of factors. According to Hair, Black et al. (2010),

Factors loadings in the range of ±0.30 to ±0.40 – minimal level for interpretation of structure.

Factors loadings around ±0.50 or higher – practically significant.

Additionally, the standard value of the factor loadings should depend on the sample size. For different sample sizes, the weighting factor for observable variables is statistically significant. More detail, we could look at the table below:

**Table 5.3** Guidelines for identifying factor loadings based on sample size

| Factor loading | Sample size needed for significance[a] |
|---|---|
| 0.30 | 350 |
| 0.35 | 250 |
| 0.40 | 200 |
| 0.45 | 150 |
| 0.50 | 120 |
| 0.55 | 100 |
| 0.60 | 85 |
| 0.65 | 70 |
| 0.70 | 60 |
| 0.75 | 50 |

*[a]Significance is based on a 0.05 significance level (α), a power level of 80 percent, and standard errors assumed to be twice those of conventional correlation coefficients*

However, it seems to be quite difficult to remember factor loadings for each sample size. Thus, it is often assumed that the factor loading is 0.45 or 0.5 as standard value with the sample size of 120 to 350 and 0.3 with the sample size of 350 or more. In this study, the value of 0.4 would be selected as the loading that makes the correlations between observed variables and factors more significant. It is observed that most of factors already comply with the criteria for factor loadings given above, reaching satisfactory value – 0.4, except six items such as PI3, PI8, SI6, PL3, PL5 and IE1 (see in Appendix B). It also means that the total number of 42 items right now would be reduced into 36 and kept going on the next run. Afterthat, the whole items were evidently retained with considerable values of factor loadings, almost higher than 0.60. The final results of factor analysis are shown in detail in **Figure 5.2** and **Table 5.4** below.

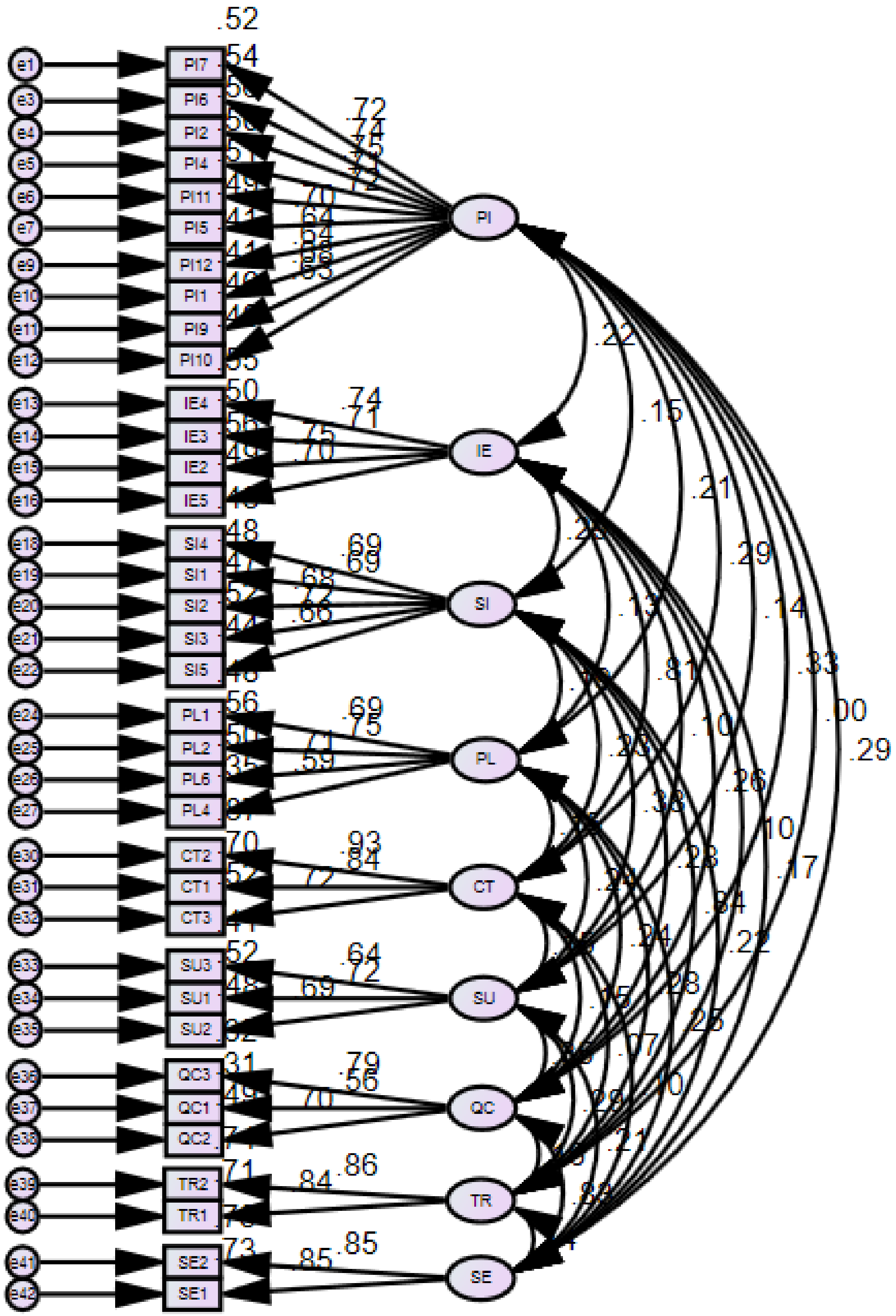


**Figure 5.2** Structure of influential factors on material management effectiveness – Final result

**Table 5.4** Standardized Regression Weights explained for factors influencing material management effectiveness (N =200) – Final result

| Item | PI | SI | PL | IE | CT | QC | SU | TR | SE |
|---|---|---|---|---|---|---|---|---|---|
| PI2 | 0.746 | | | | | | | | |
| PI6 | 0.737 | | | | | | | | |
| PI7 | 0.721 | | | | | | | | |
| PI11 | 0.717 | | | | | | | | |
| PI4 | 0.707 | | | | | | | | |
| PI5 | 0.701 | | | | | | | | |
| PI9 | 0.680 | | | | | | | | |
| PI1 | 0.644 | | | | | | | | |
| PI12 | 0.639 | | | | | | | | |
| PI10 | 0.629 | | | | | | | | |
| SI3 | | 0.721 | | | | | | | |
| SI4 | | 0.694 | | | | | | | |
| SI1 | | 0.693 | | | | | | | |
| SI2 | | 0.684 | | | | | | | |
| SI5 | | 0.663 | | | | | | | |
| PL2 | | | 0.745 | | | | | | |
| PL6 | | | 0.710 | | | | | | |
| PL1 | | | 0.690 | | | | | | |
| PL4 | | | 0.594 | | | | | | |
| IE4 | | | | 0.743 | | | | | |
| IE2 | | | | 0.747 | | | | | |
| IE3 | | | | 0.707 | | | | | |
| IE5 | | | | 0.702 | | | | | |
| CT2 | | | | | 0.932 | | | | |
| CT1 | | | | | 0.835 | | | | |
| CT3 | | | | | 0.723 | | | | |
| QC3 | | | | | | 0.787 | | | |
| QC2 | | | | | | 0.701 | | | |
| QC1 | | | | | | 0.555 | | | |
| SU1 | | | | | | | 0.719 | | |
| SU2 | | | | | | | 0.690 | | |
| SU3 | | | | | | | 0.638 | | |
| TR2 | | | | | | | | 0.863 | |
| TR1 | | | | | | | | 0.843 | |
| SE2 | | | | | | | | | 0.854 |
| SE1 | | | | | | | | | 0.854 |

Besides, the correlation matrix of factor is also displayed in **Table 5.5**. The results showed the strength of the relationship among 9 factors is not high; mostly the correlation did not exceed 0.30.

**Table 5.5** Component Correlation Matrix

| Factors | PI | SI | PL | IE | CT | QC | SU | TR | SE |
|---|---|---|---|---|---|---|---|---|---|
| PI | 1.000 | | | | | | | | |
| SI | 0.164 | 1.000 | | | | | | | |
| PL | 0.236 | 0.204 | 1.000 | | | | | | |
| IE | 0.222 | 0.302 | 0.153 | 1.000 | | | | | |
| CT | 0.291 | 0.229 | 0.162 | 0.824 | 1.000 | | | | |
| QC | 0.326 | 0.296 | 0.241 | 0.258 | 0.151 | 1.000 | | | |
| SU | 0.144 | 0.386 | 0.242 | 0.098 | 0.146 | 0.352 | 1.000 | | |
| TR | 0.002 | 0.838 | 0.293 | 0.098 | 0.073 | 0.161 | 0.283 | 1.000 | |
| SE | 0.293 | 0.229 | 0.244 | 0.173 | 0.102 | 0.826 | 0.205 | 0.145 | 1.000 |

### 5.2.5 Factor Interpretation

From confirmatory factor analysis presented above, there are nine groups of factors that could influence material management in their construction projects. Each of them contains some items which have a strong correlation with their features. They are already named in accordance with the meaning of all items that they can represent. The following section will discuss about the meaning of each factor.

The first factor, “Procurement issues”, comprises ten items. It includes Material budget management, Material quantity takeoff, Material supervision and control capacity, Progress of material procurement, Progress in forwarding information on sizes of materials to be used, Paperwork preparation for material requisition, Co-ordination between main office and site office, Co-ordination in construction sites, Experience and qualification of staff and Timing in decision making. It indicates the degree of manager’s concern about management simply because it strongly affects the effectiveness of their project aspects. The majority of items are very impressive with high factor loadings (≥ 0.60). With such figures, however, recommend that the item “Co-ordination in construction sites” is relatively weak connected with this factor. It is an interesting result as normally the good co-ordination could influence quite highly their management. Besides, the highest factor loading item is “Material quantity takeoff” showing that the important role of quantity takeoff stage initially. They recognized quantity takeoff as an association with management which has to be accurately estimated. This result also stresses the role of quantity takeoff task in creating any achievements in material management. In other words, this finding partly contributes further support to previous researches on material or other fields about the role of management. In addition, project budget need to be carefully managed to ensure for future payments; paperwork preparation for material requisition should be well supervised. This research gives additional evidence about the way that material management could have an indirect impact on certain aspects of projects while managers' activities would directly affect their work performance.

The second factor, "Site conditions", contains five items. This in turn includes Material receiving and placement condition on site; Checking, reception of material quality on site; Storage location for transportation, loading/unloading; Area for material storage space and Checking, reception of material quantity on site. These are associated with conditions on site that are quite significant to ensure the quality and quantity of materials or make materials undamaged. Inspite of the fact that unexpected conditions are difficult to anticipate, some particular preventive measures to cope with some of the bad situations can minimize material deterioration. Further, tests always need to be employed at the time for receiving, this doing not only helps to avoid changes later but also advance the safety or quality of entire construction projects.

The third factor, "Planning and handling on site", comprises four items. It includes Construction schedule, Material supply plan, Readiness of design documents and Material handling on site. As we know, material planning includes planning purchasing work, supply planning, and how material handling should be carried out at the construction site. The planning is a very important process to increase the productivity, profit, and assisting the time to complete the construction projects. The productivity of the construction project will be hanged if the material planning process is not performed properly. Hence, there is no doubt about planning's role during construction in which material supply plan as well as current construction schedule should be carefully paid attention. This is seriously shown in analysis outcome with factor loadings of more than 0.70. Besides, if design documents are occasionally not ready, it is hard to proceed the next tasks or project delays will happen. Disorganized materials on site also could make us waste a lot of time in selection and control process of material types for use in future. Therefore, good and proper material planning and preparation can improve the efficiency and even the safety of the construction operation which may lead to the success of a project including the quality and time consumed in completing the project. To achieve a high performance, the step of material planning can not be eliminated or skipped in order to save the construction time and money.

The fourth factor, "Industrial environments", contains four items. This includes Adjustment about material demand; Availability of material in market; Label, source, quality certification of material and Adjustment about material price that are related to properties of project material. First, we should look at "Adjustment about material demand" and "Label, source, quality certification of material".Sometimes, the amount of necessary materials could vary depending on performing tasks at the construction sites and it is noted that material's label, source and quality should be confirmed when going to the site so that construction progress is ensured as well as not interrupted. The next two items, "Availability of material in market" and "Adjustment about material price" are observed to be greatly associated with these factors, also showing high factor loadings in this group. It is important to make sure about material availability in market; otherwise, it will have a strong effect on the project schedule, managers should be remarked and aware of all such cases. This may express a significant impact on material management effectiveness in practice.

The fifth factor, "Contractual issues", contains three items. This includes Payment and inspection conditions; Material price stipulation and Adjustment of material specification during construction, pertaining to properties of project contract. Generally, this group of items demonstrates the characteristics as well as conditions in material contract that possibly affect material management effectiveness. All of items get relatively large factor loadings (> 0.70). The first and the second rank are "Payment and inspection conditions" and "Material price stipulation". The late payment and unclear provisions of material price maybe restrict the project completion. Clearly, both are highly correlated and there are various unexplained and external reasons relating to payment and clauses of material price. They themselves are also under the pressure to ensure the payment on time more than ever. Next, "Adjustment of material specification during construction" may happen due to some changes regarding some items in contruction process to adapt with unexpected real situations, so everything should be correctly implemented at that time.

The sixth factor, "Quality control", includes three items. It includes Regulations about material using and installation; Regulations about material procurement and Certificate of material origin and quality (CO/CQ). This is one of the most influential factors on material management effectiveness. The first two subfactors with high factor loadings are in connection with rules, it demonstrates a moderate perception of managers about the importance level of compliance with state regulations on the use and installation of construction materials. Materials need to be purchased and used in accordance with the proposed goals and procedures in order to improve fairness in the market as well as the quality of the whole project. More importantly, materials also must be certified in both origin and quality so that material management can be carried out smoothly and quickly.

The seventh factor, "Suppliers and manufacturers' issues", combines again three items which are Product quality of manufacturer, Delivery plan/schedule of manufacturer and Supplier/manufacturer selection. All of them have relatively high factor loadings (> 0.60). In the construction industry, material suppliers, distributors or manufacturers refer to organisations contracted as part of the delivery of material. As a rule, manufacturers can positively or negatively affect the quality of our building materials which is the most concern in material management, so we should be smart in selecting them based on their prestige and relationship got in the construction market. Additionally, we also need to care about their timely deliveries simply because it could represent their reliability level or maybe considered as a key to minimize our inventory, which in turn translates to less risk of inventory obsolescence and lower cash needs.

The eighth factor, “Transportation in and out site”, encompases two major items. They make up quite highly in factor loadings, namely Delivery of materials to site and install on site and Delivery date estimation. Both are obviously in very close relationship, if we make wrong estimation about delivery date of material, material delivery to site is affected by some problems on the path or inappropriate division of materials to install on site, it could cause a bad chain effect to our project planning.

The ninth or the last factor, “Security on site”, similarly consists of two items. It includes Site security system and Contract with security company. According to experts’ opinions, insurers usually see a particularly large number of claims relating to the theft of materials from construction sites. If materials have to be ordered in bulk, these should be stored in a security compound or an area where theft will not be noticed quickly. Surprisingly, they are also proved by getting very high factor loadings – over 0.80. Managers should invest in advanced tools that can closely monitor all activities happening on the site, assisting for future investigation of potential frauds. Thus, site security issues are always put on top priorities.

## 5.3 Structural Equation Modeling (SEM) – AMOS

Structural equation modeling (SEM) is performed to establish a model for explaining material management effectiveness. This technique is applied by using AMOS 20 software. Nine independent variables which are Procurement issues; Site conditions; Planning and handling on site; Industrial environments; Contractual issues; Quality control; Suppliers and manufacturers’ issues; Transportation in and out site; Security on site are explored in turn to know their influence on material management effectiveness as discussed in Chapter 4. With SEM technique, researchers also can find out the complex relationship among several dependent variables and independent variables in multi-layer of linkage at the same time. This research expected to develop a model for explaining complicated relationship between infuential factors and the effectiveness of material management, so SEM is considered as an appropriate tool to apply.

Sample size is a strict requirement in SEM so as to achieve a stability and reliability of the parameter estimates. In SEM, sample size has to exceed fifteen cases per measured variable (Bacon, 2001). Replication with multiple samples would demonstrate the stability of the results, but many times this is not feasible. For one sample analysis, there is no exact rule for the number of participants needed; but fifteen cases per estimated parameter appear to be the general consensus (Bacon, 2001). Because factor analysis could determine the number of variables to nine factors, combined with measured variables of material management effectiveness, a satisfactory ratio of 15:1 cases per measured variable was achieved. Moreover, the developed model also needs to satisfy conditions for a number of statistic criteria. It is shown clearly in **Table 5.6** and **Section 5.3.1** for a complete description of these and their threshold acceptance levels.

### 5.3.1 Goodness-of-fit Measures

Researcher typically uses the following criteria to obtain the statistical significant and substantive meaning of developed model. **Table 5.6** provides a summary on the most common SEM model fit indexes. In adherence to model fit, numerous goodness-of-fit indicators were used to assess the model (Tabachnick and Fidell, 2007; Hair, Black et al., 2010). The more criteria a model satisfies, the better its fit.

**Table 5.6** Cutoff criteria for several fit indexes

| Indexes | Short-hand | General rule for acceptable fit | Recommend |
|---|---|---|---|
| Absolute/predictive fit | | | |
| Chi-square | $\chi^2$ | Ratio of $\chi^2$ to df $\leq 2$ or 3, useful for nested models/model trimming | Used |
| Akaike information criterion | AIC | Smaller the better; good for model comparison (nonnested), not a single model | |
| Browne-Cudeck criterion | BCC | Smaller the better; good for model comparison (nonnested), not a single model | |
| Bayes information criterion | BIC | Smaller the better; good for model comparison (nonnested), not a single model | |
| Consistent AIC | CAIC | Smaller the better; good for model comparison (nonnested), not a single model | |
| Expected cross-validation index | ECVI | Smaller the better; good for model comparison (nonnested), not a single model | |
| Comparative fit | | Comparison to a baseline (independence) or other model | |
| Normal fit index | NFI | >0.95 (Good); > 0.9 (Acceptable) | Used |
| Incremental fit index | IFI | >0.95 (Good); > 0.9 (Acceptable) | |
| Tucker-Lewis index | TLI | >0.95 (Good); > 0.9 (Acceptable) | Used |
| Comparative fit index | CFI | >0.95 (Good); > 0.9 (Acceptable) | Used |
| Relative noncentrality fit index | RNI | Similar to CFI but can be negative, therefore CFI better choice | |
| Parsimonious fit | | | |
| Parsimony-adjusted NFI | PNFI | Very sensitive to model size | |
| Parsimony-adjusted CFI | PCFI | Sensitive to model size | |
| Parsimony-adjusted GFI | PGFI | Closer to 1 the better, though typically lower than other indexes and sensitive to model size | |

**Table 5.6** Cutoff criteria for several fit indexes (Cont.)

| Indexes | Short-hand | General rule for acceptable fit | Recommend |
|---|---|---|---|
| Others | | | |
| Goodness-of-fit index | GFI | >0.95 (Good); > 0.9 (Adequate) | Used |
| Adjusted GFI | AGFI | >0.95 Performance poor in simulation studies | Used |
| Hoelter .05 index | | Critical *N* largest sample size for accepting that model is correct | |
| Hoelter .01 index | | Hoelter suggestion, *N* = 200, better for satisfactory fit | |
| Root mean square residual | RMR | Smaller, the better; 0 indicates perfect fit | |
| Standardized RMR | SRMR | <0.08 | |
| Weighted root mean residual | WRMR | <0.9 | |
| Root mean square error of approximation | RMSEA | < 0.06 to 0.08 with confidence interval | Used |

Some common fit indexes, the Normed Fit Index (NFI), Non-Normed Fit Index (NNFI, also known as TLI), Incremental Fit Index (IFI), Comparative Fit Index (CFI), and root mean square error of approximation (RMSEA), will be used. The following section will report the fit indexes chosen for this study together with the justification for choosing those indexes.

The $\chi 2$ statistic. This statistic is an absolute fit index indicating how well an analysis succeeded in minimizing the discrepancy between the hypothesized covariance matrix and the sample covariance matrix. The smaller the value of $\chi 2$ the better the fit, with zero indicating perfect fit and a value with an associated probability greater than 0.05 indicating acceptable fit (Tabachnick and Fidell, 2007). However, a number of writers have raised concern about the use of this statistic as a test of model fit because of its sensitivity to data that are not multi-variate normally distributed and its tendency to indicate misfit as sample size increases (because of power). Despite these reservations, it has been used here as it allows for comparisons between models, with the $\chi 2$ statistic for the hypothesized model providing a baseline value against which all subsequent tests of invariance can be compared. Moreover, in cross-validation analysis, the $\chi 2$- difference test can be used whereby a non-significant difference between the $\chi 2$ for the calibration sample and the $\chi 2$ for the validation sample indicates no difference between the two models.

The $\chi 2$ /DF ratio. Researchers have addressed some of the limitations of the $\chi 2$ statistic by developing a number of alternative goodness-of-fit indices (Bacon, 2001; Tabachnick and Fidell, 2007). One of these indices is the $\chi 2$ /degrees of freedom ratio (reported as CMIN/DF), an index that is designed to compensate for the tendency of the $\chi 2$ test to reject models when sample sizes are large. As with the $\chi 2$ statistic, this ratio provides an indication of the efficiency of the hypothetical model in reproducing the sample data. Values of 2 or less represent a good fit (Schreiber, Nora et al., 2006).

The Root Mean-Square Error of Approximation Index (RMSEA). The RMSEA takes into account the error of approximation in the population and relaxes the stringent requirement on $\chi 2$ that the model holds exactly in the population. Values of 0.05 or less indicate the hypothetical model is a close fit to the sample data (Schreiber, Nora et al., 2006). However, some authors suggest that models with RMSEA values of 0.08 or less can be accepted (Tabachnick and Fidell, 2007; Hair, Black et al., 2010).

The Tucker-Lewis Index (TLI). This index is an incremental (or comparative) fit index which provides a measure of improvement in fit when the hypothesized model is compared with a more restricted baseline model. TLI is recommended when the maximum likelihood estimation method is used as was the case in this study. TLI should be greater than 0.95 although values greater than 0.9 indicate reasonable fit (Schreiber, Nora et al., 2006). This index can exceed a value of 1 (i.e., it is a non-normed fit index), however, this indicates a lack of parsimony.

The Confirmatory Fit Index (CFI). The CFI is also an incremental fit index and is recommended when data are not multivariate normally distributed, as the CFI shows minimum estimation bias when this is the case. This index is normed with values constrained to fall between 0 and 1. CFI should be greater than 0.95 although values greater than 0.9 indicate reasonable fit (Schreiber, Nora et al., 2006; Hair, Black et al., 2010).

The Goodness-of-fit index (GFI). The GFI is the goodness of fit index, which indicates the proportion of the observed covariances explained by the model-implied covariances. GFI varies from 0 to 1, but theoretically can yield meaningless negative values. By convention, GFI should be equal to or greater than 0.90 to accept the model (Schreiber, Nora et al., 2006).

The Adjusted GFI (AGFI). The AGFI is the adjusted goodness of fit index. This adjustment is to cater for the phenomenon of SEM, whereby more complex models fit the same data better than simpler models. The AGFI takes this accommodation into account by adjusting the GFI value downwards as the number of model parameters increases. AGFI varies from 0 to 1, but theoretically can yield meaningless negative values. AGFI should be at least 0.9 to accept the model (Schreiber, Nora et al., 2006).

The Normed fit index (NFI). The NFI indicates the proportion of improvement of the model relative to a null model that assumes the variables are uncorrelated. NFI ranges from 0 to 1, with value over 0.9 indicative of an acceptable fit of the model to the data, and values close to 1 indicating perfect fit (Schreiber, Nora et al., 2006).

### 5.3.2 Structural Equation Model for Material Management Effectiveness Based on Practical Projects

To prepare for running SEM model, it is necessary to check the reliability scale and then carry out factor analysis of items that would be used for the measurement of material management effectiveness in construction projects. It was shown in section 4 of questionnaire. Regarding rating scale in this part, the researcher used 10-point refered from practical evaluation of construction projects to represent the effectiveness of material management. Theory as well as criteria for analyses were clearly given in **Section 5.2**. However, in order to easily analyze the gathered data, the rating scale was converted into five-point Likert scale that was described as follows:

| *Rating score* | *Converted scale* | *Description* |
|---|---|---|
| 0.00 – 2.00 | 1 | Unacceptable |
| 3.00 – 4.00 | 2 | Not Satisfactory |
| 5.00 – 6.00 | 3 | Cautionary |
| 7.00 – 8.00 | 4 | Satisfactory |
| 9.00 – 10.00 | 5 | Good |

❖ **Reliability Analysis**

**Table 5.7** Cronbach’s Alpha for factor scale measuring material managemet effectiveness (N = 15)

| Label | Items of Scale | Cronbach's Alpha | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| **T** | **TIME** | **0.846** | | |
| T1 | Material supply plan | | 0.582 | 0.829 |
| T2 | Contract signing plan for material procurement | | 0.671 | 0.812 |
| T3 | Material receiving plan | | 0.646 | 0.817 |
| T4 | Material payment plan | | 0.640 | 0.817 |
| T5 | Material installation plan | | 0.648 | 0.816 |
| T6 | Material inspection and handover plan | | 0.571 | 0.831 |
| **C** | **COST** | **0.763** | | |
| C7 | Material unit price comparing to budget | | 0.520 | 0.729 |
| C8 | Construction material quantity comparing to loss ratio of project | | 0.649 | 0.658 |
| C9 | Commitment contract to keep material price according to construction progress | | 0.541 | 0.719 |
| C10 | Cost control system of material management process | | 0.542 | 0.719 |

| Label | Items of Scale | Cronbach's Alpha | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| **Q** | **QUALITY** | **0.743** | | |
| Q11 | Inspection of material specifications compliant to the quality and standard of project | | 0.591 | - |
| Q12 | Evaluation and control system of material quality from procurement till using | | 0.591 | - |
| **S** | **SAFETY** | **0.803** | | |
| S13 | Transportation, loading/unloading of material comply with safety and health regulations | | 0.598 | 0.793 |
| S14 | Security on site related to material storage | | 0.666 | 0.718 |
| S15 | Work safety procedures regarding material installation | | 0.694 | 0.682 |

As we can see from **Table 5.7** above, the Cronbach's alpha coefficients range from 0.743 to 0.846, which are higher than the ideal value of 0.70. Therefore, all of these items would be retained.

❖ **Factor Analysis**

The tested data set of 15 variables resulted in a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.873, which is considered as a very good sign. Another mode of determining the appropriateness of factor analysis is the Bartlett test of sphericity. The analysis of Bartlett test of sphericity reached at statistical significance with Chi-square 1098.052, degree of freedom 105 and a significance level of 0.000. In addition, the result also demonstrated a cumulative percentage of variance of 64%. Accordingly, factor analysis was supposed to be totally relevant.

Next, the whole items were obviously retained with considerable values of factor loadings, higher than 0.50. The final results of factor analysis are shown in detail in **Table 5.9** below. Moreover, the correlation matrix of factor was also displayed in **Table 5.8**. The results showed the strength of the relationship among 4 factors was extremely high; most of them exceeded the value of 0.30. Thus, the assumption underlying the use of varimax rotation is satisfied.

**Table 5.8** Factor Correlation Matrix of measurement

| Factor | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 1.000 | | | |
| 2 | 0.258 | 1.000 | | |
| 3 | -0.453 | -0.324 | 1.000 | |
| 4 | 0.315 | 0.240 | -0.323 | 1.000 |

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

**Table 5.9** Pattern Matrix, Eigenvalues, Percentage of Variance explained for factors measuring material managemet effectiveness (N = 15)

| Item | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| T4 | 0.762 | | | |
| T2 | 0.745 | | | |
| T5 | 0.738 | | | |
| T3 | 0.727 | | | |
| T1 | 0.686 | | | |
| T6 | 0.624 | | | |
| C8 | | 0.766 | | |
| C7 | | 0.719 | | |
| C9 | | 0.684 | | |
| C10 | | 0.651 | | |
| S15 | | | 0.866 | |
| S14 | | | 0.828 | |
| S13 | | | 0.761 | |
| Q12 | | | | 0.843 |
| Q11 | | | | 0.796 |
| Eigenvalues | 5.477 | 1.835 | 1.227 | 1.066 |
| Percentage of Variance Explained | 36.513 | 12.235 | 8.179 | 7.104 |

Extraction Method: Principal Component Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

❖ **Structural Equation Model**

Structural model was undertaken using the SEM technique to uncover the significant inter-relationships between the factors retained from EFA in **Section 5.2**. The conceptual model was described in **Figure 5.3**. Nine constructs related to influential factors on material management effectiveness which were explored from factor analysis, and another four constructs represented for material management effectiveness were illustrated in this model. The details of each observed indicators were depicted in **Table 5.10**.

In order to achieve a higher Goodness-of-Fit model, some links between errors were sequentially added based on the result from Modification Indices (MI). The final notable model which was described in **Figure 5.4** was the optimum model that achieved most of criteria for several fit indexes without too complicated relationship.

**Table 5.10** Observed indicators used in practice model explaining factors influencing material management effectiveness

| Construct | Variable | Scale | Item |
|---|---|---|---|
| Procurement issues (PI) | Material budget management | 1-5 (Poor-Excellent) | PI1 |
| | Material quantity takeoff | | PI2 |
| | Awareness of material types | | PI3 |
| | Material supervision and control capacity | | PI4 |
| | Progress of material procurement | | PI5 |
| | Progress in forwarding information on sizes of materials to be used | | PI6 |
| | Paperwork preparation for material requisition | | PI7 |
| | Documentation storage and organization | | PI8 |
| | Co-ordination between main office and site office | | PI9 |
| | Co-ordination in construction sites | | PI10 |
| | Experience and qualification of staff | 1-5 (<2 years->=5 years) | PI11 |
| | Timing in decision making | 1-5 (Hardly ever-Always) | PI12 |
| Site conditions (SI) | Storage location for transportation, loading/unloading | 1-5 (Poor-Excellent) | SI1 |
| | Area for material storage space | | SI2 |
| | Material receiving and placement condition on site | | SI3 |
| | Checking, reception of material quality on site | | SI4 |
| | Checking, reception of material quantity on site | | SI5 |
| | Weather conditions | | SI6 |
| Planning and handling on site (PL) | Construction schedule | 1-5 (Poor-Excellent) | PL1 |
| | Material supply plan | | PL2 |
| | Material protection during construction | | PL3 |
| | Material handling on site | | PL4 |
| | Equipment selection for unloading | | PL5 |
| | Readiness of design documents | | PL6 |

**Table 5.10** Observed indicators used in practice model explaining factors influencing material management effectiveness (Cont.)

| Construct | Variable | Scale | Item |
|---|---|---|---|
| Industrial environments (IE) | Material status as arriving to the site | 1-5 (Poor-Excellent) | IE1 |
| | Label, source, quality certification of material | | IE2 |
| | Availability of material in market | 1-5 (Hardly ever-Always) | IE3 |
| | Adjustment about material demand | 1-5 (Always-Hardly ever) | IE4 |
| | Adjustment about material price | | IE5 |
| Contractual issues (CT) | Material price stipulation | 1-5 (Poor-Excellent) | CT1 |
| | Payment and inspection conditions | | CT2 |
| | Adjustment of material specification during construction | 1-5 (Always-Hardly ever) | CT3 |
| Quality control (QC) | Certificate of material origin and quality (CO/CQ) | 1-5 (Poor-Excellent) | QC1 |
| | Regulations about material procurement | | QC2 |
| | Regulations about material using and installation | | QC3 |
| Suppliers and manufacturers' issues (SU) | Supplier/manufacturer selection | 1-5 (Poor-Excellent) | SU1 |
| | Delivery plan/schedule of manufacturer | | SU2 |
| | Product quality of manufacturer | | SU3 |
| Transportation in and out site (TR) | Delivery of materials to site and install on site | 1-5 (Poor-Excellent) | TR1 |
| | Delivery date estimation | | TR2 |
| Security on site (SE) | Contract with security company | 1-5 (Poor-Excellent) | SE1 |
| | Site security system | | SE2 |
| TIME | Evaluation criteria related to time | 0-10 (Unacceptable - Good) | T1-T6 |
| COST | Evaluation criteria related to cost | | C7-C10 |
| QUALITY | Evaluation criteria related to quality | | Q11-Q12 |
| SAFETY | Evaluation criteria related to safety | | S13-S15 |

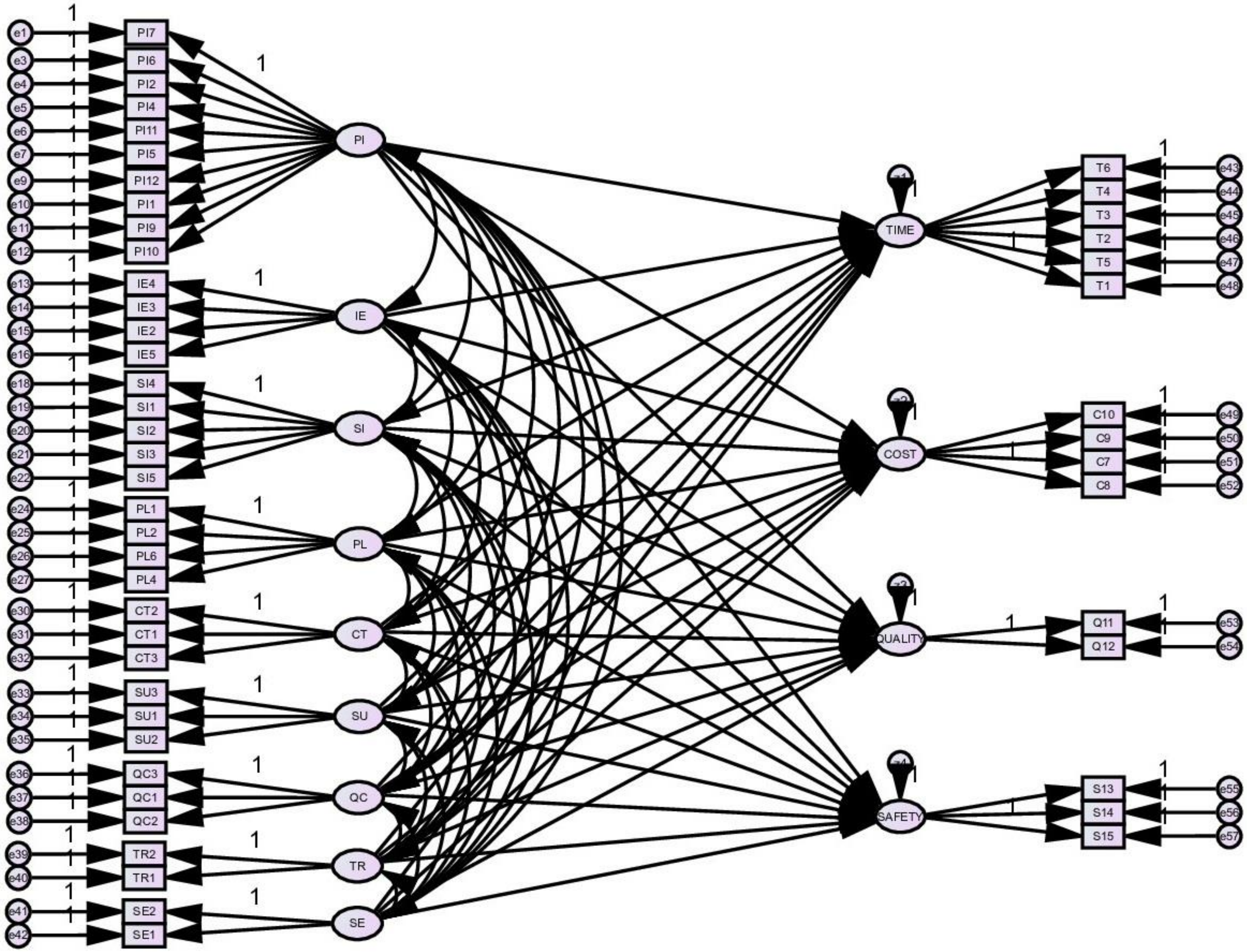


**Figure 5.3** Conceptual model for explaining influential factors

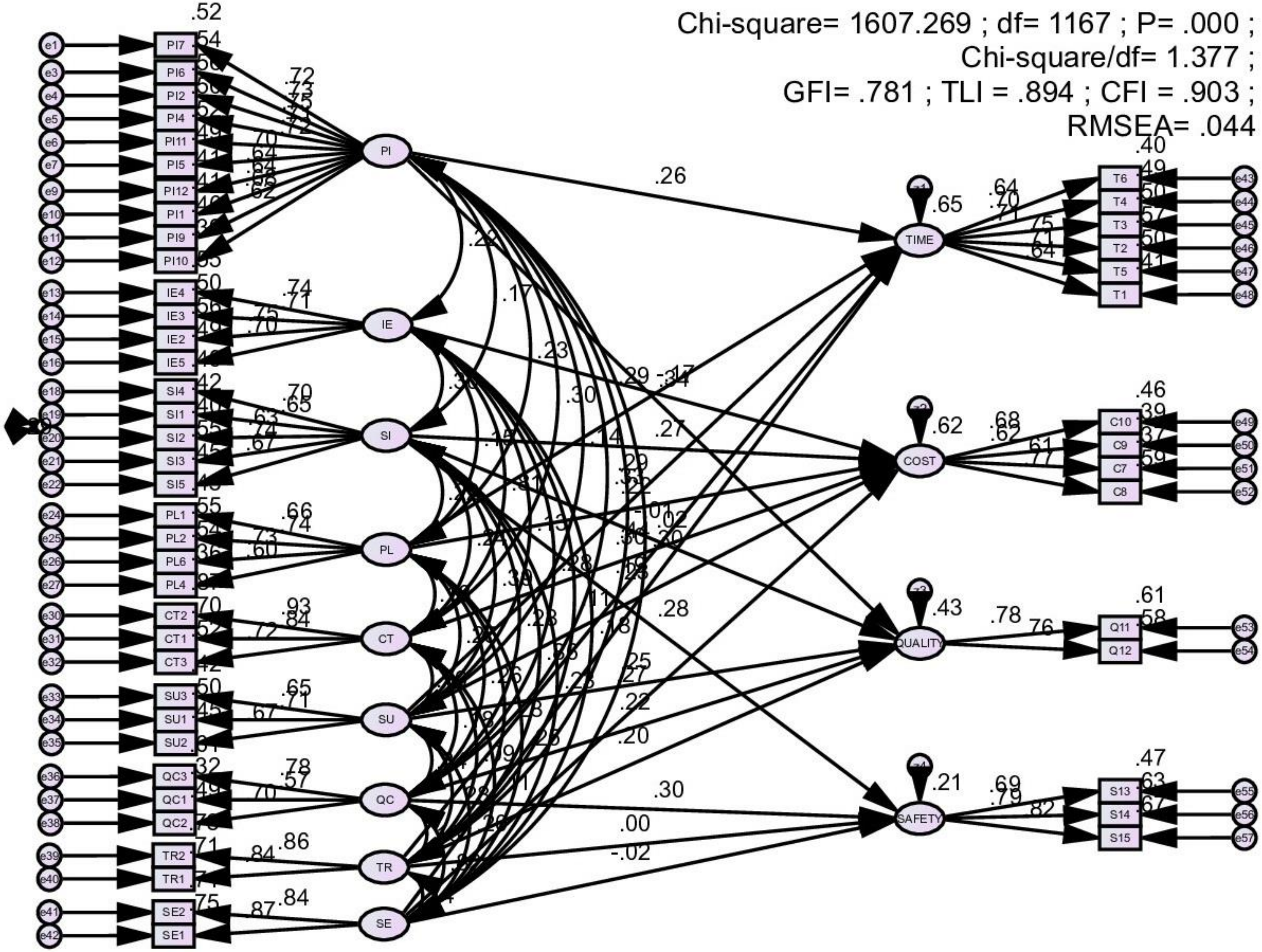


**Figure 5.4** Final model for explaining influential factors

### 5.3.3 Assessment and Results of SEM

From the analysis, it was found that “Procurement issues”s influence on cost and safety criteria; “Site conditions”s influence on time criterion; “Planning and handling on site”s influence on quality and safety criteria; “Industrial environments” and “Contractual issues”s influence on time, quality and safety criteria; “Quality control”s influence on time and cost criteria; “Suppliers and manufacturers’ issues”s influence on safety criterion; “Transportation in and out site”s influence on cost criterion and “Security on site”s influence on quality criterion did not appear in the final model. It did not conflict with the result of CFA and was not hard to understand. Even though these nine factors existed as important factors but they did not have significant statistics due to large p-value (> 0.05) indicated from SEM results. The remaining factors had significant influence on the effectiveness of material management as shown in **Figure 5.4**. In addition, scatter plots between the nine groups of factors were conducted to ensure that a linear trend would best represent (i.e. the highest R2 fit) for their relationship. This model has the following fit coefficients: CMIN/DF = 1.377; RMSEA = 0.044; GFI = 0.781; AGFI = 0.752; NFI = 0.724; CFI = 0.903; and TLI = 0.894, comparing with the critical value are shown in **Table 5.11**. The final model satisfied more than 50% of critical standards and above the threshold of almost important standards. Therefore, it could be concluded that the model has been suitable and could continue to analyze the outcome of the causal effects.

**Figure 5.4** provided the results of testing the structural links of the proposed research model using AMOS program. The estimated path coefficients (standardized) were given. All path coefficients could be considered as valid at the 95% significance level providing the support for twenty relationships. These results represented were explaining factors’ influence on the effectiveness of material management. The effects of criteria in material management effectiveness and nine existing groups of factors (Procurement issues, Site conditions, Planning and handling on site, Industrial environments, Contractual issues, Quality control, Suppliers and manufacturers’ issues, Transportation in and out site, Security on site) accounted for 33% of the variance in each variable of material management effectiveness. This is an indication of the good explanatory power of the model to measure the effectiveness of material management.

In total, structural equations explained the twenty causal relationships (paths) which existed between the nine enablers and four outcome factors, shown in **Figure 5.5**. A summary of the developed structural equations, path coefficients and significance levels was provided in **Table 5.12**, for more details, authors demonstrated in Appendix C. The following section will discuss about the practical implications of each structural equation and its’ associated predictor variables.

**Table 5.11** Goodness of Fit Indexes for Practical Model

| Indexes | General rule for acceptable fit | Final Model | Comment |
|---|---|---|---|
| $\chi^2 / df$ | Ratio of $\chi^2$ to df ≤ 2 or 3, useful for nested Models/model trimming | 1.377 | Good |
| NFI | >0.95 (Good); > 0.9 (Acceptable) | 0.724 | Not Acceptable |
| TLI | >0.95 (Good); > 0.9 (Acceptable) | 0.894 □ 0.9 | Acceptable |
| CFI | >0.95 (Good); > 0.9 (Acceptable) | 0.903 □ 0.9 | Acceptable |
| GFI | >0.95 (Good); > 0.9 (Acceptable) | 0.781 | Not Acceptable |
| AGFI | >0.95 Performance poor in simulation studies | 0.752 | Not Acceptable |
| RMSEA | < 0.06 to 0.08 with confidence interval | 0.044 | Good Fit |

**Table 5.12** Path coefficients and structural equations

| Path | Estimate Standardized | Estimate Un-stand | S.E | C.R. | P |
|---|---|---|---|---|---|
| PL→TIME | 0.283 | 0.186 | 0.052 | 3.604 | *** |
| TR→TIME | 0.303 | 0.150 | 0.036 | 4.191 | *** |
| SU→TIME | 0.289 | 0.189 | 0.053 | 3.596 | *** |
| PI→TIME | 0.254 | 0.147 | 0.040 | 3.654 | *** |
| SE→TIME | 0.194 | 0.096 | 0.034 | 2.840 | ** |
| IE→COST | 0.200 | 0.147 | 0.118 | 1.243 | 0.014 |
| CT→COST | 0.463 | 0.279 | 0.093 | 2.991 | ** |
| SU→COST | 0.221 | 0.191 | 0.076 | 2.500 | 0.012 |
| PL→COST | 0.239 | 0.207 | 0.068 | 3.023 | ** |
| SE→COST | 0.270 | 0.176 | 0.049 | 3.604 | *** |
| SI→COST | 0.263 | 0.211 | 0.067 | 3.137 | ** |
| PI→QUALITY | 0.344 | 0.270 | 0.073 | 3.725 | *** |
| SU→QUALITY | 0.258 | 0.231 | 0.091 | 2.533 | 0.011 |
| QC→QUALITY | 0.221 | 0.161 | 0.068 | 2.347 | 0.019 |
| SI→QUALITY | 0.037 | 0.031 | 0.188 | 0.163 | 0.047 |
| TR→QUALITY | 0.252 | 0.170 | 0.142 | 1.200 | 0.023 |
| TR→SAFETY | 0.320 | 0.255 | 0.161 | 1.582 | 0.014 |
| SI→SAFETY | 0.280 | 0.210 | 0.137 | 0.154 | 0.038 |
| SE→SAFETY | 0.209 | 0.190 | 0.194 | 0.982 | 0.026 |
| QC→SAFETY | 0.073 | 0.054 | 0.150 | 0.362 | 0.017 |

(***) P < 0.001; (**) P < 0.01

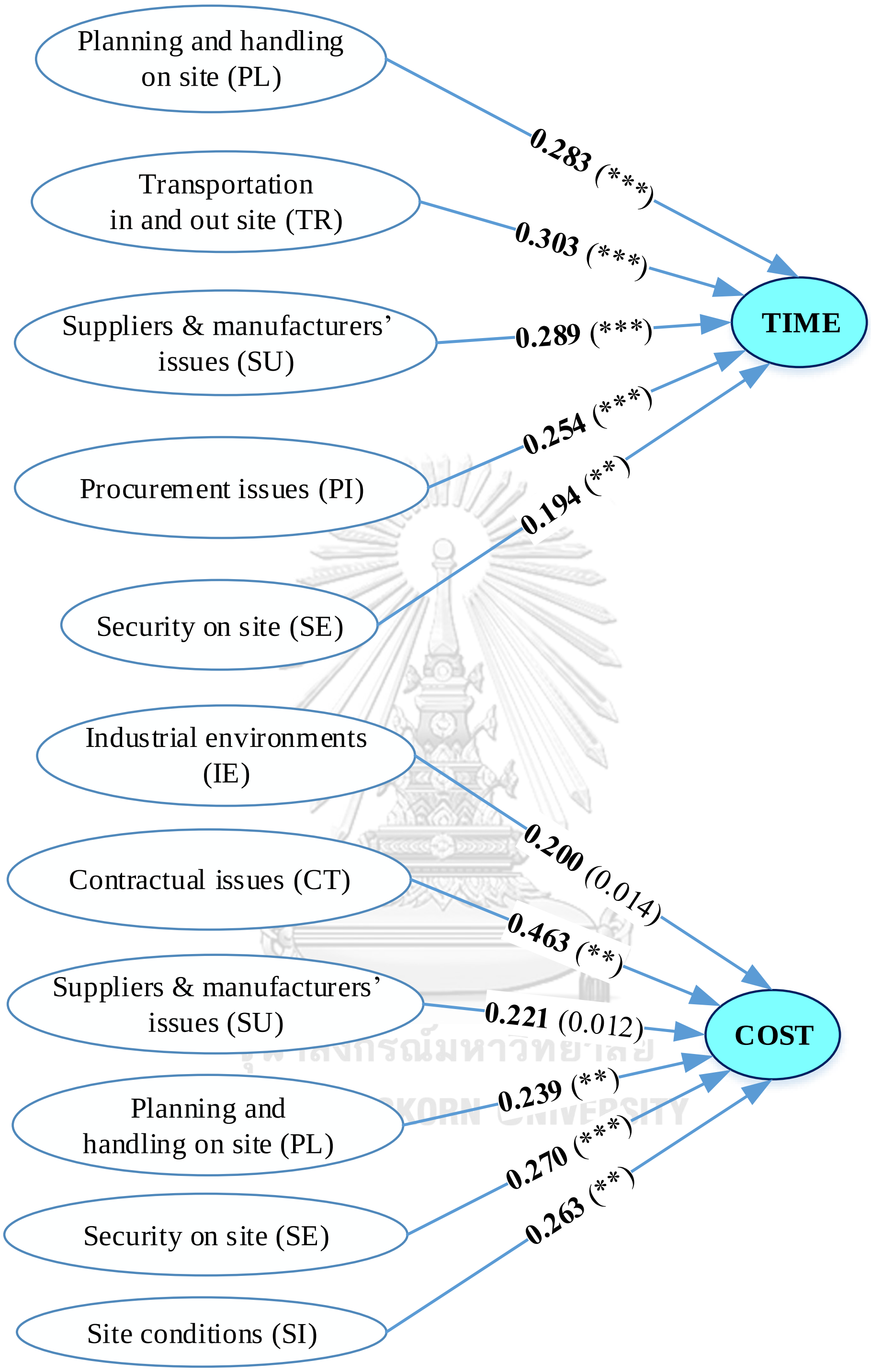


**Figure 5.5** Path practice model for explaining influential factors on material management effectiveness

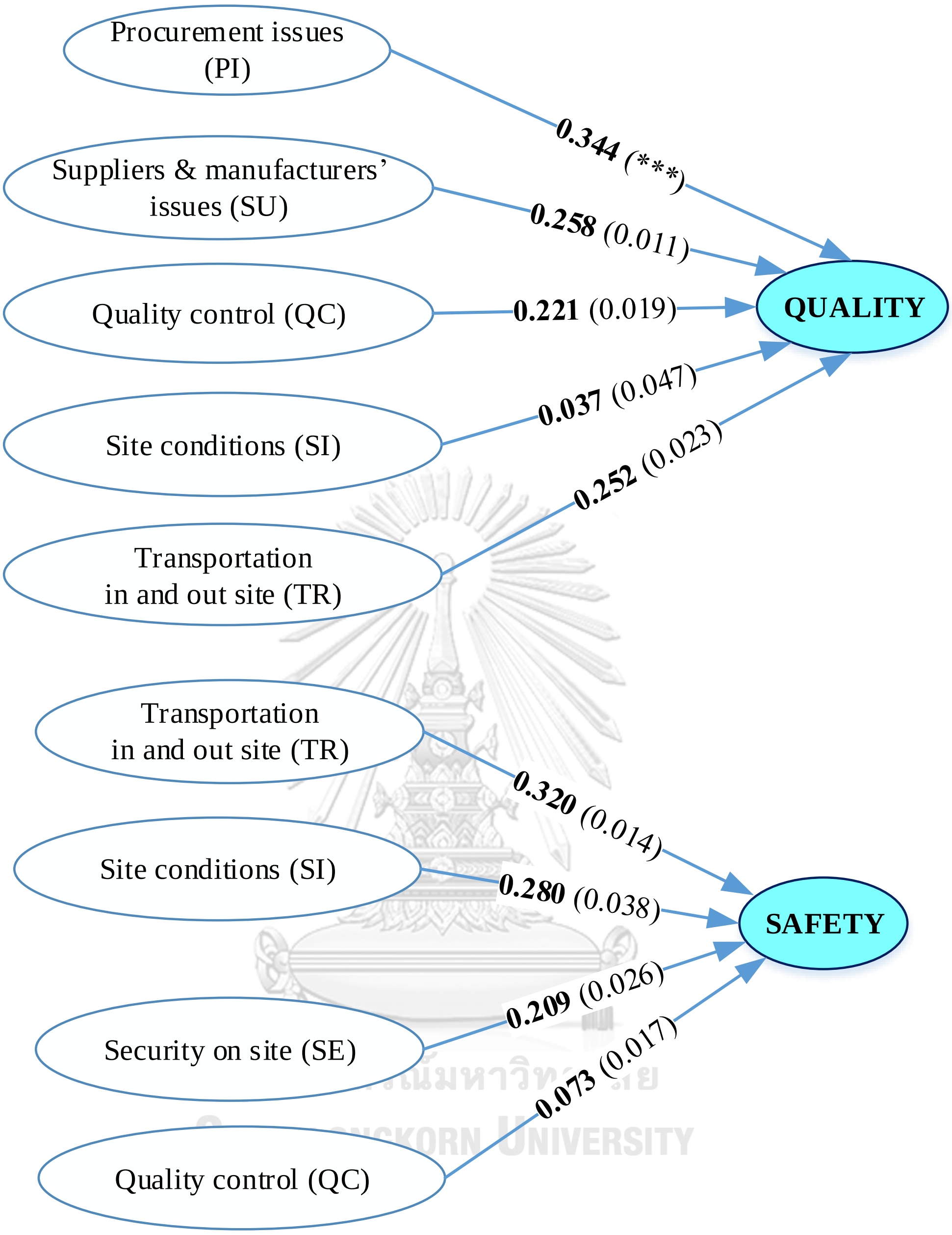


**Figure 5.5** Path practice model for explaining influential factors on material management effectiveness (Cont.)

As we can see from the SEM results in **Table 5.12** and the path practice model in **Figure 5.5**, each of project criteria had been positively affected by various factors with different levels which has been in line with forecasts. In general, statistical report is totally expressing the result less than 95% at a significant level. It helps to achieve a fairly accurate view about influential factors on material management effectiveness.

Firstly, in terms of time aspect, this criterion seems to be quite sensitive in construction as all survey factors have an effect on it. For instance, “Transportation in and out site” has the most influence on the time criterion ($\beta = 0.303, p = 0.000$). Delayed receipt of materials will result in wastage of the time required to complete the project. Another mistake involves in estimating the wrong date of material receiving, which can be caused by inexperienced people or simply being negligent in their work. Next, “Suppliers and manufacturers’ issues” and “Planning and handling on site” are observed at the second and third rank about the influence level ( $\beta = 0.289, p = 0.000$ and $\beta = 0.283, p = 0.004$, respectively). It could be explained that the duration of projects may be affected by the supplier or manufacturer because sometimes we really need that type of material but in fact it is unavailable or reversely, their distribution is delayed in some bad situations. In addition, as mentioned before, the construction schedule should be revised as frequently as possible in order to monitor whether work is progressing as planned. In other words, it is absolutely pivotal to keep accurate track of the materials needs of the project. Furthermore, some other fators also observed to have an actual impact on the time criterion are associated with “Procurement issues” and “Security on site” (in turn, $\beta = 0.254, p = 0.000$; $\beta = 0.194, p = 0.005$). It is clear that if the investment budget for the material purchase is lost, coordination among stakeholders is inconsistent, poor working experience or delays in making important decisions in work can make the progress of project affected. Besides, loss of materials due to poor security system sometimes also impede the project time to finish.

Secondly, project success is possibly decided by how well the project cost has been handled in the project and material plays an imperative role in that. In this study, regarding cost aspect, there are six major influential factors in which “Contractual issues” is the most noticeable factor ($\beta = 0.463, p = 0.003$). The stipulation of material prices need to be transparent between two parties and the adjustment of material technical specifications must go hand in hand with a reasonable consideration of material prices. Next, “Security on site” and “Site conditions” also affect the cost criterion but in a slightly lesser level (in turn, $\beta = 0.270, p = 0.000$ and $\beta = 0.263, p = 0.002$). These two groups are quite similar. Materials should be stored attentively on site; otherwise, when they were lost and then we have to spend a considerable amount of money to repeat the procurement process to ensure that the project progress is still on schedule. Besides, the location of materials should be appropriately arranged and when arriving to the site, they should be strictly checked in the quantity and quality to avoid spending to master undesired damages. Factors with minor influence but no less important matter to take into consideration are “Planning and handling on site” ($\beta = 0.239, p = 0.003$) and “Suppliers and manufacturers’ issues” ($\beta = 0.221, p = 0.012$). This shows that planning the right materials in each item along with a clear construction schedule can help to estimate the project cost more smoothly and accurately. In addition, the selection of a reputable material supplier or manufacturer, which has a long-term relationship with reasonable price, will greatly contribute to the reduction of unexpected costs. The factor found to have the least influence is "Industrial environments" ($\beta = 0.200, p = 0.014$). As we know, changes in demand as well as market prices of materials are unavoidable in order to ensure the suitability during construction. As a result, the calculation and estimation of necessary expenses for the project should be carefully carried out in order to avoid potential risks.

Thirdly, the quality aspect of material management linked with proper quality management in all the phases of project life cycle is one of the critical factors in measuring the success of construction projects. In here, it is found that "Procurement issues" ($\beta = 0.344, p = 0.000$) and "Suppliers and manufacturers' issues" ($\beta = 0.258, p = 0.011$) are respectively considered as the first and second rank about the influence level on the quality criterion. Management commitment and leadership in construction organizations must be followed as poor management practices may directly and indirectly lead to the decline of construction productivity and ultimately affect project quality. It is agreed that experienced managers are very intelligent and conscious of making the best and wisest decisions in bad situations and so, they can supervise and control well materials on site. Further, in the construction phase, extent of teamwork among parties participating in the construction process should be also appreciated to achieve the targets quickly and efficiently. More importantly, the quality of project materials always accompanies with the popularity and trust in suppliers or manufacturers. The following factors with a quite modest level of influence are "Transportation in and out site" ($\beta = 0.252, p = 0.014$). It could be understood that material quality of construction projects can be regarded as the fulfillment of expectations of the project participants by optimizing their satisfaction; hence, examining the transportation conditions to secure the packages is truly an important stage. The next one that continue to be concerned is "Quality control" ($\beta = 0.221, p = 0.019$). As we know, materials need to be verified and proven clearly before being put into use, then complying with regulations for material installation in the right order also can maximize their function. The remaining item that receives less attention is "Site conditions" ($\beta = 0.037, p = 0.047$). Doing a comprehensive check of material quality prior to receiving is so critical. Unless the quality outcomes of the project materials are adherence with required standards, faulty construction or errors may take place and it will result in being costly for rework of defective.

Last but not least, safety in construction industry is not a matter to be taken lightly since it is prone to many hazards and accidents potential. In fact, the main types of accidents which cause death or serious injury on construction sites include falls, incidents with site vehicles, collapsing materials and contact with overhead power lines. In this research, "Transportation in and out site" ($\beta = 0.320, p = 0.014$) and "Site conditions" ($\beta = 0.280, p = 0.038$) are indicated as the most two influential factor on the safety criterion. It is not difficult to explain because this result is close to the fact that high rise buildings remain predominant in big cities, the transportation of large quantities of materials is always considered as risky with frequent and high danger rate if we do not comply with the regulations on occupational safety. One more thing, a untidy site or space constraints, particularly in urban work sites maybe the underlying cause of other accidents, for example, tripping, slipping or falling over materials which have been left lying around. Besides, another interesting result is observed that "Security on site" and "Quality control" ($\beta = 0.209, p = 0.026$ and $\beta = 0.073, p = 0.017$ in turn) also have a certain effect on the safety aspect although the direct influence from these factors can not be distinctly seen. It seems to be unpredictable what risks will happen if we do not follow the regulations to use and install materials on site or materials fail to meet quality standards as well as have undetermined origin. Additionally, the security system on site also needs to be closely managed and coordinated to achieve a higher quality.

## 5.4 Summary

This chapter aims to explore influential factors on the effectiveness of material management in order to get more understanding about how to improve their current works. Factor analysis indicates nine main groups of factors that have the significant impact on the effectiveness of material management such as "Procurement issues", "Site conditions", "Planning and handling on site", "Industrial environments" "Contractual issues", "Quality control", "Suppliers and manufacturers' issues", "Transportation in and out site", "Security on site". Generally, material management can be influenced through several stages including planning, procurement, transportation and storing. Some highlights related to planning given were construction scheduling, material arrangement and supply on site. In addition, the output also pointed out the strong influence from material supervision and control capacity as an imperative factor in management system. Further, material payment employed on time and origin of materials fully verified will prevent the project performance from unworthy risks.

According to SEM model, the relationship among these factors has been carefully explored. They all are definitely illustrated as their positive effects on four criteria of material management – time, cost, quality and safety. It is expected that having a profound understanding of various factors in the current result can enormously contribute to changing or improving the performance approach at construction site.

# Chapter 6

# Discussions and Conclusions

Based on data analysis and findings, this final chapter will first discuss about research conclusion. Next, the implication for research and the implication for practice will be explained, followed then by research limitations and suggestions for the future research.

## 6.1 Research Conclusions

### 6.1.1 Consideration of criteria to measure material management effectiveness

According to the statistical results, it is obvious that four representative criteria such as time, cost, quality and safety are considered to take a well-performing role in evaluating quite adequately the effectiveness of material management of most projects.

In terms of time, the majority of criteria got scores above the average while few projects achieve a perfect number. This shows that material managers have not nearly utilized their maximum capacity. As we know, in order to operate a process well, the first thing is to plan thoroughly the materials needed for the project along with working out a backup plan to minimize losses. Those plans, of course, require those with good thinking and experience to know how to allocate resources appropriately. In spite of being aware of this, in some cases too hasty to get the job done or simply not get mutual support in their work, it may result in the fact that these plans presented are sketchy or just meet formal requirements. Therefore, it is really difficult to control the risks arising afterwards. Also, negligence in detailing the provisions of the material supply contract as well as some unspecified contents will be very time-consuming in resolving disputes later on because the legal system is extremely complicated. As a result, it is necessary to consider and clarify the regulations before officially signing the contract. In addition, the materials received in accordance with the plan are very important in ensuring the progress of projects. Sometimes, due to some objective reasons, the plan of receiving materials encountered some problems, the manager should be very calm and wise to make temporary and appropriate solutions to such situations. Besides, the payment of materials procurement costs in the contract should be implemented in accordance with the proposed plan. Pertaining to the survey, the ineffective management of costs in some projects has led to payment delays or even inability in this clause, the supplier thereby may suspend their material supply, from which project progress is also affected. After receiving materials, installation plan of materials is also equally important, materials should be arranged to comply with each item and use purposes in order to avoid having to repeat unnecessary works, causing time waste to complete the project. This is clearly visible in the fact that most of the projects have satisfactorily completed this stage, with very few serious cases reported. Furthermore, one of the criteria for assessing the effectiveness of material management to guarantee the project schedule is material inspection and handover plan. This should be seriously and carefully employed so as to detect and investigate early any serious errors related to the materials used, which could suggest corrective measures on the basis of time optimization to complete the project. And it seems that managers are well aware of the importance of this part, so the recorded data demonstrate projects' successful fulfilment.

Considering the cost factor, based on data analysis, the evaluation criteria have a great variation in scores, the majority of projects assess management effectiveness of this factor at the satisfactory level while the remaining projects at the cautionary level are also quite significant. As a result, managers need to look more carefully at solutions to improve the efficiency of this category. The matter experts first concerned when evaluating this criterion was the compliance of material unit price with the project budget. The material volume should be reasonably calculated and considered to choose materials whose prices match the existing financial possibilities. This is now reported to be quite good from projects. Next, the volume of construction materials must be guaranteed to meet the loss ratio of project, which we need to reserve in advance, otherwise it will make the project spend an additional significant cost for purchasing supplementary materials, not to mention the labor hiring cost. In practice, it is hard to control perfectly this clause simply because it is only an estimated volume of materials that is sometimes entirely inaccurate. Also, it is very important to have a contractual commitment to keep the material price during the construction process. If the material price has large fluctuations in the market but for some unexpected reasons, the project is in need of extra materials and then of course, the project cost will be again adjusted and this can help to limit the negative impact caused by this effect at that time. In this category, most projects are rated above the satisfactory level. Additionally, each project of different contractors should also have a consistent system of cost control in handling emerging issues quickly and flexibly, which can be attributed to the support of technical management softwares. And it is clear that in the majority of projects surveyed, managers are well understanding and applied this management system in parallel with improving and developing it further in the future.

Regarding the quality factor, the observed data are very positive as most of the projects are evaluated with impressive scores. As usual, materials need to be strictly adhered to the quality standards of project, so it is preferably purchased from reputable manufacturers. At the time of material receiving, managers should also conduct rigorous tests of the input criteria to ensure the quality of the entire project. In fact, this work is well accomplished at high levels of satisfaction while still a small number of projects are just classified as a cautionary level. Moreover, the quality control and evaluation system in the project also have to be transparent and clear for each item, constantly open to new ideas and timely detect errors in order to enhance the productivity. Similarly, this criterion shows that projects are performing very well.

Pertaining to safety factor, the occurrence frequency of accidents involving the construction materials in the projects is quite low. Although training programs about safety are regularly deployed at construction sites, it still remains some sporadic cases concerning material collapse and handling on site, which may be due to poor sense of workers. To assess this criterion, there are three primary parts to bear in mind, firstly the transportation and loading of materials must conform to occupational safety and health disciplines. Nobody could anticipate what risks will come to us, so raising our self-awareness and being careful in any cases would be better. Next, the construction security system must be safeguarded to prevent or warn some excessive behaviors that may affect health as well as threaten the safety of those working there. One more thing, workplace safety procedures also need to be eternally updated and ready to approve creative thoughts to simplify complicated processes so that workers can feel catchy and easy to manipulate.

In short, the weaknesses of the project managers are occasionally lacking the patience leading to unproductive decisions, or doing everything to catch up with the work schedule without balancing other aspects of project. In order to reinforce the effectiveness of material management, it is greatly necessary to spend a precious period of time analyzing and investigating deep causes of failure and then, we can find out the next directions accordingly. Most importantly, sharing each other's experiences, especially the high spirit of cooperation in working groups should be aggressively promoted to maximize the productivity of work.

### 6.1.2 Influential factors on material management effectiveness

The results of this study indicated highly significant level of variables influencing the effectiveness of material management in construction projects. These factors were Procurement issues, Site conditions, Planning and handling on site, Material condition, Contractual issues, Quality control, Suppliers and manufacturers' issues, Transportation in and out site, Security on site. In the item point of view, material management effectiveness is affected from Material supply plan, Material supervision and control capacity, Payment and inspection conditions, Certificate of material origin and quality (CO/CQ) and Construction schedule. These five items are the top rankings among thirty-six items surveyed in this research.

In general, material management effectiveness could be influenced by several levels of factor from planning until installation stage. This may be conceived in different levels of intensity and the following section will discuss more closely about these effects.

In terms of time aspect, the analysis results discovered and featured the influence from all nine main factor groups as stated above. It is quite interestingly observed that "Contract signing plan for material procurement" is the most prominent item to measure the time criterion as the provisions as well as commitments of execution time can be obviously referred in the contract. There is no doubt about the role of planning and material handling on site in which material supply plan has a great impact on the whole process. Design documents should be prepared in time together with suitable material placement on site can help the project progress be implemented as outlined plan. Besides, we also should consider site condition and transportation. This takes precedence over all and in order to keep the materials uninterrupted during use and installation, the estimated delivery date must be roughly accurate. Material receiving schedule must be systematically implemented and materials should be stored in a convenient place so that they can be easily transported when needed, thereby saving time. Next, the selection of reliable suppliers or manufacturers also greatly affect the project fulfillment which no contractors expects their jobs on site to be suspended just for the sake of late material delivery. Following that, management and organization factors are also evaluated with a noteworthy influence level. Experienced people, of course, will manage their work better and imaginably make timely decisions. Instead of spending too much time for preparing papers to request material supply, we should focus on how to effectively work or coordinate between the site and the office. Another surprising outcome is found that "Quality control" and "Security on site" similarly have an effect on time aspect but may not seem significant. Contractors have to abide by governmental regulations so as to avoid a halt in using materials, causing time wastes in vain.

Regarding cost criterion, the results emphasized the influence of all factor groups except "Procurement issues", "Quality control" and "Transportation in and out site" in which the compatibility of material unit price with the project budget is demonstrated as the most critical criterion in evaluating this category. As we can see evidently from the first thing that the scarcity of materials in market, fluctuations in both material demand and prices or variations in technical specifications of materials during construction will have a great influence to the adjustment of cost criterion at that time. As a result, it should also be added that the plan related to the volume of materials supplied and used need to be clearly calculated and outlined from the outset in order to avoid major losses or changes in the future. Once again, the selection of material suppliers or manufacturers having a long-term relationship and being capable of providing products with reasonable prices may help contractors worry less about spending on this feature. Also, theft or loss of materials frequently occurring on the site are recognized as being associated with many different causes. It can be regarded as an alarm bell for contractors who have to strengthen training, self-consciousness education for workers about asset protection on the construction site and strictly handle the cases detected. And more importantly, it is necessary to promote the cooperation efficiency between the site and professional security companies. Moreover, the volume of materials should be checked and ensured the right quantity as soon as they are received. At the same time, the space for material storage need to meet the established standards so as to avoid generating additional costs for damaged materials.

In association with quality aspect, the results pointed out that the factor groups except “Planning and handling on site”, “Industrial environments”, “Contractual issues” or “Security on site”, have different scope of influence on the material quality of projects. In general, materials must conform to the project’s quality standards and be continuously evaluated, updated in a flexible and effective management system. “Procurement issues” is still found as the most important factor in which managers should have intensive experience and ability to coordinate well in work. Since then, they could control and acknowledge what kind of materials will be suitable for the project along with thinking and making opportune decisions. Additionally, it is also quite interesting to know that the appropriate handling and allocation of materials on construction sites can significantly affect material quality. But certainly, the storage space of materials as well as the convenient location for transportation will be of great concern to managers after completing the necessary quality inspection procedures for material receiving. Specifically, characteristics related to materials such as labels, origin as well as quality certification need to be transparent and universally recognized in the market. Last but not least, the image of material quality can be vividly reflected in collaboration with reputable brands or material suppliers in the construction industry. This was explicitly discussed in previous sections.

Referring to the safety aspect, everyone definitely have to concern when working in the construction environment. Also, it will not be too surprised that the safety procedures are listed by construction projects as top priority criteria whenever evaluating management effectiveness in this side. According to data analysis, there are totally four key elements related to material management which potentially affect occupational safety issues on the site including “Transportation in and out site”, “Site conditions”, “Security on site” and “Quality control”. As we all know that material transportation on the road always faces with risks or accidents, so we must constantly raise awareness, be careful at all times even during the phase of material loading and unloading. Further, compliance with the regulations in the use and installation of each type of material should also be minded in a certain extent, especially materials considered special or the worse case regarding a unclear origin would be more concerned. And it is recommended that the construction site should have timely alarm systems when any behaviors are identified as highly dangerous and likely threaten the safety of people around. One more thing, materials should be neatly organized, in accordance with the layout on the site to hinder the appearance of bad problems and simultaneously optimize the conformity with occupational safety procedures of individuals performing their works there.

All in all, by profoundly understanding these groups of factors, managers may conceive what strengths their current project has along with which constraints need to be overcome. Besides, a detailed presentation about the influence level of these factors to the aspects of material management effectiveness can be viewed as credible references for managers who can promptly give accurate directions in building up and perfecting the management system as well as proposing training programs consistent with the current context.

### 6.1.3 Suggestions of experts in improving material management effectiveness

In terms of planning:

- Need to put forward appropriate suppliers and source of materials first.
- Coordinate and prepare site works well.
- Construction progress must be regularly monitored weekly or monthly to be adjusted according to reality.

With regards to procurement issues:

- The volume of materials should be fully calculated from initial steps.
- Select suppliers or manufacturers that have financial capacity and quality certification, supply schedule should be mastered in order to match construction progress.
- Delivery and receiving of materials should be tested and measured with the right quality and quantity.
- It is necessary to frequently organize training programs, update new knowledge for relevant working positions, from which inexperienced people will be guided by their predecessors.

In association with industrial environments and contracts:

- Contract to keep material prices is needed to avoid market price slippage.
- Need to negotiate material prices with various qualified suppliers to choose the best price.
- Need to update the market price fluctuation aiming to achieve a database in order to prevent arising cases in relation to the material volume afterwards.

Talking about site conditions and transportation:

- The transportation should be noted about using proper equipments, machinery or forklifts to avoid breakage, ensuring no loss of materials.
- Arrange the site so that the road between the vehicle location and the aggregate is short and convenient. In addition, the gathering place should have a roof or a silver cover to avoid wind and rain during loading.
- Receiving plan has to restrict a long wait while the vehicle comes in and out the site as this may incur additional costs for vehicles waiting to drop off and park.
- Allocate sufficient staff (storekeepers, QA/QC) to check the quality and quantity of materials clearly before receiving.

Related to suppliers and manufacturers:

- Find out preliminary information about suppliers before signing the contract, suppliers evaluation should be periodically taken place until the end of project.

- Clearly stipulate the penalties in the contract when materials were late in delivery, poor quality, and in case of material return.

- Warranty conditions of materials should be corresponded to the project warranty of investors.

In connection with quality control:

- Materials must conform to the standards prescribed by the Ministry of Construction and have a full quality certification as well.

- Fences on site need to be ensured in quality and security gates should be equipped with cameras.

- Select reputable and highly reliable security companies.

In addition, it is critical to totally exploit the utility of material management softwares at present, such as data management for suppliers' catalog; contract management; data updates relating to purchasing invoices; transportation and supply management and so forth. Data are stored most effectively only when the information technology is applied. The entire volume of materials will be synthesized from the majority of suppliers, and from there will know how much materials are allocated to all construction projects. The selection or report searching will accordingly be implemented very fast and beneficially rather than the raw typing. Further, the inventory will be easily viewed and counted, limiting the shortage of materials when conducting manual calculations. Moreover, managers can also refer to how the average price of materials at that time (monthly) is, which is intended to clarify, assume responsibility as well as the work schedule of departments and construction sites, from that may urge their performance.

### 6.2 Contribution to Research

As we have seen, one of critical components to operate a construction business is construction material management. This component is commonly known as a system for planning and controlling all the necessary resources to ensure that the correct quality and quantity of materials are properly specified in a timely manner, achieved at a reasonable cost and most importantly, available at the point of use when needed. In other words, this component significantly affects the project performance of contractors and is likened to a key to success of construction projects accordingly. Many researchers have examined techniques in construction material management and general causes affecting the project performance. However, none have discovered the causal relationship between two components, indicating a gap in the knowledge of this field. Thus, this study aimed to illuminate this connection via SEM. The CFA was then performed to confirm the structure of these components before SEM was used to determine their effect.

This research has several implications for theory, methodology and practice related to material management at construction site. The results of the current study uphold this viewpoint and reveal that it would be more favorable for material researchers to engage in restructuring the organizational system. In fact, the significance of this investigation is largely to feature prominent influential factors in association with material management so that construction managers could avoid the occurrence of those cases and mitigate risks on the overall performance of construction projects. Therefore, this study could have been regarded as a supplement in series of material management researches.

Besides, this research established a new model to clarify specific effects of factors on each actual aspect of material management effectiveness at construction site. The practice model in this study, therefore, further contributed to previous authors on the detailed and unambiguous interpretation of influential factors on the effectiveness of material management. To be precise, the role of procurement issues was emphasized with significant impact on time and quality criteria. Next, the importance of planning and material handling on site; site conditions; transportation in and out site; industrial environments; contractual issues and quality control were also reminded from the results in accordance with all four main criteria of material management effectiveness. Moreover, another supplementary key factor in current research was found as security on site which has a great effect on time, cost and safety aspects of material management and projects as well while suppliers and manufacturers' issues were similarly described about its impact on time, cost and quality item.

It is concluded that the practice model helps contractors well perceive the real situation of material management in their construction projects and it correspondingly contributes to the improvement of performance approaches at construction site. By thoroughly understanding such important factors, managers can change and fulfill their policies or operating systems which positively influence on the effectiveness of material management. From that point, in order for material management to achieve a maximum efficiency as well as reduce the high rate of risks, the results indicated the material supply plan needs to be clearly prepared, the volume of materials should be attentively and precisely determined, the project budget could be guaranteed in order for payment proposal and material receiving to be implemented in the allotted time. At the same time, it is necessary to be smart in selecting trustworthy suppliers or manufacturers who can commit to the quality and price of materials to fit in the construction market, together with material transportation not to be regularly delayed and match with the construction progress of project. Also, the plan for material using and installation on site must abide by occupational safety regulations and the contract with security company in protecting materials during construction should be deployed effectively to alleviate unwanted losses. And above all, training programs could be periodically organized to share experiences with each other, foster the essential skills and newfound knowledge for employees in perceiving and well coordinating in work.

Soon as errors are detected in material management, it is advised to remain alert and patient to find out the fundamental reasons of those bad results. Clearly understanding the factors affecting the effectiveness of material management may assist project managers in making lucid decisions soon and then likely changing their situation in a very leveraged way. The intensity and directions of these impacts in improving the effectiveness of material management has been presented in detail in this research by elucidating the model from the parameters observed in practice. In other words, this practical model could reflect on the existing picture of how much real issues have the effect on material management effectiveness. From these results, top managers can get to know their company's current management system, which potentials brought to the benefits could be promoted and which barriers attached to negative effects could be modified and eliminated. From the significance of each of those influential factors, accordingly, company can consider to improve their management approaches based on their available resources at present. Everything could be simply construed as a rule that the stronger positive effects, the more attention and priority they will get.

### 6.3 Limitations and Directions for Future Research

Even though best efforts have been put in this research and findings do make a significant contribution for industry, this study has some limitations. To begin with, the sample size of 200 is considered to be on the small side for statistical analysis, instead, it will be more relevant if more than 630 valid responses are collected. For the sake of time limitation, the samples gathered in this study consisted of participants working in the field of material management from various sites of Ho Chi Minh city in Vietnam only. Lack of data from respondents in other countries may have some effects on the final results. Hence, it is greatly recommended for furture research in this context that the sample of data collection should be expanded to have a more accurate view of influential factors on material management system.

The next limitation is the method used to evaluate the effectiveness of material management. This study used indirect observation including interviews, distributing questionnaires based on predefined rating scales to obtain information related to material management in construction projects. The use of self-report measures for all variables is also a methodology issue in this study because these techniques may not correspond to the target of performance tactics. For instance, self-reported errors may not reflect the actual number of mistakes in the workplace. The answers also heavily rely on respondents' current memories and emotions. In addition, those who provide information probably do not report accurately all the arising cases. Thus, the direct observation method should also be recommended in the future which aims to bring more realistic and profound assessments.

In the meantime, the biggest challenge for the authors in this study is the development of criteria and scales that have to be simple and understandable in order for readers to easily answer and from then, preliminary evaluation of material management effectiveness can be considered reliable in several fundamental aspects. In fact, as well as references from many different sources, it is uncommon to find any construction projects available with a specific evaluation process for material management; therefore, the assessment criteria set up here are largely based on the management experience of leading experts. Anyway, the recorded reviews are of the sensory nature of interviewees, the answered scores are indeed difficult to absolutely mirror the reality of the whole project. Not to mention respondents are not evenly distributed among their professional roles, which potentially trigger some discrepancies in responses. As a result, the model established can be further honed based on detailed discussions and suggestions from industry experts. The relationship between influential factors and its impact on the overall effectiveness of material management in construction projects has to be further detailed, which is intended to be future work.

In essence, other factors affecting the effectiveness of material management may have some still. In other words, the further verification and expansion of this research model may not include factors examined here. The determination of these limitations may suggest upcoming directions that this research can be developed and highly applicable but still does not lessen the importance of goals set out by a series of research papers pertaining to this field before.

# APPENDICES

# APPENDIX A
# SURVEY QUESTIONNAIRE

## A1. QUESTIONNAIRE (English)

Dear Sir/Madam,

My full name is Pham Van Bao, I am now studying Master program in the field of Construction Engineering and Management in Chulalongkorn University, Thailand. At the present, I am working on the thesis entitled “Analyzing the relationship of influential factors on material management effectiveness in building construction projects: Case study in Vietnam”.

The main purpose of this survey is to analyze the relationship of influential factors on material management effectiveness in Vietnamese construction projects. Since then, some suggestions could be given to enhance and improve the effectiveness of material management. Therefore, I hope you can spend some precious time to share your experience through answering the questions listed below carefully. I assure that all information you provide will be kept secret and only used for research.

I am really looking forward to your kind consideration and help. Thank you so much!

Yours faithfully,

*Should you have any questions or comments, please do not hesitate to contact me:*

Pham Van Bao – Phone number: 01678 169 101 – Email: baopham170@gmail.com

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## PART I: BACKGROUND INFORMATION

Please fill in or tick in the check box that corresponds with your suitable answers:

**1.** Company:.......................................................................................................

**2.** Current position:..........................................................................................

**3.** Type of your building project (based on purpose of use):

☐ Residential/Housing ☐ Hospital ☐ Office

☐ Commercial, service ☐ Other: .....................................................................

**4.** Type of your building project (based on number of stories):

☐ 9 – 16 floors ☐ 17 – 25 floors ☐ 26 – 40 floors ☐ > 40 floors

**5.** What is the project duration?

☐ < 2 years ☐ 2 – 3 years

☐ 4 – 5 years ☐ > 5 years

**6.** How much is the cost of project (VND)?

☐ < 50 billion ☐ 50 – under 100 billion ☐ 100 – under 500 billion

☐ 500 – 1000 billion ☐ > 1000 billion

**7.** How long have you been working in construction area?

☐ 1 – 5 years ☐ 6 – 10 years ☐ 11 – 15 years

☐ 16 – 20 years ☐ > 20 years

**8.** How long have you been involved in material management for construction project?

☐ 1 – 5 years ☐ 6 – 10 years ☐ 11 – 15 years

☐ 16 – 20 years ☐ > 20 years

**9.** Type of material are mostly bought in your project:

☐ Iron, steel ☐ Sand ☐ Stone ☐ Brick ☐ Cement ☐ Other: .................................

**10.** Material in your project is directly ordered from:

☐ Construction site ☐ Company office ☐ Other: ................................

**11.** Material in your project is transported by:

☐ Supplier ☐ Hiring from company ☐ Other:................................

**12.** Do you have a material control system to support your work?

☐ Yes ☐ No

**13.** Beside the storage at site, does your company have any storage else?

☐ Yes ☐ No

**14.** How many percent does material cover the project cost? .......................................

**15.** How many staffs involved in material procurement? ..............................................

If possible, please kindly provide your personal information for convenience contact when needed.

Name: .........................................................................................................................

Phone number: ............................................. Email: .....................................................

**PART II:**

**IMPORTANCE LEVEL OF FACTORS AFFECTING MATERIAL MANAGEMENT EFFECTIVENESS (PERCEPTIONS)**

Please use a check mark (✓) for the appropriate box that best indicates your opinion.

| Not at all | Low | Moderate | High | Very high |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

| *Importance level of factors affecting material management effectiveness* | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Planning and handling on site** | | | | | |
| 1. Construction schedule | | | | | |
| 2. Material supply plan | | | | | |
| 3. Material protection during construction | | | | | |
| 4. Material handling on site | | | | | |
| 5. Equipment selection for unloading | | | | | |
| 6. Readiness of design documents | | | | | |
| **Procurement issues** | | | | | |
| 7. Material budget management | | | | | |
| 8. Material quantity takeoff | | | | | |
| 9. Awareness of material types | | | | | |
| 10. Material supervision and control capacity | | | | | |
| 11. Progress of material procurement | | | | | |
| 12. Progress in forwarding information of materials to be used | | | | | |
| 13. Paperwork preparation for material requisition | | | | | |
| 14. Documentation storage and organization | | | | | |
| 15. Co-ordination between main office and site office | | | | | |
| 16. Co-ordination in construction sites | | | | | |
| 17. Experience and qualification of staff | | | | | |
| 18. Timing in decision making | | | | | |
| **Industrial environments** | | | | | |
| 19. Material status as arriving to the site | | | | | |
| 20. Label, source, quality certification of material | | | | | |
| 21. Availability of material in market | | | | | |
| 22. Adjustment about material demand | | | | | |
| 23. Adjustment about material price | | | | | |
| **Transportation in and out site** | | | | | |
| 24. Delivery of materials to site and install on site | | | | | |
| 25. Delivery date estimation | | | | | |

| *Importance level of factors affecting material management effectiveness* | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Suppliers and manufacturers' issues** | | | | | |
| 26. Supplier/manufacturer selection | | | | | |
| 27. Delivery plan/schedule of manufacturer | | | | | |
| 28. Product quality of manufacturer | | | | | |
| **Contractual issues** | | | | | |
| 29. Material price stipulation | | | | | |
| 30. Payment and inspection conditions | | | | | |
| 31. Adjustment of material specification during construction | | | | | |
| **Site conditions** | | | | | |
| 32. Storage location for transportation, loading/unloading | | | | | |
| 33. Area for material storage space | | | | | |
| 34. Material receiving and placement condition on site | | | | | |
| 35. Checking, reception of material quality on site | | | | | |
| 36. Checking, reception of material quantity on site | | | | | |
| 37. Weather conditions | | | | | |
| **Quality control** | | | | | |
| 38. Certificate of material origin and quality (CO/CQ) | | | | | |
| 39. Regulations about material procurement | | | | | |
| 40. Regulations about material using and installation | | | | | |
| **Security on site** | | | | | |
| 41. Contract with security company | | | | | |
| 42. Site security system | | | | | |

## PART III:

### EVALUATING FACTORS AFFECTING MATERIAL MANAGEMENT EFFECTIVENESS (ACTUAL PRACTICE)

Please use a check mark (✓) for the appropriate box that best indicates your opinion. The scale will be given in accordance with each factor.

| *Evaluation of influential factors* | *Scale description* | | | | |
|---|---|---|---|---|---|
| | 1-Poor | 2-Fair | 3-Good | 4-Very good | 5-Excellent |
| **Planning and handling on site** | | | | | |
| 1. Construction schedule | | | | | |
| 2. Material supply plan | | | | | |
| 3. Material protection during construction | | | | | |
| 4. Material handling on site | | | | | |
| 5. Equipment selection for unloading | | | | | |
| 6. Readiness of design documents | | | | | |
| **Procurement issues** | | | | | |
| 7. Material budget management | | | | | |
| 8. Material quantity takeoff | | | | | |
| 9. Awareness of material types | | | | | |
| 10. Material supervision and control capacity | | | | | |
| 11. Progress of material procurement | | | | | |
| 12. Progress in forwarding information of materials to be used | | | | | |
| 13. Paperwork preparation for material requisition | | | | | |
| 14. Documentation storage and organization | | | | | |
| 15. Co-ordination between main office and site office | | | | | |
| 16. Co-ordination in construction sites | | | | | |
| 17. Experience and qualification of staff | <2 years | <3 years | <4 years | <5 years | >= 5 years |
| 18. Timing in decision making | Hardly ever | Occasionally | Sometimes | Frequently | Always |
| **Industrial environments** | | | | | |
| 19. Material status as arriving to the site | | | | | |
| 20. Label, source, quality certification of material | | | | | |
| 21. Availability of material in market | Hardly ever | Occasionally | Sometimes | Frequently | Always |
| 22. Adjustment about material demand | Always | Frequently | Sometimes | Occasionally | Hardly ever |

| *Evaluation of influential factors* | *Scale description* | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Industrial environments** (Cont.) | | | | | |
| 23. Adjustment about material price | Always | Frequently | Sometimes | Occasionally | Hardly ever |
| **Transportation in and out site** | | | | | |
| 24. Delivery of materials to site and install on site | | | | | |
| 25. Delivery date estimation | | | | | |
| **Suppliers and manufacturers' issues** | | | | | |
| 26. Supplier/manufacturer selection | | | | | |
| 27. Delivery plan/schedule of manufacturer | | | | | |
| 28. Product quality of manufacturer | | | | | |
| **Contractual issues** | | | | | |
| 29. Material price stipulation | | | | | |
| 30. Payment and inspection conditions | | | | | |
| 31. Adjustment of material specification during construction | Always | Frequently | Sometimes | Occasionally | Hardly ever |
| **Site conditions** | | | | | |
| 32. Storage location for transportation, loading/unloading | | | | | |
| 33. Area for material storage space | | | | | |
| 34. Material receiving and placement condition on site | | | | | |
| 35. Checking, reception of material quality on site | | | | | |
| 36. Checking, reception of material quantity on site | | | | | |
| 37. Weather conditions | | | | | |
| **Quality control** | | | | | |
| 38. Storage location for transportation, loading/unloading | | | | | |
| 39. Area for material storage space | | | | | |
| 40. Receiving plan on site | | | | | |
| **Security on site** | | | | | |
| 41. Contract with security company | | | | | |
| 42. Site security system | | | | | |

## PART IV:

## MEASUREMENT OF MATERIAL MANAGEMENT EFFECTIVENESS

This section includes 4 main parts used to represent the effectiveness of material management. Please rate yourself on each item according to scale described below:

| Rating | | Description of rating |
|---|---|---|
| 9-10 | Good | Performance meets contractual requirements and **exceeds in some area(s)** to the project's benefit. The contractual performance of the element or subelement being assessed was accomplished with some minor problems for which corrective actions taken by the Contractor/Supplier were effective. |
| 7-8 | Satisfactory | Performance **meets** contractual requirements. The contractual performance of the element or sub-element contains some minor problems for which proposed corrective actions taken by the Contractor/Supplier appear satisfactory, or completed corrective actions were satisfactory. |
| 5-6 | Cautionary | Performance **did not quite meet** contractual requirements. The contractual performance of the element or sub-element contains some minor problems for which proposed corrective actions taken by the Contractor/Supplier appear to be a continued minor concern, or completed corrective actions were slightly below satisfactory. |
| 3-4 | Not Satisfactory | Performance **does not meet some** contractual requirements. The contractual performance of the element or sub-element being assessed reflects a serious problem for which the Contractor/Supplier has submitted minimal corrective actions, if any. The Contractor/Supplier's proposed actions appear only marginally effective or were not fully implemented. |
| 0-2 | Unacceptable | Performance **does not meet** contractual requirements and/or recovery is **not likely** in a timely or cost effective manner. The contractual performance of the element or sub-element contains serious problem(s) for which the Contractor /Supplier's corrective actions appear to be or were ineffective. |

| ITEM | EVALUATION CRITERIA | SCORE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **TIME** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | Material supply plan | | | | | | | | | | | |
| 2 | Contract signing plan for material procurement | | | | | | | | | | | |
| 3 | Material receiving plan | | | | | | | | | | | |
| 4 | Material payment plan | | | | | | | | | | | |
| 5 | Material installation plan | | | | | | | | | | | |
| 6 | Material inspection and handover plan | | | | | | | | | | | |
| | **COST** | | | | | | | | | | | |
| 7 | Material unit price comparing to budget | | | | | | | | | | | |
| 8 | Construction material quantity comparing to loss ratio of project | | | | | | | | | | | |
| 9 | Commitment contract to keep material price according to construction progress | | | | | | | | | | | |
| 10 | Cost control system of material management process | | | | | | | | | | | |
| | **QUALITY** | | | | | | | | | | | |
| 11 | Inspection of material specifications compliant to the quality and standard of project | | | | | | | | | | | |
| 12 | Evaluation and control system of material quality from procurement till using | | | | | | | | | | | |
| | **SAFETY** | | | | | | | | | | | |
| 13 | Transportation, loading/unloading of material comply with safety and health regulations | | | | | | | | | | | |
| 14 | Security on site related to material storage | | | | | | | | | | | |
| 15 | Work safety procedures regarding material installation | | | | | | | | | | | |

## A2. QUESTIONNAIRE (Vietnamese)

# BẢNG CÂU HỎI KHẢO SÁT

# CÁC YẾU TỐ ẢNH HƯỞNG ĐẾN HIỆU QUẢ TRONG VIỆC QUẢN LÝ VẬT TƯ CỦA NHỮNG DỰ ÁN XÂY DỰNG TẠI VIỆT NAM

Kính gửi Quý Ông/Bà,

Tôi tên Phạm Văn Bảo, là học viên cao học chuyên ngành Công nghệ và Quản lý xây dựng của Trường Đại học Chulalongkorn, Thái Lan. Tôi đang thực hiện luận văn tốt nghiệp với đề tài nghiên cứu: Các yếu tố ảnh hưởng đến hiệu quả trong việc quản lý vật tư của những dự án xây dựng tại Việt Nam. Những thông tin mà Ông/Bà cung cấp sẽ rất bổ ích cho nghiên cứu.

Mục đích của cuộc khảo sát nhằm để phân tích mối quan hệ của những nhân tố ảnh hưởng đến hiệu quả của tiến trình quản lí vật tư từ lúc lên kế hoạch cho đến khi đưa vào sử dụng của những dự án xây dựng tại Việt Nam, từ đó có thể đưa ra một số đề xuất nhằm cải thiện và quản lý vật tư hiệu quả. Kính mong Ông/Bà vui lòng dành một ít thời gian để chia sẻ những kinh nghiệm quý báu của Ông/Bà qua việc trả lời những câu hỏi này. Tôi xin cam đoan mọi thông tin Ông/Bà cung cấp sẽ được giữ bí mật và chỉ sử dụng cho mục đích nghiên cứu. Rất mong nhận được sự quan tâm và giúp đỡ của Ông/Bà.

Xin chân thành cảm ơn!

*Mọi thông tin và ý kiến đóng góp, xin Ông/Bà vui lòng liên hệ:*

Phạm Văn Bảo – Số điện thoại: 01678 169 101 – Email: baopham170@gmail.com

----------------ജജശശ----------------

## PHẦN I: THÔNG TIN CHUNG

Ông/Bà vui lòng đánh dấu (✓) vào câu trả lời hoặc trả lời trực tiếp cho các câu hỏi sau:

**1.** Công ty Ông/Bà đang làm việc: ..........................................................................

**2.** Vị trí hiện tại của Ông/Bà:.....................................................................................

**3.** Loại công trình xây dựng mà Ông/Bà đang làm (theo mục đích sử dụng):

☐ Chung cư ☐ Y tế ☐ Văn phòng

☐ Thương mại, dịch vụ ☐ Khác: ....................................................................

**4.** Công trình xây dựng mà Ông/Bà đang làm cao bao nhiêu tầng:

☐ 9 – 16 tầng ☐ 17 – 25 tầng ☐ 26 – 40 tầng

☐ > 40 tầng

**5.** Thời gian thực hiện của dự án mà Ông/Bà đang làm là bao lâu:

☐ < 2 năm ☐ 2 – 3 năm

☐ 4 – 5 năm ☐ > 5 năm

**6.** Dự án Ông/Bà đang làm có tổng vốn đầu tư bao nhiêu (VND)?

☐ < 50 tỷ ☐ 50 – dưới 100 tỷ ☐ 100 – dưới 500 tỷ

☐ 500 – 1000 tỷ ☐ > 1000 tỷ

**7.** Ông/Bà đã làm việc trong ngành xây dựng được khoảng bao lâu:
☐ 1 – 5 năm ☐ 6 – 10 năm ☐ 11 – 15 năm
☐ 16 – 20 năm ☐ > 20 năm

**8.** Kinh nghiệm làm việc của Ông/Bà liên quan đến quản lý vật tư xây dựng được khoảng bao lâu:
☐ 1 – 5 năm ☐ 6 – 10 năm ☐ 11 – 15 năm
☐ 16 – 20 năm ☐ > 20 năm

**9.** Loại vật tư xây dựng được mua trong dự án Ông/Bà đang làm đa số là:
☐ Sắt thép ☐ Cát ☐ Đá ☐ Gạch ☐ Xi măng ☐ Khác: .......................................

**10.** Vật tư xây dựng trong dự án Ông/Bà đang làm được đặt mua trực tiếp:
☐ Từ phía công trường ☐ Thông qua văn phòng công ty ☐ Khác: ........................

**11.** Vật tư xây dựng trong dự án Ông/Bà đang làm được vận chuyển bởi:
☐ Nhà cung cấp ☐ Công ty thuê vận chuyển ☐ Khác: ............................

**12.** Dự án Ông/Bà đang làm có hệ thống kiểm soát vật tư nào để hỗ trợ hay không:
☐ Có ☐ Không

**13.** Ngoài kho lưu trữ vật tư có sẵn tại công trường thì công ty còn có kho nào khác không:
☐ Có ☐ Không

**14.** Theo Ông/Bà, vật tư xây dựng chiếm khoảng bao nhiêu *phần trăm* chi phí của dự án:
..................................................................................................................

**15.** Có khoảng bao nhiêu nhân viên làm việc trong khâu thu mua vật tư:.......................

Nếu có thể, Ông/Bà vui lòng cung cấp các thông tin cá nhân để tiện liên lạc khi cần thiết:
Họ và tên:..................................................................................................................
Số điện thoại: ............................................... Email:.....................................................

## PHẦN II:

## MỨC ĐỘ QUAN TRỌNG CỦA CÁC NHÂN TỐ ẢNH HƯỞNG ĐẾN HIỆU QUẢ QUẢN LÝ VẬT TƯ

Ông/Bà vui lòng cho biết **mức độ quan trọng** của các nhân tố ảnh hưởng đến hiệu quả quản lý vật tư bên dưới bằng cách đánh dấu (✓) vào một trong các lựa chọn trả lời theo quy ước như sau:

| Hầu như **không** | Mức độ **thấp** | Mức độ **trung bình** | Mức độ **cao** | Mức độ **rất cao** |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

| *Mức độ quan trọng của các nhân tố ảnh hưởng đến hiệu quả quản lý vật tư* | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Lên kế hoạch và sắp xếp vật tư trên công trường** | | | | | |
| 1. Tiến độ thi công | | | | | |
| 2. Việc lên kế hoạch cung cấp vật tư | | | | | |
| 3. Sự bảo vệ vật tư trong suốt quá trình xây dựng | | | | | |
| 4. Sự sắp xếp vật tư trên công trường | | | | | |
| 5. Sự lựa chọn thiết bị phục vụ cho việc dở hàng | | | | | |
| 6. Sự sẵn sàng của tài liệu thiết kế | | | | | |
| **Vấn đề thu mua** | | | | | |
| 7. Quản lí ngân sách | | | | | |
| 8. Bóc tách khối lượng | | | | | |
| 9. Nhận thức về việc sử dụng loại vật liệu | | | | | |
| 10. Khả năng giám sát và kiểm soát vât tư | | | | | |
| 11. Tiến trình thu mua vật tư | | | | | |
| 12. Tiến trình chuyển tiếp thông tin về những loại vật tư được sử dụng | | | | | |
| 13. Giấy tờ chuẩn bị cho việc yêu cầu vật tư | | | | | |
| 14. Sự chuẩn bị các tài liệu để tra cứu về sau | | | | | |
| 15. Sự phối hợp giữa văn phòng công ty và công trường | | | | | |
| 16. Sự phối hợp giữa các bên trên công trường | | | | | |
| 17. Kinh nghiệm và chất lượng của nhân viên | | | | | |
| 18. Sự đưa ra quyết định đúng lúc | | | | | |
| **Môi trường công nghiệp** | | | | | |
| 19. Tình trạng vật tư khi chuyển đến công trình | | | | | |
| 20. Nhãn mác, nguồn gốc, chứng chỉ chất lượng vật tư | | | | | |
| 21. Sự sẵn có của vật tư trên thị trường | | | | | |
| 22. Sự điều chỉnh về nhu cầu vật tư | | | | | |
| 23. Sự điều chỉnh giá vật tư | | | | | |
| **Vận chuyển** | | | | | |
| 24. Việc vận chuyển vật tư để sử dụng, lắp đặt tại công trường | | | | | |
| 25. Sự ước tính thực tế về ngày phân phát vật tư | | | | | |

| *Mức độ quan trọng của các nhân tố ảnh hưởng đến hiệu quả quản lý vật tư* | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Về phía nhà cung cấp và nhà sản xuất** | | | | | |
| 26. Lựa chọn nhà cung cấp/nhà sản xuất | | | | | |
| 27. Kế hoạch giao hàng/tiến độ của nhà sản xuất | | | | | |
| 28. Chất lượng sản phẩm của nhà sản xuất | | | | | |
| **Hợp đồng** | | | | | |
| 29. Việc quy định giá vật tư | | | | | |
| 30. Điều kiện thanh toán và nghiệm thu | | | | | |
| 31. Sự điều chỉnh đặc điểm kỹ thuật vật tư trong khi thi công | | | | | |
| **Điều kiện công trường** | | | | | |
| 32. Vị trí kho bãi cho việc vận chuyển, bốc xếp | | | | | |
| 33. Diện tích kho bãi cho mặt bằng chứa vật tư | | | | | |
| 34. Kế hoạch nhận hàng trên công trường | | | | | |
| 35. Việc kiểm tra, tiếp nhận chất lượng vật tư công trình | | | | | |
| 36. Việc kiểm tra, tiếp nhận số lượng vật tư công trình | | | | | |
| 37. Điều kiện thời tiết | | | | | |
| **Kiểm soát chất lượng** | | | | | |
| 38. Chứng nhận xuất xưởng và chất lượng của vật tư | | | | | |
| 39. Những qui định về thủ tục thu mua vật tư | | | | | |
| 40. Những qui định về công tác lắp đặt, sử dụng vật tư | | | | | |
| **An ninh công trường** | | | | | |
| 41. Hợp đồng với công ty bảo vệ | | | | | |
| 42. Hệ thống bảo vệ an ninh công trường | | | | | |

**PHẦN 3:**

**ĐÁNH GIÁ VỀ TÌNH HÌNH THỰC TẾ CỦA CÁC NHÂN TỐ ẢNH HƯỞNG ĐẾN HIỆU QUẢ QUẢN LÝ VẬT TƯ**

Ông/Bà vui lòng đánh dấu (✓) vào một trong các lựa chọn trả lời theo các mức độ tương ứng với từng nhân tố được liệt kê bên dưới.

| *Nhân tố ảnh hưởng* | *Đánh giá thực tế công trình* | | | | |
|---|---|---|---|---|---|
| | 1 – Kém | 2 – Trung bình | 3 – Khá | 4 – Tốt | 5 – Rất tốt |
| **Lên kế hoạch và sắp xếp vật tư trên công trường** | | | | | |
| 1. Tiến độ thi công | | | | | |
| 2. Việc lên kế hoạch cung cấp vật tư | | | | | |
| 3. Sự bảo vệ vật tư trong suốt quá trình xây dựng | | | | | |
| 4. Sự sắp xếp vật tư trên công trường | | | | | |
| 5. Sự lựa chọn thiết bị phục vụ cho việc dở hàng | | | | | |
| 6. Sự sẵn sàng của tài liệu thiết kế | | | | | |
| **Vấn đề thu mua** | | | | | |
| 7. Quản lí ngân sách | | | | | |
| 8. Bóc tách khối lượng | | | | | |
| 9. Nhận thức về việc sử dụng loại vật liệu | | | | | |
| 10. Khả năng giám sát và kiểm soát vât tư | | | | | |
| 11. Tiến trình thu mua vật tư | | | | | |
| 12. Tiến trình chuyển tiếp thông tin về những loại vật tư được sử dụng | | | | | |
| 13. Giấy tờ chuẩn bị cho việc yêu cầu vật tư | | | | | |
| 14. Sự chuẩn bị các tài liệu để tra cứu về sau | | | | | |
| 15. Sự phối hợp giữa văn phòng công ty và công trường | | | | | |
| 16. Sự phối hợp giữa các bên trên công trường | | | | | |
| 17. Kinh nghiệm và chất lượng của nhân viên | <2 năm | <3 năm | <4 năm | <5 năm | >= 5 năm |
| 18. Sự đưa ra quyết định đúng lúc | Hầu như không | Thỉnh thoảng | Đôi khi | Thường xuyên | Luôn luôn |

| *Nhân tố ảnh hưởng* | *Đánh giá thực tế công trình* | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Môi trường công nghiệp** | | | | | |
| 19. Tình trạng vật tư khi chuyển đến công trình | | | | | |
| 20. Nhãn mác, nguồn gốc, chứng chỉ chất lượng vật tư | | | | | |
| 21. Sự sẵn có của vật tư trên công trường | Hầu như không | Thỉnh thoảng | Đôi khi | Thường xuyên | Luôn luôn |
| 22. Sự điều chỉnh về nhu cầu vật tư | Luôn luôn | Thường xuyên | Đôi khi | Thỉnh thoảng | Hầu như không |
| 23. Sự điều chỉnh giá vật tư | Luôn luôn | Thường xuyên | Đôi khi | Thỉnh thoảng | Hầu như không |
| **Vận chuyển** | | | | | |
| 24. Việc vận chuyển vật tư để sử dụng, lắp đặt tại công trường | | | | | |
| 25. Sự ước tính thực tế về ngày phân phát vật tư | | | | | |
| **Về phía nhà cung cấp và nhà sản xuất** | | | | | |
| 26. Lựa chọn nhà cung cấp/nhà sản xuất | | | | | |
| 27. Kế hoạch giao hàng/tiến độ của nhà sản xuất | | | | | |
| 28. Chất lượng sản phẩm của nhà sản xuất | | | | | |
| **Hợp đồng** | | | | | |
| 29. Việc quy định giá vật tư | | | | | |
| 30. Điều kiện thanh toán và nghiệm thu | | | | | |
| 31. Sự điều chỉnh đặc điểm kỹ thuật vật tư trong khi thi công | Luôn luôn | Thường xuyên | Đôi khi | Thỉnh thoảng | Hầu như không |
| **Điều kiện công trường** | | | | | |
| 32. Vị trí kho bãi cho việc vận chuyển, bốc xếp | | | | | |
| 33. Diện tích kho bãi cho mặt bằng chứa vật tư | | | | | |
| 34. Kế hoạch nhận hàng trên công trường | | | | | |
| 35. Việc kiểm tra, tiếp nhận chất lượng vật tư công trình | | | | | |
| 36. Việc kiểm tra, tiếp nhận số lượng vật tư công trình | | | | | |
| 37. Điều kiện thời tiết | | | | | |
| **Kiểm soát chất lượng** | | | | | |
| 38. Chứng nhận xuất xưởng và chất lượng của vật tư | | | | | |
| 39. Những qui định về thủ tục thu mua vật tư | | | | | |
| 40. Những qui định về công tác lắp đặt, sử dụng vật tư | | | | | |
| **An ninh công trường** | | | | | |
| 41. Hợp đồng với công ty bảo vệ | | | | | |
| 42. Hệ thống bảo vệ an ninh công trường | | | | | |

## PHẦN 4:

## ĐÁNH GIÁ HIỆU QUẢ QUẢN LÝ VẬT TƯ

Phần này bao gồm 4 phần chính được sử dụng để đánh giá hiệu quả của việc quản lý vật tư. Ông/Bà vui lòng đánh dấu (✓) vào một trong các lựa chọn trả lời *(trang sau)* để đánh giá mỗi tiêu chí theo thang đo được mô tả như sau:

| Đánh giá | | Sự mô tả thang đánh giá |
|---|---|---|
| 9-10 | Tốt | Việc thực hiện hiện tại đáp ứng các yêu cầu về hợp đồng và **vượt quá một số khía cạnh** để mang lại lợi ích cho dự án. Việc thực hiện hợp đồng liên quan đến các hạng mục chính/phụ được đánh giá là đã hoàn thành với một vài vấn đề không đáng kể nảy sinh mà trong đó các hành động khắc phục của nhà thầu sau đó đã được cho là hiệu quả. |
| 7-8 | Hài lòng | Việc thực hiện **hiện tại đáp ứng** các yêu cầu về hợp đồng. Việc thực hiện hợp đồng liên quan đến các hạng mục chính/phụ bao gồm một số vấn đề nhỏ mà trong đó các hành động được đề xuất từ nhà thầu có vẻ thỏa đáng hoặc các hành động khắc phục đó đã được hoàn thành một cách thỏa đáng. |
| 5-6 | Cảnh báo | Việc thực hiện **đã không hoàn toàn đáp ứng** những yêu cầu về hợp đồng. Việc thực hiện hợp đồng liên quan đến các hạng mục chính/phụ bao gồm một số vấn đề nhỏ mà trong đó các hành động được đề xuất từ nhà thầu có vẻ tiếp tục là một mối quan tâm nhỏ hoặc các hành động khắc phục đó đã được hoàn thành nhưng hơi thấp hơn mức thỏa đáng. |
| 3-4 | Không hài lòng | Việc thực hiện **không đạt được một vài** những yêu cầu về hợp đồng. Việc thực hiện hợp đồng liên quan đến các hạng mục chính/phụ được đánh giá phản ánh một vấn đề nghiêm trọng mà trong đó Nhà thầu đã đưa ra một số hành động khắc phục tối thiểu, nếu có thể. Các hành động được đề xuất của nhà thầu chỉ có hiệu quả đôi chút hoặc không được triển khai đầy đủ. |
| 0-2 | Không chấp nhận được | Việc thực hiện **không đạt** được những yêu cầu về hợp đồng và/hoặc **không có khả năng** được phục hồi một cách kịp thời và hiệu quả về mặt chi phí. Việc thực hiện hợp đồng liên quan đến các hạng mục chính/phụ bao gồm một (những) vấn đề nghiêm trọng mà trong đó hành động khắc phục của Nhà thầu bây giờ/ trước đó có vẻ như không hiệu quả. |

| STT | TIÊU CHUẨN ĐÁNH GIÁ | ĐIỂM | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **THỜI GIAN** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | Kế hoạch cung cấp | | | | | | | | | | | |
| 2 | Kế hoạch ký hợp đồng thu mua vật tư | | | | | | | | | | | |
| 3 | Kế hoạch nhận hàng | | | | | | | | | | | |
| 4 | Kế hoạch thanh toán | | | | | | | | | | | |
| 5 | Kế hoạch lắp đặt vật tư | | | | | | | | | | | |
| 6 | Kế hoạch nghiệm thu, bàn giao | | | | | | | | | | | |
| | **CHI PHÍ** | | | | | | | | | | | |
| 7 | Đơn giá vật tư so với ngân sách | | | | | | | | | | | |
| 8 | Khối lượng vật tư thi công so với hệ số hao hụt của dự án | | | | | | | | | | | |
| 9 | Hợp đồng cam kết giữ giá vật tư theo tiến độ thi công | | | | | | | | | | | |
| 10 | Hệ thống kiểm soát chi phí của tiến trình quản lý vật tư | | | | | | | | | | | |
| | **CHẤT LƯỢNG** | | | | | | | | | | | |
| 11 | Tuân thủ với chất lượng, tiêu chuẩn của dự án | | | | | | | | | | | |
| 12 | Hệ thống đánh giá, kiểm soát chất lượng vật tư từ khâu thu mua cho đến sử dụng | | | | | | | | | | | |
| | **AN TOÀN LAO ĐỘNG** | | | | | | | | | | | |
| 13 | Việc vận chuyển, bốc xếp vật tư tuân thủ hành vi an toàn lao động và sức khỏe | | | | | | | | | | | |
| 14 | An ninh công trường liên quan đến việc lưu trữ vật tư | | | | | | | | | | | |
| 15 | Quy trình an toàn lao động liên quan đến việc lắp đặt vật tư | | | | | | | | | | | |

# APPENDIX B
# FACTOR ANALYSIS RESULTS FROM SPSS PROGRAM

**B1.** Cronbach's alpha for pilot study (N = 30)

**Case Processing Summary**

| | | N | % |
|---|---|---|---|
| Cases | Valid | 30 | 100.0 |
| | Excluded[a] | 0 | .0 |
| | Total | 30 | 100.0 |

a. Listwise deletion based on all variables in the procedure.

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| **.966** | 43 |

**B2.** Cronbach's alpha for large scale study (N = 200)

❖ Reliability analysis for scale of influential factors:

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .718 | 6 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| PL1 | 18.67 | 11.440 | .573 | .643 |
| PL2 | 18.67 | 11.329 | .575 | .642 |
| PL3 | 18.46 | 13.747 | .221 | .741 |
| PL4 | 18.66 | 11.572 | .519 | .659 |
| PL5 | 18.97 | 12.406 | .282 | .739 |
| PL6 | 18.64 | 11.136 | .592 | .635 |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .881 | 12 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| PI1 | 40.40 | 64.211 | .591 | .871 |
| PI2 | 40.39 | 62.450 | .697 | .865 |
| PI3 | 40.44 | 68.861 | .256 | .891 |
| PI4 | 40.41 | 62.684 | .651 | .868 |
| PI5 | 40.42 | 62.777 | .669 | .867 |
| PI6 | 40.45 | 61.726 | .693 | .865 |
| PI7 | 40.40 | 63.095 | .653 | .868 |
| PI8 | 40.62 | 67.704 | .298 | .889 |
| PI9 | 40.38 | 62.487 | .658 | .867 |
| PI10 | 40.33 | 64.283 | .587 | .871 |
| PI11 | 40.46 | 60.882 | .662 | .867 |
| PI12 | 40.31 | 64.034 | .603 | .871 |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .778 | 5 |



**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| IE1 | 14.83 | 11.502 | .311 | .816 |
| IE2 | 14.73 | 9.997 | .603 | .720 |
| IE3 | 14.83 | 9.773 | .634 | .709 |
| IE4 | 14.84 | 9.867 | .620 | .714 |
| IE5 | 14.79 | 9.677 | .620 | .713 |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .868 | 3 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| CT1 | 7.49 | 3.477 | .759 | .805 |
| CT2 | 7.40 | 3.356 | .808 | .760 |
| CT3 | 7.54 | 3.677 | .682 | .874 |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .723 | 3 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| SU1 | 7.58 | 2.859 | .550 | .628 |
| SU2 | 7.55 | 2.842 | .553 | .624 |
| SU3 | 7.47 | 2.763 | .529 | .655 |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .786 | 6 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| SI1 | 18.34 | 14.184 | .560 | .748 |
| SI2 | 18.26 | 13.729 | .606 | .737 |
| SI3 | 18.27 | 14.236 | .585 | .743 |
| SI4 | 18.32 | 13.815 | .632 | .732 |
| SI5 | 18.31 | 13.642 | .608 | .736 |
| SI6 | 18.57 | 15.412 | .285 | .821 |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .841 | 2 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| TR1 | 3.81 | 1.056 | .727 | . |
| TR2 | 3.79 | .918 | .727 | . |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .730 | 3 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| QC1 | 7.34 | 3.190 | .530 | .669 |
| QC2 | 7.18 | 3.271 | .529 | .670 |
| QC3 | 7.20 | 3.052 | .599 | .586 |



**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .844 | 2 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| SE1 | 3.77 | 1.072 | .730 | . |
| SE2 | 3.71 | 1.031 | .730 | . |

❖ Reliability analysis for scale of material management effectiveness:

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| **.846** | 6 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| T1 | 19.31 | 7.503 | .582 | .829 |
| T2 | 19.24 | 7.128 | .671 | .812 |
| T3 | 19.22 | 7.235 | .646 | .817 |
| T4 | 19.29 | 7.182 | .640 | .817 |
| T5 | 19.23 | 6.999 | .648 | .816 |
| T6 | 19.27 | 7.372 | .571 | .831 |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| **.763** | 4 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| C7 | 11.54 | 3.044 | .520 | .729 |
| C8 | 11.62 | 2.620 | .649 | .658 |
| C9 | 11.56 | 2.931 | .541 | .719 |
| C10 | 11.51 | 2.874 | .542 | .719 |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .743 | 2 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| Q11 | 3.89 | .611 | .591 | . |
| Q12 | 3.88 | .619 | .591 | . |

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .803 | 3 |

**Item-Total Statistics**

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| S13 | 7.88 | 1.939 | .598 | .793 |
| S14 | 7.97 | 2.155 | .666 | .718 |
| S15 | 7.89 | 1.968 | .694 | .682 |



**B3.** Factor analysis for large scale study (N = 200)

❖ Confirmatory factor analysis for influential factors on material management effectiveness – Final result:

**Result (Default model)**

Minimum was achieved
Chi-square = 1068.692
Degrees of freedom = 783
Probability level = .000

**Computation of degrees of freedom (Default model)**

| | |
|---|---|
| Number of distinct sample moments: | 903 |
| Number of distinct parameters to be estimated: | 120 |
| Degrees of freedom (903 - 120): | 783 |

**Standardized Regression Weights: (Group number 1 - Default model)**

| | | | Estimate |
|---|---|---|---|
| PI7 | <--- | PI | .721 |
| PI6 | <--- | PI | .737 |
| PI2 | <--- | PI | .746 |
| PI4 | <--- | PI | .707 |
| PI11 | <--- | PI | .717 |
| PI5 | <--- | PI | .701 |
| PI12 | <--- | PI | .639 |
| PI1 | <--- | PI | .644 |
| PI9 | <--- | PI | .680 |
| PI10 | <--- | PI | .629 |
| IE4 | <--- | IE | .743 |
| IE3 | <--- | IE | .707 |
| IE2 | <--- | IE | .747 |
| IE5 | <--- | IE | .702 |
| SI4 | <--- | SI | .694 |
| SI1 | <--- | SI | .693 |
| SI2 | <--- | SI | .684 |
| SI3 | <--- | SI | .721 |
| SI5 | <--- | SI | .663 |
| PL1 | <--- | PL | .690 |
| PL2 | <--- | PL | .745 |
| PL6 | <--- | PL | .710 |
| PL4 | <--- | PL | .594 |
| CT2 | <--- | CT | .932 |
| CT1 | <--- | CT | .835 |
| CT3 | <--- | CT | .723 |
| SU3 | <--- | SU | .638 |
| SU1 | <--- | SU | .719 |
| SU2 | <--- | SU | .690 |
| QC3 | <--- | QC | .787 |
| QC1 | <--- | QC | .555 |
| QC2 | <--- | QC | .701 |
| TR2 | <--- | TR | .863 |
| TR1 | <--- | TR | .843 |
| SE2 | <--- | SE | .854 |
| SE1 | <--- | SE | .854 |

**Correlations: (Group number 1 - Default model)**

| | | | Estimate |
|---|---|---|---|
| PI | <--> | IE | .222 |
| PI | <--> | SI | .164 |
| PI | <--> | PL | .236 |
| PI | <--> | CT | .291 |
| PI | <--> | SU | .144 |
| PI | <--> | QC | .326 |
| PI | <--> | TR | .002 |
| PI | <--> | SE | .293 |
| IE | <--> | SI | .302 |
| IE | <--> | PL | .153 |
| IE | <--> | CT | .824 |
| IE | <--> | SU | .098 |
| IE | <--> | QC | .258 |
| IE | <--> | TR | .098 |
| IE | <--> | SE | .173 |
| SI | <--> | PL | .204 |
| SI | <--> | CT | .229 |
| SI | <--> | SU | .386 |
| SI | <--> | QC | .296 |
| SI | <--> | TR | .838 |
| SI | <--> | SE | .229 |
| PL | <--> | CT | .162 |
| PL | <--> | SU | .242 |
| PL | <--> | QC | .241 |
| PL | <--> | TR | .293 |
| PL | <--> | SE | .244 |
| CT | <--> | SU | .146 |
| CT | <--> | QC | .151 |
| CT | <--> | TR | .073 |
| CT | <--> | SE | .102 |
| SU | <--> | QC | .352 |
| SU | <--> | TR | .283 |
| SU | <--> | SE | .205 |
| QC | <--> | TR | .161 |
| QC | <--> | SE | .826 |
| TR | <--> | SE | .145 |

❖ Factor analysis for items to evaluate material management effectiveness:

**KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .873 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1098.052 |
| | df | 105 |
| | Sig. | .000 |

**Communalities**

| | Initial | Extraction |
|---|---|---|
| T1 | 1.000 | .541 |
| T2 | 1.000 | .618 |
| T3 | 1.000 | .596 |
| T4 | 1.000 | .626 |
| T5 | 1.000 | .604 |
| T6 | 1.000 | .509 |
| C7 | 1.000 | .577 |
| C8 | 1.000 | .702 |
| C9 | 1.000 | .574 |
| C10 | 1.000 | .545 |
| Q11 | 1.000 | .751 |
| Q12 | 1.000 | .810 |
| S13 | 1.000 | .641 |
| S14 | 1.000 | .729 |
| S15 | 1.000 | .781 |

Extraction Method: Principal Component Analysis.



**Total Variance Explained**

| Factor | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings[a] |
|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total |
| 1 | 5.477 | 36.513 | 36.513 | 5.477 | 36.513 | 36.513 | 3.384 |
| 2 | 1.835 | 12.235 | 48.748 | 1.835 | 12.235 | 48.748 | 2.371 |
| 3 | 1.227 | 8.179 | 56.927 | 1.227 | 8.179 | 56.927 | 2.256 |
| 4 | 1.066 | 7.104 | 64.031 | 1.066 | 7.104 | 64.031 | 1.594 |

Extraction Method: Principal Component Analysis.

**Rotated Component Matrix[a]**

| | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| T4 | .762 | | | |
| T2 | .745 | | | |
| T5 | .738 | | | |
| T3 | .727 | | | |
| T1 | .686 | | | |
| T6 | .624 | | | |
| C8 | | .766 | | |
| C9 | | .719 | | |
| C7 | | .684 | | |
| C10 | | .651 | | |
| S15 | | | .866 | |
| S14 | | | .828 | |
| S13 | | | .761 | |
| Q12 | | | | .843 |
| Q11 | | | | .796 |

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

**Component Correlation Matrix**

| Component | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 1.000 | .258 | -.453 | .315 |
| 2 | .258 | 1.000 | -.324 | .240 |
| 3 | -.453 | -.324 | 1.000 | -.323 |
| 4 | .315 | .240 | -.323 | 1.000 |

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

**B4.** Independent Samples T Test (N = 200)

❖ Actual practice of influential factors on material management effectiveness:

**Group Statistics**

| | Workplace | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| PL1 | Construction site | 157 | 3.76 | 1.014 | .081 |
| | Company office | 43 | 3.67 | .919 | .140 |
| PL2 | Construction site | 157 | 3.74 | 1.020 | .081 |
| | Company office | 43 | 3.77 | .996 | .152 |

| | | | | | |
|---|---|---|---|---|---|
| PL3 | Construction site | 157 | 3.91 | 1.002 | .080 |
| | Company office | 43 | 4.12 | .823 | .125 |
| PL4 | Construction site | 157 | 3.76 | 1.069 | .085 |
| | Company office | 43 | 3.70 | .887 | .135 |
| PL5 | Construction site | 157 | 3.41 | 1.261 | .101 |
| | Company office | 43 | 3.58 | 1.006 | .153 |
| PL6 | Construction site | 157 | 3.81 | 1.051 | .084 |
| | Company office | 43 | 3.63 | .952 | .145 |
| PI1 | Construction site | 157 | 3.63 | 1.076 | .086 |
| | Company office | 43 | 3.91 | .840 | .128 |
| PI2 | Construction site | 157 | 3.66 | 1.072 | .086 |
| | Company office | 43 | 3.86 | .941 | .143 |
| PI3 | Construction site | 157 | 3.69 | 1.159 | .093 |
| | Company office | 43 | 3.51 | 1.121 | .171 |
| PI4 | Construction site | 157 | 3.70 | 1.112 | .089 |
| | Company office | 43 | 3.63 | 1.001 | .153 |
| PI5 | Construction site | 157 | 3.70 | 1.077 | .086 |
| | Company office | 43 | 3.58 | .982 | .150 |
| PI6 | Construction site | 157 | 3.61 | 1.137 | .091 |
| | Company office | 43 | 3.77 | 1.020 | .156 |
| PI7 | Construction site | 157 | 3.70 | 1.077 | .086 |
| | Company office | 43 | 3.65 | .948 | .145 |
| PI8 | Construction site | 157 | 3.46 | 1.233 | .098 |
| | Company office | 43 | 3.49 | 1.121 | .171 |
| PI9 | Construction site | 157 | 3.69 | 1.130 | .090 |
| | Company office | 43 | 3.79 | .965 | .147 |
| PI10 | Construction site | 157 | 3.80 | 1.040 | .083 |
| | Company office | 43 | 3.60 | 1.003 | .153 |
| PI11 | Construction site | 157 | 3.59 | 1.261 | .101 |
| | Company office | 43 | 3.79 | 1.103 | .168 |
| PI12 | Construction site | 157 | 3.80 | 1.067 | .085 |
| | Company office | 43 | 3.72 | .908 | .139 |
| IE1 | Construction site | 157 | 3.71 | 1.099 | .088 |
| | Company office | 43 | 3.56 | 1.119 | .171 |
| IE2 | Construction site | 157 | 3.75 | 1.074 | .086 |
| | Company office | 43 | 3.86 | .915 | .140 |
| IE3 | Construction site | 157 | 3.65 | 1.073 | .086 |
| | Company office | 43 | 3.77 | .972 | .148 |

| | | | | | |
|---|---|---|---|---|---|
| IE4 | Construction site | 157 | 3.66 | 1.053 | .084 |
| | Company office | 43 | 3.67 | 1.040 | .159 |
| IE5 | Construction site | 157 | 3.69 | 1.120 | .089 |
| | Company office | 43 | 3.81 | .958 | .146 |
| CT1 | Construction site | 157 | 3.73 | 1.046 | .083 |
| | Company office | 43 | 3.67 | .919 | .140 |
| CT2 | Construction site | 157 | 3.83 | 1.055 | .084 |
| | Company office | 43 | 3.77 | .868 | .132 |
| CT3 | Construction site | 157 | 3.67 | 1.040 | .083 |
| | Company office | 43 | 3.70 | .964 | .147 |
| SU1 | Construction site | 157 | 3.75 | 1.018 | .081 |
| | Company office | 43 | 3.63 | .725 | .110 |
| SU2 | Construction site | 157 | 3.76 | 1.015 | .081 |
| | Company office | 43 | 3.72 | .766 | .117 |
| SU3 | Construction site | 157 | 3.82 | 1.053 | .084 |
| | Company office | 43 | 3.84 | .871 | .133 |
| SI1 | Construction site | 157 | 3.66 | 1.047 | .084 |
| | Company office | 43 | 3.72 | .959 | .146 |
| SI2 | Construction site | 157 | 3.78 | 1.066 | .085 |
| | Company office | 43 | 3.67 | 1.017 | .155 |
| SI3 | Construction site | 157 | 3.77 | 1.006 | .080 |
| | Company office | 43 | 3.65 | .923 | .141 |
| SI4 | Construction site | 157 | 3.68 | 1.038 | .083 |
| | Company office | 43 | 3.74 | .902 | .138 |
| SI5 | Construction site | 157 | 3.68 | 1.116 | .089 |
| | Company office | 43 | 3.79 | .861 | .131 |
| SI6 | Construction site | 157 | 3.43 | 1.236 | .099 |
| | Company office | 43 | 3.49 | 1.099 | .168 |
| TR1 | Construction site | 157 | 3.85 | .955 | .076 |
| | Company office | 43 | 3.60 | .955 | .146 |
| TR2 | Construction site | 157 | 3.86 | 1.028 | .082 |
| | Company office | 43 | 3.65 | 1.021 | .156 |
| QC1 | Construction site | 157 | 3.54 | 1.059 | .085 |
| | Company office | 43 | 3.44 | 1.031 | .157 |
| QC2 | Construction site | 157 | 3.71 | 1.070 | .085 |
| | Company office | 43 | 3.58 | .852 | .130 |
| QC3 | Construction site | 157 | 3.71 | 1.032 | .082 |
| | Company office | 43 | 3.47 | 1.032 | .157 |

| | | | | | |
|---|---|---|---|---|---|
| SE1 | Construction site | 157 | 3.75 | 1.017 | .081 |
| | Company office | 43 | 3.56 | 1.007 | .154 |
| SE2 | Construction site | 157 | 3.82 | 1.059 | .085 |
| | Company office | 43 | 3.58 | .932 | .142 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| PL1 | Equal variances assumed | 1.103 | .295 | .525 | 198 | .600 | .090 | .171 | -.248 | .427 |
| | Equal variances not assumed | | | .556 | 72.511 | .580 | .090 | .162 | -.233 | .412 |
| PL2 | Equal variances assumed | .245 | .621 | -.164 | 198 | .870 | -.029 | .175 | -.373 | .316 |
| | Equal variances not assumed | | | -.166 | 68.073 | .869 | -.029 | .172 | -.372 | .315 |
| PL3 | Equal variances assumed | 2.830 | .094 | -1.234 | 198 | .219 | -.205 | .166 | -.534 | .123 |
| | Equal variances not assumed | | | -1.381 | 79.569 | .171 | -.205 | .149 | -.502 | .091 |
| PL4 | Equal variances assumed | 4.030 | .046 | .375 | 198 | .708 | .067 | .178 | -.284 | .417 |
| | Equal variances not assumed | | | .417 | 78.682 | .678 | .067 | .160 | -.252 | .385 |
| PL5 | Equal variances assumed | 5.195 | .024 | -.834 | 198 | .406 | -.174 | .208 | -.585 | .237 |
| | Equal variances not assumed | | | -.947 | 81.860 | .346 | -.174 | .183 | -.539 | .191 |
| PL6 | Equal variances assumed | .795 | .374 | 1.020 | 198 | .309 | .181 | .177 | -.169 | .531 |
| | Equal variances not assumed | | | 1.080 | 72.550 | .284 | .181 | .168 | -.153 | .515 |
| PI1 | Equal variances assumed | 13.901 | .000 | -1.559 | 198 | .121 | -.276 | .177 | -.626 | .073 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Equal variances not assumed | | | -1.792 | 83.683 | .077 | -.276 | .154 | -.583 | .030 |
| PI2 | Equal variances assumed | 5.038 | .026 | -1.136 | 198 | .258 | -.204 | .180 | -.559 | .151 |
| | Equal variances not assumed | | | -1.224 | 74.681 | .225 | -.204 | .167 | -.537 | .128 |
| PI3 | Equal variances assumed | .199 | .656 | .890 | 198 | .375 | .176 | .198 | -.215 | .567 |
| | Equal variances not assumed | | | .907 | 68.648 | .368 | .176 | .194 | -.211 | .564 |
| PI4 | Equal variances assumed | 1.073 | .301 | .388 | 198 | .699 | .073 | .188 | -.297 | .442 |
| | Equal variances not assumed | | | .412 | 72.980 | .682 | .073 | .177 | -.279 | .425 |
| PI5 | Equal variances assumed | .830 | .364 | .655 | 198 | .513 | .119 | .182 | -.240 | .478 |
| | Equal variances not assumed | | | .691 | 72.149 | .492 | .119 | .173 | -.225 | .463 |
| PI6 | Equal variances assumed | 2.686 | .103 | -.848 | 198 | .398 | -.162 | .192 | -.540 | .215 |
| | Equal variances not assumed | | | -.902 | 73.161 | .370 | -.162 | .180 | -.521 | .196 |
| PI7 | Equal variances assumed | 1.724 | .191 | .274 | 198 | .785 | .049 | .181 | -.307 | .406 |
| | Equal variances not assumed | | | .294 | 74.414 | .770 | .049 | .168 | -.286 | .385 |
| PI8 | Equal variances assumed | 1.171 | .280 | -.112 | 198 | .911 | -.023 | .208 | -.434 | .387 |
| | Equal variances not assumed | | | -.119 | 72.314 | .906 | -.023 | .197 | -.416 | .370 |
| PI9 | Equal variances assumed | 5.375 | .021 | -.511 | 198 | .610 | -.096 | .189 | -.469 | .276 |
| | Equal variances not assumed | | | -.559 | 76.582 | .578 | -.096 | .173 | -.440 | .247 |
| PI10 | Equal variances assumed | .009 | .924 | 1.113 | 198 | .267 | .198 | .178 | -.153 | .548 |
| | Equal variances not assumed | | | 1.137 | 68.779 | .260 | .198 | .174 | -.149 | .545 |
| PI11 | Equal variances assumed | 4.613 | .033 | -.938 | 198 | .350 | -.198 | .212 | -.615 | .219 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Equal variances not assumed | | | -1.012 | 74.835 | .315 | -.198 | .196 | -.589 | .192 |
| PI12 | Equal variances assumed | 1.612 | .206 | .422 | 198 | .673 | .075 | .178 | -.276 | .427 |
| | Equal variances not assumed | | | .463 | 76.768 | .645 | .075 | .163 | -.249 | .399 |
| IE1 | Equal variances assumed | .009 | .924 | .784 | 198 | .434 | .149 | .190 | -.226 | .523 |
| | Equal variances not assumed | | | .776 | 65.892 | .441 | .149 | .192 | -.234 | .532 |
| IE2 | Equal variances assumed | 4.809 | .029 | -.643 | 198 | .521 | -.115 | .179 | -.469 | .238 |
| | Equal variances not assumed | | | -.704 | 76.709 | .484 | -.115 | .164 | -.441 | .211 |
| IE3 | Equal variances assumed | 1.588 | .209 | -.650 | 198 | .516 | -.118 | .181 | -.475 | .240 |
| | Equal variances not assumed | | | -.688 | 72.567 | .494 | -.118 | .171 | -.459 | .223 |
| IE4 | Equal variances assumed | .060 | .807 | -.066 | 198 | .947 | -.012 | .181 | -.369 | .345 |
| | Equal variances not assumed | | | -.067 | 67.476 | .947 | -.012 | .180 | -.370 | .346 |
| IE5 | Equal variances assumed | 3.958 | .048 | -.673 | 198 | .501 | -.126 | .187 | -.495 | .243 |
| | Equal variances not assumed | | | -.736 | 76.483 | .464 | -.126 | .171 | -.467 | .215 |
| CT1 | Equal variances assumed | 1.648 | .201 | .331 | 198 | .741 | .058 | .176 | -.288 | .404 |
| | Equal variances not assumed | | | .356 | 74.610 | .723 | .058 | .163 | -.267 | .383 |
| CT2 | Equal variances assumed | 3.525 | .062 | .382 | 198 | .703 | .067 | .175 | -.279 | .413 |
| | Equal variances not assumed | | | .427 | 79.341 | .671 | .067 | .157 | -.245 | .379 |
| CT3 | Equal variances assumed | .476 | .491 | -.164 | 198 | .870 | -.029 | .176 | -.377 | .319 |
| | Equal variances not assumed | | | -.171 | 71.077 | .865 | -.029 | .169 | -.366 | .308 |
| SU1 | Equal variances assumed | 9.377 | .003 | .707 | 198 | .480 | .117 | .166 | -.210 | .444 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Equal variances not assumed | | | .855 | 92.470 | .395 | .117 | .137 | -.155 | .390 |
| SU2 | Equal variances assumed | 6.750 | .010 | .222 | 198 | .824 | .037 | .167 | -.291 | .366 |
| | Equal variances not assumed | | | .260 | 86.720 | .795 | .037 | .142 | -.246 | .320 |
| SU3 | Equal variances assumed | 5.387 | .021 | -.089 | 198 | .929 | -.016 | .175 | -.361 | .330 |
| | Equal variances not assumed | | | -.099 | 78.960 | .921 | -.016 | .157 | -.328 | .297 |
| SI1 | Equal variances assumed | 1.317 | .253 | -.330 | 198 | .742 | -.059 | .177 | -.408 | .291 |
| | Equal variances not assumed | | | -.347 | 71.836 | .729 | -.059 | .168 | -.394 | .277 |
| SI2 | Equal variances assumed | .329 | .567 | .565 | 198 | .573 | .103 | .182 | -.256 | .461 |
| | Equal variances not assumed | | | .580 | 69.375 | .564 | .103 | .177 | -.250 | .455 |
| SI3 | Equal variances assumed | .348 | .556 | .703 | 198 | .483 | .120 | .170 | -.216 | .455 |
| | Equal variances not assumed | | | .738 | 71.717 | .463 | .120 | .162 | -.203 | .443 |
| SI4 | Equal variances assumed | 2.818 | .095 | -.360 | 198 | .719 | -.063 | .174 | -.406 | .280 |
| | Equal variances not assumed | | | -.390 | 75.308 | .698 | -.063 | .161 | -.383 | .257 |
| SI5 | Equal variances assumed | 9.127 | .003 | -.629 | 198 | .530 | -.116 | .184 | -.478 | .247 |
| | Equal variances not assumed | | | -.728 | 84.775 | .468 | -.116 | .159 | -.431 | .200 |
| SI6 | Equal variances assumed | 3.287 | .071 | -.296 | 198 | .767 | -.062 | .208 | -.472 | .349 |
| | Equal variances not assumed | | | -.317 | 73.758 | .752 | -.062 | .195 | -.449 | .326 |
| TR1 | Equal variances assumed | .036 | .849 | 1.475 | 198 | .142 | .242 | .164 | -.082 | .567 |
| | Equal variances not assumed | | | 1.476 | 66.836 | .145 | .242 | .164 | -.086 | .571 |
| TR2 | Equal variances assumed | .000 | .988 | 1.181 | 198 | .239 | .209 | .177 | -.140 | .557 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Equal variances not assumed | | | 1.186 | 67.185 | .240 | .209 | .176 | -.143 | .560 |
| QC1 | Equal variances assumed | .321 | .572 | .514 | 198 | .608 | .093 | .181 | -.264 | .451 |
| | Equal variances not assumed | | | .522 | 68.287 | .603 | .093 | .178 | -.263 | .449 |
| QC2 | Equal variances assumed | 4.267 | .040 | .710 | 198 | .478 | .126 | .177 | -.223 | .474 |
| | Equal variances not assumed | | | .808 | 82.015 | .421 | .126 | .155 | -.184 | .435 |
| QC3 | Equal variances assumed | .064 | .800 | 1.398 | 198 | .164 | .248 | .178 | -.102 | .598 |
| | Equal variances not assumed | | | 1.398 | 66.821 | .167 | .248 | .178 | -.106 | .603 |
| SE1 | Equal variances assumed | .005 | .943 | 1.108 | 198 | .269 | .193 | .175 | -.151 | .538 |
| | Equal variances not assumed | | | 1.114 | 67.313 | .269 | .193 | .174 | -.153 | .540 |
| SE2 | Equal variances assumed | .755 | .386 | 1.351 | 198 | .178 | .240 | .178 | -.111 | .591 |
| | Equal variances not assumed | | | 1.453 | 74.476 | .150 | .240 | .165 | -.089 | .570 |

# APPENDIX C
# MODEL RESULTS FROM AMOS PROGRAM

❖ Final Model Results:

**Regression Weights: (Group number 1 - Default model)**

| | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| TIME | <--- | PL | .186 | .052 | 3.604 | *** | |
| TIME | <--- | TR | .15 | .036 | 4.191 | *** | |
| TIME | <--- | SU | .189 | .053 | 3.596 | *** | |
| TIME | <--- | PI | .147 | .040 | 3.654 | *** | |
| TIME | <--- | SE | .096 | .034 | 2.840 | .005 | |
| COST | <--- | IE | .147 | .118 | 1.243 | .014 | |
| COST | <--- | CT | .279 | .093 | 2.991 | .003 | |
| COST | <--- | SU | .191 | .076 | 2.500 | .012 | |
| COST | <--- | PL | .207 | .068 | 3.023 | .003 | |
| COST | <--- | SE | .176 | .049 | 3.604 | *** | |
| COST | <--- | SI | .211 | .067 | 3.137 | .002 | |
| QUALITY | <--- | PI | .27 | .073 | 3.725 | *** | |
| QUALITY | <--- | SU | .231 | .091 | 2.533 | .011 | |
| QUALITY | <--- | QC | .161 | .068 | 2.347 | .019 | |
| QUALITY | <--- | SI | .031 | .188 | 0.163 | .047 | |
| QUALITY | <--- | TR | .17 | .142 | 1.200 | .023 | |
| SAFETY | <--- | TR | .255 | .161 | 1.582 | .014 | |
| SAFETY | <--- | SI | .21 | .137 | .154 | .038 | |
| SAFETY | <--- | SE | .19 | .194 | .982 | .026 | |
| SAFETY | <--- | QC | .054 | .150 | .362 | .017 | |
| PI7 | <--- | PI | 1.000 | | | | |
| PI6 | <--- | PI | 1.086 | .110 | 9.867 | *** | |
| PI2 | <--- | PI | 1.042 | .104 | 10.057 | *** | |
| PI4 | <--- | PI | 1.022 | .108 | 9.506 | *** | |
| PI11 | <--- | PI | 1.177 | .122 | 9.677 | *** | |
| PI5 | <--- | PI | .989 | .104 | 9.463 | *** | |
| PI12 | <--- | PI | .881 | .102 | 8.622 | *** | |
| PI1 | <--- | PI | .882 | .102 | 8.620 | *** | |
| PI9 | <--- | PI | 1.002 | .108 | 9.245 | *** | |
| PI10 | <--- | PI | .859 | .102 | 8.399 | *** | |
| IE4 | <--- | IE | 1.000 | | | | |
| IE3 | <--- | IE | .963 | .102 | 9.413 | *** | |
| IE2 | <--- | IE | .986 | .101 | 9.735 | *** | |
| IE5 | <--- | IE | .981 | .106 | 9.282 | *** | |
| SI4 | <--- | SI | 1.000 | | | | |
| SI1 | <--- | SI | .933 | .113 | 8.283 | *** | |
| SI2 | <--- | SI | .941 | .116 | 8.146 | *** | |
| SI3 | <--- | SI | 1.021 | .109 | 9.380 | *** | |

| | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| SI5 | <--- | SI | 1.014 | .117 | 8.684 | *** | |
| PL1 | <--- | PL | 1.000 | | | | |
| PL2 | <--- | PL | 1.120 | .139 | 8.086 | *** | |
| PL6 | <--- | PL | 1.145 | .141 | 8.107 | *** | |
| PL4 | <--- | PL | .960 | .135 | 7.113 | *** | |
| CT2 | <--- | CT | 1.000 | | | | |
| CT1 | <--- | CT | .904 | .057 | 15.994 | *** | |
| CT3 | <--- | CT | .779 | .063 | 12.383 | *** | |
| SU3 | <--- | SU | 1.000 | | | | |
| SU1 | <--- | SU | 1.033 | .147 | 7.027 | *** | |
| SU2 | <--- | SU | .980 | .143 | 6.866 | *** | |
| QC3 | <--- | QC | 1.000 | | | | |
| QC1 | <--- | QC | .733 | .099 | 7.394 | *** | |
| QC2 | <--- | QC | .880 | .097 | 9.094 | *** | |
| TR2 | <--- | TR | 1.000 | | | | |
| TR1 | <--- | TR | .930 | .071 | 13.007 | *** | |
| SE2 | <--- | SE | 1.000 | | | | |
| SE1 | <--- | SE | 1.007 | .082 | 12.242 | *** | |
| T1 | <--- | TIME | 1.000 | | | | |
| T5 | <--- | TIME | 1.214 | .146 | 8.291 | *** | |
| T2 | <--- | TIME | 1.217 | .139 | 8.741 | *** | |
| T3 | <--- | TIME | 1.128 | .136 | 8.311 | *** | |
| T4 | <--- | TIME | 1.148 | .139 | 8.268 | *** | |
| T6 | <--- | TIME | 1.055 | .138 | 7.641 | *** | |
| C8 | <--- | COST | 1.000 | | | | |
| C7 | <--- | COST | .725 | .091 | 7.933 | *** | |
| C9 | <--- | COST | .768 | .095 | 8.075 | *** | |
| C10 | <--- | COST | .859 | .098 | 8.755 | *** | |
| Q12 | <--- | QUALITY | 1.000 | | | | |
| Q11 | <--- | QUALITY | 1.044 | .139 | 7.508 | *** | |
| S15 | <--- | SAFETY | 1.000 | | | | |
| S14 | <--- | SAFETY | .900 | .092 | 9.831 | *** | |
| S13 | <--- | SAFETY | .920 | .102 | 9.043 | *** | |

**Standardized Regression Weights: (Group number 1 - Default model)**

| | | | Estimate |
|---|---|---|---|
| TIME | <--- | PL | .283 |
| TIME | <--- | TR | .303 |
| TIME | <--- | SU | .289 |
| TIME | <--- | PI | .254 |
| TIME | <--- | SE | .194 |
| COST | <--- | IE | .200 |
| COST | <--- | CT | .463 |
| COST | <--- | SU | .221 |
| COST | <--- | PL | .239 |
| COST | <--- | SE | .270 |
| COST | <--- | SI | .263 |
| QUALITY | <--- | PI | .344 |
| QUALITY | <--- | SU | .258 |
| QUALITY | <--- | QC | .221 |
| QUALITY | <--- | SI | .037 |
| QUALITY | <--- | TR | .252 |
| SAFETY | <--- | TR | .320 |
| SAFETY | <--- | SI | .280 |
| SAFETY | <--- | SE | .209 |
| SAFETY | <--- | QC | .073 |
| PI7 | <--- | PI | .716 |
| PI6 | <--- | PI | .733 |
| PI2 | <--- | PI | .747 |
| PI4 | <--- | PI | .706 |
| PI11 | <--- | PI | .719 |
| PI5 | <--- | PI | .703 |
| PI12 | <--- | PI | .640 |
| PI1 | <--- | PI | .640 |
| PI9 | <--- | PI | .686 |
| PI10 | <--- | PI | .624 |
| IE4 | <--- | IE | .739 |
| IE3 | <--- | IE | .709 |
| IE2 | <--- | IE | .734 |
| IE5 | <--- | IE | .700 |
| SI4 | <--- | SI | .706 |
| SI1 | <--- | SI | .646 |
| SI2 | <--- | SI | .635 |
| SI3 | <--- | SI | .736 |
| SI5 | <--- | SI | .677 |
| PL1 | <--- | PL | .663 |

| | | | Estimate |
|---|---|---|---|
| PL2 | <--- | PL | .728 |
| PL6 | <--- | PL | .731 |
| PL4 | <--- | PL | .612 |
| CT2 | <--- | CT | .930 |
| CT1 | <--- | CT | .839 |
| CT3 | <--- | CT | .720 |
| SU3 | <--- | SU | .650 |
| SU1 | <--- | SU | .708 |
| SU2 | <--- | SU | .670 |
| QC3 | <--- | QC | .785 |
| QC1 | <--- | QC | .566 |
| QC2 | <--- | QC | .696 |
| TR2 | <--- | TR | .849 |
| TR1 | <--- | TR | .847 |
| SE2 | <--- | SE | .844 |
| SE1 | <--- | SE | .866 |
| T1 | <--- | TIME | .641 |
| T5 | <--- | TIME | .705 |
| T2 | <--- | TIME | .756 |
| T3 | <--- | TIME | .707 |
| T4 | <--- | TIME | .702 |
| T6 | <--- | TIME | .637 |
| C8 | <--- | COST | .769 |
| C7 | <--- | COST | .612 |
| C9 | <--- | COST | .623 |
| C10 | <--- | COST | .677 |
| Q12 | <--- | QUALITY | .755 |
| Q11 | <--- | QUALITY | .783 |
| S15 | <--- | SAFETY | .819 |
| S14 | <--- | SAFETY | .792 |
| S13 | <--- | SAFETY | .687 |

**Covariances: (Group number 1 - Default model)**

| | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| PI | <--> | IE | .130 | .050 | 2.608 | .009 | |
| PI | <--> | SI | .095 | .045 | 2.099 | .036 | |
| PI | <--> | PL | .122 | .044 | 2.778 | .005 | |
| PI | <--> | CT | .215 | .059 | 3.629 | *** | |
| PI | <--> | SU | .070 | .044 | 1.583 | .114 | |
| PI | <--> | QC | .200 | .056 | 3.556 | *** | |
| PI | <--> | TR | .000 | .053 | .006 | .995 | |
| PI | <--> | SE | .193 | .057 | 3.396 | *** | |
| IE | <--> | SI | .171 | .052 | 3.301 | *** | |
| IE | <--> | PL | .085 | .046 | 1.857 | .063 | |
| IE | <--> | CT | .601 | .083 | 7.230 | *** | |
| IE | <--> | SU | .063 | .047 | 1.341 | .180 | |
| IE | <--> | QC | .172 | .059 | 2.905 | .004 | |
| IE | <--> | TR | .075 | .058 | 1.296 | .195 | |
| IE | <--> | SE | .122 | .059 | 2.073 | .038 | |
| SI | <--> | PL | .105 | .043 | 2.417 | .016 | |
| SI | <--> | CT | .158 | .058 | 2.747 | .006 | |
| SI | <--> | SU | .185 | .050 | 3.713 | *** | |
| SI | <--> | QC | .168 | .055 | 3.036 | .002 | |
| SI | <--> | TR | .526 | .077 | 6.834 | *** | |
| SI | <--> | SE | .149 | .055 | 2.686 | .007 | |
| PL | <--> | CT | .112 | .053 | 2.123 | .034 | |
| PL | <--> | SU | .108 | .043 | 2.500 | .012 | |
| PL | <--> | QC | .140 | .051 | 2.740 | .006 | |
| PL | <--> | TR | .167 | .053 | 3.140 | .002 | |
| PL | <--> | SE | .140 | .052 | 2.691 | .007 | |
| CT | <--> | SU | .116 | .056 | 2.090 | .037 | |
| CT | <--> | QC | .135 | .066 | 2.034 | .042 | |
| CT | <--> | TR | .078 | .067 | 1.161 | .246 | |
| CT | <--> | SE | .090 | .067 | 1.341 | .180 | |
| SU | <--> | QC | .183 | .056 | 3.281 | .001 | |
| SU | <--> | TR | .157 | .056 | 2.820 | .005 | |
| SU | <--> | SE | .114 | .054 | 2.121 | .034 | |
| QC | <--> | TR | .112 | .064 | 1.753 | .080 | |
| QC | <--> | SE | .576 | .083 | 6.902 | *** | |
| TR | <--> | SE | .108 | .065 | 1.674 | .094 | |
| e19 | <--> | e20 | .188 | .054 | 3.470 | *** | |

**Correlations: (Group number 1 - Default model)**

| | | | Estimate |
|---|---|---|---|
| PI | <--> | IE | .225 |
| PI | <--> | SI | .179 |
| PI | <--> | PL | .248 |
| PI | <--> | CT | .304 |
| PI | <--> | SU | .142 |
| PI | <--> | QC | .331 |
| PI | <--> | TR | .000 |
| PI | <--> | SE | .296 |
| IE | <--> | SI | .311 |
| IE | <--> | PL | .167 |
| IE | <--> | CT | .826 |
| IE | <--> | SU | .125 |
| IE | <--> | QC | .274 |
| IE | <--> | TR | .112 |
| IE | <--> | SE | .181 |
| SI | <--> | PL | .225 |
| SI | <--> | CT | .236 |
| SI | <--> | SU | .396 |
| SI | <--> | QC | .292 |
| SI | <--> | TR | .851 |
| SI | <--> | SE | .241 |
| PL | <--> | CT | .182 |
| PL | <--> | SU | .250 |
| PL | <--> | QC | .264 |
| PL | <--> | TR | .293 |
| PL | <--> | SE | .245 |
| CT | <--> | SU | .187 |
| CT | <--> | QC | .177 |
| CT | <--> | TR | .095 |
| CT | <--> | SE | .109 |
| SU | <--> | QC | .344 |
| SU | <--> | TR | .274 |
| SU | <--> | SE | .199 |
| QC | <--> | TR | .159 |
| QC | <--> | SE | .816 |
| TR | <--> | SE | .143 |
| e19 | <--> | e20 | .297 |

**Variances: (Group number 1 - Default model)**

| | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|
| PI | .560 | .099 | 5.640 | *** | |
| IE | .597 | .104 | 5.733 | *** | |
| SI | .504 | .093 | 5.398 | *** | |
| PL | .430 | .090 | 4.767 | *** | |
| CT | .888 | .107 | 8.322 | *** | |
| SU | .433 | .098 | 4.403 | *** | |
| QC | .655 | .110 | 5.949 | *** | |
| TR | .758 | .109 | 6.976 | *** | |
| SE | .760 | .112 | 6.770 | *** | |
| z1 | .066 | .016 | 4.120 | *** | |
| z2 | .121 | .028 | 4.269 | *** | |
| z3 | .196 | .044 | 4.456 | *** | |
| z4 | .332 | .057 | 5.849 | *** | |
| e1 | .534 | .060 | 8.931 | *** | |
| e3 | .570 | .065 | 8.822 | *** | |
| e4 | .482 | .055 | 8.719 | *** | |
| e5 | .590 | .066 | 8.988 | *** | |
| e6 | .726 | .081 | 8.913 | *** | |
| e7 | .562 | .062 | 9.006 | *** | |
| e9 | .627 | .067 | 9.286 | *** | |
| e10 | .628 | .068 | 9.287 | *** | |
| e11 | .631 | .069 | 9.090 | *** | |
| e12 | .649 | .069 | 9.344 | *** | |
| e13 | .496 | .062 | 8.053 | *** | |
| e14 | .546 | .065 | 8.365 | *** | |
| e15 | .496 | .061 | 8.111 | *** | |
| e16 | .599 | .071 | 8.455 | *** | |
| e18 | .508 | .060 | 8.461 | *** | |
| e19 | .611 | .069 | 8.823 | *** | |
| e20 | .659 | .074 | 8.883 | *** | |
| e21 | .445 | .055 | 8.159 | *** | |
| e22 | .612 | .070 | 8.689 | *** | |
| e24 | .550 | .068 | 8.133 | *** | |
| e25 | .480 | .066 | 7.311 | *** | |
| e26 | .493 | .068 | 7.264 | *** | |
| e27 | .661 | .077 | 8.572 | *** | |
| e30 | .140 | .034 | 4.095 | *** | |
| e31 | .306 | .041 | 7.490 | *** | |
| e32 | .500 | .056 | 8.962 | *** | |
| e33 | .591 | .078 | 7.531 | *** | |

| | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|
| e34 | .459 | .070 | 6.605 | *** | |
| e35 | .511 | .071 | 7.249 | *** | |
| e36 | .409 | .064 | 6.384 | *** | |
| e37 | .748 | .083 | 8.985 | *** | |
| e38 | .540 | .068 | 7.941 | *** | |
| e39 | .293 | .049 | 5.943 | *** | |
| e40 | .258 | .043 | 6.007 | *** | |
| e41 | .307 | .055 | 5.555 | *** | |
| e42 | .256 | .053 | 4.825 | *** | |
| e48 | .267 | .030 | 8.986 | *** | |
| e47 | .278 | .032 | 8.569 | *** | |
| e46 | .207 | .026 | 8.074 | *** | |
| e45 | .237 | .028 | 8.552 | *** | |
| e44 | .252 | .029 | 8.590 | *** | |
| e43 | .304 | .034 | 9.009 | *** | |
| e52 | .223 | .033 | 6.858 | *** | |
| e51 | .284 | .033 | 8.712 | *** | |
| e50 | .301 | .035 | 8.635 | *** | |
| e49 | .282 | .034 | 8.172 | *** | |
| e54 | .261 | .048 | 5.487 | *** | |
| e53 | .238 | .049 | 4.808 | *** | |
| e57 | .206 | .039 | 5.279 | *** | |
| e56 | .201 | .034 | 5.980 | *** | |
| e55 | .396 | .049 | 7.998 | *** | |

**Squared Multiple Correlations: (Group number 1 - Default model)**



| | Estimate |
|---|---|
| SAFETY | .206 |
| QUALITY | .434 |
| COST | .625 |
| TIME | .648 |
| S13 | .472 |
| S14 | .627 |
| S15 | .670 |
| Q11 | .614 |
| Q12 | .570 |
| C10 | .458 |
| C9 | .388 |
| C7 | .374 |
| C8 | .591 |
| T6 | .405 |

| | Estimate |
|---|---|
| T4 | .493 |
| T3 | .500 |
| T2 | .571 |
| T5 | .497 |
| T1 | .411 |
| SE1 | .751 |
| SE2 | .712 |
| TR1 | .718 |
| TR2 | .721 |
| QC2 | .484 |
| QC1 | .320 |
| QC3 | .616 |
| SU2 | .449 |
| SU1 | .502 |
| SU3 | .423 |
| CT3 | .519 |
| CT1 | .703 |
| CT2 | .864 |
| PL4 | .375 |
| PL6 | .534 |
| PL2 | .529 |
| PL1 | .439 |
| SI5 | .458 |
| SI3 | .542 |
| SI2 | .404 |
| SI1 | .418 |
| SI4 | .498 |
| IE5 | .489 |
| IE2 | .539 |
| IE3 | .503 |
| IE4 | .546 |
| PI10 | .389 |
| PI9 | .471 |
| PI1 | .410 |
| PI12 | .410 |
| PI5 | .494 |
| PI11 | .516 |
| PI4 | .498 |
| PI2 | .558 |
| PI6 | .537 |
| PI7 | .512 |

**Model Fit Summary**

**CMIN**

| Model | NPAR | CMIN | DF | P | CMIN/DF |
|---|---|---|---|---|---|
| Default model | 159 | 1607.269 | 1167 | .000 | 1.377 |
| Saturated model | 1326 | .000 | 0 | | |
| Independence model | 51 | 5819.159 | 1275 | .000 | 4.564 |

**RMR, GFI**

| Model | RMR | GFI | AGFI | PGFI |
|---|---|---|---|---|
| Default model | .053 | .781 | .752 | .688 |
| Saturated model | .000 | 1.000 | | |
| Independence model | .211 | .263 | .233 | .253 |

**Baseline Comparisons**

| Model | NFI Delta1 | RFI rho1 | IFI Delta2 | TLI rho2 | CFI |
|---|---|---|---|---|---|
| Default model | .724 | .698 | .905 | .894 | .903 |
| Saturated model | 1.000 | | 1.000 | | 1.000 |
| Independence model | .000 | .000 | .000 | .000 | .000 |

**Parsimony-Adjusted Measures**

| Model | PRATIO | PNFI | PCFI |
|---|---|---|---|
| Default model | .915 | .662 | .827 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 1.000 | .000 | .000 |



**NCP**

| Model | NCP | LO 90 | HI 90 |
|---|---|---|---|
| Default model | 440.269 | 339.005 | 549.572 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 4544.159 | 4310.752 | 4784.339 |

**FMIN**

| Model | FMIN | F0 | LO 90 | HI 90 |
|---|---|---|---|---|
| Default model | 8.077 | 2.212 | 1.704 | 2.762 |
| Saturated model | .000 | .000 | .000 | .000 |
| Independence model | 29.242 | 22.835 | 21.662 | 24.042 |

**RMSEA**

| Model | RMSEA | LO 90 | HI 90 | PCLOSE |
|---|---|---|---|---|
| Default model | .044 | .038 | .049 | .982 |
| Independence model | .134 | .130 | .137 | .000 |

**AIC**

| Model | AIC | BCC | BIC | CAIC |
|---|---|---|---|---|
| Default model | 1925.269 | 2037.758 | 2449.701 | 2608.701 |
| Saturated model | 2652.000 | 3590.122 | 7025.569 | 8351.569 |
| Independence model | 5921.159 | 5957.241 | 6089.373 | 6140.373 |

**ECVI**

| Model | ECVI | LO 90 | HI 90 | MECVI |
|---|---|---|---|---|
| Default model | 9.675 | 9.166 | 10.224 | 10.240 |
| Saturated model | 13.327 | 13.327 | 13.327 | 18.041 |
| Independence model | 29.755 | 28.582 | 30.962 | 29.936 |

**HOELTER**

| Model | HOELTER .05 | HOELTER .01 |
|---|---|---|
| Default model | 155 | 159 |
| Independence model | 47 | 48 |

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