

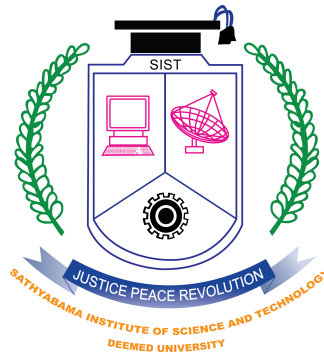
TOTAL QUALITY MANAGEMENT IN SUPPLY CHAIN FOR ELECTRICAL SERVICES

A Thesis

Submitted in partial fulfillment of the requirements for the award of
Master of Architecture degree in Building Management

by

POONILA.K (40840012)



**DEPARTMENT OF ARCHITECTURE
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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ABSTRACT

Materials are one of the areas that require special attention while creating a project's master plan as well as during the daily construction progress. The absence of materials when needed is one of the main causes of loss of productivity at a jobsite. Inefficient materials management can lead to an increase of 50% in work hours. As a result, a detailed plan for the materials management of each construction project is necessary. Currently, materials management functions in the construction industry are often performed on a fragmented basis with minimal communication and no clearly established responsibilities among the parties involved. In addition, the collaboration required among departments has not been considered and implemented. This fragmentation creates gaps in information flow, which leads to delays in material ordering and receiving, expediting costs, excessive inventories of some items and project delays. Total quality management (TQM) is increasingly being adopted by construction companies as an initiative to solve quality problems in the construction industry and to meet the needs. TQM should incorporate the integrated quality management activities in the supply chain. This supply chain context is especially salient in the quality assurance of construction projects. Therefore, aim is to identify the supply chain management issues in total quality management for electrical services in construction projects. the strategy, structure and tasks for managing relationships between TQM in SCM. The result will help in providing a greater understanding of identified TQM and SCM practices that will lead to the successful implementation of TQM and SCM strategies to enhance business performance in terms of the improved levels of customer service. Decision models are ever-present in the materials management processes of industries other than construction and have proven their worth in improving productivity and profitability. Knowledge-management concepts were applied to design an integrated, effective system of decision-support tools for materials-management decisions of an electrical contractor during the construction phase of a project. The research created detailed mappings of the essential decisions, decision models and data that are required to support supply-chain activities of construction throughout a project life cycle.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Recent trends in the business world has forced companies to expand their activities into new regions where they can find qualified manpower, lower production costs, high availability of raw materials giving rise to wider and more complex supply chains but also bringing in new opportunities to leverage their competitive advantages. These changes require the implementation of new organizational models with different suppliers and partners responsible for an important part of the final product and consequently to provide a service of excellence to satisfy customers. In order to produce value and optimize profitability, it is fundamental to establish successful partnerships with the supply chain organizations that can be achieved by new models of cooperation, improved communication and integration among all the supply chain partners. The use of advanced management practices is essential to accomplish these objectives. In this context, the use of integrated approaches to quality management, and SCM becomes fundamental. Therefore, it will be important to take advantage of TQM and SCM synergies in order to improve customer satisfaction, increase employee's motivation and to promote performance of the organization.

1.2 AIM

The main aim is to analyze and discuss the issues in supply chain quality management and brings new insights on their impact in electrical services on construction industry .

1.3 OBJECTIVES

- To identify critical risk in supply chain quality management
- To study about integration of total quality management in supply chain
- To review the positive impact of quality management on supply chain management
- To study present cases of supply chain improvements through quality management
- To discuss the best practice recommendations, relationship between total quality management factors and transition to supply chain quality management

1.4 SCOPE

- To improve customer satisfaction
- Increase employee's motivation
- To promote good quality performance
- Minimizing time and cost

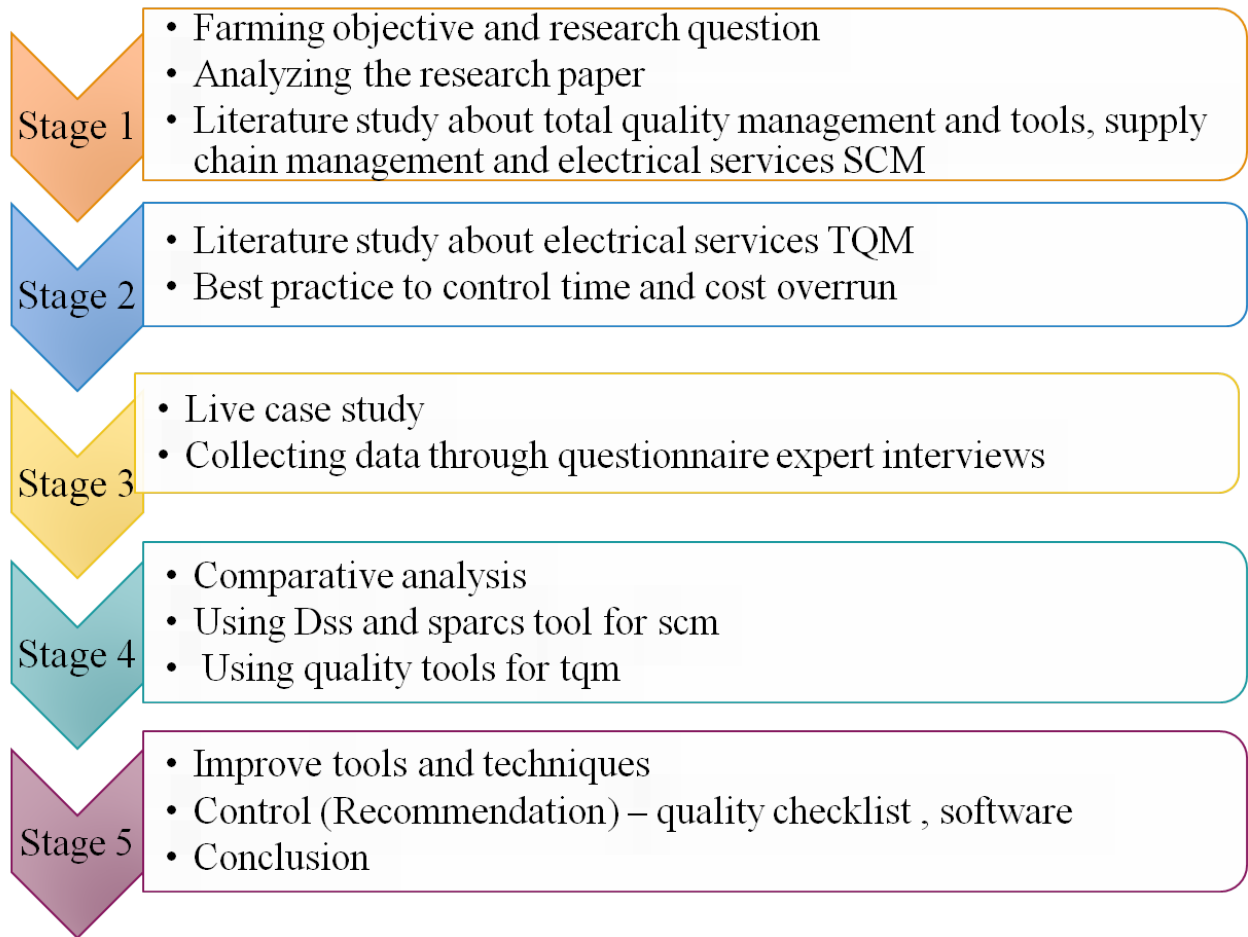
1.5 LIMITATION

- Total quality management in supply chain focusing on electrical services in construction industry

1.6 RESEARCH QUESTION

1. How to integrate total quality management in supply chain ?
2. What are the factors constraining the application of SCM in TQM ?
3. Whether issues in supply chain due to poor quality management ?
4. How to increase the customer satisfaction ?

1.7 METHODOLOGY



1.8 TOOLS



Fig 1.1 Tools and techniques

1.9 DATA COLLECTION METHOD

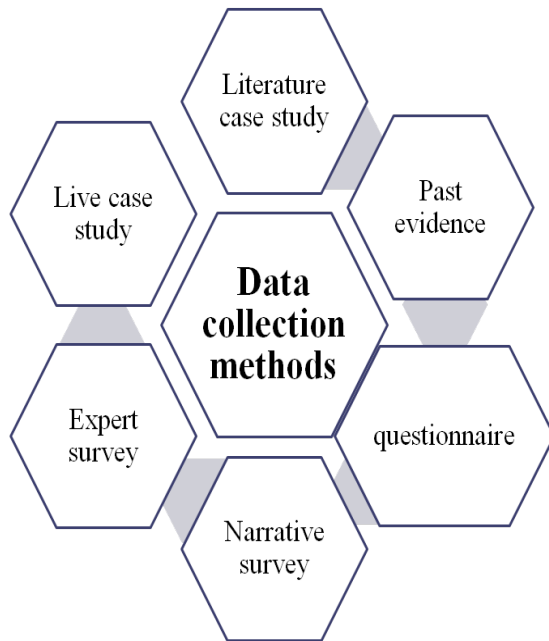


Fig 1.2 Data collection method

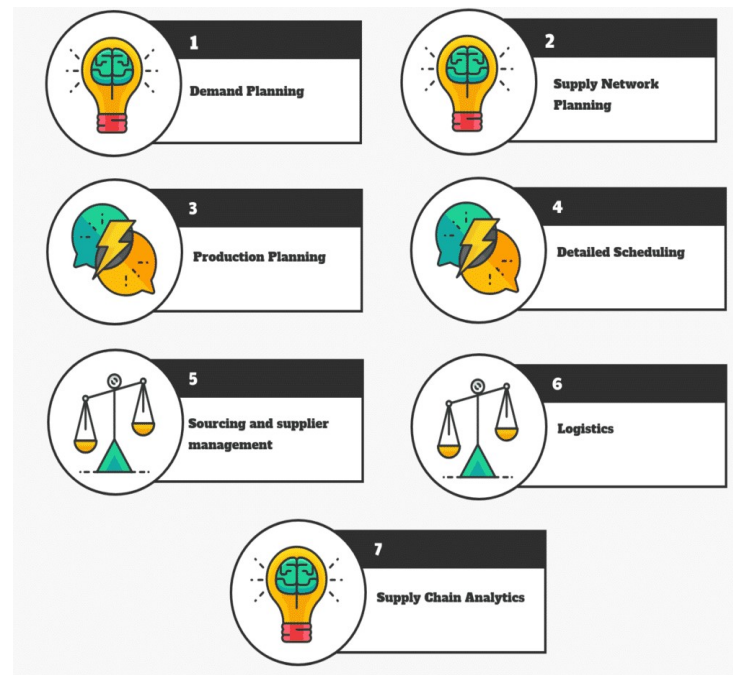


Fig 1.3 supply management software



Fig 1.4 quality tools

CHAPTER 2 LITERATURE STUDY

2.1 PAPER REVIEW

2.1.1 Research paper 1

Total quality management in construction industry - 1Savita Sangle¹, 2 M.C. Aher, 3R.V. Devalkar

Need of study

- The construction industry in many parts of the world suffers from problems such as workmanship defects, time, and cost overrun. Construction industry for its poor performance and history of waste and rework, coupled with chronically low levels of customer satisfaction.
- A need for change becomes inevitable in order to improve the condition of the construction industry. The industry problems will remain until each organization in the procurement of construction industry begins to take the responsibility for initiating changes within their own organization. Such change can be initiated through the effective implementations of a total quality management (TQM) system.

Objective

- It is to point out the latest studies which focused on increase the business quality through implementation of TQM in construction industry and its suitable application in different phases of project construction and it also describes the basic theory of Six sigma, principles, methodology, and various tools used for reducing defects.

Elements of tqm

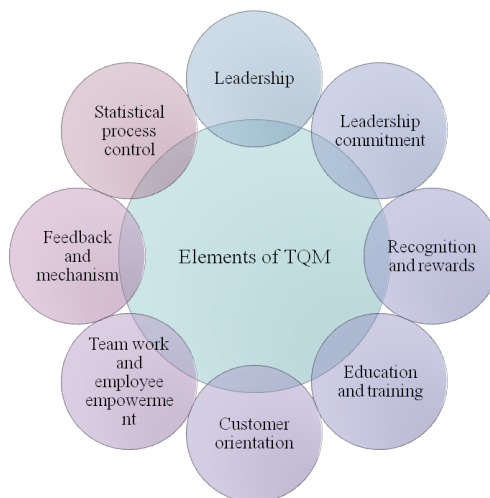


Fig 2.1 Elements of TQM

- Leadership - The first step towards the excellence is the major decision to provide leadership for quality as a basic strategic goal.
- Leadership commitment - Members of top management must lead to TQM efforts.
- Recognition and rewards - It is essential as people need to be accepted by others and recognition helps them to find themselves in a winning role
- Customer orientation - The customer want value at reasonable price
- Team work and employee empowerment - common goal gained at less expense
- Feedback and mechanism - For success of the TQM program, feedback mechanisms for the both external and internal customers need to be developed.
- Statistical process control - help the organization to reduce the inspection and improve the quality.

Elements of quality in construction

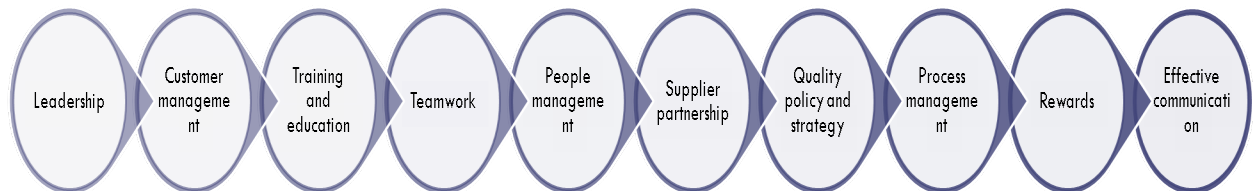


Fig 2.2 Elements of quality in construction

Six Sigma is a continuous improvement methodology which known as DMAIC (define, measure, analyze, improve, control) aims to enhance the efficiency of the existing processes and increase customer satisfaction through designed products and services. DMAIC framework is a integration of several techniques such as QFD (quality function deployment), SPC (statistical quality control), DOE (design of experiments), and FMEA (failure mode and effects analysis) in a logical direction. This approach is more suitable when the current design of the products, services and processes are correct and satisfactory regarding to the requirements, customers and business.

CONSIDER A RESIDENTIAL BUILDING AND TRY TO IMPROVE THE QUALITY OF INTERNAL FINISHING WORK.

1. Define – SIPOC – Suppliers Input Process Output Customer Measure – Pareto Diagrams Analysis – Cause and Effect Diagram Improvement – Corrective Action Control – Control Plan

2. Case Study Data Analysis For Preliminary Survey By using various tools ie. Check sheets, Pareto Chart, Fishbone Diagram, different analysis and graph data is obtained and analysis is done.

Table 2.1 check sheets for site work

Type	Check	Subtotal
Surface cracks	III III III IIII	19
Segregation	III	5
Efflorescence	III III	8
Spalling	III	5
Blisters	III I	6
Pop outs	IIII	4
Disintegration	--	00

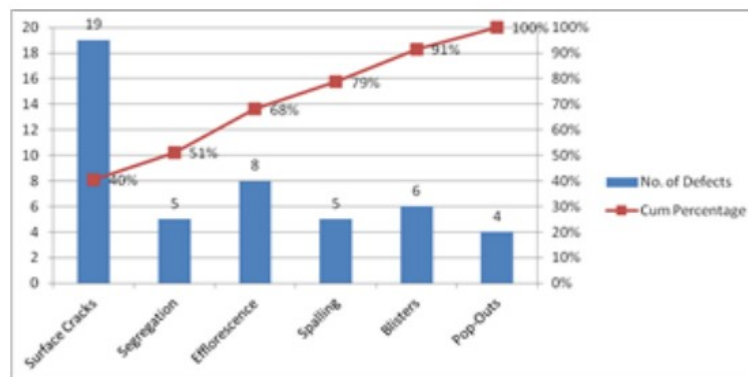


Fig 2.3 No of defects in building

Pareto chart

A Pareto Chart can answer the following questions: What are the largest issues facing our team or business? • What 20% of sources are causing 80% of the problems? • Where should we focus our efforts to achieve the greatest improvements?

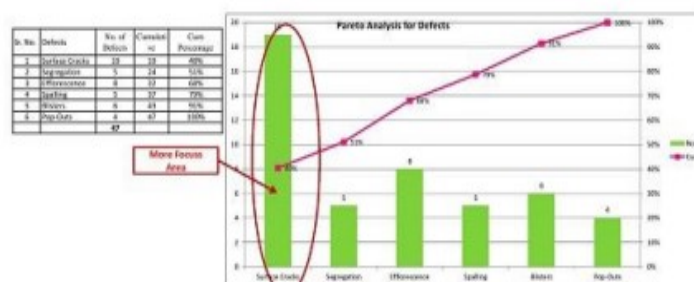


Fig 2.4 Pareto chart

Cause and effect diagram

Cause and Effect diagram helps us to visualize in a graphical manner the outcome and various factors that influence that outcome

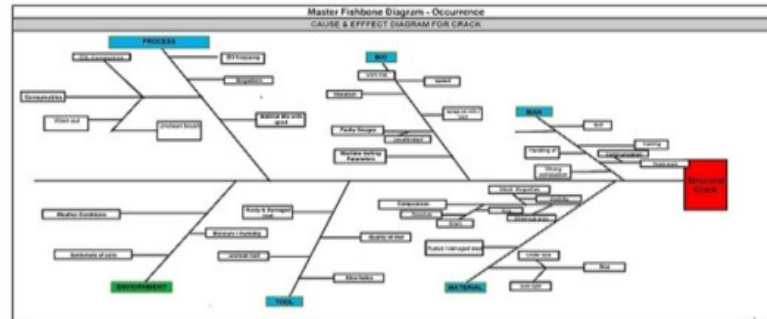


Fig 2.5 Cause and effect diagram

Control plan will help us to keep a check on the various preventive measures which are taken to achieve the desired result two plans are used WHY WHY Analysis and Cause analysis

Table 2.2 Why why analysis

WhyWhy Analysis Causes		WHY	WHY	WHY	WHY	ACTION PLAN
Sr. No.	Description					
1	INSUFFICIENT CURING	SHORTAGE OF WATER,	IMPROPER EQUIPMENT FOR WATER LIFTING; WEATHER CONDITIONS ARE UNCONTROLLABLE	NEGLECTANCE IN PLANNING OF EQUIPMENTS PROPERLY; CONCRETING NOT DONE IN PROPER WEATHER CONDITION	FAULT OF EXECUTION DEPARTMENT	1. CRACK CAN BE HEALED BY CEMENT GROUTING 2. CRACKS CAN BE PREVENT BY REGULAR PROPER INSPECTION 3. CONTINUOUS AVAILABILITY OF WATER ON SITE 4. AVOIDING CONCRETING IN EXTREME HEAT CONDITIONS 5. USING STANDARTD METHOS FOR HOT WEATHER CONCRETING

Table 2.3 cause analysis

Causes		Is there any Standard/ specification ? (YES/NO)	If YES what is the specification ?	What is the basis of Spec?	Is it checked?	What is Actual?	Is there any Difference?
No	Description						
1	UNSKILL MANPOWER	YES	NOT ALLOWED	LABOUR SHOULD BE PROPERLY TRAINED	YES	TRAINED	NO
2	INSUFFICIENT CURING	YES	NOT ALLOWED	ACCORDING TO WEATHER CONDITIONS	NO	NOT CHECKED	YES
3	ADVERSE WEATHER CONDITIONS	YES	ACCORDING TO WEATHER CONDITION	VISUAL CHECKING	YES	CHECKED	NO

Conclusion

- It is seen that no proper quality control was practiced on site.
- lack of QA and QC resulting into various defects on structure which mainly due to improper inspection and control.
- If we apply 7 QC tools properly on site we can go through details of each and every defect and Root cause of the defect can be studied deeply and action plan can be taken correctly.
- TQM can bring to your construction business (Improve business quality, increase customer satisfaction, reduce cost, save time and much more).
- The reason that the construction industry has arrived late to TQM is that the construction professionals unaware of the TQM principles and techniques.
- To bring these benefits to the construction industry, more efforts must be made to spread the culture of TQM among the construction

2.1.2 Research paper 2

Roles of supply chain management in construction - Ruben Vrijhoef¹ and Lauri Koskela²

Concept of supply chain management

The supply chain has been defined as ‘the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer

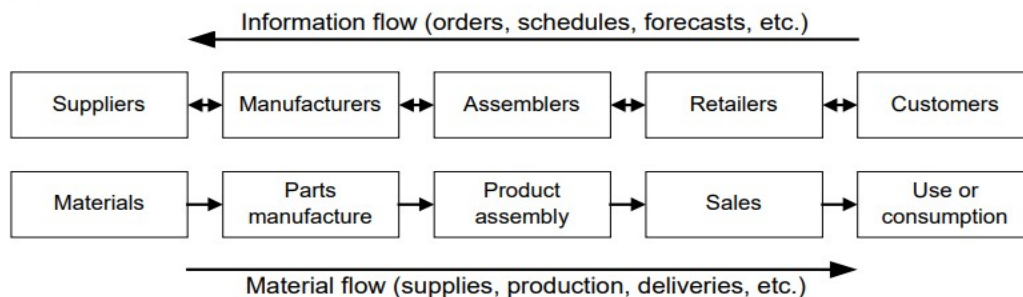


Fig 2.6 Concept of supply chain management

Methodology of SCM

consists of four main elements:

- (1) Supply chain assessment
- (2) Supply chain redesign
- (3) Supply chain control
- (4) Continuous supply chain improvement.

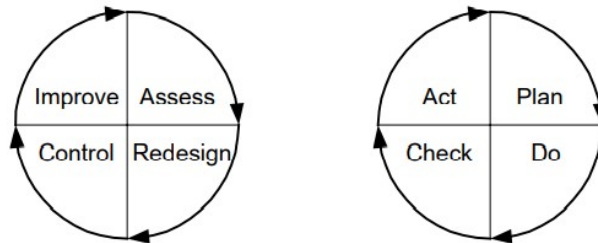


Fig 2.7 Methodology of SCM

Assessing construction supply chains through case studies

- In this section, three case studies that were executed in the Netherlands and Finland are being described, representing three exercises of supply chain assessment.
- The case studies represent three separate analyses of different supply chains.
- The case studies give some insight in the waste, problems and causes

Table 2.4 Casestudy

Method		Case study 1	Case study 2	Case study 3
Quantitative analysis	Measurement	Waste: time buffers		
Qualitative analysis	Observations, interviews etc.		Problems: controllability problems	
Implicit analysis	Impressions etc.			Causes: traditional trading

1st - Time buffers along a part of a chain process of concrete wall elements in residential building

2nd - Represented a problem analysis (i.e. Qualitative analysis) to identify and locate controllability problems in a chain process of composite façade elements in residential building

3rd - Represented a quick scan of the cost impact of trading methods used by a main contractor to purchase materials

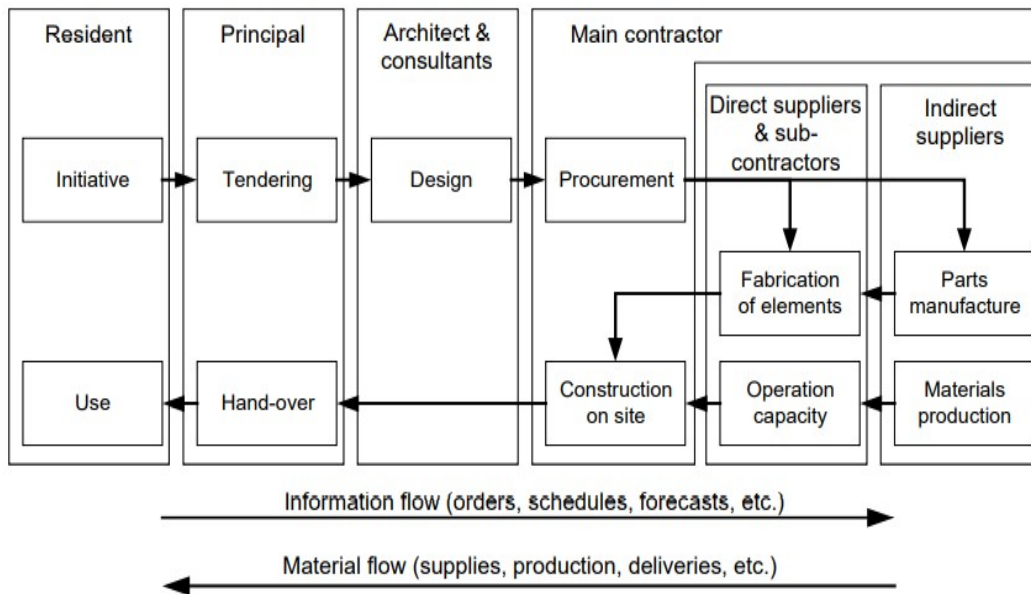


Fig 2.8 Flow of SCM

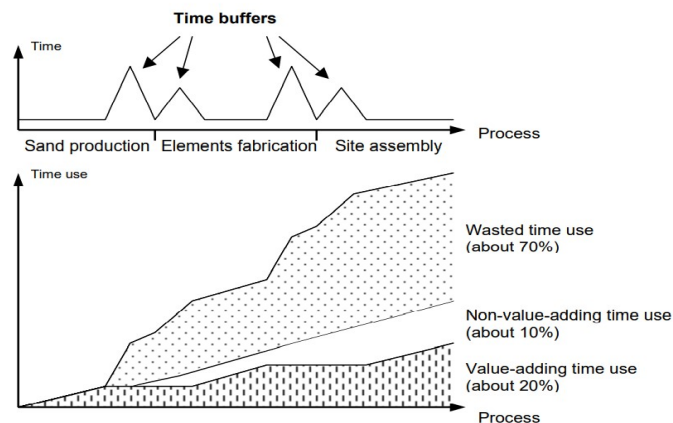


Fig 2.9 Time measurement of concrete wall elements

Table 2.5 Casestudy comparison

	Case study 1	Case study 2
Description	This case study refers to time measurement to detect and analyze time buffers in a part of a supply chain process of concrete wall elements including the excavation and delivery of sand, the fabrication and delivery of elements, and the site installation of elements.	Involves problem analysis to identify and locate controllability problems in a part of a chain process of composite façade elements. The observed part included the job preparation, price bargaining, engineering, assembly, and site installation of the elements.
Objective	Analysis of the time use along the process in order to get insight in the time buildup, and the magnitude and location of time buffers.	Analysis of the controllability problems along the process in order to get insight in the occurrence and causality among the problems and their causes.
Method	Decomposition of the process in sub-processes and activities Time measurement of the activities Categorizing time use per activity: wasted, non-value-adding, value-adding Locating and quantifying time buffers Composing the process time buildup	Decomposing the process in sub-processes Uncovering the controllability problems per sub-process Identifying and locating the causes Finding connections between the problems and causes
Results	It appeared that at the beginning and the end of the sub-processes remarkable time buffers occurred. The time buffers were particularly due to inventory and delays. The share of the time buffers compared to the total lead-time was quite large (70-80%). Underlying problems of the time buffers included separate planning. The problems referred to various root causes including inter-organizational barriers.	The controllability problems were numerous. Root causes included non-collaborative working relations between parties, and adversarial bargaining. Most problems that were encountered on an operational and managerial level were caused by strategic and cultural issues. These included lacking common targets, reluctance and opportunism.

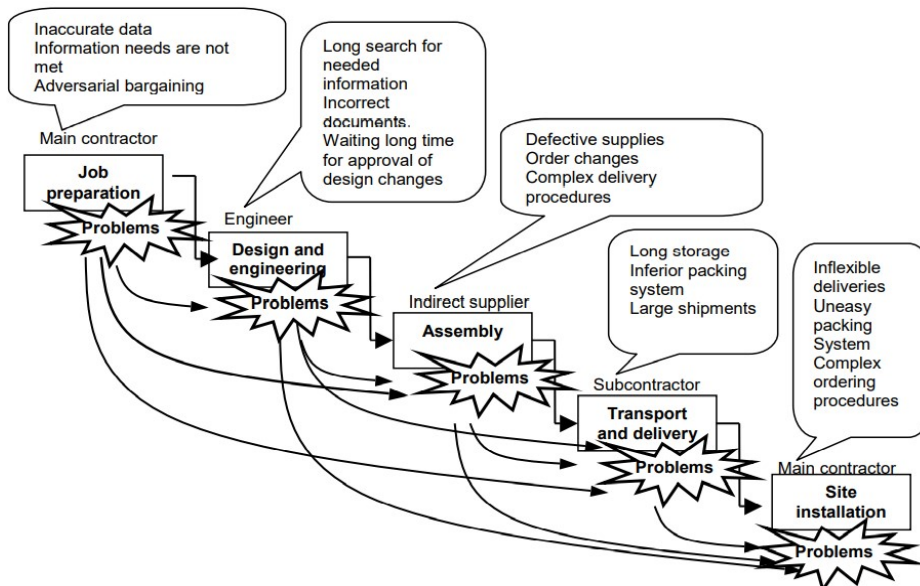


Fig 2.10 Risk and cause of problem in each stage

Conclusion

- Based on the insight gained by means of supply chain assessment, the SCM methodology needs to be fully applied to resolve the problems that were found in the construction supply chain.
- Because most problems spread across the supply chain, solutions are needed that equally cover multiple stages of the supply chain, including the actors involved.
- The range of the solutions and the part of the supply chain involved depend on the scale of the problems.

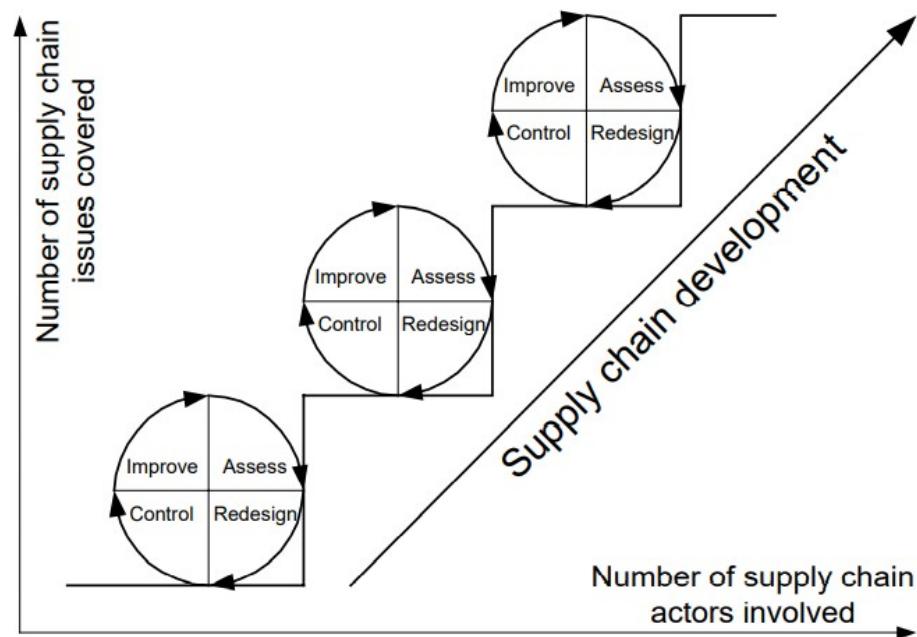


Fig 2.11 Supply chain development

2.1.3 Research paper 3

A framework for a decision support model for supply chain management in the construction industry - Jose luis perdomo-rivera

Need for study

- Current materials management practices in the electrical contracting industry are performed on a fragmented basis with unstructured communication and no clearly established responsibilities between the parties involved.
- This fragmentation creates gaps in information flow, which affects the decision making process and lead to delays in material ordering and receiving, among other problems.
- The investigation considered the entire range of activities necessary for procuring the needed material, starting with the estimating process and ending with site delivery, distribution and storage logistics.

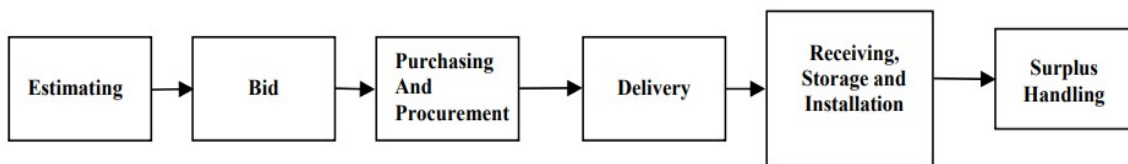


Fig 2.12 Framework for SCM

Framework for Decision Models

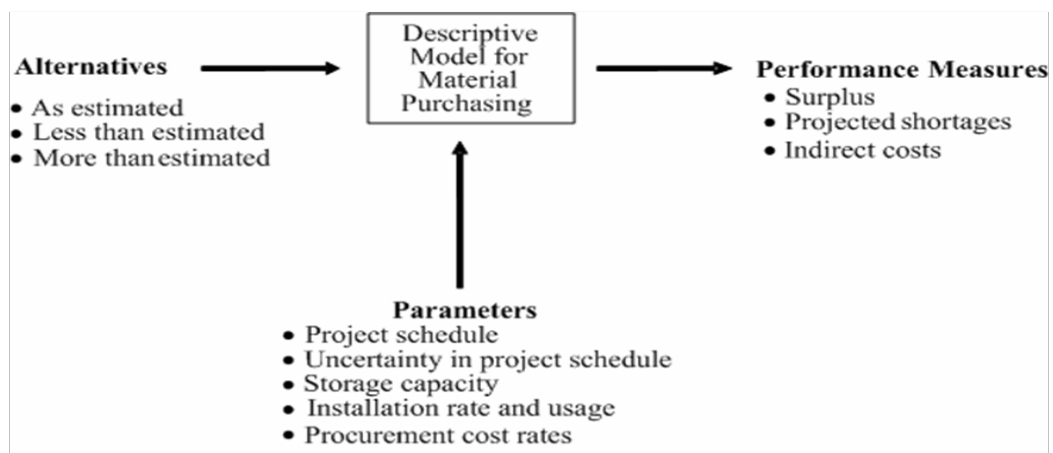


Fig 2.13 Framework for decision models

Where to deliver?	• Jobsite • Warehouse/Pre-fab shop • Subcontractor	• Storage capacity • Immediate installation vs. critical item not be installed immediately • To be used in pre-fab or not • Costs • Location of the project • Location of the warehouse	• Availability when needed • Quality • Quantity • Costs
Where on site to store?	• “Sea cans” • on floor inside the building	• on-floor space available • schedule	• loss • theft • damage • re-handling

The typical tasks associated with a material management system are

- Procurement and purchasing
- Expediting
- Materials planning
- Materials handling
- Distribution
- Cost control
- Inventory management / Receiving/ Warehousing
- Transportation

Purchasing and procurement deals with the acquisition of materials to be used in the operations. The primary function of purchasing and procurement is to get the materials at the lowest cost possible, but keeping in mind quality requirements

2.2 TOTAL QUALITY MANAGEMENT

2.2.1 Introduction

- Total Quality Management is a management approach that originated in the 1950s and has steadily become more popular since the early 1980s.
- Total Quality Management (TQM) seeks to improve the quality of goods and services delivered through the participation of all levels and functions of the organization.
- Total Quality Management has proved to be a useful tool in ensuring the achievement of set standard and successful productivity improvements in the construction industry.
- TQM is a method to refining the competitiveness, effectiveness, and flexibility of the whole organization
- TQM is a way of thinking about goals, organizations, processes, and people to guarantee that the right things are done right the first time
- The construction industry differs from the manufacturing in such a way that makes introducing TQM more challenging.
- The construction industry suffers from the problems such as workmanship defects, time and cost overrun.
- Poor or non-existent quality-control and quality assurance procedures can allow costly errors to go undetected in the design and contract document

2.2.2 Evolution of TQM

Inspection

- Aimed at checking, measuring and testing of one or more products.
- Usually performed by specialized personnel and does not fall within the responsibility of production workers.
- Products that don't comply with the specifications are rejected or returned to improve.

Quality control

- It involves verifying the product or evaluating a product with the requirement specification.
- Testing is the key technique used to perform product evaluation.

- QC is work product oriented; it measures the product, identifies deficiencies and suggests improvement

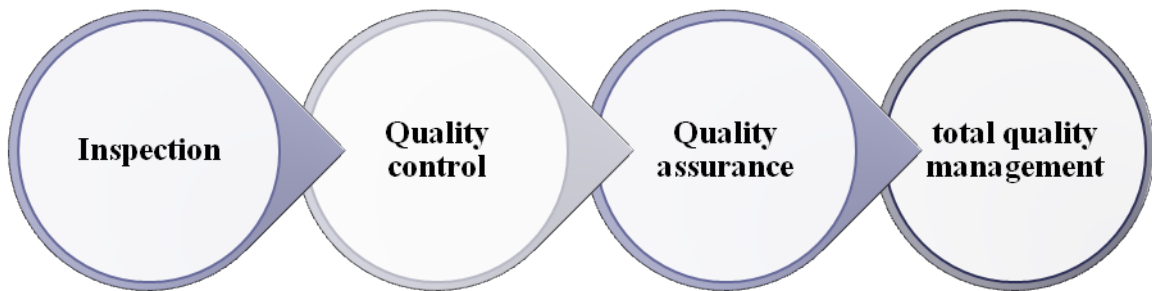


Fig 2.15 Evolution of TQM

Quality assurance

- It involves the entire development of process, monitoring and improving the process, making sure that the agreed upon standards and procedures are followed throughout the life cycle.
- It is oriented to preventing the defects from occurring in the products.
- Audits are key techniques for process monitoring

Total quality management

- Total quality management can be summarized as a management system for a customer-focused organization that involves all employees in continual improvement.
- It uses strategy, data, effective communications and involvement of all level employees to integrate the quality discipline into the culture and activities of the organization

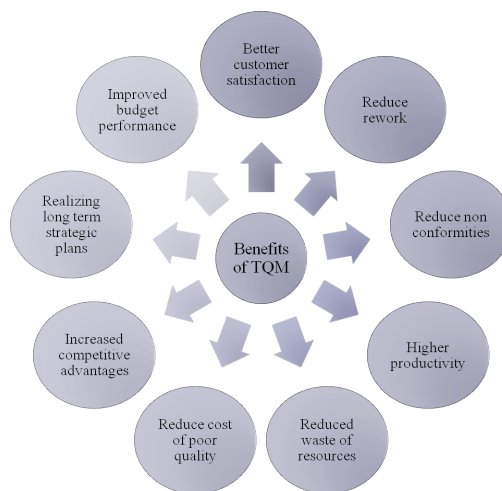


Fig 2.16 Benefits of TQM

2.2.3 Factors of TQM



Fig 2.17 Factors of TQM

Customer Focus - Quality management process aims to meet customer requirements and deliver beyond expected levels of product or service.

Commitment from the leadership - the leadership is responsible to create a conducive environment so as to achieve the quality objectives of the organization.

People engagement - This principle states that all the people in the organization must be competent, empowered and engaged in delivering value. This also enhances the capability to create value.

Process Approach - All the activities should be managed as interrelated processes to create consistent and predictable results. These interrelated activities function as a coherent system

Continuous improvements - An ongoing focus on improvement is a fundamental principle for the success of an organization.

Evidence-based decision making - The decisions are based on the insights gained from analyzing and evaluating data. This will help to produce desired results.

Relationship Management - Organizations should manage their relationships with interested parties such as suppliers very well. This will help to sustain the levels of success achieved.

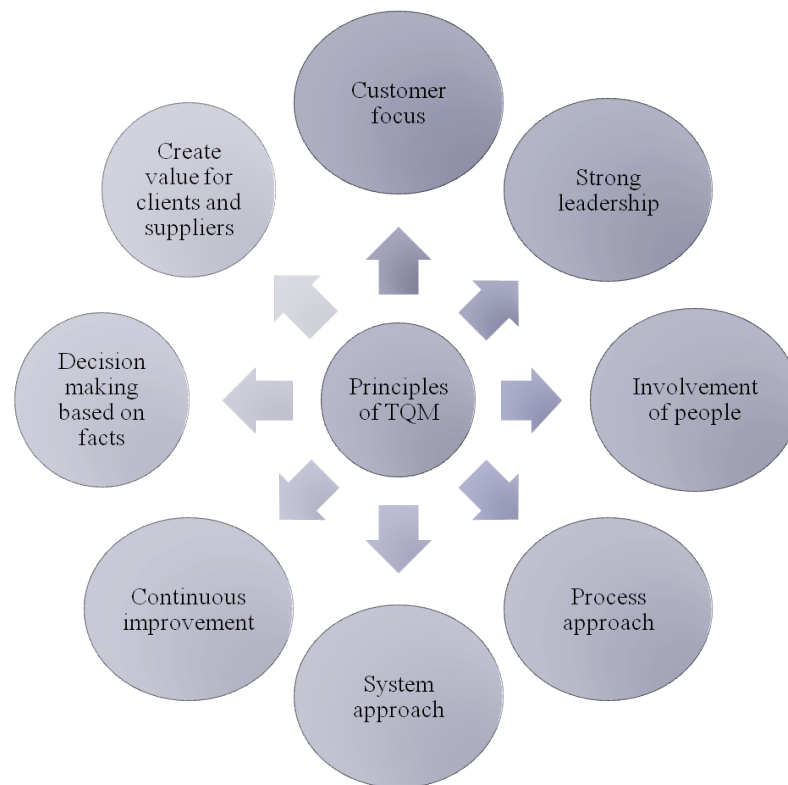


Fig 2.18 Principles of TQM

2.2.4 Why not having TQM

Lack of a continuous improvement process will allow a product to stagnate, while the products with which it competes continue to improve in quality, function, and use.

- TQM involves discovering the deficiencies that exist in the production of a product, and reducing the number of defective products that get delivered to the consumer.
- A continuous improvement program can decrease manufacturing costs by decreasing defective product, can increase production through continuous analysis and refinement of the manufacturing process, and can find and eliminate inefficiencies throughout the organization.

The workforce will become disengaged, decreasing productivity and increasing attrition.

- TQM requires that employees be engaged and involved in the development and manufacturing process from beginning to end on a continual basis.
- Without such involvement, workers will come to believe that their ideas are not wanted or valued, relegating them to an “eight-and-the-gate” mentality.

- Without incentive or involvement, morale will suffer, productivity will decrease, and seasoned employees will leave the business in favor of more satisfying work, increasing training costs and the likelihood of increased defective manufacturing as younger, inexperienced workers move in to take their place.

Lack of a customer satisfaction program will drive customers to look elsewhere for similar products from companies who respond to their needs.

- Total quality management has continuously improving customer satisfaction at its heart.
- A company that is not committed to satisfying customers will quickly lose them to competitors who do respond to consumers demands.
- In a competitive environment, alternate products that continue to improve in quality and meet the needs of customers will win the hearts and minds of consumers, who will migrate to that product, reducing market share for the stagnant company.

Lack of a document control and management system will prevent a business from getting better at what it does, because it has no formal starting point.

- Total quality management sets out requirements for the development, approval, and [periodic review of procedures](#) that govern a business' activities.
- Without such documents, the workforce is left to operate as it sees fit, with no accountability and no recognized method of manufacture or product control.
- Long-term employees who leave the company take irreplaceable information with them, leaving others to figure it out and the business to suffer in terms of quality.
- It is also virtually impossible to pinpoint the cause of a defect in the process develop corrective actions without formal procedures, leaving a company to founder with excessive costs for scrap.

Not having a formalized quality management system can prevent a company from obtaining contracts or doing business with top-tier organizations.

- Quality management systems requires that suppliers to a business have a formal quality management system of their own.
- Since most major businesses subscribe to TQM in some form or fashion, they require their suppliers to have similar programs.

- Without a quality management system, a business will not be asked to bid on or be granted a contract, limiting the ability of the business to expand its outreach and position.

2.3 QUALITY MANAGEMENT TOOLS

2.3.1 Stratification

Stratification also known as a flow chart or run chart is a technique that separates the data gathered from a variety of sources so that patterns can be seen i.e., the path an entity has taken through a defined process.

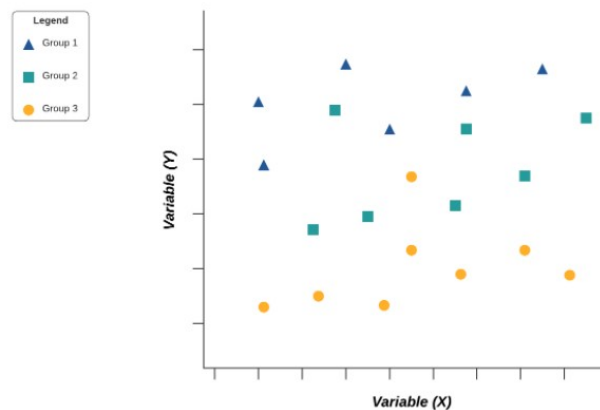


Fig 2.19 Stratification

2.3.2 Check sheet

Check sheet is a structured process which helps to collect and analyzing data. It is an effective tool that can be for a variety of purposes.

Type of Defects	Checks	Frequency
Wrong Specification		17
Cracks		11
Surface scars		7
Broken		4
Others		2
Total defects		41

Fig 2.20 Check sheet

2.3.3 Histogram

Histogram is commonly used a graph that shows the data and its frequency of distribution to help users identify each different value in a set of data occurs.

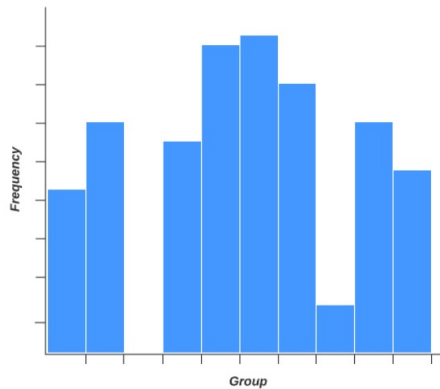


Fig 2.21 Histogram

2.3.4 Cause and Effect Diagram

- Cause and Effect Diagram also known as Fishbone Diagram helps in identifying the potential causes of an effect or a problem.
- In addition to sorting ideas in respective categories, it also helps in understanding the areas of opportunity through effective brainstorming.
- Fishbone training empowers you to identify the potential cause in the problem.

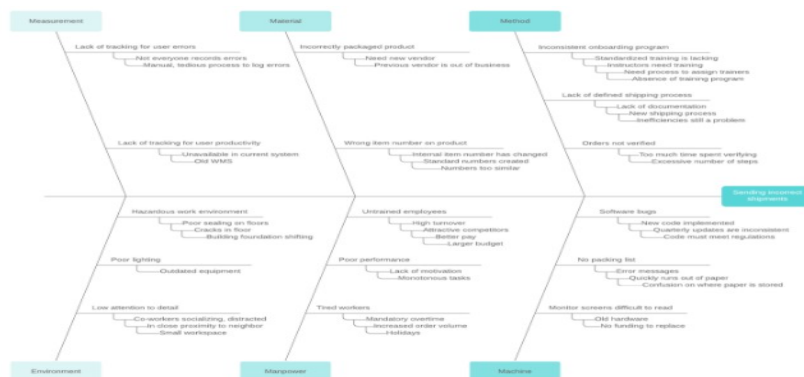


Fig 2.22 Cause and effect diagram

2.3.5 Pareto chart

- The Pareto chart operates according to the 80-20 rule. This rule assumes that in any process, 80% of a process's or system's problems are caused by 20% of major factors, often referred to as the "vital few." The remaining 20% of problems are caused by 80% of minor factors.
- A combination of a bar and line graph, the Pareto chart depicts individual values in descending order using bars, while the cumulative total is represented by the line.

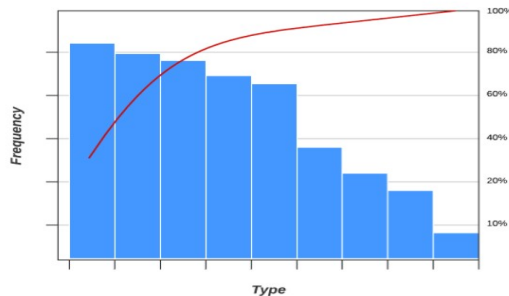


Fig 2.23 Pareto chart

2.3.6 Flow chart

- [Flowcharts](#) are most commonly used to document organizational structures and process flows, making them ideal for identifying bottlenecks and unnecessary steps within your process or system.
- Mapping out your current process can help you to more effectively pinpoint which activities are completed when and by whom, how processes flow from one department or task to another, and which steps can be eliminated to streamline your process

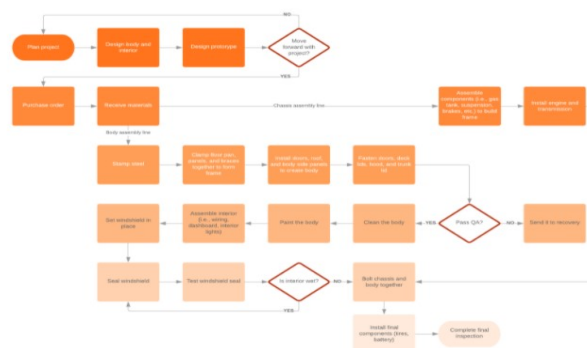


Fig 2.24 Flow chart

2.3.7 Scatter diagrams

- Scatter diagrams can prove useful as a quality control tool when used to define relationships between quality defects and possible causes such as environment, activity, personnel, and other variables.
- Once the relationship between a particular defect and its cause has been established, you can implement focused solutions with better outcomes.

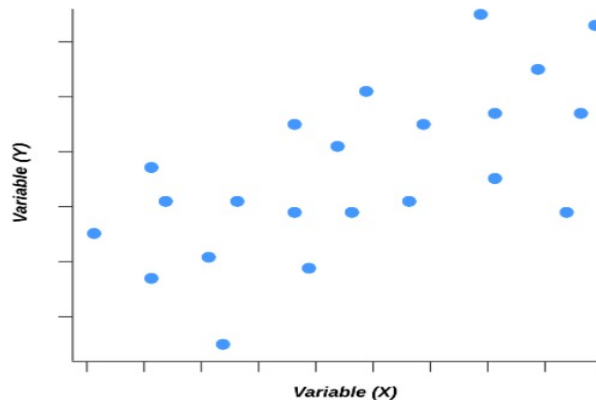


Fig 2.25 Scatter diagrams

2.4 SUPPLY CHAIN MANAGEMENT

2.4.1 Introduction

- In general supply chain is a network of organizations involved, from the supplier of the supplier until the client of the client, on the different processes and activities that produce value in the form of products and services for the final client.
- Its major components are the suppliers' network, the transformation unit and the clients' network.
- The effective management of the supply chain is necessary for successful competition in today's global markets.
- SCM is a philosophy that describes how organizations should manage their supply chains to achieve strategic advantages.
- Its goal is to synchronize the client requirements with the materials and information flows along the supply chain, until reaching a balance between the client satisfaction and the cost.

- It refers then to the coordination of the activities of all that participate in the supply chain, to knowing the production requirements with the purpose of satisfying the client, to delivering of products of higher value and to reducing the costs of the organization that apply these principles.

Table 2.7 Problems in different interfaces in SCM

DIFFERENT INTERFACE	PROBLEMS
Client / Feed, Design Interface	difficulties in finding out client's wishes, changes of client's wishes, long procedures to discuss changes, interfaces with other relevant parties throughout feed and design period.
Feed Design / Engineering Interface	incorrect documents, design changes, extended time for design changes and approval, wrong calculations, designs not in accordance with the well-known construction methods, no constructability.
Engineering / Procurement, Vendors Interface	inaccurate data, engineering drawings not fit for use.
Engineering / Site Interface	engineering team not present on site for the field engineering
Engineering / Commissioning, Procurement / Commissioning, Main Contractor / Commissioning, Subcontractors, Suppliers / Commissioning Interfaces	difficult interfaces between various disciplines, problematic completion due to quality problems.
Project Completion / Commissioning Interface	problematic completion due to quality or safety problems, problems with local communities.
Procurement, Vendors / Suppliers Interface and Procurement, Vendors / Subcontractors	inaccurate data, technical specifications not met, other changes, lack of coordination, collaboration and commitment between suppliers, poor quality of materials and components.
Procurement / Logistics Interface	not proper logistic studies, not effective logistics routes, not obtained permits & licenses needed, customs clearance delays.

DIFFERENT INTERFACE	PROBLEMS
Logistics / Site Interface	large shipments, not proper packing, bad weather or political conditions, long storage period.
Main Contractor / Subcontractors Interface	deliveries not according to planning late deliveries of permanent materials, wrong and defective deliveries, large shipments, long storage period, interfaces with several subcontractors and suppliers, poor training of contractor's suppliers, subcontractors and workers, inadequate management within the supply chain, mainly poor.
Suppliers and Subcontractors / Site Interface	deliveries not in conformance with planning, wrong and defective deliveries, long storage period, subcontracted work not delivered according to main design, contract and planning, low productivity of several subcontractors, poor training of workers, deficient communication and information transfer.
Site / Completion of Project and Project Completion / Commissioning Interfaces	problematic completion due to quality or safety problems, problems with local communities.
Commissioning / Operation Interface	unresolved quality and technical problems, delayed operational time due to late completion.

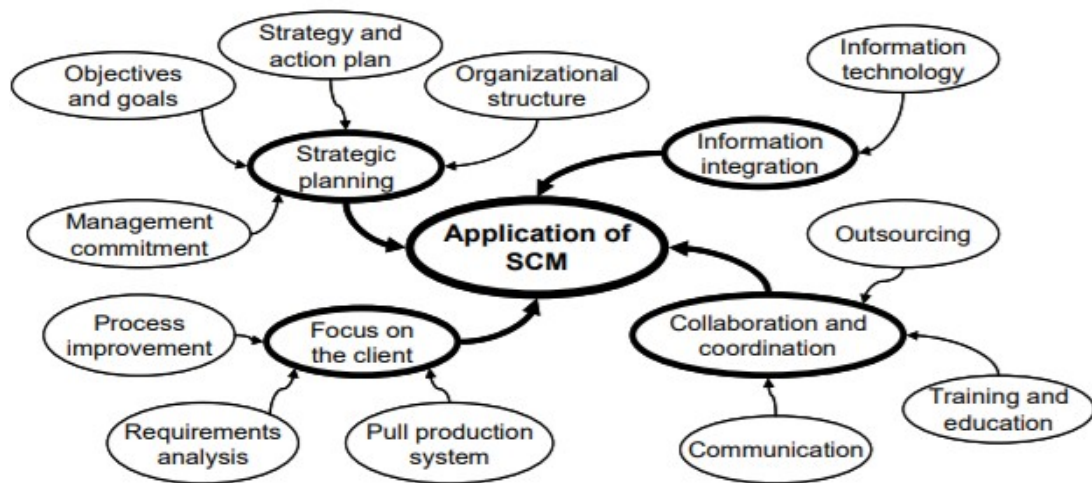


Fig 2.26 Application of SCM

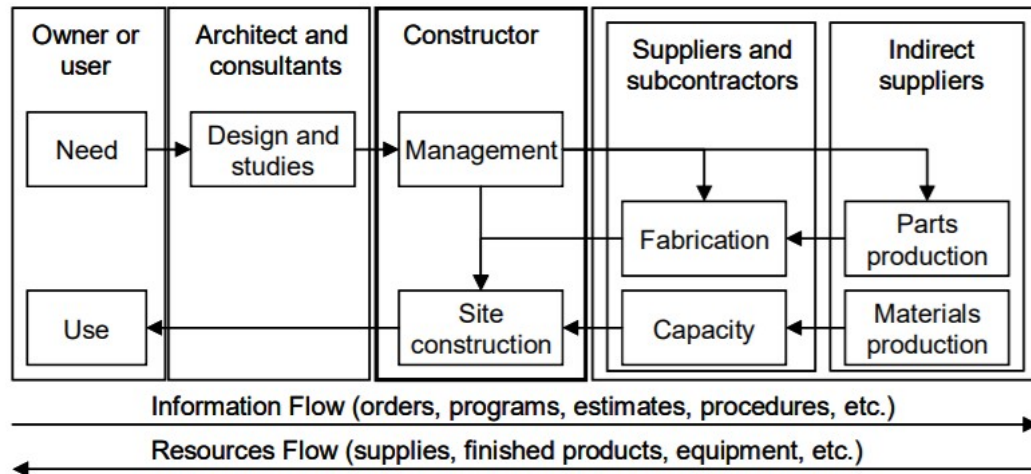


Fig 2.27 Flow of SCM

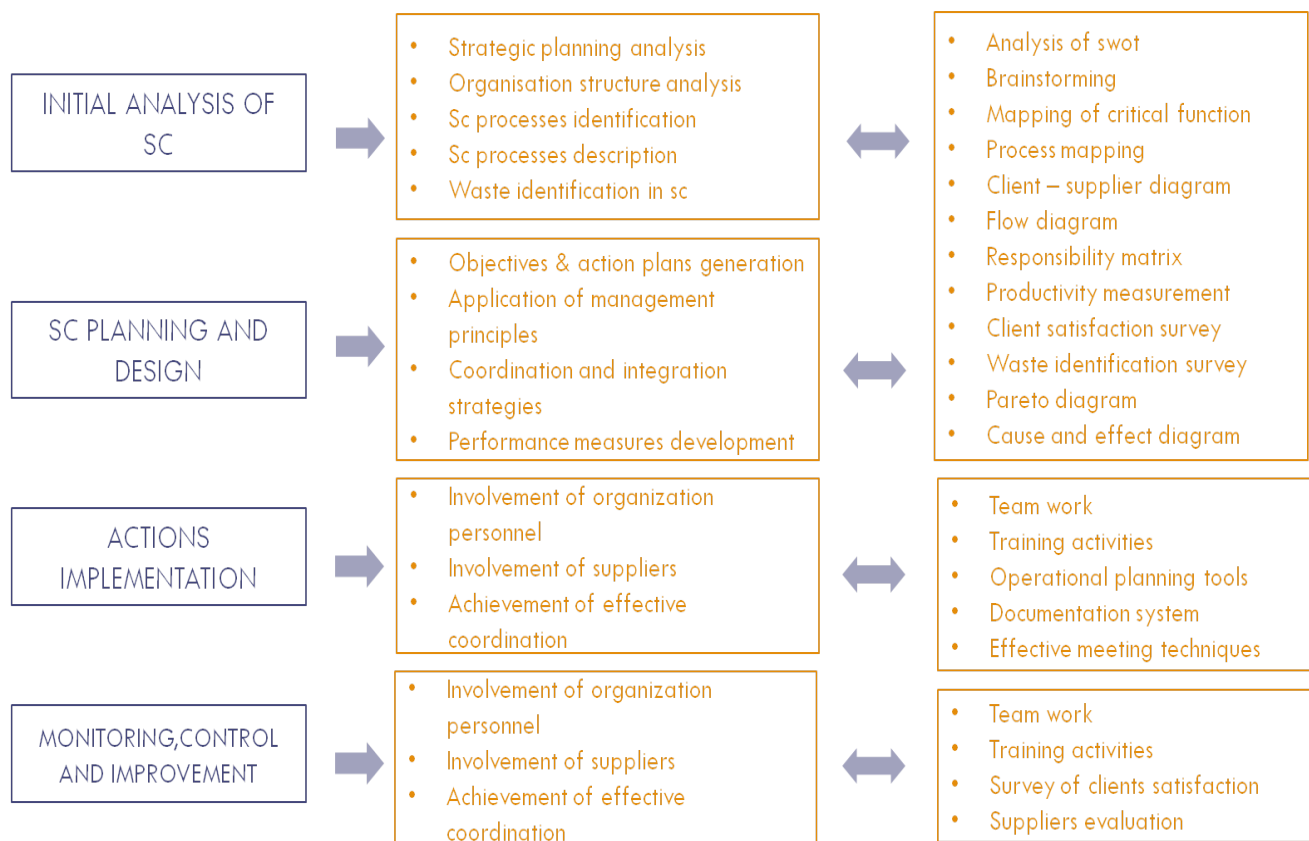


Fig 2.28 Different stages, causes and tools used in SCM

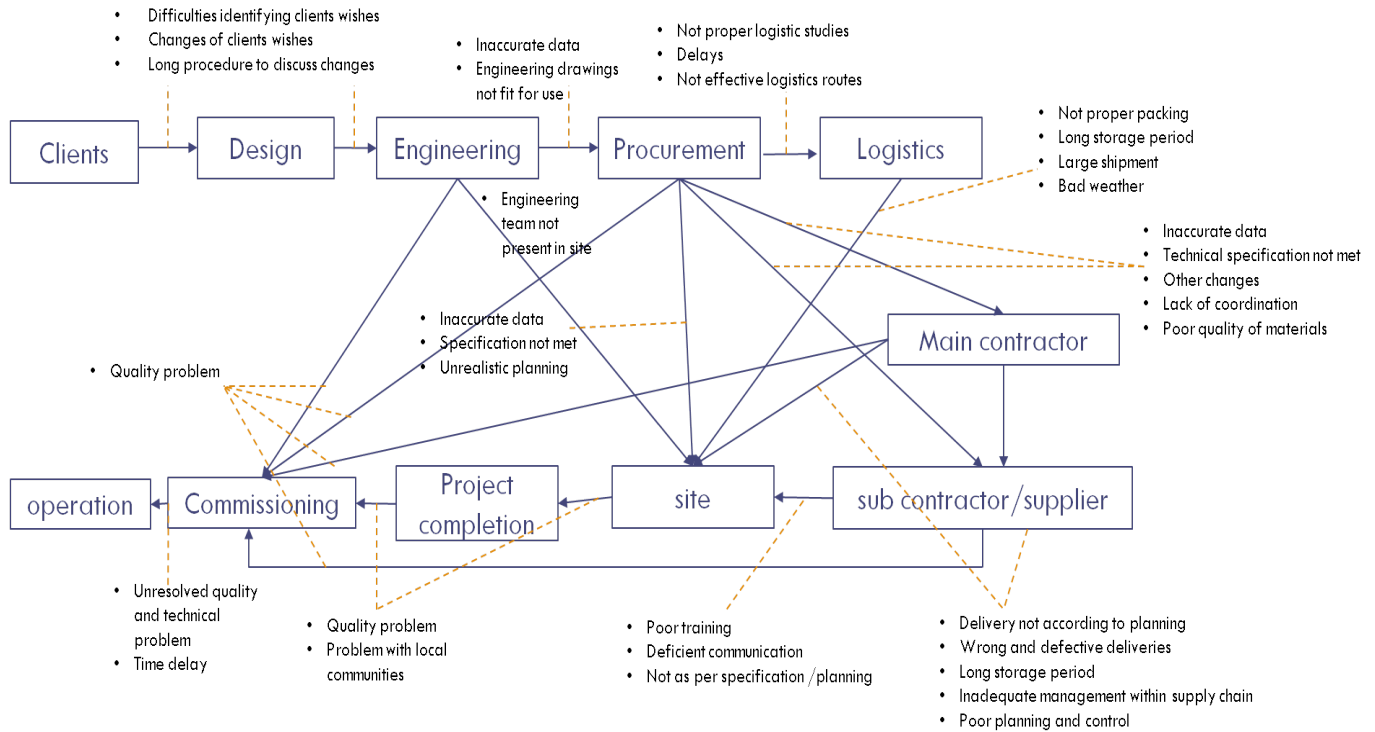


Fig 2.29 Flow diagram different stages, causes and tools used in SCM

2.4.2 Definition of Construction Project Supply Chain

- In the construction of the project, the core contractor control information flow, logistics and capital flow, and integrate the consulting company, the designer, the design subcontractors, the material suppliers, the engineering subcontractors and the labor services, and form complete supply and demand network model.
- The supply chain management not only emphasizes the inter-departmental integrated management within the enterprise, but also emphasizes the integrated management of with external companies. By establishing common strategic goals among enterprises, perfect trust and cooperation mechanisms, collaborative work patterns and information sharing mechanisms, the enterprise can improve performance and respond quickly to customer needs, thereby enhancing our core competitiveness.

2.4.3 Composition of the Construction Supply Chain

Broad-sense construction supply chain starts from specific project needs, through the preparation, implementation, acceptance, delivery and use stage, until the expansion and demolition of the later stage of the building and other related organizational activities. The narrow-sense supply chain is based on the needs of the owner and takes the general contracting as the core; it connects the engineering material supplier, mechanical equipment supplier, designer, subcontractor, consulting company and owner into a network through information flow, material flow and capital flow.

2.4.4 Characteristics of the Construction Supply Chain

Each project in the construction supply chain have different requirements for the project construction, which drives the flow of information flow, capital flow and material flow in the project supply chain. The relationship of the various enterprises in the supply chain ends with the completion of the project, which has certain dynamics; moreover, because the enterprises are not very close, it has a certain temporary nature. There are many risk factors in the supply chain of the construction project, which will reduce the production efficiency of the construction supply chain, therefore, it is necessary to cooperate and negotiate with the enterprises to complete the project better.

2.4.5 Advantages of Supply Chain Management in Construction Projects

- Modern construction enterprises pay more and more attention to the competition of customer response time and construction time, after implementing supply chain management, construction enterprises can reorganize and integrate production process by removing some duplicate links and process, and implement multiple projects at the same time, which can greatly reduce unnecessary waiting time and consumption, thus speeding up the construction progress.
- Construction project supply chain is a supply network of construction products and services based on reasonable division of business and long-term partnership, this cooperation based on enterprise core competence and specialized division of labor will greatly improve the business competence of each supply chain member, improve the skilled degree and technical level of workers, and continuously improve the engineering quality of construction project.
- In addition, supply chain management of construction projects reduces uncertainties through information sharing, which leads to supply delay and interruption of upstream enterprises in supply chain, and increases construction costs in downstream enterprises due to stopping work and waiting for materials, it reduces

construction costs and reduces risks through integrated management and coordination of supply chain

2.4.6 Major Risk Analysis of Construction Project

Risk of Material Purchase

- Timing, purchase place and purchase times control in the purchase process of building materials will cause material purchase risk in external project contracting. In the whole life cycle of a project, purchase involves a long-time span, which plays a vital role in the progress, quality and cost control of the project, only by strictly grasping the purchase link and controlling the purchase risk, can the goal of construction progress, quality and cost be more effectively supported
- If the materials cannot be supplied in time and cannot meet the construction progress and quality requirements, it will inevitably lead to adverse consequences
- If we store material as much as possible for supply at any time, on the one hand, the cost of stock increases, on the other hand, because a large number of raw materials purchases occupies additional funds, which because circulating capital cannot to be allocated more reasonably, potentially increasing logistics costs
- Different building materials need to be purchased from different suppliers; quantity, quality and performance require many inspection processes to complete, it will take time and effort.

Risk of Natural Condition

- Natural condition risks refer to the factors that may have adverse effects on project construction, such as geological hazards, bad weather, interference sources around the project and bad transportation conditions.
- For example, unpredictable geological disasters such as earthquakes, debris flows, and abnormal bad weather such as rain, snow, freezing and bad transportation conditions may cause supply disruption, etc.
- According to the risk theory of project management, the risk brought by natural conditions belongs to the risk of force majeure. These risks are the most unpredictable and the most difficult to control.

Risk of Project Information Flow

- The delay and inaccuracy of information transmission are caused by the separation of construction management units and construction sites.

- Sharing and coordination of information is not smooth, which affects the completeness of information retention, the relevance of information processing and the timeliness of information records, these are the key factors of project construction quality, schedule and cost control.
- Delays the progress, and it is not conducive to the realization of project construction objectives

2.5 ELECTRICAL SERVICES SCM

- In order to achieve the maximum productivity of the crew it is very important to have the material, equipment and tools at the right place and when needed.
- Common literature classifies the products used by electrical contractors into two major categories: power products and equipment, and low voltage products and equipment.
- Power products and equipment are products used to deliver energy to the customers and products that use that energy.
- Among such products and equipment the following examples can be included:
 - Boxes & Fittings
 - Emergency Lighting
 - Fixtures (lighting)
 - Floor Boxes
 - Fuses
 - Lamps (lighting)
 - Lighting Controls
 - Metal-clad Cable
 - Meters & Sub meters

Low voltage products and equipment refer to products that are not directly related to energy transmission. Examples of such products and equipment include:

- Fiber Optic Cable
- Fiber Optic Components

- Fire Alarm Systems
 - Intercom & Nurse Call Systems
 - Premise Wiring Hubs (voice/data)
 - Raceway (voice/data)
 - Routers (voice/data)
 - Security Equipment
 - Smoke Alarms
- materials purchased by electrical contractors fall into two categories;
 - miscellaneous material or commodities,
 - major materials.
 - Miscellaneous materials refer to off-the-shelf items such as cables, conduits, straps and fittings.

Major materials include switch gears, lighting fixtures, alarm systems and other items that need to be designed/fabricated specifically for a given job.

- Transformer- A device that changes, or transforms, alternating current from one voltage to another.
- Switch- A device that closes and opens an electric circuit by moving two electrical conductors into contact to close the circuit or separate them to open the circuit.
- Switchgear- A freestanding assembly including primary (disconnect) switches, secondary (feeder) switches, and overcurrent protection device (fuses and circuit breakers).
- Lighting Fixture- An assembly having one or more lampholders, or a lampholder used in lieu of such an assembly.
- Control Panel- A panel, cabinet, or enclosure containing two or more controllers, contractors, relays, or other control devices for the control of electrical circuits, equipment, apparatus or system.
- Circuit Breaker- A switch which stops the flow of current by opening the circuit automatically when more electricity flows through the circuit than the circuit is capable of carrying; resetting may be either automatic or manual.

- **Distribution Panel-** The main electrical control center, which contains switches or circuit breakers, is connected to the service wires, and delivers current to the various branch circuits.
Substation- an assembly comprised by voltage switches and circuit breakers, a step down transformer, meters, buswork, and secondary low voltage switchgear
- **Raceway.** Any channel courses supporting and protecting electrical conductors, including conduits, wireways, surface metal raceway, cable trays, floor and ceiling raceways, busways, and cable bus.
- **Panelboard-** A single panelboard or group of panel units designed for assembly in the form of a single panel including buses and with or without switches or automatic overcurrent protective devices, or both, for the control of light, heat, or power in a cabinet or enclosure placed in or against a wall or partition and accessible only from the front; also called a Switchboard.
- **Busway-** An assembly of copper or aluminum bars in a metallic housing used when it is necessary to tap onto an electrical power conductor.
- **Electrical Metallic Tubing (EMT) -** Unthreaded light weight piping for running electrical conductors; easier to handle than rigid conduit and installed more rapidly because of the type of non-threaded fittings used with it; also called Thin Wall Conduit.
- **Flexible Conduit-** Electrical conduit made of a spirally wound metallic strip.
- **Aluminum Conduit-** A pipe constructed of a light alloy material used to enclose electric wires to protect them from damage.
- **Plastic Coated Conduit-** A type of conduit for electrical wiring that is used around moist areas and highly corrosive fumes.
- **PVC Conduit-** Lengths of rigid plastic pipe made of polyvinyl chloride.
- **Steel Conduit-** A pipe, tube, or channel used to enclose electric wires or direct the flow of a fluid.
- **Fitting-** A device used for connecting pipes together.
- **Cable Fitting-** Couplings, elbows, tees or unions used to form a junction or connect cable lines together.
- **Hanger-** A device attached to walls or other structure for support of pipe lines.
- **Cable-** A bundle of two or more electrical conductors.

- Wire- A metal drawn out into the form of a thread or thin flexible rod, used for fencing, binding, or to conduct an electrical current
- Bolt- A threaded metal rod or pin for joining parts, having a head and usually used with a threaded nut.
- Nut- A small square or hexagonal flat piece of metal or other material with a threaded hole through it for screwing on the end of a bolt to secure it.

2.5.1 Phase 1: Bidding

- The materials management process starts from the time that the contractor receives the drawings and specifications.
- The materials takeoff and identification process is the first step in this phase and involves identifying the materials needed as well as any special requirements or special materials to be used in the project.
- Quantities needed are estimated and a bid package is put together and submitted, typically to the GC.
- Most of the contractors create “electronic” or computerized estimates by using a software package (e.g., Accubid, TRF, and ConEst) or by preparing a customized program that is suitable for their needs by using a computer application such as Microsoft Excel.
- The majority of the companies that make computerized estimates use assemblies (e.g. gear box) for material takeoff that are embedded in the software packages rather than estimating the individual components (e.g. wiring or piping).
- The use of these assemblies makes the estimating process easier and faster.
- Other companies prepare manual estimates, which are verified several times prior to submitting the bid.
- Some companies use internal cost codes for material takeoff and identification that are assigned to the material being estimated.
- In some companies, project managers are involved in the estimating phase. The involvement of the project managers could lead to the preparation of more realistic
- estimates due to the project manager’s knowledge of electrical systems, materials and equipment.

- After successfully winning the bid for a particular project, some companies schedule a kick-off meeting that includes the superintendent, the project manager and all the foremen.
- At this meeting, the foremen and the project manager re-estimate the quantities for major material and commodities.
- They generate a material requisition schedule (e.g. release forms) specifying material types, quantities needed, dates when the material should be delivered and any additional information needed for clarification. In addition, any notes related to particular items and the drawings for the job are included.
- Other companies do not re-estimate the project as long as the quality and clarity of drawings provided is good and no changes were made to the design. In these companies, the initial estimate is verified 2-3 times before submitting the bid.

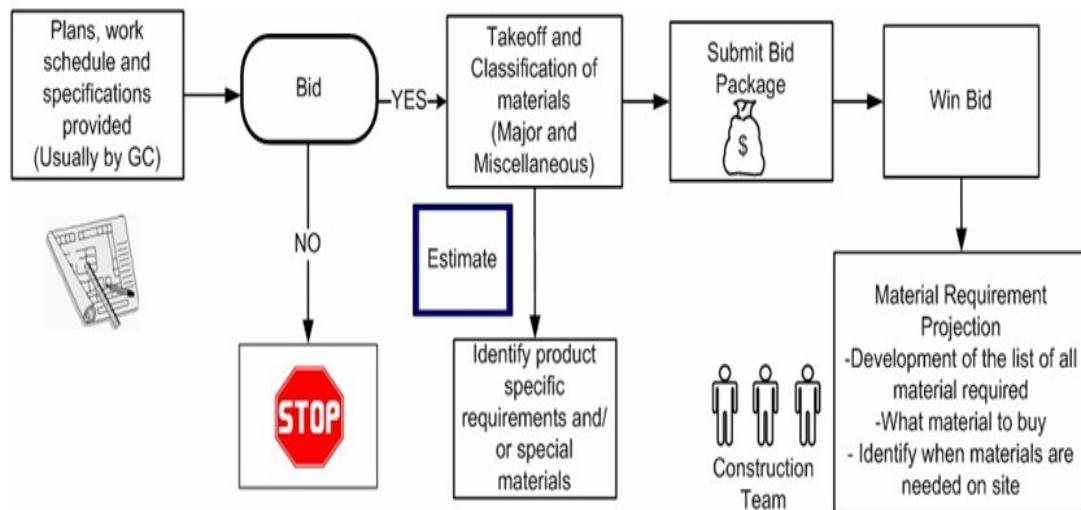


Fig 2.30 Bidding

2.5.2 Phase 2: Sourcing

- The selection of suppliers is critical and the contractor needs to verify that the supplier is capable of delivering the right material (i.e. type, quality and quantity) when needed (i.e. at dates specified).
- In general, most materials (miscellaneous and major) are purchased through suppliers/distributors.

- Most EC's prefer to buy materials from their local suppliers and from suppliers with whom they had worked before.
- Some companies have specialized agents within their purchasing department for supplier selection and procurement.
- In order to do business with these suppliers, they need to verify that the supplier is capable of delivering the material when needed.
- In addition, in order to get reasonably good prices for the material, they request quotations from different suppliers. Suppliers are usually selected based on lowest price, however, contractors may consider suppliers with higher prices but that will provide better service or that have a record to supply the right material in the quantities needed at the times specified.
- In some situations incomplete proposals from suppliers may delay the selection process.

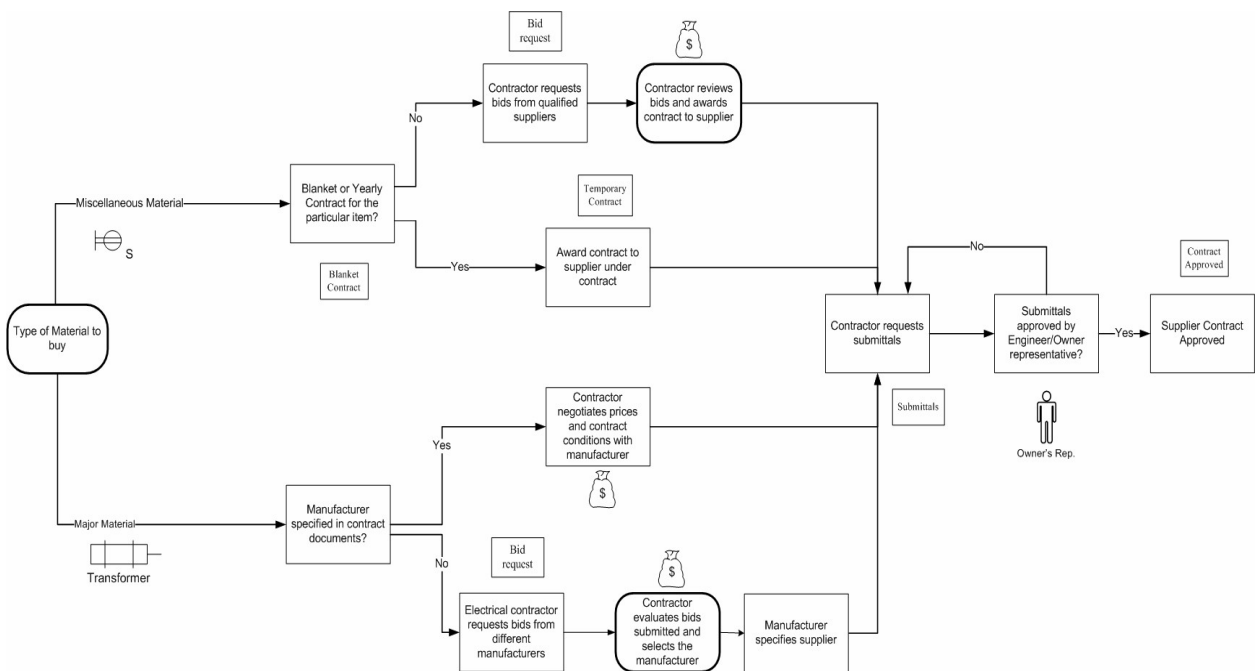


Fig 2.31 Sourcing

2.5.3 Phase 3: Material Procurement

- The material requisition and expediting phase is very critical to the success of a material management process.

- The person in charge of procuring materials or the purchasing department, in the case of a large company, needs to ensure that the correct materials in the correct quantities are delivered. This person also needs to verify the release dates at which the material is needed and to clearly specify those delivery dates and the location of delivery to the supplier
- In many companies, this process starts with the generation of a material requisition schedule. In large jobs, the schedule is usually prepared by the site staff and then is sent to the purchasing department for material request from the suppliers/distributors under contract.
- In smaller companies or in smaller size jobs, material may be requisitioned directly by the field personnel. In companies that have a warehouse, the purchasing department first verifies availability of materials in the warehouse before requisitioning any materials from suppliers

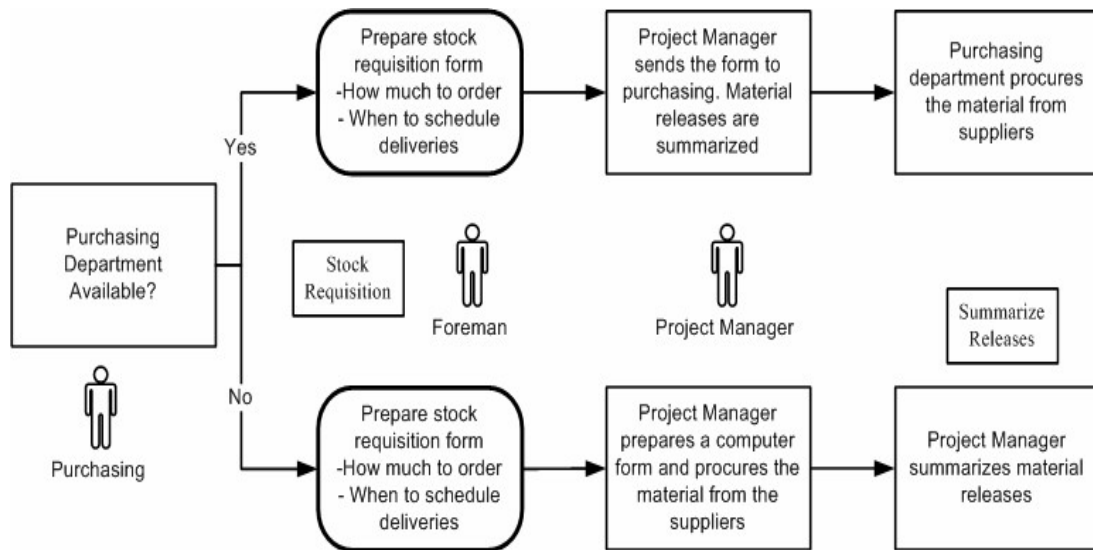


Fig 2.32 Material procurement

2.5.4 Phase 4: Construction

- Material delivery usually occurs during the construction phase. Material is generally requested for delivery to the jobsite.
- In some instances material delivery to the jobsite may not be feasible due to storage or access limitations. Material is delivered to a warehouse in cases such as when critical specialty items are ordered early and are not going to be installed immediately, when storage area at the job-site is unavailable, or if the material will be used for pre-fabrication.

- Storage of the material at the warehouse prior to moving it to the jobsite increases indirect costs due to re-handling
- Some companies utilize a pre-fabrication shop facility to assemble components in a controlled environment.
- Advantages of pre-assembly include increased production time and reduced labor costs compared to performing the assembly process in the field where poor weather conditions and space limitations may cause work delays.
- The increase in productivity and savings in labor costs out weigh additional costs encountered due to pre- fabrication and re-handling.

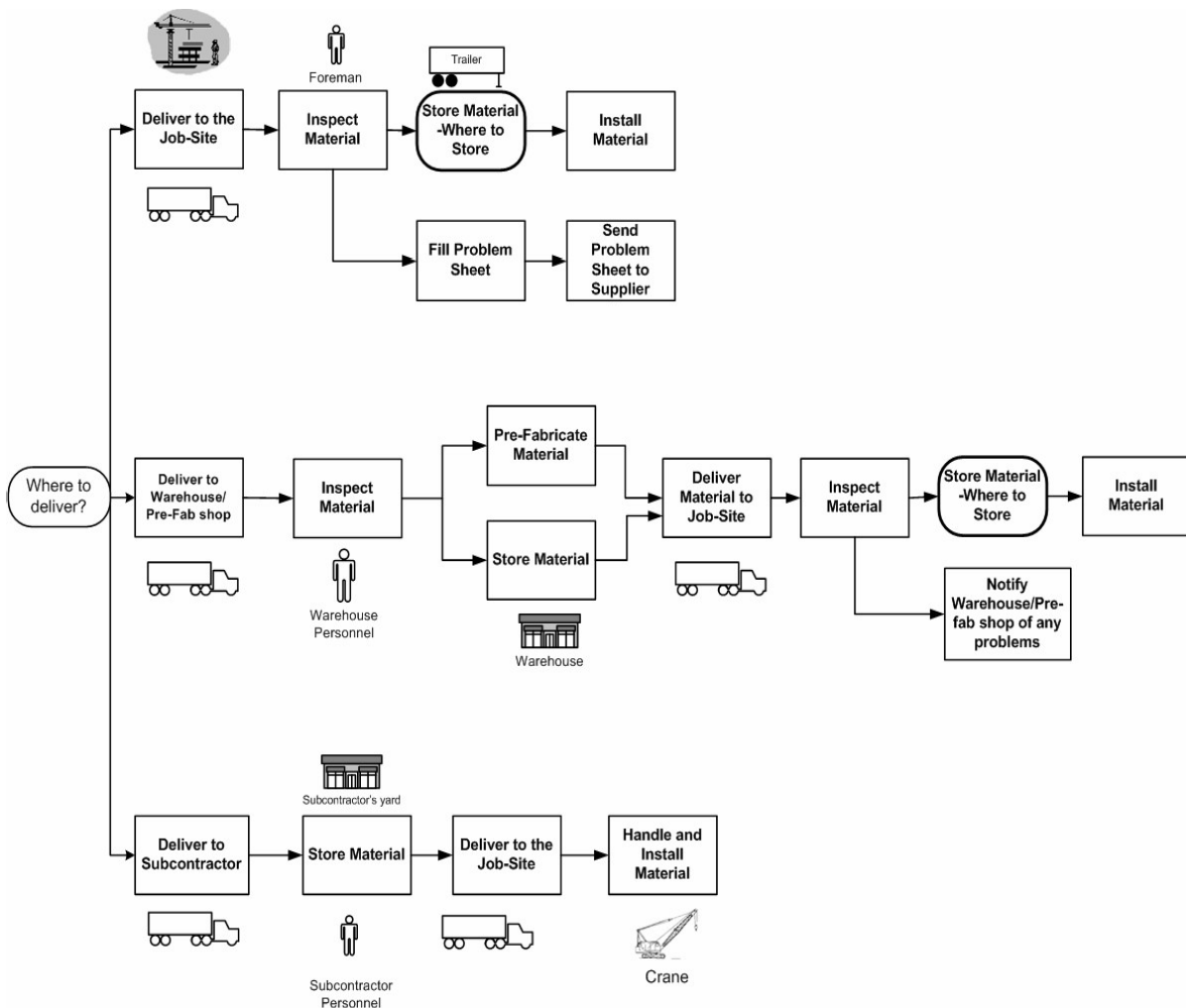


Fig 2.33 Construction

2.5.5 Phase 5: Post-Construction

- After installation of the materials on the structure, the EC has to manage any surplus material.
- The surplus is handled differently depending on the type of material and also whether or not the contractor has a warehouse.
- If the company has a warehouse, the surplus material is stored in the warehouse for use in future projects.
- Other companies return surplus material to the supplier for reimbursement.
- Usually, there is no penalty or re-stocking fee for commodity items. For specialty items there is usually a 20-25% penalty.
- An effective material management system is essential to avoid material shortages, misplacements, loss, and theft which might result in increases in crew idle times, loss of productivity and delay of activities.
- Electrical contractors should implement an efficient material management system due to the fact that in most of the cases they are asked to squeeze their bids in order to keep the costs of project under budget.

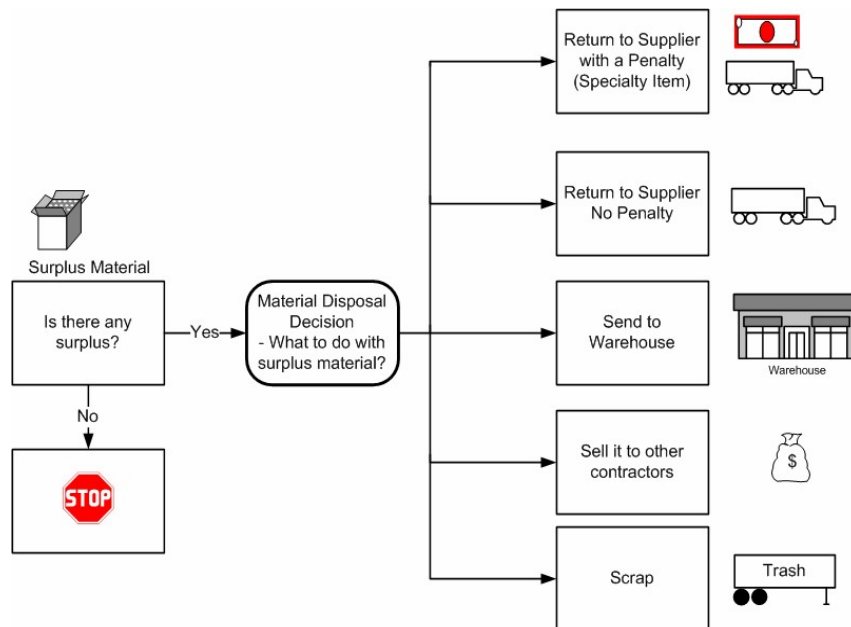


Fig 2.34 Post construction

2.5.6 Material Requisition Process

- Material requisition problems greatly affect the construction stage and failure to manage this phase effectively could result in project disruption and possible delays due to late deliveries, stockouts due to small quantities bought, material delivered to the wrong locations, material backordered and effects in overall costs.
- The requisition process for miscellaneous material starts in the construction phase and is focused on how much material to buy, when to buy this material, where to deliver this material, when to deliver, which supplier to buy from, where to store on site.
- The decision of when to deliver requires knowledge of the schedule and actual installation rates.
- The decision of which supplier to buy from depends on contract agreements, specifications and performance of the supplier.
- The decision on where to store on site depends on site restrictions and space availability.
- The purpose of this form is to keep records of the material being used in the project and the balance available for requisition. A copy of the summarized releases is sent to the foreman.
- The purchasing department requests the material from pre-selected suppliers/vendors and instructs the supplier/vendors about material type, quantities needed, time when the material is to be delivered and instructions for delivery

2.6 TQM IN ELECTRICAL

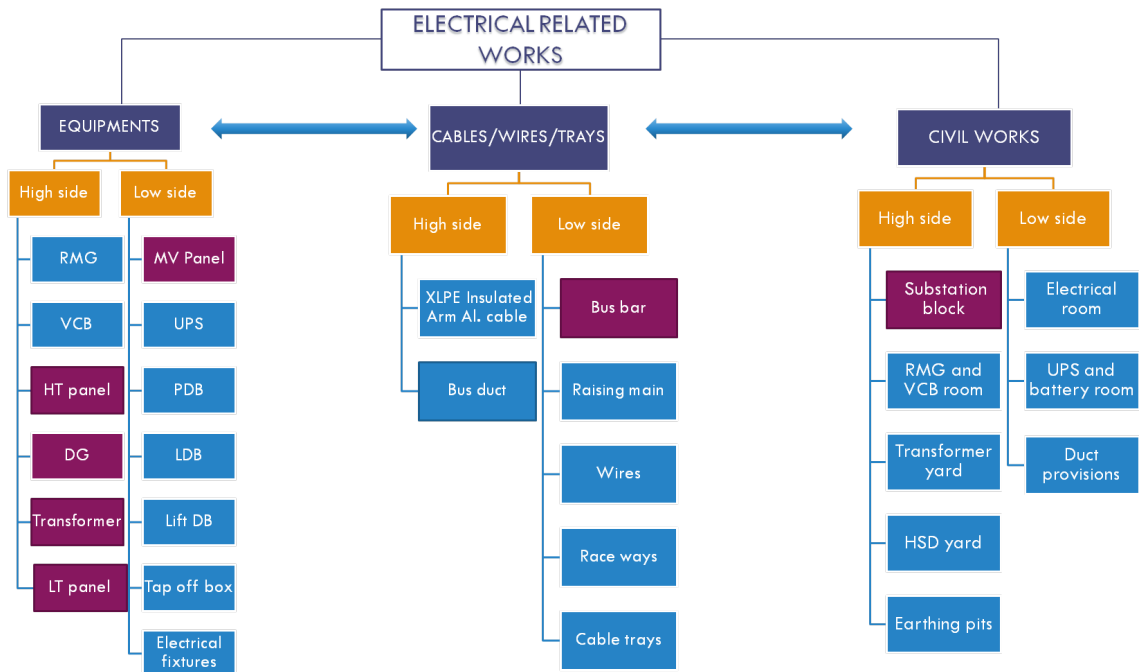


Fig 2.35 Electrical related works

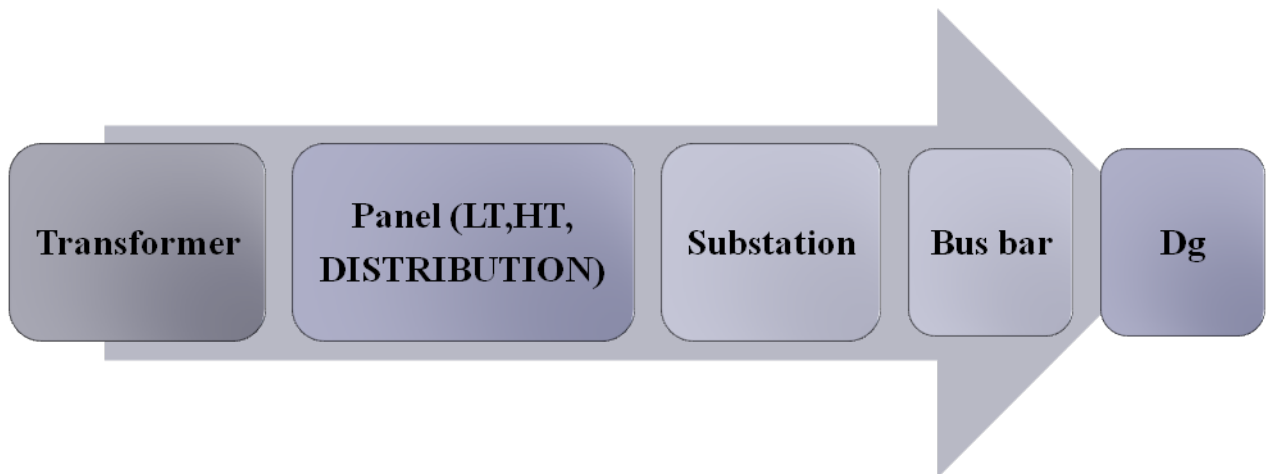


Fig 2.36 Total quality management for shortlisted electrical equipments

2.6.1 DG set – Diesel generator

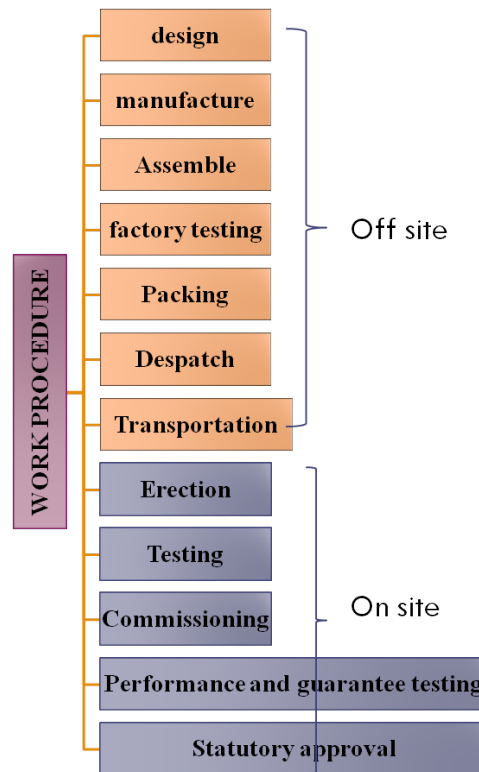


Fig 2.37 SCM of dg

2.6.1.1. Design

Bidding

- The materials takeoff and identification process is the first step in this phase and involves identifying the materials needed.
- Quantities needed are estimated and a bid package is put together and submitted, typically to the GC.

Sourcing

- The selection of suppliers is critical and the contractor needs to verify that the supplier is capable of delivering the right material (i.e. type, quality and quantity) when needed (i.e. at dates specified).

2.6.1.2. Manufacture and assemble

Diesel engine

The engine shall be fitted with following accessories subject to the design of the manufacturer:

- Dynamically balanced Fly wheel
- Necessary flexible coupling and guard for alternator and engine
- Air cleaner
- A mechanical/ electronic governor to maintain engine speed at all conditions of load.
- Daily fuel service tank of minimum capacity fabricated from M.S. sheet with inlet, outlet connections air vent tap, drain plug and level indicator (gauge) M.S. fuel piping from tank to engine with valves, unions, reducers, flexible hose connection and floor mounting pedestals, twin fuel filters and fuel injectors. The location of the tank shall depend on standard manufacturers design
- Dry exhaust manifold with suitable exhaust residential grade silencer to reduce the noise level.
- Suitable self-starter for 12 V/ 24 V DC
- Battery charging alternator unit and voltage regulator, suitable for starting batteries, battery racks with interconnecting leads and terminals.
- Necessary gear driven oil pump for lubricating oil, priming of engine bearing as well as fuel systems as per manufacturer recommendations.
- Naturally aspirated/ turbo charger
- Lubrication oil cooler
- Lubrication oil filters with replaceable elements
- Fuel injection: Engine should have suitable fuel injection system in order to achieve low fuel consumption
 - Fuel pump with engine speed adjustment
- Engine Control Panel: fitted and having digital display for following:
 - o Start/stop key switch.
 - o Lube oil pressure indication
 - o Water temp. indication

- o RPM indication
- o Engine Hours indications
- o Battery charging indication
- o Low lub. Oil trip indication
- o High water temp. indication
- o Over speed indication
- All moving parts of the engine shall be mechanically guarded in such a manner that a human finger cannot touch any moving part

Fuel system

Pipe sealant should be used for sealing for all connections. No Teflon tape to be used.

Lubricating oil system

- Necessary priming pump for the lub. oil circuit as per recommendation of manufacturer shall be installed, to keep bearings primed.
- This pump shall be normally automatically operative on AC/ DC supply available with the set.

Starting system

- Battery capacity shall be suitable for meeting the needs of starting system
- The system shall be capable of starting the DG set within 20-30 sec.

Common bed plate

- both units shall be mounted on a common bed plate together with all auxiliaries to ensure perfect alignment of engine and alternator with minimum vibrations.
- The bed plate shall be suitable for installation on suitable anti-vibration mounting

Earth terminals

- DG Set of 500 KVA capacity or above:- Copper strip
- DG Set below 500 KVA capacity:- GI strip

Fault tripping

In the event of any fault e.g. over voltage/ high bearing temperature/ high winding temperature or an external fault, the AVR shall remove the excitation voltage to the alternator. An emergency trip shall also be provided.

Battery / electrical system

- Batteries supplied with Genset are generally dry and uncharged.
- First charging of uncharged batteries is very important and should be done from authorized battery charging centre. Initial charging should be done for 72-80 hours.
- Batteries should be placed on stands and relatively at cool place.

Diesel generator control panel

- The control panel shall be sheet steel enclosed and shall be dust, weather and vermin proof providing a degree of protection of IP-52.
- Sheet steel used shall be cold rolled and at least 2.0 mm thick and properly braced and stiffened.
- Control panel shall be provided with hidden hinged door(s) with pad locking arrangement and suitable brackets/channels shall be provided for floor mounting.
- All doors, removable covers and plates shall be gasketed all around with neoprene gaskets. All accessible live connections shall be shrouded and it shall be possible to change individual switches, fuses, ACBS without danger of contact with live metal.
- All live parts shall be provided with at least phase to phase and phase to earth clearances in air of 30 mm and 25 mm respectively.
- Adequate interior cabling space and suitable removable cable gland plate shall be provided. Necessary number of cable glands shall be supplied and fitted on to this gland plate. Cable glands shall be screwed on type and made of brass.
- All sheet steel work shall be degreased, pickled, phosphate and then applied with two coats of finishing powder coating both inside and outside of shade Siemens Gray

Piping Work

- This shall include necessary flexible pieces in the exhaust, fuel, lub. oil and water lines as are necessary in view of the vibration isolation requirement in the installation.
- Piping of adequate size shall be used for lub. oil of the material as per manufacturer standard. only M.S. pipes for the exhaust shall be used.

- For fuel lines within the acoustic enclosure, PVC braided pipe as per can be used. However, for fuel lines outside the acoustics enclosure only MS pipe be used.
- The pipe work shall be inclusive of all fittings and accessories required such as bends, reducers, elbows, flanges, flexible connections, necessary hardware etc.
- The installation shall cover clamps, supports, hangers etc. as are necessary for completing the work.

Air System

- It is preferable to provide vacuum indicator with all engines to indicate choked filter.
- Maximum air intake restrictions with clean and choked filters should be within prescribed limit as per OEM/ manufacturer recommendation for the particular model of the engine.
- Gensets should be supplied with medium duty/ heavy duty air cleaners
- Heavy duty air cleaner should be used for installations in dusty or polluted surroundings.
- Cooling System
- System should be designed for ambient temperature of 40 Deg.C.
- Water softening/ demineralizing plants should be used, if raw water quality is not acceptable.
- Radiator fan flow should be free from any obstruction.
- For radiator cooled DG Set, proper room ventilation should be planned at the time of construction of DG room.

2.6.1.3. Factory Tests

- The alternator of each type and rating shall be type tested for the all tests as per IS:4722, IEEE 115 & BS:5000. Required type test certificates shall be furnished for information.
- The alternators and the starting motors shall be tested for the routine tests
- The control panels shall be tested/checked for following
 - (a) Compliance to drawing, data sheet and this specification.
 - (b) Check for workmanship, wiring, conformity to functional requirements.
 - (c) Calibration of instruments, meters C.T., P.T. etc.

(d) H.V. Test –high voltage

(e) I.R. Test insulation resistance before and after HV test.

- The acceptance and routine tests of battery shall be done

a) All routine tests as per relevant IS.

b) Test for ripple factor & regulation

c) Heat run test (as type test)

d) Operational and functional tests.

2.6.1.4. Packing

There are four common ways to pack dg sets.

- Each genset manufacturer has their own standard packing method. Usually, manufacturers will confirm it with their clients.
- If clients do not have special requirements, they will just follow the standard packing way. But the way may be changed due to different special requirements, distances or different shipping methods.

Soft Packing

This is the most common way to pack diesel engine generators. They use foam, plastic wrap or bubble film to wrap the whole dg set with two or three layers. This packing way is cost-effective, convenient and efficient.

Wooden packing

The cost of wooden packing is much higher than the soft packing, but it will give a safer & stronger protection for genset unit. And it is also convenient for loading and unloading. It should be noted that all the woods used in the packing should be fumigated

Carton Packing

Cartons are always made to order in bulk based on a certain size. Some cartons will be with brand, logo or other information printed on the surface.

Iron Packing

This way is always for clients' special requirements, which is seldomly used. The whole machine is packed with iron sheet & steel tube. The cost is really high, but it also gives the genset unit a great protection, even with weather proof effect.



Fig 2.38 packing types

2.6.1.5. Erection

- Unload the DG Set from the base rail/enclosure by lifting with proper DG Set lifting tackle or nylon sling /steel rope of suitable capacity and crane so as to ensure no damage to oil sump, air cleaner, radiator pipes etc
- Do not lift the DG Set from engine and alternator hooks. These are designed for lifting individual items only.
- Keep the DG Set covered with polyethylene or tarpaulin during installation to ensure that water does not enter inside.
- Spreader bar / spacer plate of suitable size must be used to avoid damages to DG Set components. While unloading/ shifting of DG set.

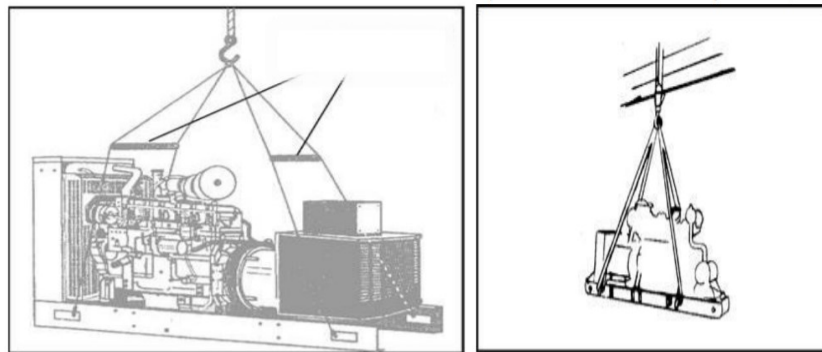


Fig 2.39 unloading of DG

Location

- The emergency power supply (such as generating sets) should not be allowed to be installed **above ground floor or below the first basement level of the building.**
- position the DG set so that the **prevailing wind do not enter into the radiator/exhaust outlet.** If this is not possible, install a **wind barrier**

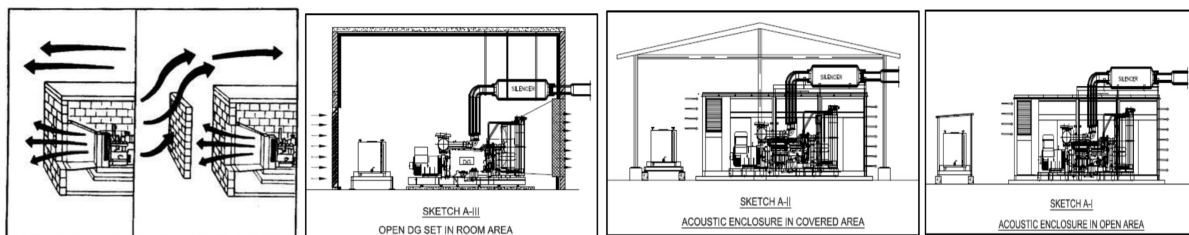


Fig 2.40 location of DG

Height

- The height of diesel generating (DG) set rooms shall however be not more than 3 000 mm above the DG set height, unless required due to DG room ventilation requirements

Space design

- Adequate space shall be provided for storing of fuel.
- relative to the location of the installed equipment has to be kept in the layout design for removal of equipment or sub-assemblies for repair or maintenance.

Access

- When it is located at a place, other than the ground level with direct equipment access, a hatch or ramp shall be provided.

Table 2.8 spacing guidance for DG

A.6 Spacing Guidance

No.	Description	DG set with Acoustic Enclosure in Open Area.	DG set with Acoustic Enclosure in Covered Area.	Open DG set in room.
1	Free space on both sides	Min. 1.5 m	Min. 1.5 m	Min. 2 m
2	Free space at front side (Radiator- - Hot air outlet at front)	Min. 3 m	Min. 3m (with ducting to avoid re-circulation)	Min. 1.5 m
3	Free space at front side (Radiator- Hot air outlet at top)	Min. 1m	Min. 1.5m	N/a
4	Free space at rear side (Alternator)	Min. 2 m	Min. 2 m	Min. 2 m
5	Fresh air inlet opening area	N/A	N/A	Min 1.5 times of the Radiator area.
6	Hot air discharge opening area	N/A	N/A	Min. 2.5 times of the Radiator area.
7	Distance between two sets	Min 1.5m between two canopies	Min 1.5m between two canopies	Min 1.5m between two foundations.

Ventilation

- If installed in the enclosed space, facilities for forced ventilation shall be provided such that there is minimum derating of the equipment.
- Providing forced air thru axial flow fans at rear side of DG set and hot air outlet through louvers provided at DG front area
- Providing forced air thru axial flow fans and hot air exhaust through axial flow fans. Exhaust fan capacity should be less than 70 to 75% of fresh air supply fan capacity.
- Providing natural air from rear side of DG set and hot air exhaust thru axial flow fans from front side of DG set

Foundation

- Do not install DG Set on loose soil or sand clay, unless kept temporary
- Foundation should be designed considering safe bearing capacity of soil and DG set static and dynamic load. Anti-Vibration Mounts (AVMs) are provided to reduce generator set vibration and noise transmission to the surrounding structure
- It is recommended to have foundation elevation 150 mm above finish ground level. It helps to maintain cleanliness of DG Set. For areas having heavy rainfall, a higher platform/ rain shed (not mandatory) may be required to prevent water entry and it also helps in operator's safety

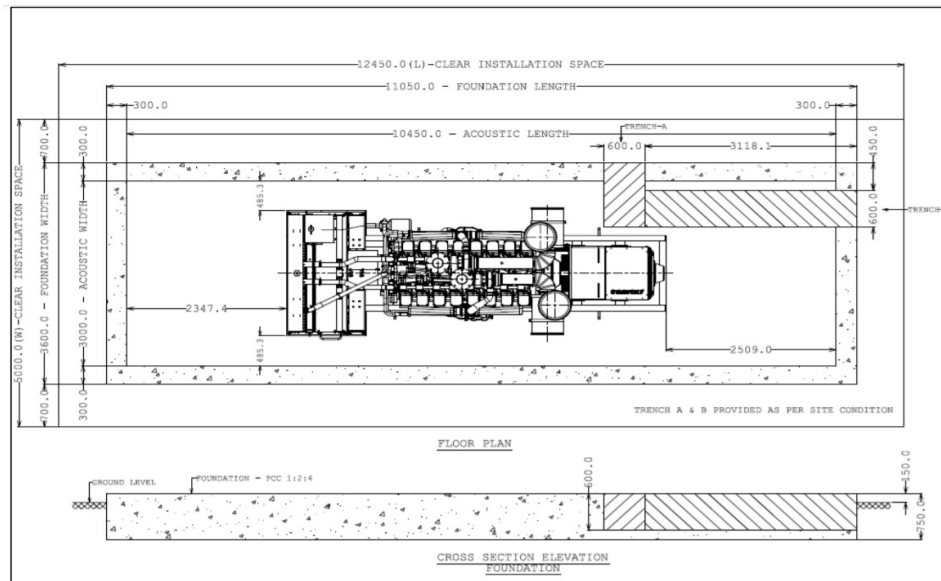


Fig 2.41 foundation of DG

Avoid transfer of vibration and noise

- The generating set should preferably be housed adjacent to MV switchgear in the substation building to enable transfer of electrical load efficiently and also to avoid transfer of vibration and noise to the main building

Exhaust system

- Use of thimble is must while passing the pipe through concrete wall. The clearance around the pipe in wall is must, for free movement and expansion.
- DG set duct entry to stack should be at an angle of 45 deg. max

Earthing

- The generating set and all associated equipment, control and switch gear panels must be earthed before the set is put into operation.
- Numbers earth pits are required as per Indian Electricity rules or local electricity board.
- earthing pits for genset / control panel body
- earthing pits for neutral
- Copper or GI strips of suitable size may be used for earthing. Please note that for normal soil, earth resistance should not exceed one ohm.
- For gensets with AVM's between engine / alternator and base rail. The earthing MUST be done at the engine / alternator and NOT at baserail.

2.6.1.6. Commissioning Check Tests/Performance and Guarantee Test

Load Test

- The engine shall be given test run for a period of at least 13 hours depending upon the actual power factor of the load and set shall be subjected to the maximum achievable load without exceeding the engine or alternator capacity.
- This full load test is to be followed immediately by a 10% overload run for one hour.
- The performance of the engine, alternator and exciter shall be satisfactory at the end of this overload run.
- At the end of the full-load run, and again at the end of the over-load run, tests for temperature rise and insulation resistance of the alternator as specified shall be taken. • During the load test half hourly records of the following shall be taken:
 - a) Ambient temperature b) Exhaust temp. C)when exhaust thermometer is fitted. d) Lubricating oil pressure e) Speed f) Voltage, wattage and current output. g) Oil tank level h) Stored diesel oil temperature

Regulation Test

- The automatic and manual regulation of the alternator load at half and full rated load shall be 1 tested for a nominal volts of 240 volts, between phase to neutral and at 0.8 p.f. to verify the requirements of voltage and frequency variation Speed and Governing
- The speed of the engine shall be verified to ensure that it conforms to the requirement

Vibrations

- The vibrations shall be measured during full load test as well as during the overload test and the limit shall be limited to 250 microns.

Check of Fuel Consumption

- A check of the fuel consumption shall be made throughout the test run of full load and overload.

Insulation Resistance of Wiring

- On completion of the engine tests, the insulation of each unit of local wiring in the control cubicles and other components of the engine set, shall be tested with a 500 V insulation tester. The insulation resistance shall not be less than one mega-ohm. between wires in a cable and engine set frame of cable sheath.

Functional Tests

- Protective equipment on the engine against excessive cylinder temperature and low lubrication oil pressure
- Type of starting provided for the engine.
- Pilot and fault indication lamps.

Safety guidelines

- DG room should have proper escape routes.
- An escape map may be displayed in the DG room which should be clearly visible to all would be helpful during any accident or fire.
- provide proper Fire Extinguishers in DG Set room area.
- put Hazard Signs for Electricals Panels, Fuel and Lubricants etc.
- Personal Protection gadgets like -Safety hand gloves, goggles and ear plugs for protection of all operators, engineers and staff would make them safe, while working in DG Set room.

2.6.1.7. Statutory approval

- Vendor shall give necessary inputs for designing the foundations & shall be responsible for design, erection shall happen after completion of foundation works
- Vendor shall co-ordinate with other agencies like electrical contractors, civil contractors etc.
- Further to erection, testing and commissioning of the DGs, the termination of cables at DGs, Between DGs and Main LT panel end shall be done by the main electrical contractor.
- Calibration of CTs, approval from statutory authorities like electrical inspectorate, PCB etc shall be the responsibility of the DG supplier.
- DG supplier shall coordinate with main electrical contractor for necessary control & power cable termination.

2.6.2. Panels – LT, HT, MV, DB, switch board

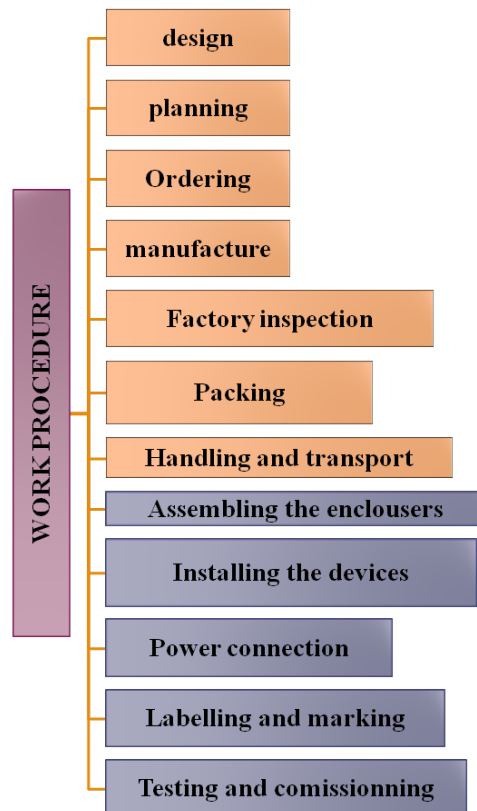


Fig 2.42 scm of panel

2.6.2.1. Design

- The panel board shall be designed such that the switchgear, instruments, relays, bus bars, small wiring etc. are arranged and mounted with due consideration for the following:-
- Facility for inspection, maintenance and repairs of testing terminals and terminal boards for ease of external connection.
- Minimum noise and vibrations.
- Risk of accidental short circuits and open circuits.
- Secured and vibration proof connections for power and control circuits.
- Risk of accidental contact and danger to personnel due to live connections.
- Mountings at approachable height.

2.6.2.2. Planning

Bidding

- Quantities needed are estimated and a bid package is put together and submitted, typically to the GC.

Sourcing

- The selection of suppliers is critical and the contractor needs to verify that the supplier is capable of delivering the right material (i.e. type, quality and quantity) when needed (i.e. at dates specified).

2.6.2.3. Ordering

- make a purchase order for panels with clear specification

2.6.2.4. manufacture

Structure

- It shall be metal clad enclosed and be fabricated out of high quality CRCA sheet, suitable for indoor installation, front operated and floor mounting type.
- CRCA sheet steel used in the construction of the panel shall be 2 mm thick for structure, 1.6 mm thick for doors, covers, shrouds and 3 mm thick for gland plate and shall be folded and braced as necessary to provide a rigid support for all components.
- Joints of any kind in sheet shall be seam welded, all welding slag ground off and welding pits wiped smooth with plumber metal.

- The It panel shall be totally enclosed, completely dust and vermin proof and degree of protection being no less than IP-54 confirming to IS 2147.
- Gaskets between all adjacent units and beneath all covers shall be provided to render the joints dust proof. All doors and covers shall be fully gasketed with neoprene gaskets and shall be lockable.
- All panels and covers shall be properly fitted and secured with the frame, and holes in the panel correctly positioned. Fixing screw shall enter into holes tapped into an adequate thickness of metal or provided with bolts and nuts. Self threading screws shall not be used in the construction of pccs / mccs / pdds.
- A base channel of 75 mm x 75 mm x 5 mm or as per the weight of the panel shall be provided at the bottom.
- Lt panel shall be arranged in multi-tier formation
- Lt panel shall be of adequate size to facilitate enough space for maintenance and cooling.
- The size of the It panel shall be designed in such a way that the internal space is sufficient for hot air movement, and the electrical component does not attain temperature more than 40 degree Celsius. Openings shall provide for natural ventilation, but the said openings shall be screened with fine weld mesh.
- Knockout holes of appropriate size and number shall be provided in the It panel in conformity with number, and size of incoming and outgoing conduits / cables.
- Alternatively the It panel shall provided with removable sheet plates at top and bottom to drill holes for cable / conduit entry at site.

Powder coating

- All sheet steel material shall undergo seven-tank process after all the necessary shearing and other mechanical works are completed.
- After the seven-tank process powder coating treatment shall be adopted using powder of reputed make.
- After the powder coating is complete welding in the panel or any sort of shearing, bending or cutting activity shall not be done.
- The colour shall be Siemens Grey 631

Circuit compartment

- Each circuit breaker and switch fuse units shall be housed in separate compartments and shall be enclosed an all sides.

- Sheet steel hinged lockable door shall be duly inter locked with the breaker / switch fuse units in ON and OFF position.
- Safety interlocks shall be provided for non-opening of the door when the breaker is in ON position. The door shall not form integral part of the draw out position of the circuit breaker.
- All instruments and indicating lamp shall be mounted on the compartment door. Sheet steel barriers shall be provided between the tires in a vertical section.

Instrument compartment

- Separate and adequate compartment shall provided for accommodating instruments, indicating lamp, control contactors, relays and control fuses etc.
- These components shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, switch fuse units, bus bars and connections.

Terminals

- The outgoing terminals and neutral link shall be brought out to a cable alley suitably located and accessible from the panel front.
- The current transformer for instrument metering shall be mounted on the disconnecting type terminal blocks.
- No direct connection of incoming and outgoing cables to internal components connection of the distribution board is permitted. Only one conductor may be connected in one terminal.

Wire ways

- A horizontal PVC wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical sections.

Bus bar

- The switch board shall be single bus bar pattern with air insulated encapsulated busbars housed in a separate compartment, segregated from other compartments

Material

- The bus bars shall be of high conductivity electrolytic copper rated as specified with a minimum rated current of 630 Amps.
- The bus bars shall be sized for carrying the rated and short circuit current without overheating. Maximum bus bar temperature shall not exceed 95 degree C.

Small wiring

- The small wiring shall be carried out with minimum 1.5 sq. mm FRLS/ HFFR insulated copper conductor cables.
- CT wiring shall be done with minimum 2.5 sq mm wires with color code: RYB, Gray for auxiliary DC circuits and Black for auxiliary AC circuits.
- The wiring shall be securely fixed and neatly arranged to enable easy tracing of wires. Identification tags shall be fitted to all wire terminals to render identification easy and to facilitate checking in accordance with IS 375.

Cable boxes

- Cable boxes shall be situated in a compartment at the rear / side of the housing as specified.

Cable entry

- Provision for top (bus ducts preferred for top entry) / bottom or such other side entry shall be made as per requirement with sufficient head room for cable termination. 3 mm thick removable gland plate shall be provided for cable termination

Breaker Truck

- The breaker carriage shall be fabricated from steel, providing a sturdy vehicle for the circuit breaker and its operating and tripping mechanism.
- The carriage shall be, moving on guides, designed to align correctly and allow easy movement of the circuit breaker and for removing the carriage for inspection and maintenance purposes.

2.6.2.5. Factory inspections / testing

- checked for rigid mounting, earthing connections, proper rating and size of components, internal wiring, etc.
- All mechanical fasteners and electrical connections shall be checked and tightened before installation.

Type test

- Type test certificates for all switchgears shall be provided.

Routine Test

- a) Mechanical endurance test shall be carried out by closing and opening of all the ACB's, MCB's switches etc.
- b) Over voltage and Insulation resistance test shall be carried out between phases and between phase to earth bus, keeping the isolating switch in ON position. Similar test shall be carried out keeping the isolating switch in closed position.

- c) All the interlocks, controls and tripping mechanism of the switchgears shall be tested for their proper functioning.
- d) High voltage test, Continuity test, Control circuit test shall be carried out

2.6.2.6. Packing

- The switchboards are usually shipped complete with circuit breakers, voltage transformers fitted into the relevant compartments, except when otherwise agreed.
- The circuit breaker with draw able truck are packed inside the respective panel and positioned in the isolated/test position.
- Each switchboard section is packed in preparation for containerised shipping.
- Each group is protected by an aluminium sheet which is heat sealed. The bags are vacuummed and desiccant bags placed inside each bag.
- Each panel group is placed on a wooden pallet and a wooden crate surrounds the group. This crate serves to protect the panels during transportation and also to provide lashing points.



Fig 2.43 packing and loading of panel

2.6.2.7. Transport, unloading and storage

- Follow the symbols and instructions shown on the packaging carefully.
- Transport the panels upright. Take the high centre of gravity into account. Only carry out loading operations when it has been ensured that all precautionary measures to protect personnel and materials have been taken.
- The wooden crate must be fixed to the vehicle by means of ropes so as to avoid any violent impact or turning over in case of sharp turns or sudden stops. Moreover, the vehicle must be fitted with a canvas covering the whole load.
- The capacity load of the lifting equipment must guarantee proper weight distribution.

- If the apparatus is unloaded in the warehouse or in the installation room, the access must be at least 3m high x 2.5 m wide with an area at the same level. Small differences in level can be compensated with temporary structures using wooden boards.

Control on receipt

- On receipt, immediately check the packing and apparatus conditions.
- If the panels are going to be used immediately, open the packing and check that no damage occurred during transport and make sure that the rating plate data correspond to those listed in the Substation general arrangement.

Intermediate storage

- Store the panels upright and do not stack panels. Store the units protected from the weather in a dry, dust-free, non-corrosive place and safe from any damage.
- Check the packing for damage and regularly check for any condensation until installation is started. If any damage to the packing is noticed, carefully open the packing and inspect the units for signs of transportation damage or water ingress. If no damage is noticed, replace the drying agents and re-seal the aluminium bags.
- When the maximum storage period is too long the protective function of the packing can no longer be guaranteed and suitable action must be taken if intermediate storage is to continue.
- The packaging contains dehydrating bags that must be replaced every six months. In particular instances of very long storage, it is advisable to store the units in an indoor space.

Moving & lifting

- The importance cannot be over stressed regarding the care in handling, rigging, hoisting, rolling, or moving assembled panel into place.
- LT panels are designed to be handled only in the upright position and should never be handled in any other way without first consulting with the factory.
- When lifting shipping units with a crane, it is preferable to use two hooks simultaneously, one on each end. Each pair of lifting hooks should be equipped with a spanner bar to prevent excessive distortion. If only a single hook crane is available, arrange spanner to lifting rig.
- Lifting from front and rear of units permits placing shipping sections side by side for bolting without interference from lifting rig or hooks.
- When cranes are not available, equipment can be rolled into place on shipping skids when provided. Pushing or pulling forces should be applied to the skid .

- Shipping skids can be removed by using a foot jack in each corner of the shipping section after the switchboards has been moved to its final location.

2.6.2.8. Erection

INSTALLATION

- The LT panels should be fully compartmentalized in dust and vermin proof sheet steel enclosures.

Base frame

- The base frame shall be of minimum ISMC 100, integral to the LT panels and shall be suitable for tack welding to the purchasers floor embedded channels.

Working space

- This space must be at least 6.5 feet high and three square feet away from the wall, and must have a 30-inch width. This allows for safe, simple service when needed

Doors

- Each module, bus bar chambers, cable alley should be provided with hinged independent doors.
- All the elements of LT panels (frames, cubicles, doors etc.,) shall undergo seven tank surface treatments.
- All the doors and covers shall have gasket to prevent any ingress of dust. The enclosure shall be for Indoor type and completely dust, damp and vermin proof. Gasket used for doors shall be of double-lipped neoprene.

Paint

- Panels shall be painted by powder coating of approved shade / color process with two coats of zinc chromate primer and two coats of powder painting. painting should be done to get a smooth, scratch free and corrosion resistance surface.

Height

- LT panels shall be of uniform height, not exceeding 2400 mm. The operating height shall be restricted to 300 mm minimum & 1800 mm maximum.

Construction

- The LT panels shall have provision to expand horizontally for future requirements.
- The LT panels shall be metal clad, compartmentalized, fully Type Tested assembly floor mounted, free standing, modular type suitable for indoor installation.
- The LT panels shall be of bolted construction (No welded construction).

- The panel shall be fabricated in no. of sections so that it is for easy for transportation and positioning the panels in the panel rooms after which they can be integrated
- Removable gland plates shall be provided at the bottom of the switchboards for bottom cable entry.
- LT panels shall be easily extendable on both sides by addition of vertical section after removing the end cover.
- Single piece rubber mat of suitable grading confirming to Indian standard shall be provided in front of the LT panels.

Labels

- Engraved Aluminium sheet labels shall be provided on all incoming and outgoing feeders.
- Single line circuit diagram showing the arrangements of circuit inside the distribution board shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet.

Name plate

- A name plate with panel designation in bold letter shall be fixed at top of the central in panel.
- A separate name plate giving feeder details shall be provided for each feeder module door.
- Inside the feeder compartment, the electrical component, equipments, accessories like switchgear, contactor, lamp, relays etc. shall suitably be identified by providing stickers.
- Engraved nameplates shall be of Aluminium strip of black colour and silver letters format.

Danger notice plate

- • The danger notice plate shall indicate danger notice both in Hindi and English and with a sign of skull and bones.
- • Overall dimension of the danger notice plate shall be 200 mm wide and 150 mm high.
- • The danger notice plate shall be made from minimum 1.6 mm thick mild steel sheet and after due pretreatment to the plate, the same shall be painted white with vitreous enamel paint on both front and rear surface of the plate. the figure and the sign of skull and bones be painted in single red colour

Indicating Lights

- Indicating lights shall be of transformer type with connected lamps rated at 6.3 volts 1 watt filament.
- The indication must be clearly visible from front at a distance of 15 meters in a normally illuminated room.
- The bodies of indicating lights shall be ventilated to ensure efficient heat dissipation. Connection to lights shall be by screw to clamp terminals, soldered termination are unacceptable.

Earthing

- Copper earth busbar of minimum 25 mm x 6 mm size shall be provided for the entire length of panel.
- As per the rating of the main busbars the size of earthing busbar shall be decided.
- The framework of the LT panel shall be connected to this earth busbar. Provisions shall be made for connection from earth busbar to the main earthing bar coming from the earth pit on both sides of the LT panel.
- The earth continuity conductor of each incoming and outgoing feeder shall be connected to this earth bar.
- The armour shall be properly connected with earthing clamp and the clamp shall be ultimately bounded with the earth bar.

Power connections

- The installation work shall cover assembly of panels lining up, grouting the units etc.
- In the case of multi panels switch boards after connecting up the bus bar all joint shall be insulated with HV insulation tape or with approved insulation compound.
- A common earth bar shall be run preferably at the back of the switch board connecting all the sections for connecting the earth system.
- All protection, indications & metering connections and wirings shall be completed.
- Where trip supply battery is installed the unit shall be commissioned, completing initial charging of the batteries.
- All relay instruments and meters shall be mounted and connected with appropriate wiring.

2.6.2.9. Testing and commissioning

- Operation checks and lubrication of all moving parts.
- Interlock function checks.

- Continuity checks of wiring, fuses etc. as required.
- Insulation tests.
- Trip test and protection gear tests.
- The complete panel shall be tested with 5000 V megger for insulation between poles and poles to earth. Insulation test of secondary of CTs and VT to earth shall be conducted using 500 V megger.
- Any other tests as may be required by the Licensee / Inspector shall be conducted.
- Where specified, the entire switch board shall withstand high voltage test after installation.



Fig 2.44 panel

2.6.3. Substation

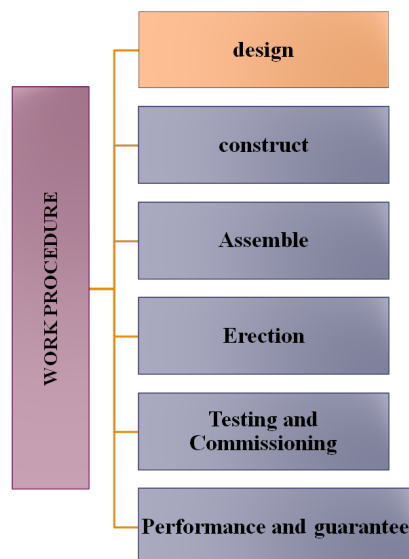


Fig 2.45 scm of substation

2.6.3.1. Design

- A sub-station installation is a combination of a number of major equipments like Transformers, High Voltage Panel, Medium Voltage (MV) Panels, Inter-connecting Cables, Bus Ducts, Protection and Metering etc. individually engineered in each case depending upon the requirements, size and capacity of sub-station and in coordination with the licensee of the area concerned.

ITEMS OF WORK

A sub-station installation work shall generally comprise of supply, installation, testing and commissioning of the following:

- (a) High Voltage Panels.
- (b) Step down Transformers, complete with associated auxiliaries as specified.
- (c) High voltage cable for inter-connection between the H.V. panel and transformers including terminations.
- (d) M.V. Panel(s).
- (e) L.T. cable, for upto 400 KVA Transformers and Bus trunking for higher than 400 KVA transformers, inter-connection between transformer's M.V. terminals and the M.V. Panel as specified.
- (f) Power factor improvement capacitors/ Power Conditioner Savers.
- (g) Earthing system.
- (h) Safety Equipments.
- (i) Emergency M.V. Panel if required.
- (j) Miscellaneous items.

2.6.3.2. Construction and assemble

- Construction of sub-station building.
- The contractor should select such equipment for installation as can be properly installed in the spaces shown in specification drawings.
- Cable trench, entry pipe for cable, manholes for drawing of cables, manhole covers etc. as per requirements.
- Construction of necessary soak pits, drainage arrangement for soak pit etc., if required. Provision of storage space at site during the contract period free of cost.

- All minor building works, such as equipments foundation if required cutting and making good holes, grouting of channels belts as required. Cutting and making good damages etc.
- Provision of supports / clamps for equipments, cables etc. wherever required.
- Small wiring, inter-connection etc. inclusive of all materials and accessories, necessary to comply with the regulations as well as proper and trouble free operation of the equipment.
- Closing of the cable entry points in sub-station against seepage of water, rodents etc.
- Tools and tackles required for handling and installation. Necessary testing equipments for commissioning.
- Watch and Ward of materials and/or installation and equipments till their handing over to the department

Other Requirements

- The substation should preferably be located in a separate utility building and may be adjacent to the generator room, if any. Location of substation in the basement should be avoided, as far as possible.
- In case there is only one basement in a building, the substation /switch room shall not be provided in the basement. Also the floor level of the substation shall not be the lowest point of the basement.
- Oil-filled installation- Substations with oil-filled equipment require great consideration for the fire detection, protection and suppression.
- Substations with oil-filled equipment/apparatus (Transformers and high voltage panels) shall either be located in open or in a utility building. They shall not be located in any floor other than the ground floor or the first basement of a utility building. They shall have direct access from outside the building for operation and maintenance of the equipment.
- Dry-type Installation: In case electric substation has to be located within the main multi-storeyed building itself for unavoidable reasons, it shall be a dry type installation with very little combustible material. Such substation shall be located on the ground floor or on first basement and shall have direct access from the outside of the building for operation and maintenance of the equipment.
- In case of two transformers (dry type or transformers with oil quantity less than 2000 litres) located next to each other without intermittent wall, the distance between the two shall be minimum 1500 mm for 11 kV, minimum 2000 mm for 22 kV and minimum 2500 mm for 33 kV. Beyond 33 kV, two transformers shall be separated by a baffle wall 4 h fire rating.

- Each substation should have provision of addition for at least one transformer and extension of LT Panel to take care of future growth of load.

2.6.3.3. Erection

Location and Other Requirements

- Availability of power lines nearby may be kept in view while deciding the location of the substation.
- The substation should preferably be located in a separate utility building and may be adjacent to the generator room, if any. Location of substation in the basement should be avoided, as far as possible.
- In case there is only one basement in a building, the substation/switchroom shall not be provided in the basement. Also, the floor level of the substation shall not be lowest point of the basement.
- Ideal location for an electrical substation for a group of buildings will be at the electrical load centre. Generally the load centre will be somewhere between the geometrical centre and the air conditioning plant room

Openings

- All door openings from substation, electrical rooms, etc, should open outwards. Vertical shutters may also be acceptable provided they are combined with a single leaf door opening outwards for exit in case of emergency.
- For large substation room/electrical room having multiple equipment, two or more doors shall be provided which shall be remotely located from each other
- No service or ventilation shaft shall open into the substation or switch room unless specific to substation
- All the rooms shall be provided with partitions up to the ceiling and shall have proper ventilation. Special care should be taken to dissipate transformer heat and where necessary fresh air louvers at lower level and exhaust fans at higher level shall be provided at suitable locations.

Height

- The minimum height of substation room/HV switch room/MV switch room shall be arrived at considering 1 200 mm clearance requirement from top of the equipment to the below of the soffit of the beam .
- In case cable entry/exit is from above the equipment height of substation room/HV switch room/MV switch room shall also take into account requirement of space for turning radius of cable above the equipment height.

Coordinate according to water :- (strom water , plumbing water tank , flood)

- In order to prevent storm water entering the transformer and switch rooms through the soak- pits, the floor level of the substation/ switchroom shall be at least 300 mm above the highest flood water level that may be anticipated in the locality. Also, facility shall be provided for automatic removal of water.
- Substation shall not be located immediately above or below plumbing water tanks or sewage treatment plant (STP) water tanks at the same location
- In places where flooding can occur and water level may go above 1 000 mm, the base substation may be located on one level above the ground level of a utility building. In such cases, one feeder should feed ground level and levels below with automatic tripping of the feeder to avoid electrocution in case of live electricity coming in contact with water.
- In case of cable trench in substation/HV switch room/MV switch room, the same shall be adequately drained to ensure no water is stagnated at any time with live cables.

Substation Safety

- Enclose any part of the substation which is open to the air, with a fence (earthed efficiently at both ends) or wall not less than 1 800 mm (preferably not less than 2 400 mm) in height to prevent, so far as is reasonably practicable, danger of electric shock or unauthorized access
- sufficient safety signs of such size and placed in such positions as are necessary to give due warning of such danger as is reasonably foreseeable in the circumstances;
- Take all reasonable precautions to minimize the risk of fire associated with the equipment; and
- Ensure that, in addition to provisions mentioned in, name and emergency telephone number of the authorized personnel shall also be displayed at the substation and instructions covering schematic diagram; requirements of switchgear interlocking

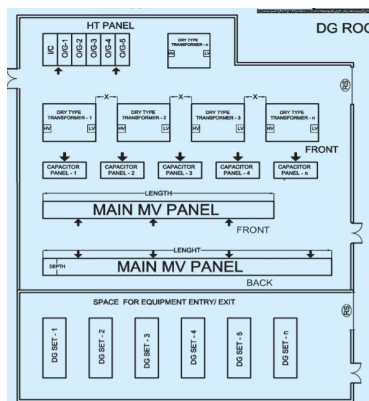


Fig 2.46 substation

Care of buildings

- Care shall be taken, while handling/ installing the equipment to avoid damage to the building.
- On completion of the installation, the contractor shall arrange to repair all damages to the building caused during plant installation so as to bring to the original condition.
- It shall also arrange to remove all unwanted waste materials from substation room and other areas

Painting and protection

- All damages to painting during transport and installation shall be set right to the satisfaction of the department before handing over.
- All structural frame work for support of various items of equipment shall be given the final coat of paint of approved shade at site after erection is complete.
- Additional protection measures against corrosion shall be provided when installed in special environment.

2.6.3.4. Inspection and testing

- When the installation is complete, the contractor shall arrange for inspection and testing of the installation.
- Test results obtained shall be recorded. The installation shall not be accepted until it complies with the requirement of these Specifications.
- The Sub Station installation shall be got inspected by the contractor from local licensee and/or CEA and their clearance taken before energizing the Sub Station.

Guarantee

- The contractor shall guarantee the entire sub-station installation as per specifications. All equipments shall be guaranteed for one year from the date of acceptance against unsatisfactory performance or break down due to defective design, manufacture and installation.
- The installation shall be covered by the conditions that whole installation or any part there of found defective within one year from the date of taking over shall be replaced or repaired by the contractor free of charge as decided by the department. The warranty shall cover the following:-
- Quality, strength and performance of materials used.
- Safe mechanical and electrical stress on all parts under all specified conditions of operation.

- Satisfactory operation during the maintenance period.

2.6.4. Transformer

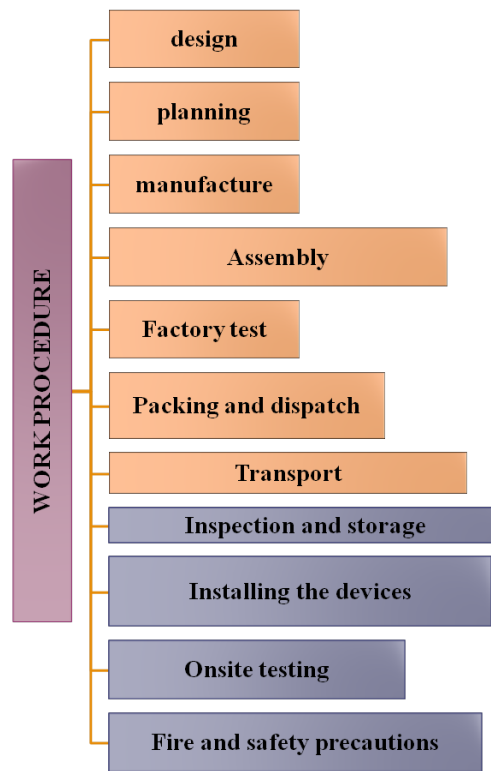


Fig 2.47 scm of transformer

2.6.4.1. Design and planning

- Transformers may be used only in sub-stations located in separate single or two storied service buildings outside the main building structure and there shall at least be 6 meter clear distance between the adjoining buildings and sub-station such that fire tender is able to pass between the two structures
- Transformers installed inside buildings, where the oil capacity exceeds 2 000 litres of oil, shall be provided with oil soak pits.
- Oil soak pits may also be made of rcc tanks.
- For indoor transformers, oil soak pits shall be provided either under the transformer or outside the transformer room.
- If two or more transformers are installed side by side, they shall be separated by fire-separation walls. Fire separation walls are deemed to be adequate from fire-safety point of view, even if oil capacity of individual transformers do not exceed 2 000

litres, and total capacity of all transformers installed side by side exceeds 2 000 litres.

- The capacity of the oil soak pit shall be such that to soak the entire oil content of the transformer, it is intended for individual soak pits for each transformer with capacity as above or a common soak pit to contain the entire oil content of the biggest of the transformers shall be adequate.
- Soak pits shall be designed in such a way to provide for safe draining of liquids to soak pits.

2.6.4.2. Assembly

- The transformer shall be complete with the following fittings: -
- Oil conservator with oil level indicator, minimum level marking and drain plug for all transformers of capacity 50 KVA and above.
- Off circuit type tap changer with position indicator and locking arrangement for all transformers.
- Thermometer pocket with plug for all transformers of capacity 100 KVA and above.
- 100 mm dial type /stem type thermometer with metal guard Dial type thermometer may have max. temperature indicator and resetting device for all transformers of capacity 250 KVA and above.
- Lifting lugs for all transformers.
- Bi-directional /Unidirectional Rollers to be specified.
- Rating diagram and terminal marking plate for all transformers.
- Explosion vent for all transformers of capacity 400 KVA and above.
- Additional Neutral separately brought out on a bushing for earthing for all transformers.
- Earth terminals (2 Nos.) for body earthing for all transformers.
- Valves for filtration, drainage and filling etc. with necessary plugs for all transformers.
- Radiator assembly for all transformers.
- Silica gel breather for all transformers.
- Air release plug for all transformers.

- First filling of oil to IS 335:1993 including make-up fill during installation for all transformers.
- Facility to connect up Buchholtz relay for all transformers of capacity 800 KVA and above.
- Inspection covers on tank cover for access to terminal connections for all transformers.
- Bushing terminations or cable box terminations as specified.
- Necessary hardware, clamps, lugs etc. for termination on HV/MV etc. for all transformers.

2.6.4.3. Manufacture

Explosion Vent

- Explosion vent or pressure relief device shall be provided of sufficient size for rapid release of any pressure that may be generated within the tank and which might result in damage to the equipment.
- Means shall be provided to prevent the ingress of moisture and of such a design to prevent gas accumulation.

Rating and diagram plates

- The following plates shall be fixed to Transformer in a visible position.
- A rating plate of weather proof material bearing the data specified in the appropriate clauses of IS 2026:1977.
- A diagram plate showing the internal connection and also the voltage vector relationship of the several windings in accordance with IS 2026:1977 and a plan view of the transformer giving the correct physical relationship of the terminals.

Joints and Gaskets

- All gaskets used for making oil tight joints shall be of proven material such as granulated cork bonded with synthetic rubber gaskets or synthetic rubber or such other good material.

Gas and oil actuated (buchholtz) relays

- Buchholtz Relay shall be provided for transformers of capacity 800 KVA and above.

- The design of the relay mounting arrangements, the associated pipe work shall be such that mal-operation of the relays shall not take place under normal service.
- The pipe work shall be so arranged that all gas arising from the transformer shall pass through the gas and oil-actuated relay.
- The oil circuit through the relay shall not form a delivery path in parallel with any circulating oil pipe, nor shall it be tied into or connected through the pressure relief vent.
- Sharp bends in the pipe work shall be avoided.
- All wiring connections, terminal boards, fuses and links etc. connected with gas actuated relays shall be suitable for tropical atmosphere.
- Any wiring liable to be in contact with oil shall have oil resistant insulation and the bared ends of stranded wire shall be sealed together to prevent seepage of oil entering connection boxes used for cables or wiring.

2.6.4.4. Factory tests

- In addition to the prescribed routine tests, temperature rise test shall be invariably done on one transformer of each design.
- A copy of the impulse test certificate done on the same type/ design of the transformer shall be furnished in accordance with IS for purpose of record.
- If no impulse test was done in an earlier unit of the same design and capacity, one transformer will be subjected to impulse test in consultation with the Inspector at the firm's cost.
- Copies of the certificates for pressure test, test for bushings, and type test for short circuit shall be supplied to the Department.

2.6.4.5. Packing and dispatch

- Transformers after processing and testing are despatched from the factory either:
 - a) dried and completely filled with oil, ready for service;
 - b) with oil covering core and coil, balance space filled with dry air or inert gas; or
 - c) completely filled with dry air or inert gas at a small positive pressure.

- All external fittings such as bushings, conservator, Buchholtz relay, de-hydrating breather, explosion vent, radiators, rollers, etc, which are liable to damage in transit shall be removed and packed separately.
- All fragile parts such as temperature indicators, oil level gauges, bushings, etc, shall be carefully packed to avoid breakage in transit.

2.6.4.6. Transportation

- Multi-axle tractor driven low-platform trailers are used for road transport.
- The tractors are to have adequate hauling capacity and the trailers loading capacity.
- Width of the road - normally not less than 5 M.



Fig 2.48 transportation

2.6.4.7. Inspection

- Transformers are liable to get damaged during transit and therefore it is recommended that immediately on arrival, the transformer should be unpacked and examined for any sign of damage in transit, particular attention being paid to the following:
 - a) Tank sides or cooling tubes dented,
 - b) Protruding fittings damaged,
 - c) Oil sight-glass broken,
 - d) Bushings cracked or broken,

- e) Bolts lose due to vibration in transit,
- f) Oil leakage (if filled with oil) particularly along the welds or reduction in the pressure of the gas (if gas filled); and
- g) Damage to auxiliaries.
- h) oil samples from the top of the conservator and the bottom of the transformer should be drawn and tested for presence of moisture and also for dielectric strength. If both the samples are free from moisture and the windings indicate satisfactory insulation resistance

2.6.4.8. Storage

- Transformers received at site and not expected to be installed immediately are likely to absorb moisture.
- Indoor type transformers should be stored under cover and the transformer should preferably be filled with oil to reduce the extent of possible condensation of moisture, and the breathing pipe should be plugged.
- Transformers which are required to be kept in storage for long periods should preferably be drained of oil and the tanks should be filled with dry nitrogen under slight pressure.
- However, if it is necessary to store them outdoors, these should be covered to prevent moisture and foreign material entering into the tank.

2.6.4.9. On site testing

- The following tests are to be particularly done before cable jointing or connecting up the bus bar trunking:
- Insulation test between HV to earth and HV to MV with 5000 volts Megger.
- Di-electric strength Test on oil.
- Buchholtz relay operation by simulation test when fitted.
- Tripping tests
- Calibrate earthing resistance
- See that neutral earthing switches are closed before making alive
- load test

- Check alarm circuit , fans and pumps

2.6.4.10. Installation and commissioning

- Necessary support channels shall be grouted in the flooring.
- The transformer shall be moved to its location and shall be correctly positioned. Transformer wheels shall be either locked or provided with wheel stoppers.
- All parts of the transformers which are supplied loose, such as conservator, radiator banks, Buchholtz relay, dial thermometer, bushing etc. shall be fitted on the transformer.
- Transformer oil supplied in drums shall be topped up into the transformer after duly testing/filtering upto the correct level required.
- Wiring of devices such as Buchholtz relay, dial thermometer etc. shall be carried out as per drawings,
- Earthing of neutral and body of the transformer shall be done
- Drying out of transformer winding will be necessary when the di-electric strength of the oil is lower than the minimum value as per IS10028 or the transformer has not been energized within 6 months of leaving the works or where the radiator assembly is done at site.
- The transformer shall be dried out by one of the methods specified in IS 10028. Drying out with centrifugal or vacuum type filters will, however, be preferred.
- The contractor shall carry out the process of drying without interruption and shall maintain a log sheet indicating time, oil temperature and insulation resistance.
- After complete drying out of the transformer, oil sample shall be collected by the contractor and shall be tested for di-electric strength as specified in IS 335:1993 with approved test kit.
- All devices such as dial type thermometers, Buchholtz relays and main alarm and trip contacts shall be checked for satisfactory operation.

Indoor

- The most important thing to be ensured with transformer installed indoors is proper ventilation, that is, free movement of air round all the four sides.

- The level of the transformer base should be higher than the highest flood and storm water level of that area.
- The transformers should be kept well away from the wall. The minimum recommended spacing between the walls of the transformer periphery from the point of proper ventilation
- The site should be so chosen that it is not normally damp because besides corroding the tank body and tubes, the dampness may find its way to the bushings and may cause them to flash over.
- There shall be no chance of water dripping either on the transformer or anywhere in the transformer room itself.
- Chemical fumes, particularly acid fumes, should not be allowed in the transformer room as they corrode the tank and also cause the oil to deteriorate.
- For indoor installations the air inlets and outlets shall be of adequate sizes and so placed as to ensure proper air circulation for the efficient cooling of the transformers. The inlets should preferably be as near the floor as possible and the outlets as high as the building allows to enable the heated air to escape readily and be replaced by cool air.
- Minimum clearance between the highest point of the conservator tank to the ceiling of the transformer room should be sufficient to remove the mounting on the transformer like the conservator. However, this clearance should not be less than 0.5 m.

Foundation

- Since the transformers operate without moving parts, generally a simple foundation is satisfactory provided it is firm, horizontal and dry. The transformer should not rock or bed down unevenly so as to tilt, as this may strain the connections. The base should be horizontal to keep the oil level correct.
- For outdoor installations, a level concrete plinth above the maximum flood or storm water level of the site, of correct size to accommodate the transformer in such a way so that no person may step on the plinth, with, if necessary, bearing plates of sufficient size and strength, should be provided for transformers.

Cabling

- Cable trenches inside sub-stations and switch stations containing cables shall be filled with sand, pebbles or similar non-inflammable materials, or completely covered with non-inflammable slabs.
- In many installations it may be advisable, for reasons of ease of maintenance to locate equipment centrally with cable galleries serving the purpose of cable trenches.
- Where a number of cable trays or racks are used, the spacing between them should be 150 mm or more, depending on the cable sizes.
- The trays may be made from suitable materials such as galvanized iron or aluminium sheets, or expanded metal.
- The cables should not be exposed to heat from other equipment.
- The cable trenches should be suitably sloped and arrangements should be made for draining them or preventing them from getting filled with water.

Precaution for fire

- Remote indication of undue rise of the temperature inside the transformer room
- Remote disconnection of the supply, and Fixed automatic fire-fighting equipment shall, Such equipment should be supplemented by suitable portable extinguishers.
- A number of these should be kept adjacent to but not inside the area of risk, so that access to them is not impeded when a fire has already started.
- For large outdoor sub-stations, protection may also be provided by the installation of a sprinkler system, activated by fire-detecting units.

Safety Precautions

- The transformer should be so installed that there is no risk of anyone receiving an electric shock.
- Although, with all metal parts of the metal tank bonded together and properly earthed, the tank may be considered quite safe,
- yet consideration should be given to the arrangement of the connections.

2.6.5. Bus bar

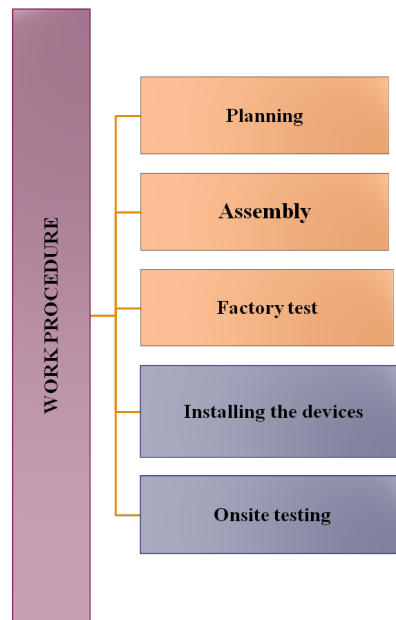


Fig 2.49 scm of bus bar

2.6.5.1. Planning

- it is important that busbar routes are carefully planned, taking into consideration how the system will accommodate other elements within the facility such as ceilings, walls, doors, and other key infrastructure. The following key planning considerations can help to improve busbar route efficiency.

Such as

- Early Specification
- Planning accuracy
- Conductor choice
- System flexibility
- Access

2.6.5.2. Assemble

Expansion joint

- Expansion joint made of aluminium/copper .strips shall be provided wherever necessary, to take care of expansion and contraction of the bus bars

- Under normal operating conditions.
- This shall be invariably provided whenever the length of the rising mains exceeds 15 m.

Enclosure

- Sheet steel of min 2mm thickness shall be used for fabricating the enclosure

Current density

- Bus bars shall be of sufficient cross-section so that a current density of 130A/sq.cm (800A/sq.inch) is not exceeded at nominal current rating for aluminium bus bars, and 160A/sq.cm (1000A/sq.inch) for copper bus bars.

Insulation

- Each bus bar shall be suitably insulated with PVC sleeves/tapes.
- The insulation of the rising mains shall be-capable of withstanding the voltage of 660V of A.C.

Bus bar supports

- Bus bar support insulators shall be class F insulators made of non-hygroscopic, non-combustible, track resistant and high strength FRP/SMC/DMC material, and shall be of suitable size and spacing to withstand the dynamic stresses due to short circuit currents.
- The spacing between two insulators should not exceed 250 mm.
- The supporting structure for the bus duct shall be strong enough to cater for the various static and dynamic loadings, such as weight of the bus duct, short circuit forces, wind load, seismic forces

Ventilation

- The bus ducts shall be normally natural cooled. Forced cooling may be considered beyond 10 000 amperes ratings.

2.6.5.3. Assembly

Bus bar Clearances

- The minimum clearance to be maintained for enclosed indoor air insulated bus bars for medium voltage applications shall be as follows:

- Between Phase to earth – 26mm min clearances
- Phase to phase - 32mm min clearances
- Bus bar joints shall be thoroughly cleaned and a suitable oxidizing grease shall be applied before making the joint
- High-tensile bolts, plain and spring washers shall be provided to ensure good contact at a joints
- The overlap of the bus bars at the joints shall be not less than the area of the cross section of BusBar

Marking

Each bus-bar or bus duct shall be provided with a name plate or plates carrying the following data, marked in a durable manner and located in a place such that it is visible and legible when the bus-bar is installed :

- a) Manufacturer's name or trade-mark;
- b) Type designation or serial number;
- c) Rated voltage;
- d) Rated frequency;
- e) Rated current;
- f) Rated short time current;
- g) Number of phases; and Country of origin.

2.6.5.4. Factory tests

Type Tests - The following shall constitute type tests :

- a) Impulse voltage test
- b) Temperature-rise test
- c) Short time current test and
- d) Power frequency voltage with stand
- e) Routine Test
- f) Power frequency voltage withstand test

2.6.5.5. Storage

- Store bus duct at site continuously in warm dry locations.
- Bus bars or bus duct will be rejected if they have been roughly handled, or marked at joints or connection points, or plating is damaged in any way.
- Do not install bus duct until that portion of the building is enclosed and dry.

2.6.5.6. Installation

- Each section of the enclosure shall be suspended from the ceiling slab with suitable MS suspenders and support angles/channels. The runs shall be neat and the route shall be as directed by the Engineer-in-Charge .
- The bus trunking shall be supported such that its weight does not come on the terminations.
- Danger notice board shall be provided on the bus trunking enclosure at suitable intervals in every room through which it passes
- The earthing strips shall be properly terminated to the earth bars at both ends.

2.6.5.7. Site test

The following site tests shall be carried out after installation of bus-bar at site :

- a) Power frequency voltage withstand test
- b) Insulation resistance test for enclosure circuit

2.6.5.8. Construction

- The encloser shall be bolted type, box type, welded type or any other type as per the manufacturer's standard practice; and shall be made out from sheet steel of minimum 2mm thickness.
- The front cover only shall be detachable.
- The section of the bus duct shall be rectangular.
- The enclosure shall be sturdy so as to withstand the internal and external forces resulting from the various operating conditions.
- The bus trunking enclosure shall be fabricated in convenient sections for easy transportation and installation.

- The sections shall be connected to form horizontal and vertical runs as required at site. The enclosure shall be provided with flanged ends with drilling arrangements suit the flanges at the switchgear and transformer terminals. AU flanges shall be provided with gaskets, nuts, bolts, washers etc.
- The entire bus trunking enclosure shall be designed for dust and vermin proof construction. The enclosure for outdoor installation shall be additionally in weatherproof construction.
- The enclosure shall have a degree of protection not less than IP 42 for indoor application, and IP 54 for outdoor application.
- Bus trunking, if required to be installed outdoors, shall be provided with a metallic-protecting & canopy of adequate size above the bus trunking, fabricated as part of the enclosure.
- Neoprene gaskets shall be provided to satisfy the operating conditions imposed by temperature, weather etc. and durability.
- Two numbers of Copper earth strips of appropriate size shall be provided along side the bus trunking enclosure and shall be bolted with each section of the bus trunking.

2.7. BEST PRACTICE TO CONTROL TIME AND COST OVERRUN IN SCM AND TQM

2.7.1. Database systems

- commonly used by owners, track status of engineered equipment and major critical materials items.
- The requisitions and purchases can be tracked and sorted according to data file parameters among other capabilities
- **Comprehensive, integrated systems**
- commonly used by contractors, track status of bulk materials as well as engineered equipment.
- The requisitions and purchases can be tracked and sorted according to data file parameters.
- These systems are capable of interacting with the contractor's estimating, scheduling and accounting systems. Other capabilities include: can interact with CAD drawings, computer takeoff assistance, analysis of vendor quotations, generation of purchase orders, trial allocation, generation of inventory reports among other capabilities

2.7.2. QMS Materials Management System was developed by QA Software.

- The purpose of QMS in regard to materials management include: management of changes to the bill of materials, automatic generation of inquiries and purchase orders for materials, management of the impact of a changing bill of materials on material orders, management of expediting of materials, control of material deliveries, management of material shortages both on fabrication and construction, control of material issues and movements, inventory/stock control management, management of material traceability, progress monitoring.
- The program offers a variety of modules to keep track of changes to the bill of materials, summarize bill of materials in minutes, with automatic documentation generation for both bid packages and/or purchase orders, keep a complete history of all changes to purchase orders, recording the receipt of materials simple with typing only of the quantities received, analyze what can be fabricated or installed, automatic generation of issue slips/dockets and/or movement dockets to save time and improves accuracy. At all times the exact quantities of material at any location is known.

2.7.3. Bar code

- Bar code applications in construction are mostly intended to provide accuracy in data collection, to improve productivity and to save time in the data collection process.
- Typically, bar codes are used for materials and inventory management.
- The scope of bar codes extends beyond materials management.
- Bar codes provide the advantage of relatively error free data collection, which improves productivity and avoid errors.
- Some construction firms that use bar codes claim that it saves time, money and labor while improving the accuracy of inventory.

The major applications of bar code

Field material control

- This technology can be used to control receiving, inspection, storage and issue of consumables, parts, equipment, and all the items that could be controlled with bar codes.
- A report can be kept when materials are taken from the storage. These materials can be scanned and the report of issuance of materials can be completed.

Warehouse maintenance and control

- When materials are received and stored, the assigned location can be entered into the computer system by scanning the bar code of the particular material.
- Bar codes allow performing inventory by scanning the bar codes of the materials.
- As the project progresses and materials are used, a better overall picture of available materials is accessible for forecasting and scheduling purposes.

Inventory control applications and tool and consumable material issue

- Although some time might be spent entering bar code data into the computer system, it might eliminate misuse of consumables. The inventory can be kept up to date as the materials and resources are consumed.

Purchasing and accounting

- Forms used for purchasing or other functions related to cost control can be printed with bar codes.
- Shipping forms from vendors can include bar codes to facilitate the receiving process.

2.7.4. RIFD

- Many researchers have used RFID in previous studies to apply them to construction.
- RFID systems could be used in the same way in which bar codes are used. However, the cost is a major factor.
- There are other applications in which RFID systems work better than bar code systems.
- RFID had been used for material tracking and material receipt in the construction industry.
- RFID allow tracking materials as the move in the jobsite since direct contact is not required for data collection. This can avoid theft and lost since managers can notice when materials are not where they are supposed to be.
- Materials Receipt
- Materials can be easily verified as they arrive to the site. The type of materials received can be known easily and verify if the right quantities were received.

2.7.5. **JIT**

- Just-in-time, or JIT, is an inventory management method in which goods are received from suppliers only as they are needed. The main objective of this method is to reduce inventory holding costs and increase inventory turnover.

Importance of just-in-time

- Just in time requires carefully planning the entire supply chain and usage of superior software in order to carry out the entire process till delivery, which increases efficiency and eliminates the scope for error as each process is monitored.
- Reduces inventory waste
- Decreases warehouse holding cost
- Gives the manufacturer more control

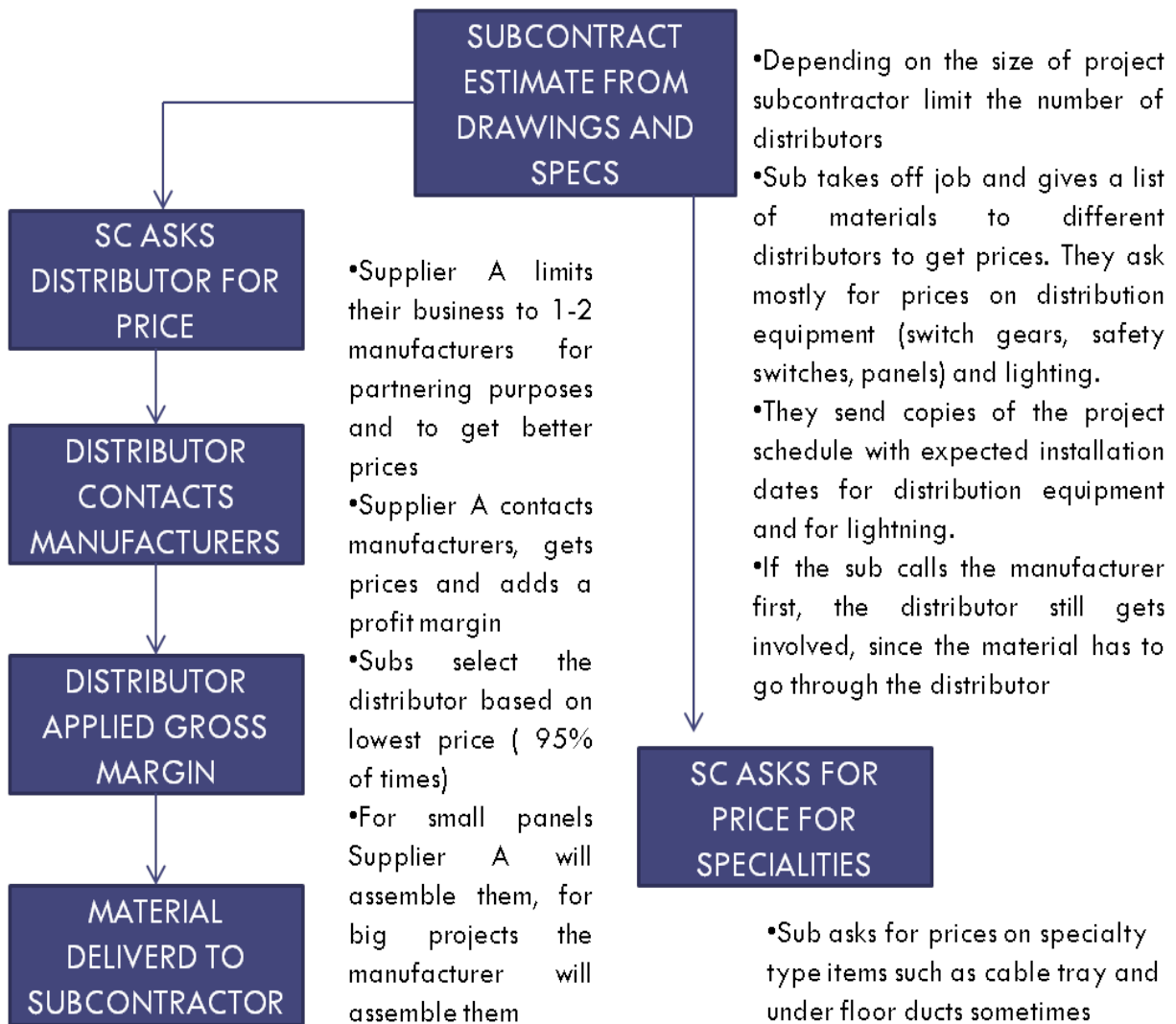
CHAPTER 3 LIVE CASE STUDY

3.1 EXPERT SURVEY



Fig 3.1 samples taken

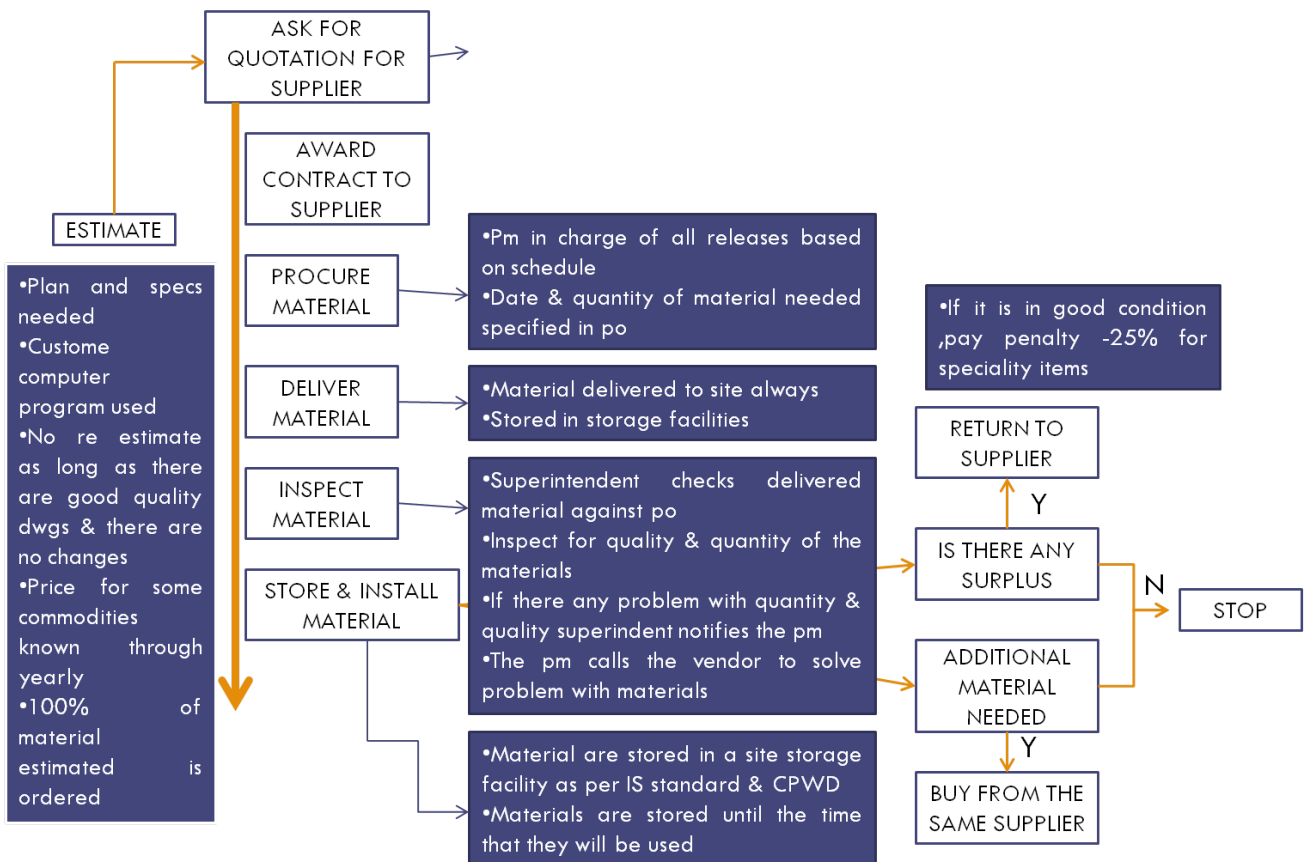
3.1.1. supplier 1



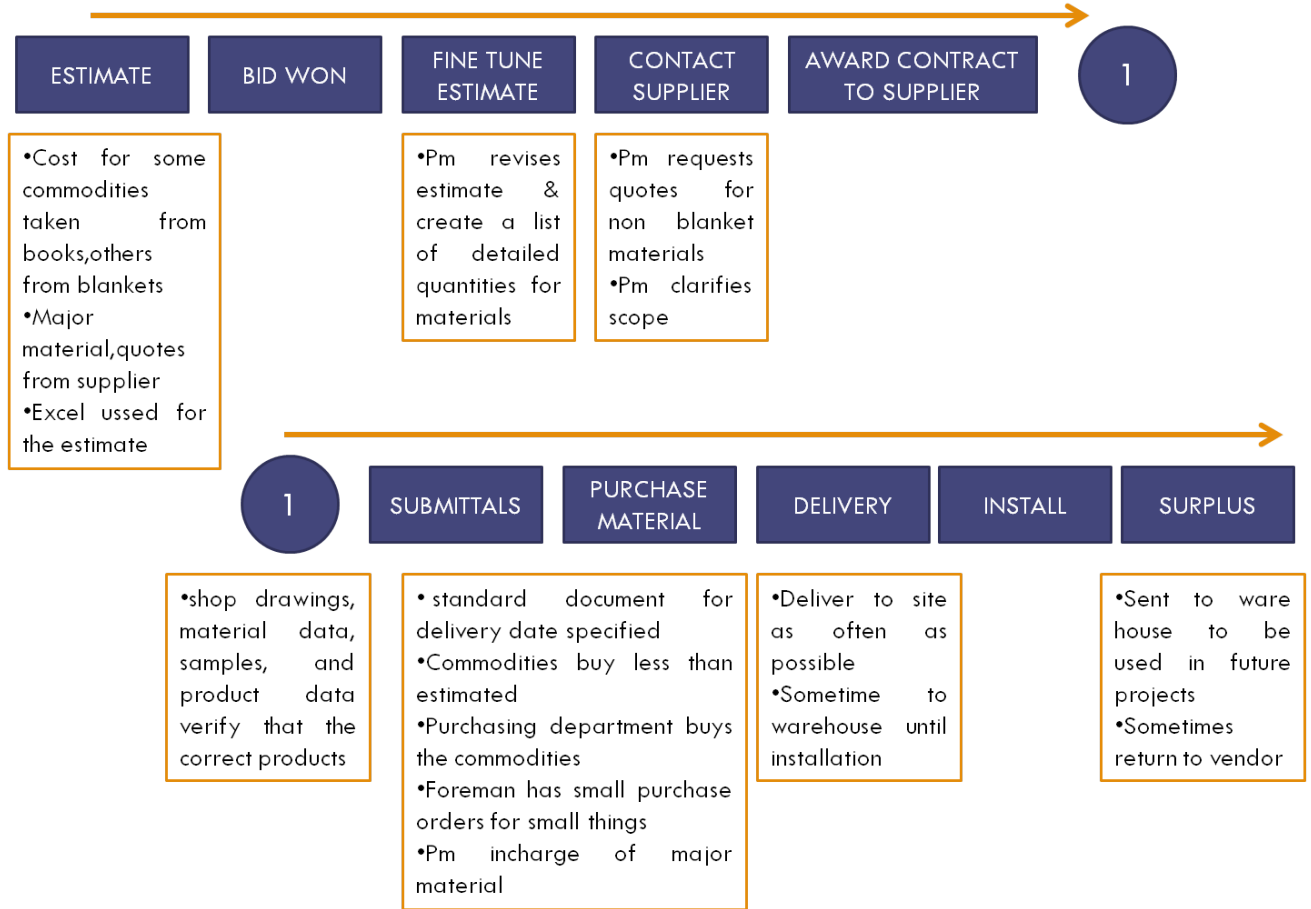
3.1.2. supplier 2



3.1.3. contractor 1



3.1.4. contractor 2



3.2 LIVE CASESTUDY

3.2.1. JIPMER karaikal campus

- The second campus of JIPMER AT KARAIKAL was started after a notification from the Ministry of Health and Family Welfare, New Delhi to establish an off-site campus of JIPMER at Karaikal.
- 38 acres of land at Kamaraj Salai for the Residential Campus
- 3 star rating by GRIHA
- 10 floors – under construction
- Using mivan technology
- Constructed by – CUBE (center for urbanization , building and environment) IIT madras



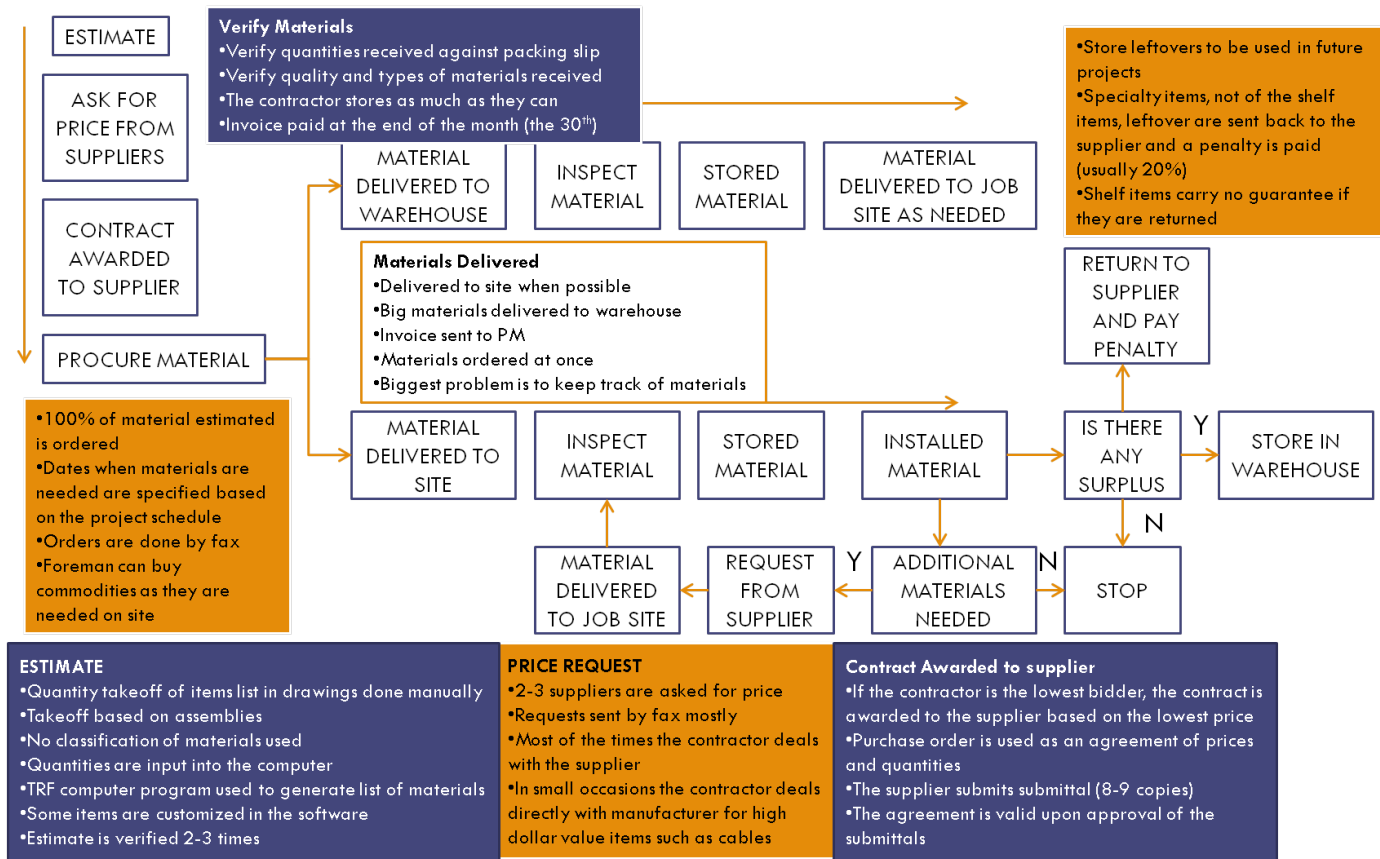
Fig 3.2 JIPMER campus

Scope of main electrical contractor

The Electrical contractor's scope covers the following.

1. Submission of application to state electricity board / distribution companies for getting load sanction, necessary follow-ups, releasing the sanction and successful commissioning.
2. Preparation of entire building drawing including equipment details, submission to CEIG, getting approval for installation.
3. Arranging inspection, getting safety certificates and energise the installation.
4. Supply, Installation, Testing and Commissioning of Transformers
5. Supply, Installation, Testing and Commissioning of RMG & HT VCB Panels
6. Supply, Installation, Testing and Commissioning of DG Sets
7. Supply, installation, Testing and Commissioning of Light fittings.
8. Supply, installation, Testing and Commissioning of required UPS, Inverters etc
9. Provision of Power outlets, provision for laying Data cabling.
10. Supply, Installation, Testing and Commissioning of LT cables, Cable trays & earthing etc
11. Supply , Installation Testing and Commissioning of MPCC & sub panels, DB's. etc
12. Necessary earthing arrangements
13. Supply, Installation of Lightning Protection system

SCM flow – project manager



Checklist

Table 3.1 checklist for cable laying and installation of db

S/N	CHECK LIST FOR CABLES LAYING	S/N	CHECK LIST FOR INSTALLATION OF DISTRIBUTION BOX
1	Technical Data Sheet / GTP made available at site.	1	Are the working drawings/ shop drawings and DB schedules approved and available at site?
2	Approval of cable, size / make and availability at site.	2	Approval of materials and availability at site.
3	Availability of tools required for joining / fixing lugs at site.	3	Cleanness of DB found ok?
4	Is the trench excavation, sleeves or ducts, sand bed as per the approved documents / technical specification?	4	Are the number of MCB's & RCD's fixed as per approval drawings?
5	Has earth continuity been checked, cable dressing been done, cable testing been carried out, cable end termination been conducted testing & final check been done?	5	Are the wires identified with necessary ferrules?
6	Protection provided as per specs.	6	Check for the tightness of terminals been done.
7	Review report for the Earthing connection & Earth continuity of cable tray from the testing documents.	7	Check Level, location, plumpness and projection etc.
8	Check IR value of cable drum before cutting the cable for laying.	8	Designation of the DB, drawing pasted and name plate of the DB's ok?
9	Segregation of the cables like HT, LT and Control Cables and support of the cables is ok?	9	Has concreting and cleaning around D/B been done.
10	After cable laying before charging cables IR value measured and recorded in the commissioning report.	10	DB dressing as per approved checklist?
11	Identification labels approved and fixed.	11	Receiving end, the cable /wires mention in the DB is found ok?
12	Check Bending radius of the cables as per the standards followed.	12	Testing and commissioning report as per approved format made available?
13	Check Voltage and current rating of the cables.		
14	Check Cables laid in the cable trays are neatly dressed and if any jumping to be cross proper manner.		
15	Check ELV cables / HT cables and LT cables should not mix at any points, same should be laid in the separate segregated cable trays in the tier arrangement form.		

Table 3.2 checklist for installation of ht panel board

S/N	CHECK LIST FOR INSTALLATION OF HT PANEL BOARD		
1	Approval of shop drawing with feeder details and availability at site?	16	Incoming and outgoing cables entry marked with the required arrow marks with the directions in the cable alley feeders.
2	Is the HT panel as per approved material/make/type?	17	Each feeder mention with the cable's sizes and number of the cables runs is mentioned.
3	Approval of manufacturer drawings and received panel as per the approved drawings with over all dimensions is same?	18	Incoming cables mention with received end feeder details with locations of the panel.
4	Is the installation done as per approved location/layout drawing?	19	Check for the Current and Voltage rating.
5	Factory testing carried out and test certificate made available?	20	Check for proper Lifting Tools and Tackles.
6	Are front/rear/side accesses /Clearances OK as per the CEIG norms?	21	Designation of each feeder, spare feeders available or not.
7	Cable entry requirements satisfied top or bottom or side entry?	22	Check for the Shrouding and Check Painting shade as per the approved color?
8	Is cable termination access OK?	23	Check for any Physical Damages occurred during transit or during erection, like front door operative kit or handle etc.
9	Is the panel enclosed properly?	24	Check for Bus bar material and dimensions as per the approved drawings.
10	Indication lamps /Meters /Relay Protection measures functioning are as per approval and any damages found.	25	Type of the breaker is it VCB /ISOLATOR/GIS/SF6 as per approved drawings.
11	Testing and commissioning report as per approved format made available.	26	Power pack self-type or external type with control voltage as per the approved drawings available?
12	Panels board name plate details marked, Caution Plates danger boards signs availability.	27	Check Control voltage from battery charger with voltage and backup as per the approved drawings or technical specification?
13	Earthing flats connected to the main /grid earthing.	28	Check Control cable entry point from side or bottom or top as per the approved drawings
14	Panels are grouted with bolt or welded with the base plate.	29	Trolley for the breaker draw out type is made available at site.
15	Panel base channel available.	30	Check spare breaker available as per the technical specification.
		31	Operating height of the panel is as per the CEIG norms.
		32	Functional test to carried out for the relay protection in the field record to be reviewed.

Table 3.3 checklist for earthing and electrical conduit and modular box

S/N	CHECK LIST FOR EARTHING	S/N	CHECKLIST FOR ELECTRICAL CONDUIT AND MODULAR BOX
1	Approval of shop drawings and availability at site.	1	Check for the detailed approved drawing Good for Construction available at site.
2	Approval of material and availability at site.	2	Check for Size of conduits are on par with approved drawing.
3	Check for all joints (nuts, bolt & welding joints) been carried out.	3	Check for Level and location of conduits.
4	Check for all electrical equipment for earthing connection been carried out.	4	Check for Blocking of ends of the conduits.
5	Check for all mechanical equipment for earthing connection been carried out.	5	Check All Conduiting are done as per Colour Coding for Power, Fire Fighting and UPS Supply and Data/Voice line.
6	Check for water line earthing been done.	6	Check for All Drop point tightness is to be ensured with reinforcement Bar
7	Mixing of Copper or GI earth used together whether bimetallic strip is used or copper flat end coated with lead in the bolting area.	7	Check for all conduit tightness of pipe with reinforcement bar
8	Location, type & size of earth pit.	8	Check for all conduit end points are taped properly
9	Earth cable laying and terminations.	9	Check for modular boxes & junction boxes are fixed at the location on par with approved Construction Drawing.
10	Check for water supply pipes earthing.	10	Check for Reinforcement Detail Around Modular Box/ fixity of Modular Box.
11	Testing as per approved format made available.	11	Check for hot water pipe/cold water pipe embedment inside the concrete wall/slab
12	Earth pit value is recorded in the commissioning report.	12	Check for cut outs of waste water line/Sewer line sleeves in concrete slab/wall.
		13	Check for concrete grooves for fixing the water line pipe in kitchen.
		14	Check for concrete grooves for fixing the hot/cold water line pipe in bathrooms.
		15	Check for switch boxes inside the apartment are fixed at approved height from FFL.
		16	Check for AC adopter box are provided as the construction drawing and fixed at approved height from FFL.
		17	Check for AC conduit duct pipe cut outs/pipe sleeves/openings are provided as per Drawing.
		18	Check for junction box provision in all the rooms are located and placed as per drawing.
		19	Check for fan box hooks and all light points are provided as per the construction drawing.

3.2.2. R&D building

- Client - KONE ELVATORS
- Contractor – ocean life space pvt . Ltd
- Consultant – CRN
- Location - sripermbatur
- Research and development block
- It's a lift testing building
- 16 floors
- Built up area - 1,00,000 sqft
- Site extent – 25 acres
- Typology – industrial building
- It consist of 2 area
 1. Tower area
 2. Non tower area
- Tower area consist of shear wall using mivan technology
- Non tower area is a office space it was constructed by conventional method
- Substation is located common for all the blocks



Fig 3.3 R&D building

Schedule

KONE _ Phase 2 _ Proposed Testing Tower Constrction	561.06 days	Fri 22-11-19	Fri 21-05-21
Pre - Construction Phase	42.06 days	Fri 22-11-19	Thu 02-01-20
Sub Strcuture	133 days	Thu 02-01-20	Mon 11-05-20
Shell & Core	338 days	Sun 19-04-20	Sun 14-03-21

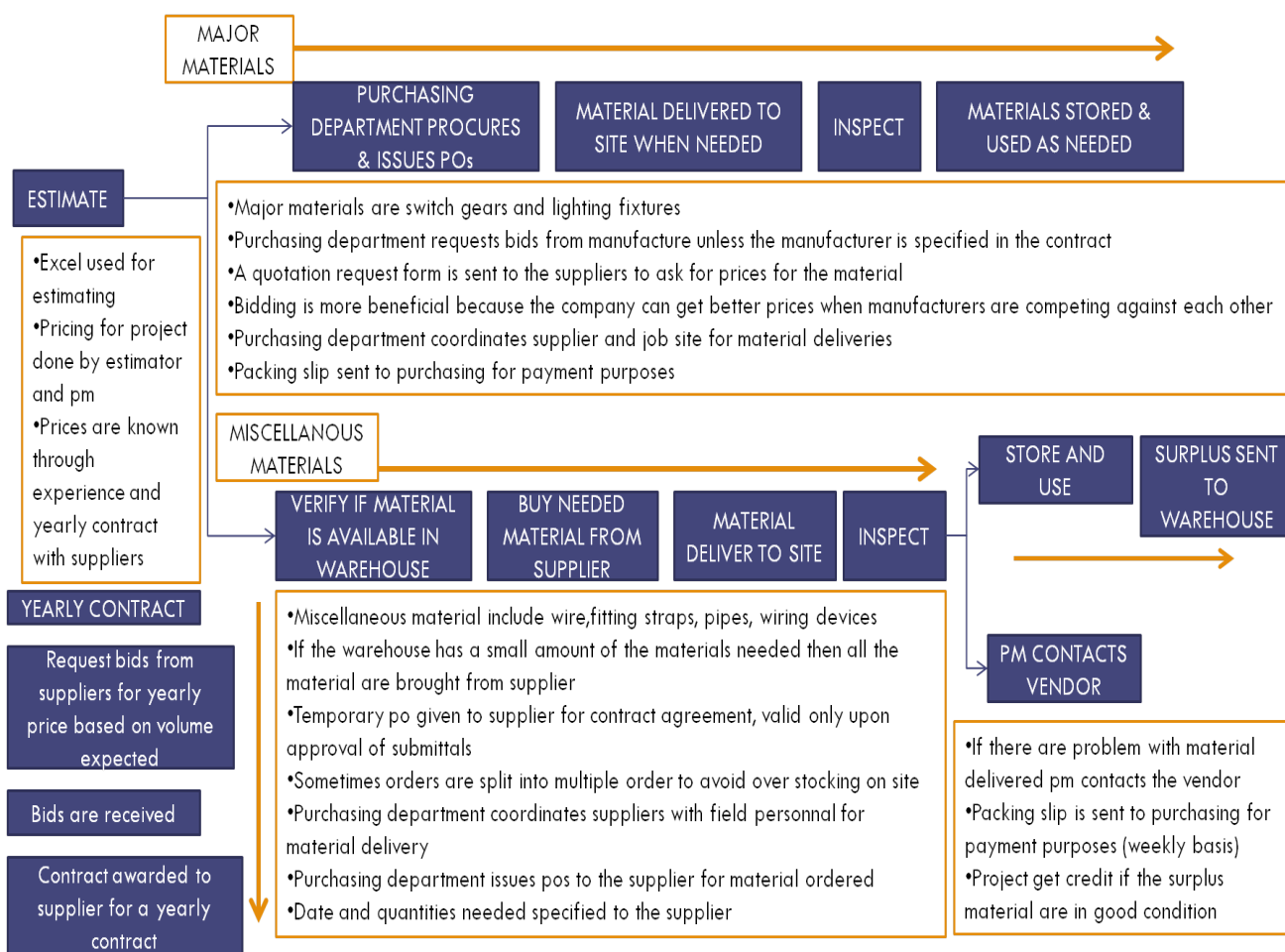
MEP	454.06 days	Sat 15-02-20	Fri 30-04-21	
Submission of Shop drawings	30 days	Sat 15-02-20	Sun 15-03-20	3FS+85 days
Approval of Shop drawings	30 days	Tue 25-02-20	Tue 24-03-20	480SS+10 days
Ordering of Long Lead items	30 days	Sun 01-03-20	Sun 29-03-20	481SS+5 days
MEP - Low side (BASEMENT TO 19 FLOORS)	274 days	Sun 31-05-20	Mon 22-02-21	
Basement Floor	20 days	Sun 31-05-20	Fri 19-06-20	
Conduiting, cable tray & raceway installation - All MEP services	10 days	Sun 31-05-20	Tue 09-06-20	300SS+20 days
Wiring - All MEP services	10 days	Fri 05-06-20	Sun 14-06-20	485SS+5 days
MEP - High side	184 days	Mon 02-11-20	Fri 30-04-21	
Site Clearance	1 day	Sat 26-12-20	Sun 27-12-20	289FS+10 days
Distribution Boards Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
Machinery Panel Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
Power Panel Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
Lighting Panel Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
Lift panel (Low rise & High rise) Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
HVAC Panel Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
Fire Panel Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
UPS Panel Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
Emergency Lighting Panel Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
Lightning Protection System Installation	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
Cable termination	80 days	Mon 18-01-21	Sun 04-04-21	739FS+20 days
Electrical Testing & Commissioning	10 days	Sun 04-04-21	Wed 14-04-21	750

Table 3.4 schedule

Table 3.5 customer satisfactory measure

S.NO	Service Attribute and Department	5	4	3	2	1	Remarks
E.	Electrical Design Department:						
1	Level of accuracy of BOQ/ Specifications and Estimates matching customer's requirements.						
2	Quality of Design Deliverables						
3	Completion of the individual activities and progress of the project and adherence to agreed timely schedule.						

SCM flow – contractor



Checklist

Table 3.6 checklist for ht panel and db

HT PANEL

INWARD

Type of HT Panel as per Approval
Make / Model / Capacity of HT Panel as per Design / Approval
All Components of HT Panel are Delivered as described in BOQ / Approved Technical Submittal
Check whether the HT Panel confirms to Manufacturer's Drgs
Examine any damage or displacement of parts, loose or broken connections, dirt or foreign material and moisture during shipment
Check whether the HT Panel matches to the casted foundation and provisions.
Check whether the Body & Neutral Earthing as per CEIG / CEA / NEC / IS 3043 standards / recommendations
Test / Warranty Certificates Attached
Any deviations, revisions or changes to be recorded for As Built

INSTALLATION

Is level and Finish of HT Panel Foundation as per the specification
Ensure all Safety Standards / codes during installation
Check the Orientation, mounting & supports as per design & drawing
Check whether Power Cabling works done properly
Check whether Control Cabling works done properly
Proper cable termination with gland earthing is done as per specification
Check cable sizes, numbers & terminations conform with design & drawing
Check the door to ensure that it can be opened and closed smoothly
Check that all bolts and nuts are securely bolted
Check that the earthing links are correctly connected to the panel earthing bars and the latter to substation earth at one point
Check the neutral and body earthing done and size of earth strips
Check the Cable routing are laid as per approved shop drgs
Check the HT Panel clearance are provided as per approved shop drgs / local electrical authority regulations
Is there any physical damages during Installation
All external and inter-panel control wirings should be checked for correct termination and continuity.
Ensure HT Breakers and Potentional Transformers are properly inserted.
Ensure Rubber Chromets, Rain shield cover and sealant are properly done.

DISTRIBUTION BOARD

INWARD

Type of Distribution Boards as per Approval
Make / Model / Capacity of Distribution Boards as per Design / Approval
All Components of Distribution Boards are delivered as described in BOQ / Approved Technical Submittal
Examine any damage or displacement of parts, loose or broken connections, dirt or foreign material and moisture during shipment
Check the Body & Neutral earth links are fixed properly
Test / Warranty Certificates Attached
Any deviations, revisions or changes to be recorded for As Built

INSTALLATION

Is surface and levels of DB mounting places are properly finished
Check the locations, mounting & supports as per design & drawing
Check the neutral and body earth link are properly fixed.
Check adequate phase link cables are provided & fixed properly
Check knock out provisions are provided for incoming/outgoings
Check cable sizes, numbers & terminations confirm with design & drawing
Check the door to ensure that it can be opened and closed smoothly
Check that all bolts and nuts are securely bolted
Is there any physical damages during Installation
Check DB and Circuit identifications done
Body earthing and gland earthings are done

Table 3.7 checklist for earthing

EARTHING

INWARD

Type of Earthing Material as per Approval
Make / Model / Capacity of Earthing Materials as per Design / Approval
All Materials are delivered as described in BOQ / Approved Technical Submittal
Examine any damage or displacement of parts, loose or broken connections, dirt or foreign material and moisture during shipment
Test / Warranty Certificates Attached
Any deviations, revisions or changes to be recorded for As Built

INSTALLATION

Check the earthing installations is carried out as per the drawings
Ensure the depth of the earth pit is as per approved BOQ/Drawings
Check all joints are properly connected
Check the earth plate/Electrode/Rod/pipe as per the approved drawings
Check the earth pits are done as per approved layout
Check earth pits identifications are done as per layout.
Check cable sizes, numbers & terminations conform with design & drawing
Check that all bolts and nuts are securely bolted
Is there any physical damages during Installation

Specification

Main power control center an panel boards

- Supply transporting and unloading of cubicle type floor mounting switch board fabricated as per specification and drwgs

Incoming

- 630a mccb 50ka with connected accessories – 1 no as incomer

Instrumental compartment

- Digital type multi function meter , indication lamp with mpcb , on and off trip indicating lamp
- Out going
- 400 A mccb 35kA – 3 nos
- 200 A mccb 35kA – 1 nos
- 125 A mccb 35kA – 4 nos
- 100 A mccb 35kA – 2 nos
- aluminium bus bar providing kwh meter on/off/trip indication lamp in all outgoing feeders
- Aluminium bus bar for cable termination door interlock
- 630 amps neutral bus bar – all neutral bus bar shall have half the capacity of phase bus bar

Distribution boards

- PDB – 8 WAY , 12 WAY
- Supply ,fixing , testing and commissioning of the double door type
- Tinned copper bus bar, interconnections , eart bus , neutral bus .
- Board shall be powder coated type fixed with concealed system in wall/ fixed in column
- Works include civil work – foundation , chipping and rough plastering etc..,

Wiring and connected accessories

- Minor civil work , necessary supports are required
- Wiring to the light point /6A plug point using 3c of 1.5 sqmm multi strand pvc insulated copper conductor in suitable size ms pipe in open system in above false ceiling and concealed system in below false ceiling

Direct db control

- Circuit main using 3c of 1.5 sqmm multi strand pvc insulated copper conductor in suitable size ms pipe in open system in above false ceiling and concealed system in below false ceiling with all accessories like bends, elbows, junction boxes , clamps, gi flexible hose

Switch boxes

- Ms conduit , pvc conduit were used
- Supply and laying of pvc insulated copper conductor in existing floor trunking
- Aluminium channel raceway including stiffener at required intervals in recessed system in floor including cutting chippling , plastering in the floor / wall to make good finish

Cables and termination

- Supply and laying of xlpe/pvc insulated outer sheathed
- Copper /aluminium armored and unarmoured conductor cable partly laid in existing cable tray and in wall / column with supporting clamps at every 1m interval
- Cable tags to be provided at every 50 m interval
- Gland earthing plate prefabricated as per gland size

Earthing

- Minor civil works and necessary supports required
- Supply and installation of earth pipe electrode as per is 3043
- 3000mm long with 100mm dia
- Watering funnel should be detachable type connection with main pipe
- The chamber will be of brick wall chamber with cement mortar and paint on all sides inner and outer

- Plate cover with hinge and stainless steel bolts nuts
- The cover should be painted at site with black and green color
- The earth pit shall be bore earthing / compressed air breaking and weather coated paints inside and outside with name plate in polycarbonate
- Excavation of hard rock and back filling with alternate layer of salt , charcoal, clay/red sand , ramming and compacting the soil etc as required full depth



Fig 3.4 panel boards , bus ducts

3.2.3. HCL Madurai

- Location: ELCOT (The Electronics Corporation of Tamil Nadu Limited) MADURAI, TN
- Total site area: 6.75 ACRES
- Total built up area: 6,00,000 SQFT (approx.)/ 55,750 SQM approx.
- Total nos. Of seats: 4,865 SEATS (11.5 sqm/ person)
- No. Of towers: 3
- No. Of floors: B+G+4 FLOORS (TOWER 2 & 3), G+2 (TOWER 1)
- FSI: 1.43
- Ground coverage : 39 %
- Construction start date: MARCH, 2016
- Phase 1 (tower 1) completion: september, 2016
- Phase 2 (tower 2 & 3) completeion: july, 2018
- Major clients: merk, deutsche bank, johnson & johnson, baxter etc

Consultants

- Architect/ structural/ mep : c r narayana rao architects & engineers pvt ltd
- Project coordinators: cbr
- Landscape consultant: dhruva landscape architects

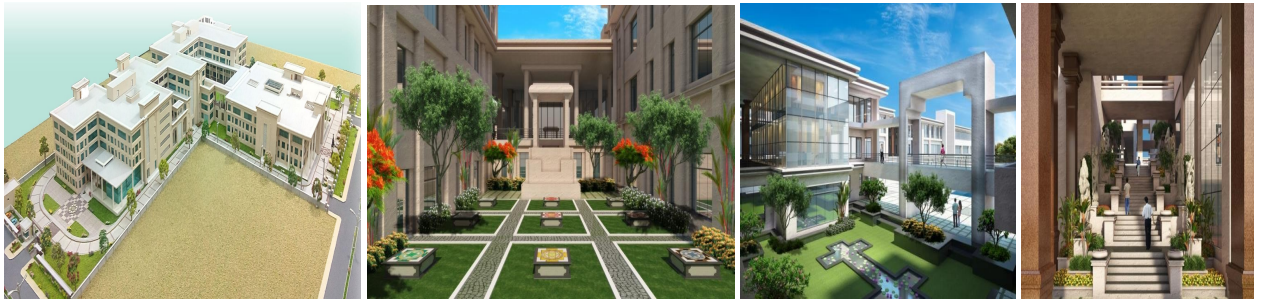
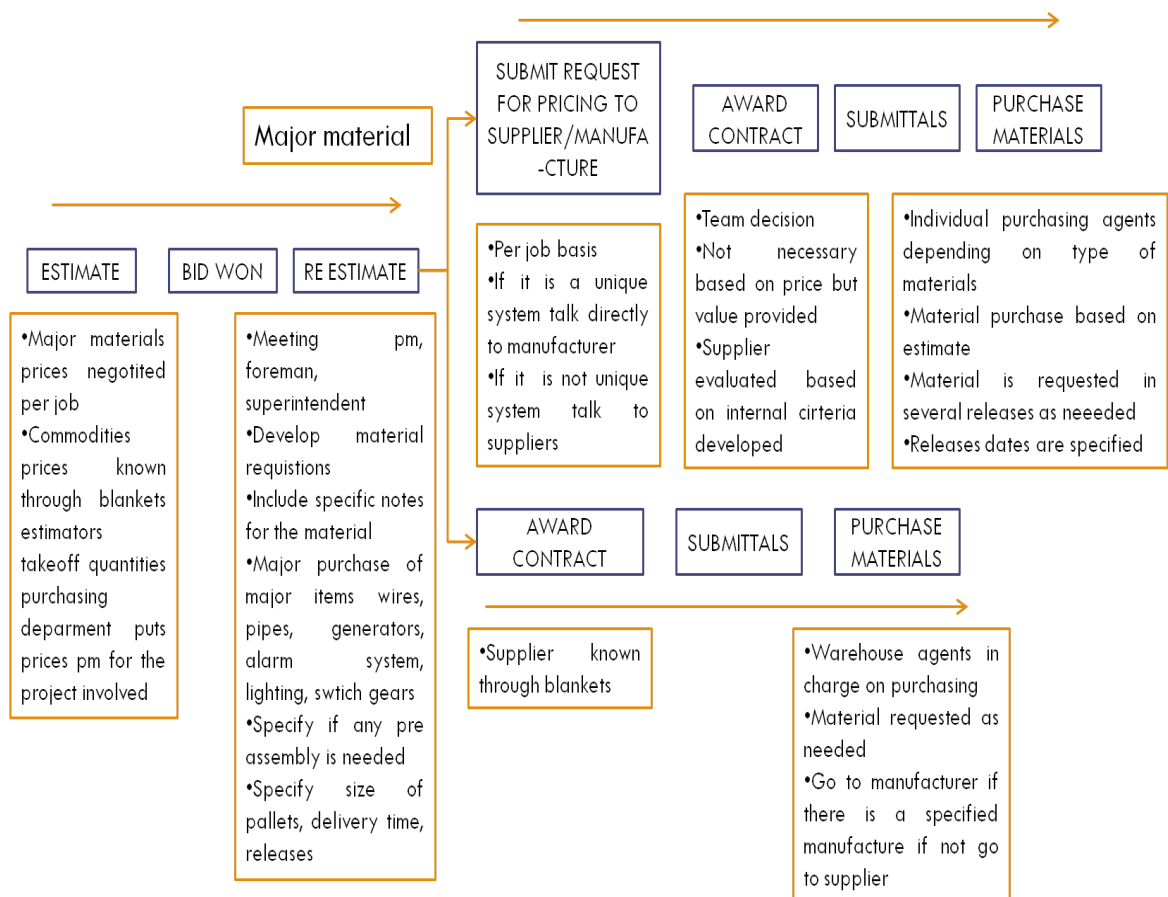


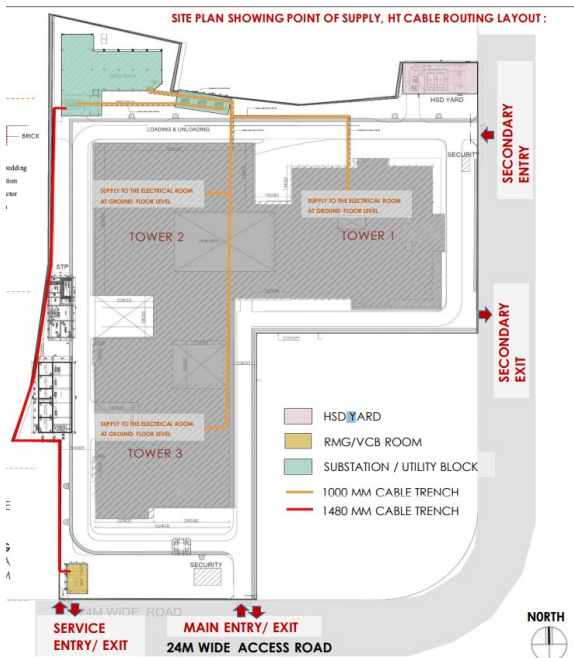
Fig 3.5 HCL Madurai

SCM flow – project manager



Site plan and list of makes

Table 3.8 list of makes

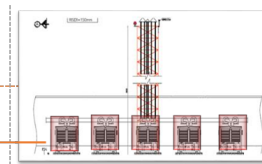
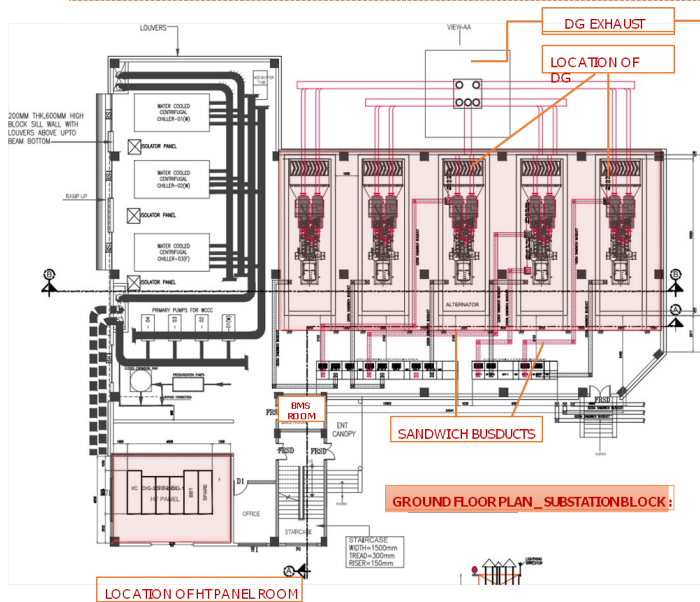


S.NO:	DESCRIPTION	MAKE/MODEL
1	Pumps & pump control	GRUNDFOS
2	All kind of distribution boards	LEGRAND
3	BMS related equipment	SIEMENS
4	Diesel generator	CATERPILLAR
5	CCTV camera's	BOSCH
6	VCB	SIEMENS
7	Outdoor industrial plug (3 phase)	SCAME
8	All the panels	POWER CONTROL EQUIPMENTS
9	Switches in the panel	SCHNEIDER
10	Column guard	MASE PRODUCT

Fig 3.6 site plan

ELECTRICAL SUPPLY :

PLANS SUBSTATION BLOCK :

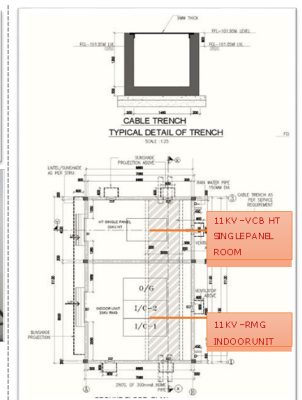


DG EXHAUST:

DG (DIESEL GENERATOR):



- CATERPILLAR SILENT DG SET HAVE BEEN INSTALLED EACH OF CAPACITY 1500 KVA, 1500 RPM WITH 0.8 POWER FACTOR, AMF WITH AUTO LOAD SHARING & AUTO SYNCHRONIZATION PANEL
- SUPPLY TO DG FROM DIESEL TANK [1000 LTS - 2 NOS TANK]



RMG AND HT VCB ROOM:

FLOORING:
BASIC CEMENT FLOORING HAS BEEN DONE INSIDE THE VCB & RMG ROOM

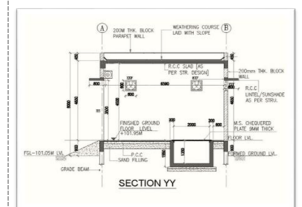


Fig 3.7 electrical supply

Table 3.9 site and NBC

DESCRIPTION	AS PER SITE	AS PER NBC
SUBSTATION LOCATION	GROUND FLOOR	SATISFIED
SUBSTATION DOOR/SHUTTER	VERTICAL SHUTTERS COMBINED WITH A SINGLE LEAF DOOR OPENING OUTWARDS FOR EXIT	SATISFIED
TRANSFORMER LOCATION(OIL TYPE)	- LOCATED 6 METRES AWAY FROM THE BUILDING - PLACED EXTERNALLY NEXT TO SUBSTATION BLOCK	SATISFIED
FENCE FOR TRANSFORMER AND BASE OF TRANSFORMER	- FENCING HAS BEEN DONE AT 1.8 METRE HEIGHT - TRANSFORMER PLACED ABOVE THE PLINTH	SATISFIED
SWITCH ROOM / MV SWITCHROOM	SWITCH ROOM / MV SWITCH WITH 1200 MM CLEARANCE REQUIREMENT FROM TOP OF THE EQUIPMENT TO THE BELOW OF THE SOFFIT OF THE BEAM	SATISFIED
UNDERGROUND CABLES	HT CABLE ARE LAID WITH SAND CUSHIONING AND SAND COVER AND ABOVE THAT BRICK PAVERS ARE LAID	SATISFIED
HV ISOLATOR	HV PANEL AND TRANSFORMER ARE LOCATED AT A DIFFERENT LEVELS	IN CASE OF HV PANEL AND TRANSFORMERS LOCATED AT DIFFERENT FLOORS OR AT A DISTANCE MORE THAN 20 M, HV ISOLATOR SHALL BE PROVIDED AT TRANSFORMER

Table 3.10 earthing in substation

SUBSTATION BLOCK	DESCRIPTION	BODY EARTHING PITS (NOS)	NEUTRAL EARTHIN G PITS (NOS)	DEDICATED EARTHING PITS (NOS)	CABLES/FLAT (TYPE)
	RMG	2	-	-	CU FLAT
	VCB PANEL	2	-	-	CU FLAT
	TRANSFORMER (3 NOS)	6	6	-	CU FLAT
	PANELS AND CHILLER UNITS	9	-	-	CU FLAT
	DG – 3 NOS	6	-	-	CU FLAT
	11KV HT PANEL	2	-	-	CU FLAT
	20KVA UPS		2	-	16 SQ.MM XLPE INS. CU. ARM CABLE
	TOTAL	27	8	-	

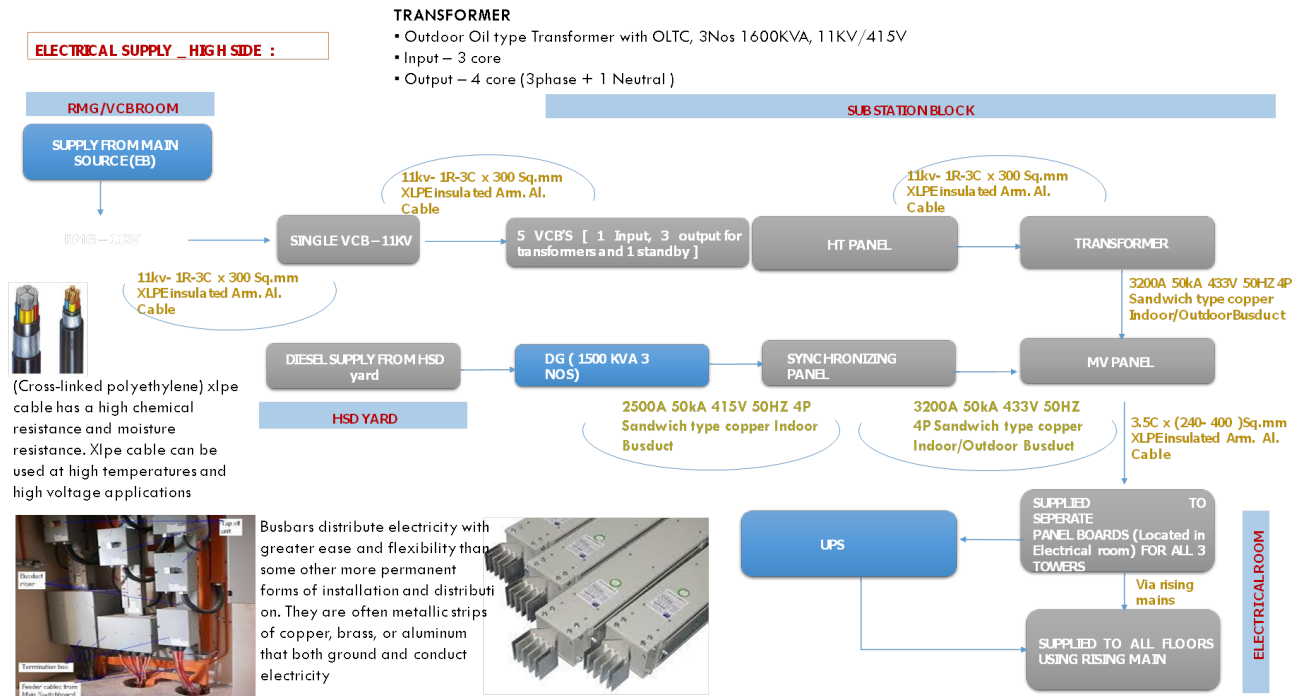


Fig 3.8 high side

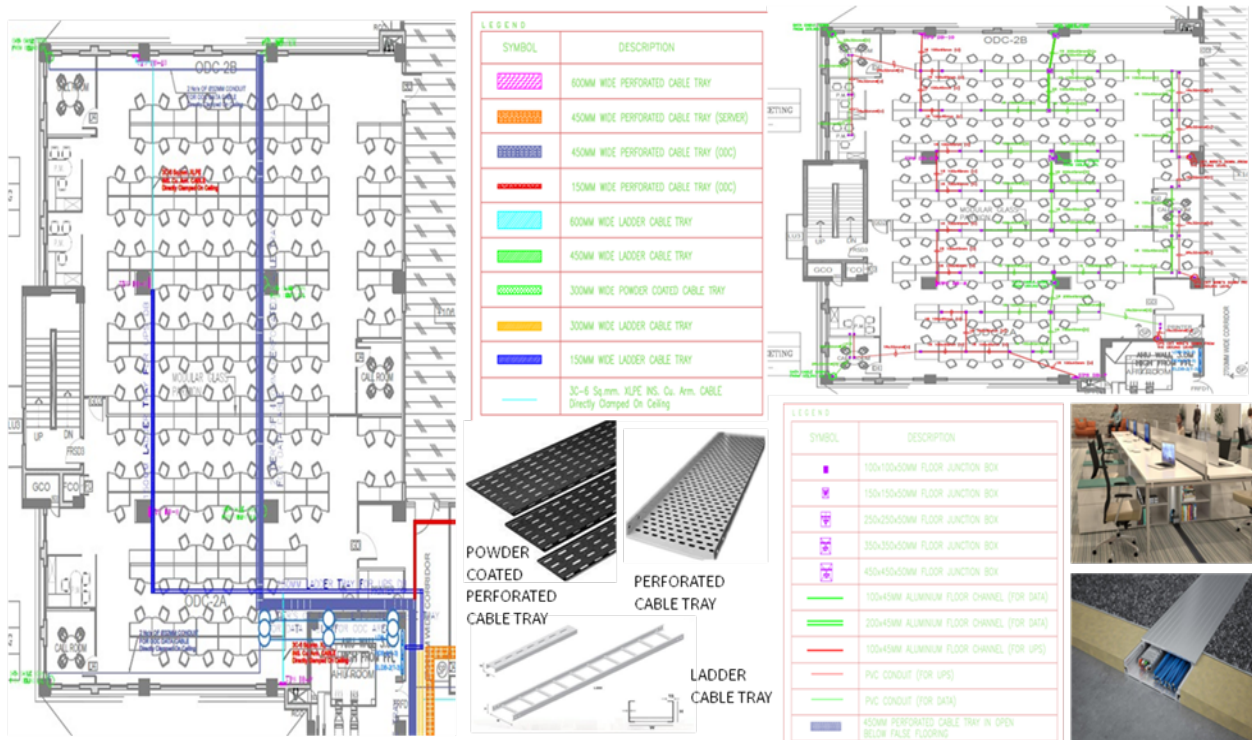


Fig 3.9 cable tray planning

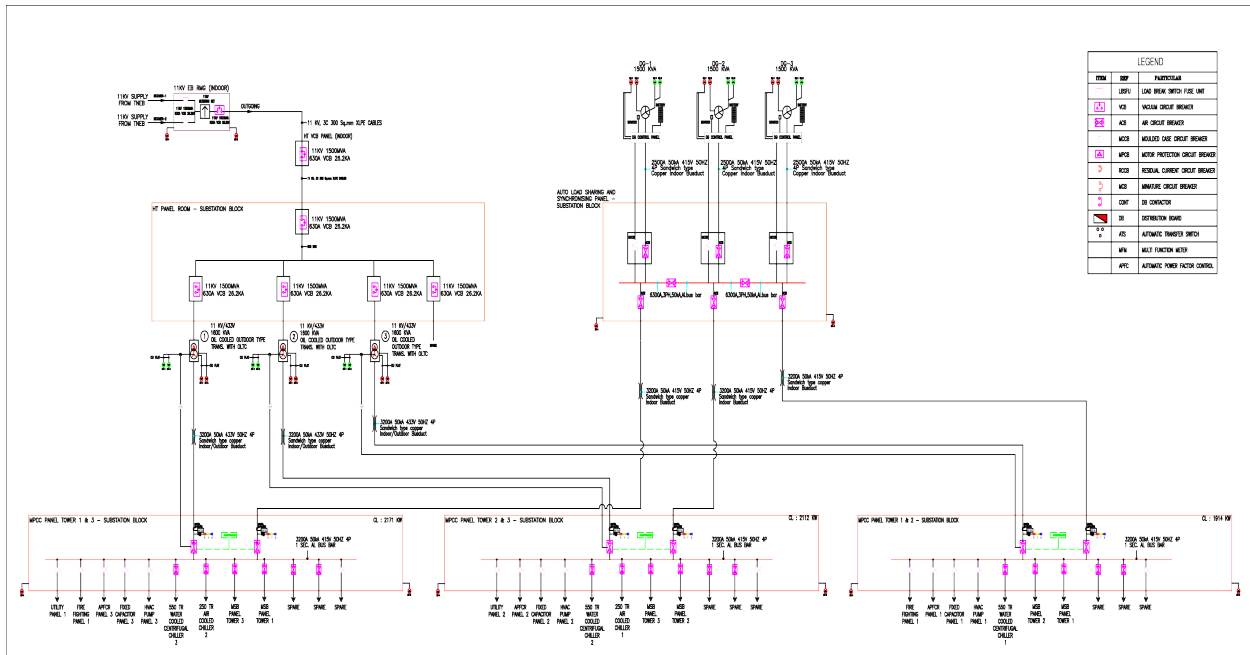


Fig 3.10 single line drawing for high side

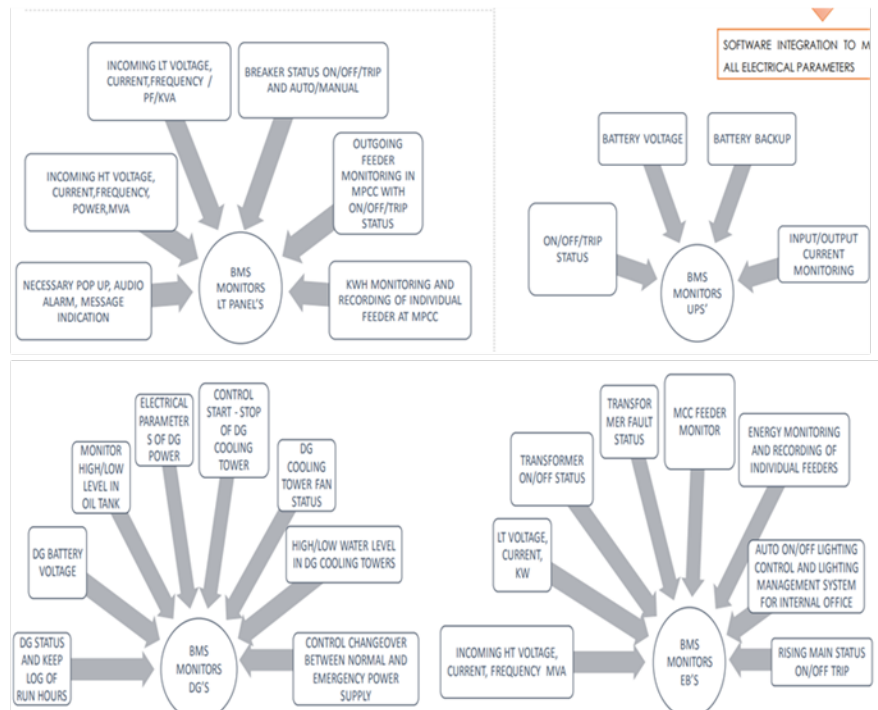
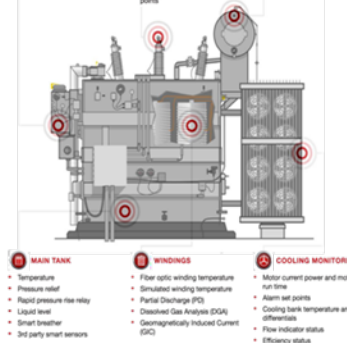
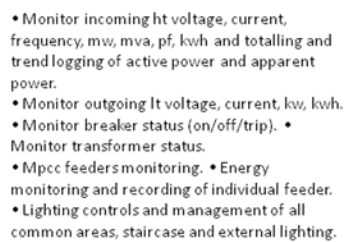


Fig 3.11 electrical IBMS

3.3 QUESTIONNAIRE SURVEY

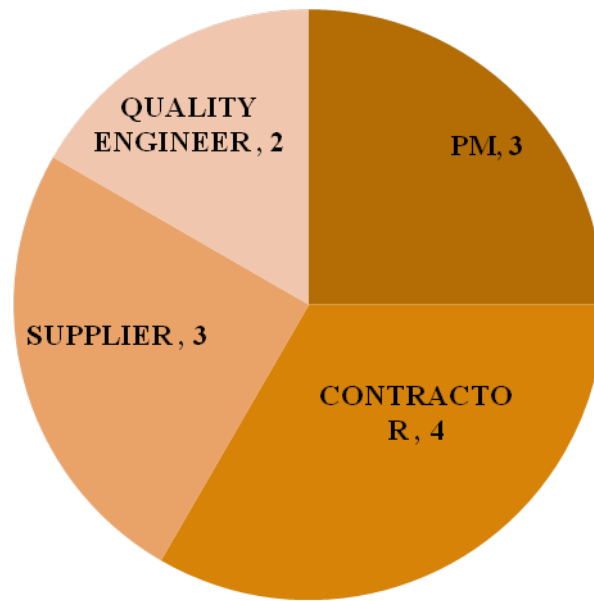


Fig 3.12 samples

Questionnaire survey sample based on

Categories into 3 sample types

1. Who will frame the structure – project manager
2. Who will execute the work – contractor , supplier
3. Who will be responsible for quality - quality engineer

Conclusion

Collected data were concluded by identify the problems through 5 stage and their description of the problem

1. Material takeoff and identification
2. Vendor selection
3. Material procurement
4. Construction phase
5. Post construction phase

Questions

Suppliers

- What type of materials do you supply?
- Typical process to place an order by a customer? (i.e. visit the store, phone)
- Once the order is placed, how it is processed?
- Do you use any computers to process the orders?
- Who monitors the process?
- Do you use any technology (i.e. bar codes, EDI, RFID) for inventory control?
- What happens if you don't have the quantity required by the customer?
- Do you have many customers asking the price matching?
- Do you do pack all the materials needed by a contractor in a pallet and have them ready for pick up by the customer?
- Do you do JIT delivery?
- How effective is your delivery in terms of time and quality?
- What are the major problems that you can identify in the system? (i.e. delivery times, quantities, relations with customers)

Contractors

- What is the type of materials that you usually buy from suppliers?
- How do you typically place an order? (i.e. visit the store, phone)
- Who monitors the process and makes sure that the materials will be on site when needed?
- Do you use any technology (i.e. bar codes, EDI, RFID) for inventory control on site?
- Do you typically pick your materials or you like the supplier to deliver them?
- Do keep inventory in site?
- Do you use JIT delivery?
- How effective is the delivery of suppliers in terms of time and quality?

- What are the major problems that you can identify in the system? (i.e. delivery times, quantities, relations with suppliers)

Storage Process

- Where are the materials stored?
- How do you keep track of materials installed/remaining? Tie with the stock requisition question

Inventory

- Who manages the on-site inventory?
- Does the distributor provide an on-site truck?
- Does the supplier provide inventory management?
- Based on what you schedule a materials release?

Materials Handling

- What are the major difficulties when handling material on-site?
- Who is in charge of the materials handling plan and procedures?
- Based on what you move materials to the site?
- How often do you move materials to the site?
- What happens if there are problems with materials shortages or materials damaged?

How to order material

- What are the types of material that you usually buy from suppliers?
- How do you typically place an order? Give examples? Is the process different for different type of materials?
 - Visit the store
 - Phone
 - Fax
 - E-mail
- Problems associated with the ordering process?

- Lost of order
- Fax not received
- Too many papers to fill out
- Not a good definition of what is wanted
- Poor communication with supplier
- Vague stated requirements
- Materials not available
Who follows up the order and makes sure that the materials will be on site when needed?

Quality Issues

- Quality is specified in the specifications for a particular project. In order for approval of the work, the contractor has to meet the quality requirements specified. How are quality issues specified to the supplier?
 - Copy of specifications
 - Orally
- Sometimes when materials arrive to the site, they are not exactly what you order or don't meet the requirements specified. What are the typical problems associated with quality issues?
 - No supplier QA
 - Materials don't meet the required quality
- The contractor has to tell the supplier the quality expected and the tolerances for the materials. How are inspection procedures specified to the suppliers? Are the inspection procedures different for different type of materials?
- Typical problems associated with inspection procedures
 - Procedures not followed
 - Non conforming items not identified
 - Non conforming items not isolated

- Typical problems associated with received materials from suppliers? Can you provide examples?
 - Lack of conformance to requirements
 - Quality problems
 - Damaged materials
 - Non-conformance with requirements
 - Late deliveries
 - Incorrect type of materials delivered
 - Incorrect sizes delivered
 - Incorrect quantities delivered
 - No supplier QA

How to qualify suppliers

- What are the procedures used to evaluate potential suppliers?
 - Forms
 - Experience of supplier
 - Reputation
 - Previously worked with the supplier
- What are the typical problems associated with the qualification process?
 - Time taken for the qualification process
 - Too many suppliers to qualify

Storage

- Do you keep inventory on site? If you do keep inventory, which materials are the most likely in your on site inventory? Which materials will never be in your inventory on site?
- How adequate are procedures for storage material on site?

- Different things can happen to materials once it is stored on site due to weather, human factors, etc. What are the typical problems that you can associate with stored material?
 - Not adequate space for storage
 - Theft
 - Corrosion
 - Deterioration
 - Keeping track of material
 - Re-handling of materials
 - Storage of materials
 - Lost of Materials
 - Theft
 - Damaging

Technology

- Do you use a computer in your company for material ordering, material tracking?
- How effective is the computer system used for materials ordering, tracking?
- Recently several electronic devices have been developed for materials tracking and inventory control. Among these devices bar codes are included.
- Do you use any technology for inventory control on site?
- What are the problems associated with technologies used for materials management?
 - Damage of bar codes
- Do you use JIT delivery?
- Typical problems associated with JIT

Table 3.11 questionnaire survey

	Problem	Description
Material takeoff and identification	Not a good scope definition	Not a good definition of what is wanted
	Lack of communication	Lack of communication between parties involved
	Incomplete Drawings	Plans are not complete and details are missing
	Lack of conformance to requirements	What is wanted by the customer is not what is prepared
	Nonstandard specifications	Use of specifications different from those commonly used
	Incomplete/ineffective meetings	Issues are not resolved in meetings
	Use of nonstandard items	Special Items that might require more time to be built
	Vague stated requirements	Don't communicate exactly what is wanted to suppliers
	Ambiguities between plans and specifications	Differences in requirements between plans and specifications
	Not determining when and what materials are needed	

Vendor Selection	Uncontrolled bid lists	Have too many suppliers bidding and don't have much information about them
	Incomplete proposals	Suppliers didn't include all documents required with the proposal
	Time spent investigating non-qualified suppliers	

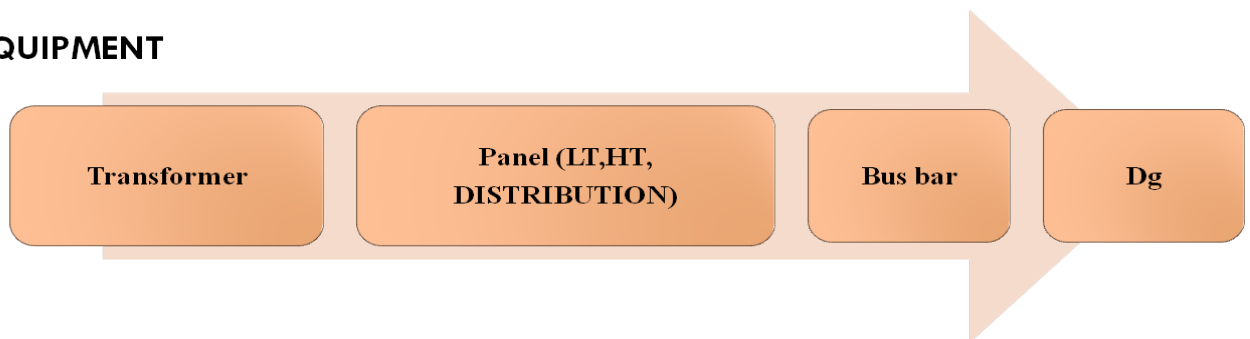
	Problem	Description
Materials Procurement	Availability of material	The requested material is in inventory and the quantities required are available
	Availability of quantities required	
	Matching price to competitor's price	Customer asks for price reduction to match your competitor's price
	Late Deliveries	Materials are not delivered as scheduled
	Late or incorrect of submittals	Submittals are not submitted and approved as planned or incorrect ones are submitted
	Late approval of submittals	
	Poor communication	Lack of communication between parties involved
	Lack of conformance to requirements	What is wanted by the customer is not what is prepared
	Unrealistic delivery dates	Delivery dates are set that are impossible to meet
	Vague stated requirements	Don't communicate exactly what is wanted to suppliers
	Re-handling of materials	Materials have to be moved from one place to another before being installed
	Storage of materials	Storage areas are limited or are far from working area
	Lost of Materials	
	Theft	
	Damaging	Materials damaged while handling or by other conditions

	Problem	Description
	Late deliveries	Materials do not arrived as scheduled
Construction Phase	Incorrect type of materials delivered	
	Incorrect sizes delivered	There are differences in the materials ordered and the materials delivered
	Incorrect quantities delivered	
	Keeping track of material	Don't know where materials are at certain period of time
	Re-handling of materials	Materials have to be moved from one place to another before being installed
	Storage of materials	Storage areas are limited or are far from working area
	Lost of Materials	
	Theft	
	Damaging	Materials damaged while handling or by other conditions
	No supplier QA	No quality assurance from the supplier
	Poor communication	Lack of communication between parties involved
	Receiving, handling and storage of unused materials	
Post-construction Phase	Can surplus be returned for credit?	
	Conditions and interests on outstanding bills	
	Return charges	
	Salvage losses	

3.4 ANALYSIS OF TQM DURING INSTALLATION

- Total—Made up of the whole.
- Quality—Degree of excellence a product or service provides.
- Management—Act, art, or manner of handling, controlling, directing, etc

EQUIPMENT



PROCESS

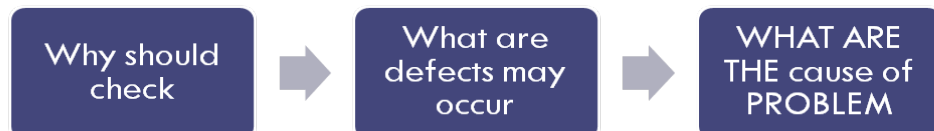


Fig 3.13 process flow

Table 3.11 LT panel

LT PANEL			LT PANEL		
CHECKS	DEFECTS	CAUSES	CHECKS	DEFECTS	CAUSES
Type of LT Panel as per Approval	Type of LT Panel NOT as per Approval	> specification is not clear > lack of coordination with in stakeholders > problem in price	Check the panels cable entry points are provided with proper gland plates	electrocution, water and other insects entry	> in and out cables were not design properly > no proper compartment design > quality of work were poor > lack of knowledge
Make / Model / Capacity of LT Panel as per Design / Approval	Make / Model / Capacity of LT Panel NOT as per Design / Approval	> dwgs were not clearly specified > lack of communication	Check the panels identifications are done	panel identification were hard	> poor quality work / material > it may cause accident
All Components of LT Panel are delivered as described in BOQ / Approved Technical Submittal	All Components of LT Panel are delivered NOT as described in BOQ / Approved Technical Submittal	> changes were not updated	Check busbar sizes, numbers & terminations confirm with design & drawing	busbar size , type , material are not as per specification and dwg	> lack of knowledge > poor coordination
Check whether the LT Panel confirms to manufacturer's Drgs	not as per dwg , changes in size, brand , material quality , compartment design	> manufacture defects > no proper check at factory > poor transportation and package	Check the compartment doors to ensure that it can be opened and closed smoothly	ingress of dust , insects may occur	> gaskets are not provide properly > its not undergo seven tank surface treatment
Examine any damage or displacement of parts, loose or broken connections, dirt or foreign material and moisture during shipment	damage or displacement of parts, loose or broken connections, dirt or foreign material and moisture during shipment	> due to weather condition while loading and unloading > fault in lifting equipments not as per needed > poor resource planning > cost constrain	Check that all bolts and nuts are securely bolted	loose connection , equipment failure	> poor quality of material > lack of inspections
Test / Warranty Certificates Attached	fault in equipments may occur , return or exchange will be take time and increase in cost	> manufacture defects > no proper check at factory > poor inspection at site	Check that the earthing links are correctly connected to the panel earthing bars and the latter to substation earth at one point	trip in circuit, electrocution	> material, size , depth not as per specification and dwgs > poor quality of work > no proper inspection
Is trenches and floor finishes are properly done for erecting panels	damage in trenches and floor finishes	> poor quality work / material	Is there any physical damages during installation	damage may occur	> poor resource planning > unsafe act of unloading
Check the locations, mounting & supports as per design & drawing	insufficient space , poor planning	> no proper planning (not as per standards)	All inter-panel control wirings should be checked for correct termination and continuity.	electrocution , loose connection , current leakage	> poor quality of wire > brand may vary not as per specification

Table 3.12 transformer

TRANSFORMER			TRANSFORMER		
CHECKS	DEFECTS	CAUSES	CHECKS	DEFECTS	CAUSES
Type of Transformer as per Approval	Type of transformer NOT as per Approval	> specification is not clear > lack of coordination with in stakeholders > problem in price	Check the Orientation, mounting & supports as per design & drawing	current leakage may occur	> changes were not updated > specification and dwgs were not clear > poor coordination within stakeholders
Make / Model / Capacity of Transformer as per Design / Approval	Make / Model / Capacity of Transformer not as per Design / Approval	> dwgs were not clearly specified > lack of communication	Check bushings, marking, terminations & sealing of both primary and secondary compartments	ingress of moisture , dust	
All Components of Transformer are Delivered as described in Approved Technical Submittal	All Components of Transformer are Delivered not as described in Approved Technical Submittal	> changes were not updated	Check both primary & secondary cable sizes, numbers & terminations conform with design & drawing	electrocution , water and other insects entry	> changes were not updated > specification and dwgs were not clear > poor coordination within stakeholders
Check whether the Transformer confirms to Manufacturer's Drgs	not as per dwg ,	> manufacture defects > no proper check at factory > poor transportation and package > due to weather condition	Check whether Busducts works (if any) done properly	loose bolt , leakage of current , ingress of moisture, dust	> quality of material is poor > work is not as per specified
Examine any damage or displacement of parts, loose or broken connections, dirt or foreign material and moisture during shipment	damage or displacement of parts, loose or broken connections, dirt or foreign material and moisture during shipment	> no proper handling of material while loading and unloading > fault in lifting equipments not as per needed > poor resource planning > cost constrain	Check whether Power Cabling works done properly	leakage of current , loose connection	> material specified is vary > quality of cable is poor
Check whether the Transformer matches to the casted foundation and provisions.	no proper foundation , base plate for transformer	> poor quality work / material > water , dust ingress	Check whether Control Cabling works done properly	indication light were not properly connected , labeling were done properly , loose connection , power leakage	> poor quality material and work > lack of inspection
Check whether the Body & Neutral Earthing as per CEIG / CEA / NEC / IS 3043 standards / recommendations	trip in circuit, electrocution	> material, size , depth not as per specification and dwgs > poor quality of work > no proper inspection	Proper cable termination with gland earthing is done as per specification	trip in circuit, electrocution, power leakage	> specification and dwgs were not clear > specified size and brand are not available that time > specified quality is not available > lack of inspection and checking
Test / Warranty Certificates Attached	fault in equipments may occur , return or exchange will be take time and increase in cost	> manufacture defects > no proper check at factory > poor inspection at site	Check the Busduct / Cable routing are laid as per approved shop drgs	connections of bus duct were not done properly , loose connection of bolts , ingress of moisture, dust	> lack of awareness > lack of coordination within stakeholders > changes were not updated
Any deviations, revisions or changes to be recorded for As Built	defects in works , rework charge will be added	> lack of coordination within stakeholders	Check the Transformer clearance are provided as per approved shop drgs / local electrical authority regulations	it may causes accident - fire	> no proper check > standards were not followed properly in some case
Is level and Finish of Transformer Foundation as per the specification	damage may occur	> poor quality material and work > lack of inspection	Is there any physical damages during installation	damage to the equipments , accident may occur , exchange of equipment may lead extra time and cost	> no proper handling equipment > poor resource planning > cost and time constrain > lack of training > lack of coordination
Ensure all Safety Standards / codes during installation	it may lead to labour accident , electrocutions	> poor planning > thinking to reduce cost and time			

Table 3.13 DG

DG					
CHECKS	DEFECTS	CAUSES			
Type of DG as per Approval	variation in dg type	> specification is not clear > lack of coordination with in stakeholders > problem in price	Check whether the Body & Neutral Earthing as per CEIG / CEA / NEC / IS 3043 standards / recommendations	electrocution , trip in circuit	> not as per dwg , standards > poor inspection
Make / Model / Capacity of DG as per Design / Approval	make , model, capacity not as per specification , changes in capacity	> dwgs were not clearly specified > lack of communication > changes were not updated	Check MS Pipes are Used as per Spec approved in Tech. data sheet	corrosion may occur , leakage	> specification were not clear > poor coordination with vendor > cost constrain
All Components of DG are Delivered as described in Approved Technical Submittal	All Components of DG are Delivered not as described in Approved Technical Submittal	> specification and dwgs were not clearly specified > lack of communication within stakeholders > changes were not updated	Check whether necessary clearances are provided on all sides as per approved shop drawings	no access space around it , may cause fire accident , rework may happen it may leads to increase in time and cost	> no proper planning > standards were not properly followed in some cases > lack of inspection > space constrain
Anti Vibration Springs delivered	more vibration affects the structure , noise level is high	> poor coordination in supply chain > ordering and delivery of material were delayed	Is level and Finish of DG Foundation as per the specification	Finish of DG Foundation not as per the specification , damage may occur , no proper access , water entry , insects dust may enter	> lack of inspection > specification were not clearly mention > poor material quality
Check whether the DG Equipment confirms to Manufacturer's Drgs	not as per dwg ,	> manufacture defects > no proper check at factory > poor quality of material and work	Is Ventilation as per the Manufacturer's recommendation	no proper ventilation , no proper exhaust design , accident may occur	> no proper planning > not consider air flow > no proper exhaust design > lack of knowledge > specification and dwgs were not clearly specified
Check whether the DG Equipment matches to the casted foundation and provisions.	damage in foundation , load does not match , ingress of water, dust etc..	> lack of inspection > specification and dwgs were not clearly specified	Check the DG set base frame fixed with Suspension / Anti Vibration pads / springs with proper tightness provided as per Manufacturer's recommendation	size of base frame may vary , damage in anti vibration pad , nuts and bolts were loose in some spots , noise and vibration to structure were more , not uniformly loaded , delay in delivery	> no proper inspection > poor quality check > purchase team delay in the ordering process
Test / Warranty Certificates Attached	fault in equipments may occur, return or exchange will be take time and increase in cost	> manufacture defects > no proper check at factory > poor inspection at site	Check Exhaust Piping including Silencer Positioned properly	rain water enter through exhaust , opening were not conclud properly	> no proper planning for exhaust > no proper inspection > dwgs were not clearly specified
Check whether the Fuel Tank Delivered as described in Approved Technical Submittal		> purchasing team ordering may delay > specification and dwgs are not clear	Check whether Expansion Bellows are provided in Exhaust pipe, Engine Side & Silencer Side	more heat may cause failure of dg	> specification were not clear
Check whether the Fuel Tank confirms to Manufacturers Drgs	capacity may vary , material are not as per specified , delay in delivery	> lack of Inspection > poor quality of work and material	Is Sufficient supports are provided for connecting exhaust Pipes	supports are not properly bolted	> no proper inspection > insufficient clamps > ordered quantity are mis match > cost and time constrain
Check whether the Fuel Tank foundation size matches to the casted foundation and provisions.					

Table 3.14 bus bar

BUS DUCT					
CHECKS	DEFECTS	CAUSES			
Type of Busduct/Raising mains as per Approval	not as per approval, insufficient to carry load	> specification is not clear > lack of coordination with in stakeholders > problem in price	Check the roof ceiling/shaft is ready for fixing busduct supports	structure failure , heavy load	> no proper planning > lack of coordination within stakeholders
Make / Model / Capacity of Busduct/Raising Mains as per Design / Approval	Make / Model / Capacity of Busduct/Raising Mains not as per Design / Approval, changes in makes and all	> dwgs were not clearly specified > lack of communication > changes were not updated > cost and time constrain	Check the location, mounting & supports as per design & drawing	changes in location may occur rework it may increase in cost and time	> changes were not updated > specification and dwgs were not clear > poor coordination within stakeholders
All Components of Busduct/Raising mains are delivered as described in BOQ / Approved Technical Submittal	delay in delivery , quantities not match as per specification , brand may vary	> specification and dwgs were not clearly specified > lack of communication within stakeholders > changes were not updated > cost constrain	Check the levels and straightness for busducts	levels may vary , it may causes accident , changes straightness	> dwgs were not clear > changes were not updated > lack of inspection > poor quality check
Check whether the Busduct/Raising mains confirms to Manufacturer's Drgs	not as per dwg ,	> manufacture defects > no proper check at factory	Check the body earth is properly connected with main earthings	trip in circuit, electrocution, power leakage	> specification and dwgs were not clear > specified size and brand are not available that time > specified quality is not available > lack of inspection and checking
Examine any damage or displacement of parts, loose or broken connections, dirt or foreign material and moisture during shipment	damage or displacement of parts, loose or broken connections, dirt or foreign material and moisture during shipment	> poor transportation and package > due to weather condition > no proper handling of material while loading and unloading > fault in lifting equipments not as per needed > poor resource planning > cost constrain	Check the busbars identification and markings done in busducts	it may cause accident , difficult to identify , color coding were not done properly	> lack of proper inspection > quality check were not done properly
Test / Warranty Certificates Attached	fault in equipments may occur, return or exchange will be take time and increase in cost	> manufacture defects > no proper check at factory > poor inspection at site	Check busbar sizes, numbers & terminations confirm with design & drawing	size , quantity may vary , lagging in time , cost constrain for reorder	> changes were not updated > specification were not clear > poor coordination with the vendor > lack of communication between stakeholders
Any deviations, revisions or changes to be recorded for As Built	changes in material quality , quantity, delay in delivery because of delayed revision	> lack of coordination within stakeholders > changes were not updated properly > no proper planning team	Check all joints/connecting portions are tightened with torque wrench	electrical leakage , electrocution, fire accident may occur , ingress of moisture, dust and insects , loose bolt and nuts	> lack of proper inspection > quality check were not done properly
			Is there any physical damages during Installation	damage to the equipments , accident may occur , exchage of equipment may lead extra time and cost	> no proper handling of equipment > poor resource planning > cost and time constrain > lack of training > lack of coordination
			Check the excess space around the busduct is closed	ingress of moisture , short circuit may occur , leakage of current , electrocution	> no proper inspection > insufficient material > time and cost constrain

3.5 COMPARATIVE ANALYSIS

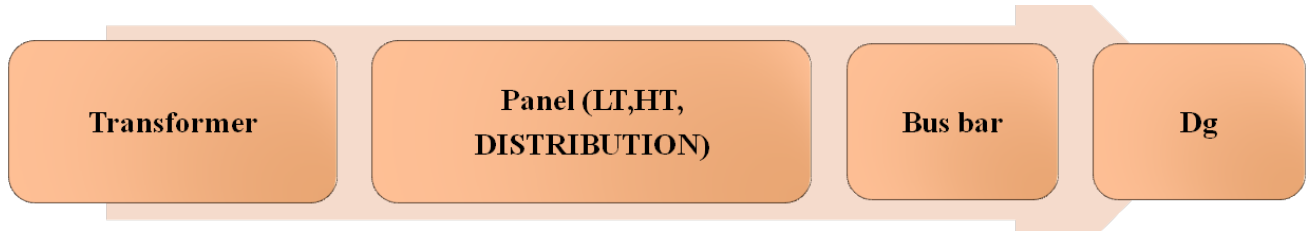


Fig 3.14 Equipments

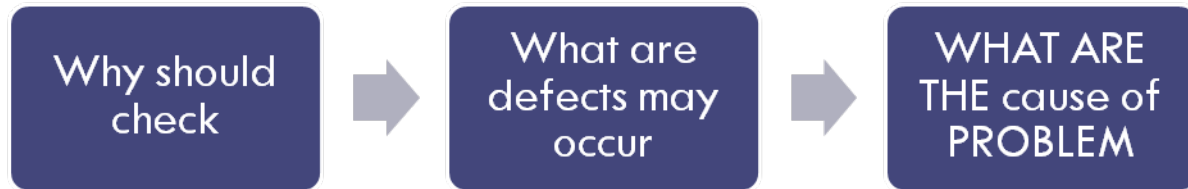


Fig 3.15 process flow

Table 3.15 DG

Equipment	Process	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect
		c1 (JIPMER)	c1 (JIPMER)	c2 (HCL)	c2 (HCL)	c3 (R&D)	c3 (R&D)
DG	design	changes in design and specification	> lack of communication > chages were not updated properly				
	manufacture			lack of conformance to requirement	> specification were not clear		
	assembly	non standard specification	> special items that might require more time to be built				
	factory testing					delay in delivery	> payment delay
	packing ,transportation	damage,increase in transportation cost	> no proper access > escalation of transportation cost	damage	> weather constain (poor packing)		
	unloading ,storage					civil work were not done properly	> lack of coordination between parties involved
	erection /installation	delay	> insufficient skilled labour	insufficient miscellniuous material	> lack of proper planning > poor coordination		
	testing at site	completion of work not done properly	> lack of knowledge > cost constrain			completion of work not done properly	> cost constrain

Table 3.16 Panels

Equipment	Process	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect
		c1 (JIPMER)	c1 (JIPMER)	c2 (HCL)	c2 (HCL)	c3 (R&D)	c3 (R&D)
LT ,MV, HT,DB, PANELS	design , planning,ordering			changes in design and specification	> lack of communication > chages were not updated properly	non standard specification	> use of specification different from commonly used
	manufacture	delay	>payment delay			delay	> special items that might require more time to built
	factory inspection			delay in delivery	> payment delay		
	packing ,transportation	cost constrain	>increase in transportation cost			hard to unload	> poor access
	assembling the encloser	insufficient miscellnious material	> poor planning > material are not delivered as scheduled				
	installing the device			scheduled delivery date were impossible to meet	> poor planning	delay	> special items that might require more time to built
	power connection	insufficient miscellnious material	> lack of proper planning > poor coordination				
	testing at site , commisioning			power leakage ,loose connection	> poor quality of material > poor inspection	trip in circuit	>poor earthing - poor inspection > poor quality of work

Table 3.17 Substation

Equipment	Process	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect
		c1 (JIPMER)	c1 (JIPMER)	c2 (HCL)	c2 (HCL)	c3 (R&D)	c3 (R&D)
substation	design , planning	changes in design and specification	> lack of communication > chages were not updated properly				
	construct			delay	> insufficient material , labour	scheduled delivery date were impossible to meet	> poor planning
	assemble	insufficient miscellnious material	> poor planning > material are not delivered as scheduled			delay	> poor planning > material are not delivered as scheduled
	erection /installation			insufficient miscellnious material	> lack of proper planning > poor coordination		
	testing and commisioning	completion of work not done properly	> lack of knowledge > cost constrain			completion of work not done properly	> cost and time constrain

Table 3.18 Transformer

Equipment	Process	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect
		c1 (JIPMER)	c1 (JIPMER)	c2 (HCL)	c2 (HCL)	c3 (R&D)	c3 (R&D)
Transformer	design , planning , ordering			changes in design and specification	> lack of communication > chages were not updated properly		
	manufacture	delay	>payment delay			delay	> special items that might require more time to built
	assembly			insufficient miscellinious material	> poor planning > material are not delivered as scheduled		
	factory test					delay in delivery	> payment delay
	packing ,transportation	damage,increase in transportation cost	> no proper access > escalation of transportation cost				
	storage , unloading					hard to unload	> no proper access
	installing the device			delay	> insufficient skilled labour	scheduled delivery date were impossible to meet	> poor planning
	on site testing	delay	> payment delay > lack of coordination				

Table 3.19 Bus bar

Equipment	Process	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect	Defects face at site	Cause of the defect
		c1 (JIPMER)	c1 (JIPMER)	c2 (HCL)	c2 (HCL)	c3 (R&D)	c3 (R&D)
Bus bar/ bus duct	planning ,ordering	quantity are not match	> no clear specification > poor planning				
	factory test			delay	> payement delay		
	package , transportation	damage	> poor packing				
	installing the device			delay	> insufficient skilled labour	insufficient miscellinious material	> poor planning > material are not delivered as scheduled
	onsite testing	loss connection , no proper joints	> poor quality works			loss connection , no proper joints	> poor quality works > time and cost constrain

Table 3.20 Summary

major problem		lack of communication	specication and dwgs were not clearly specified / changes were not updated	cost constrain	vague stated requirements	late deliveries	damaging	theft ,loss	insufficient quantity	late approval/ incorrect of submittal	lack of conformance by customer	incorrect material / size / brand delivered	poor quality of material	no proper quality inspection	poor planning - purchase team , resource
case study	c1														
	c2														
	c3														

high	
medium	
low	

CHAPTER 4 TOOLS AND TECHNIQUES

4.1 DECISION SUPPORT SYSTEM – DSS

- To use decision-modeling techniques to develop an integrated system of decision support for material procurement for the electrical services .
- The factors (or parameters) and alternatives that define the inputs of the decision model.
- Performance measures are the output of the descriptive decision model.
- Alternatives represent the different options available for a particular decision.
- Parameters are uncontrollable factors that influence a decision.
- Performance measures are used to measure the effectiveness of the choice of alternatives and parameters used as inputs

1. What material to buy
2. How much to buy
3. When to buy
4. When to deliver
5. Where to deliver
6. Where to store

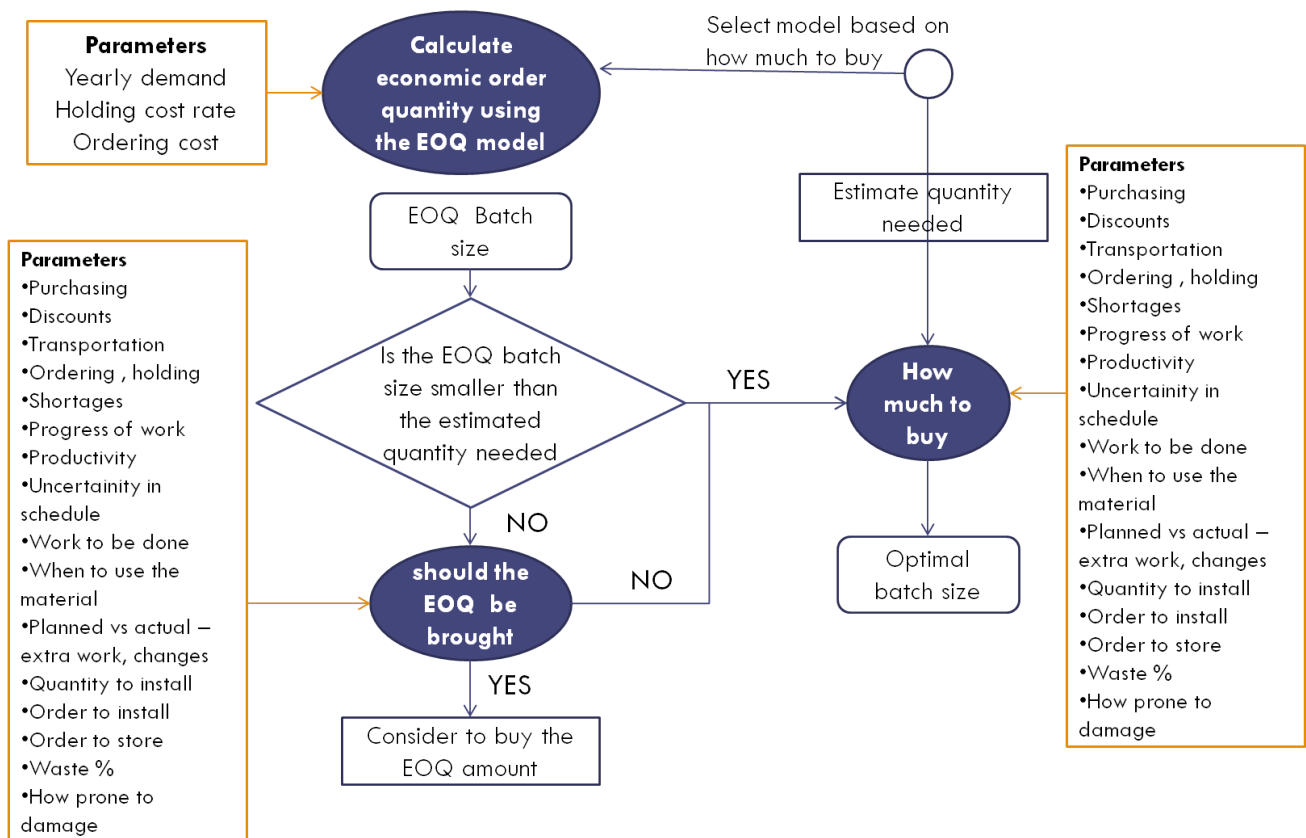


Fig 4.1 How much to buy

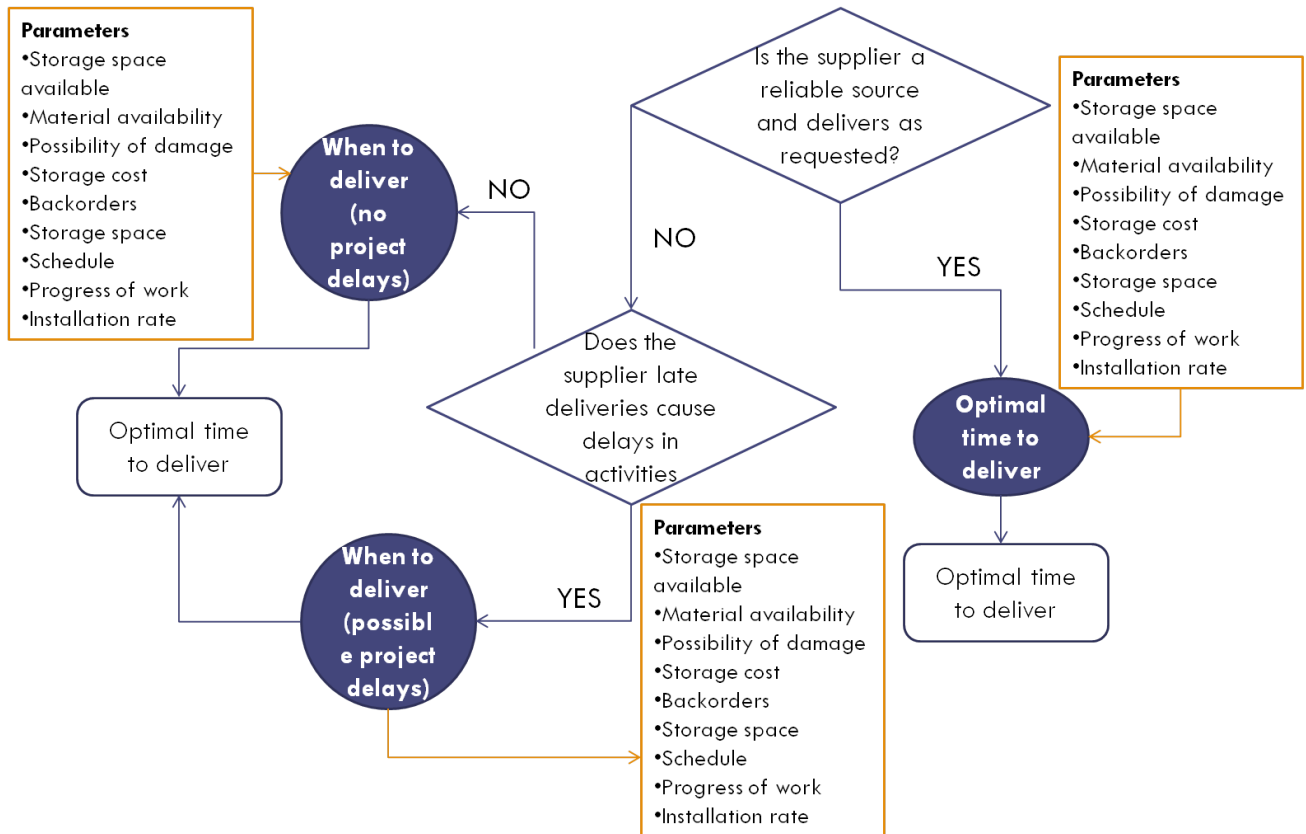
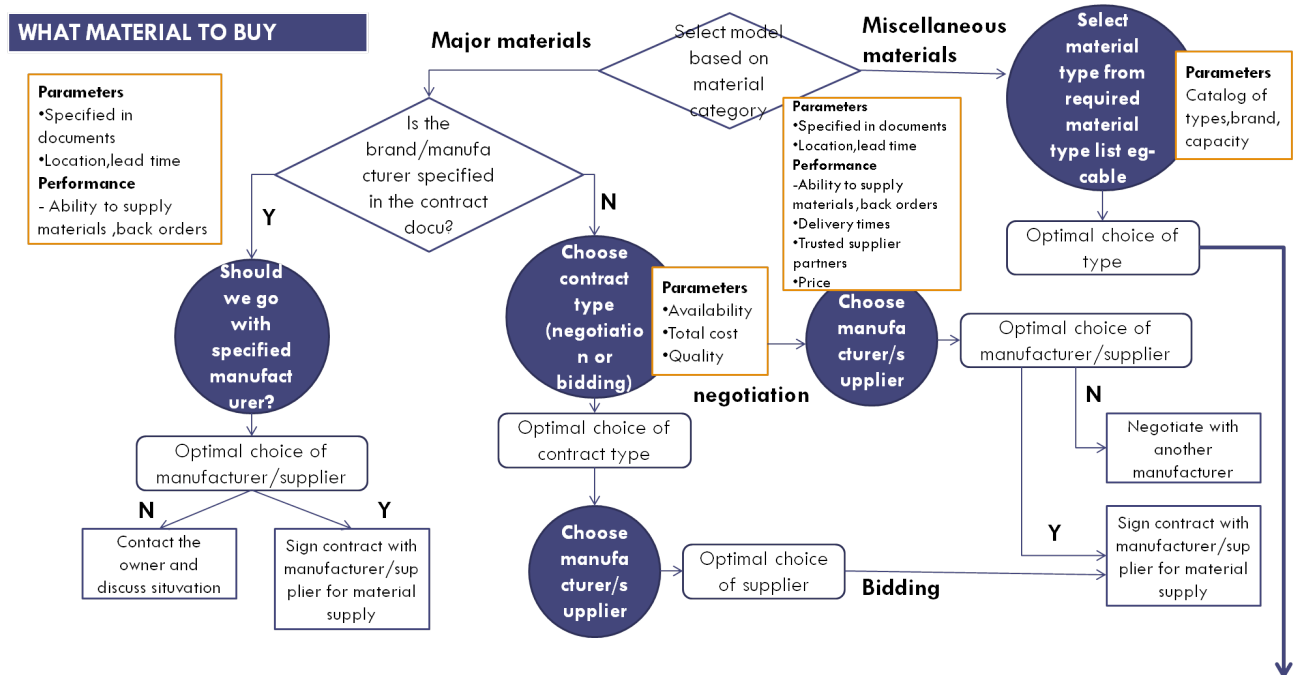


Fig 4.2 when to deliver



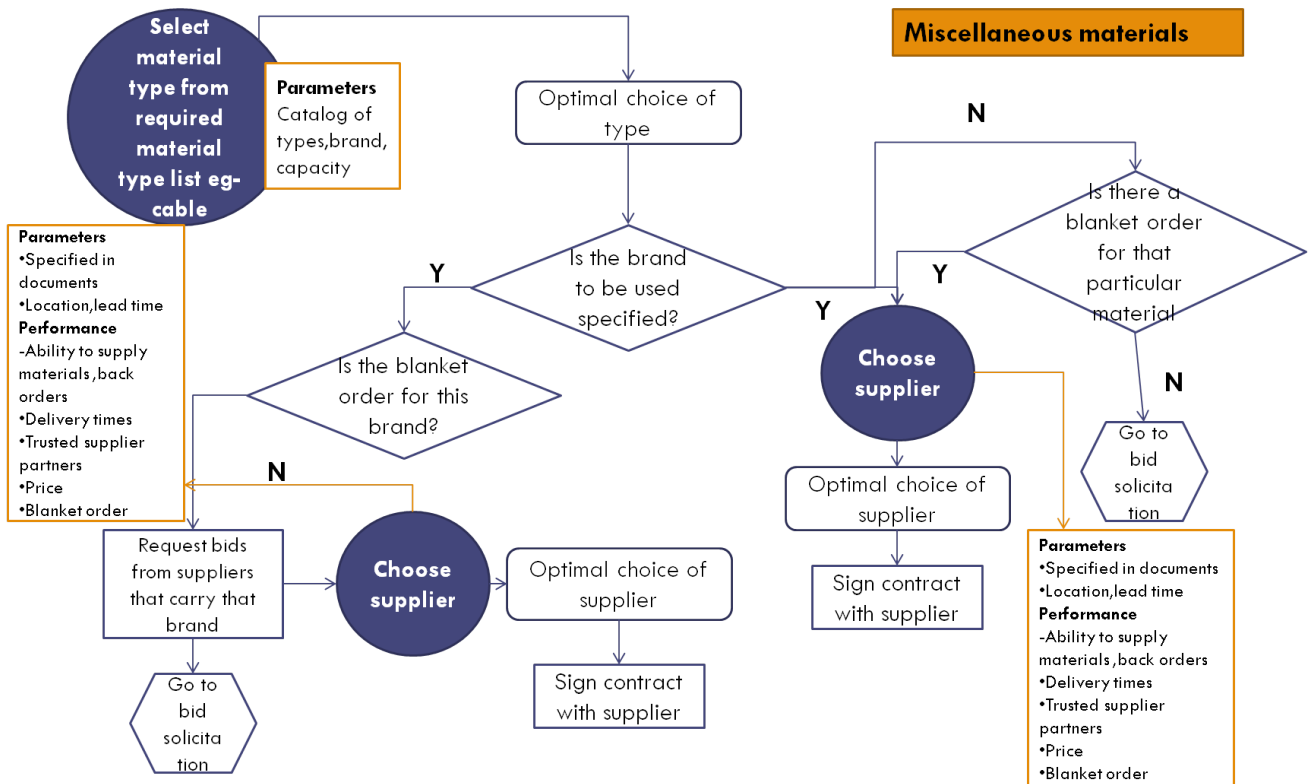


Fig 4.3 what material to buy

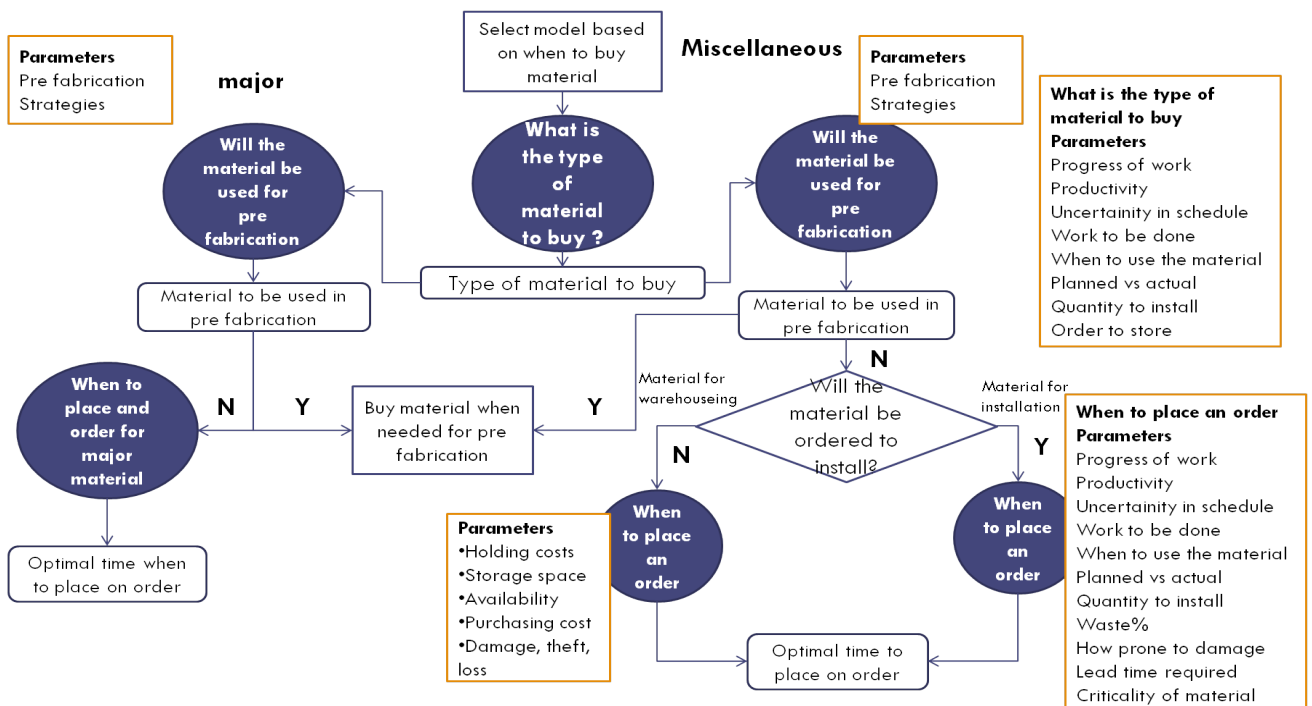


Fig 4.4 When to buy

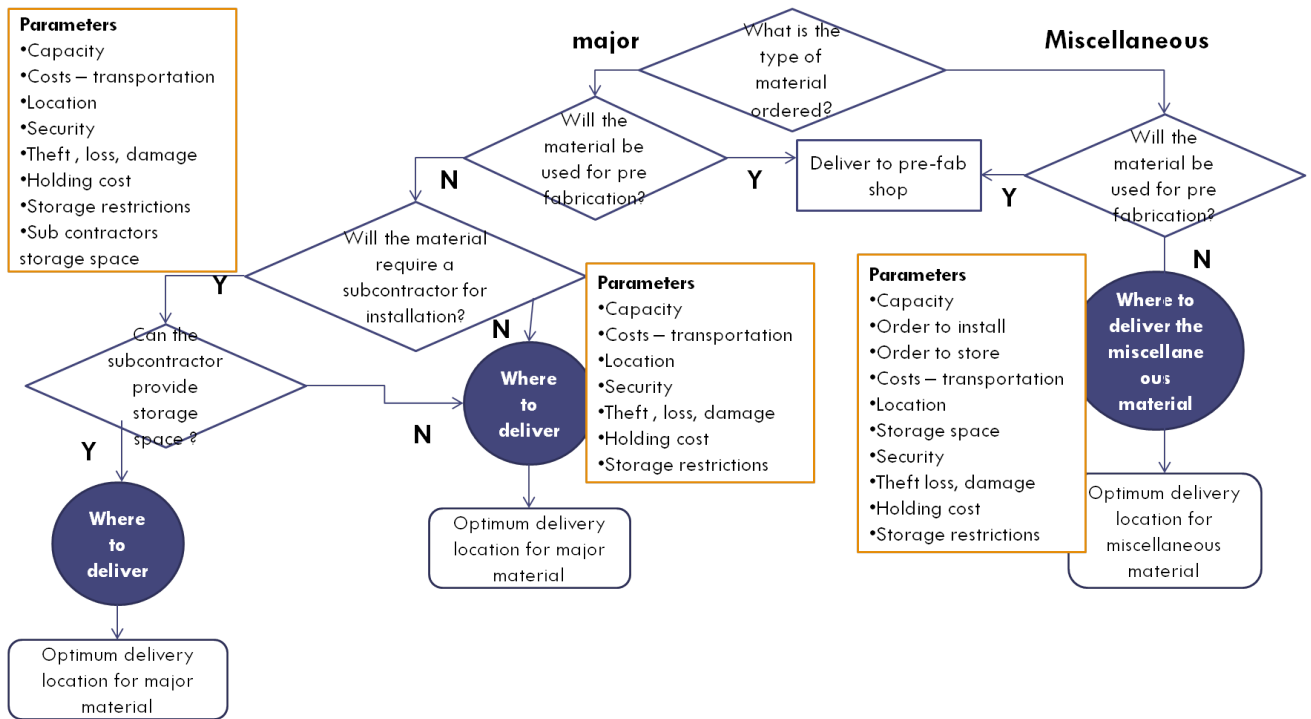


Fig 4.5 Where to deliver

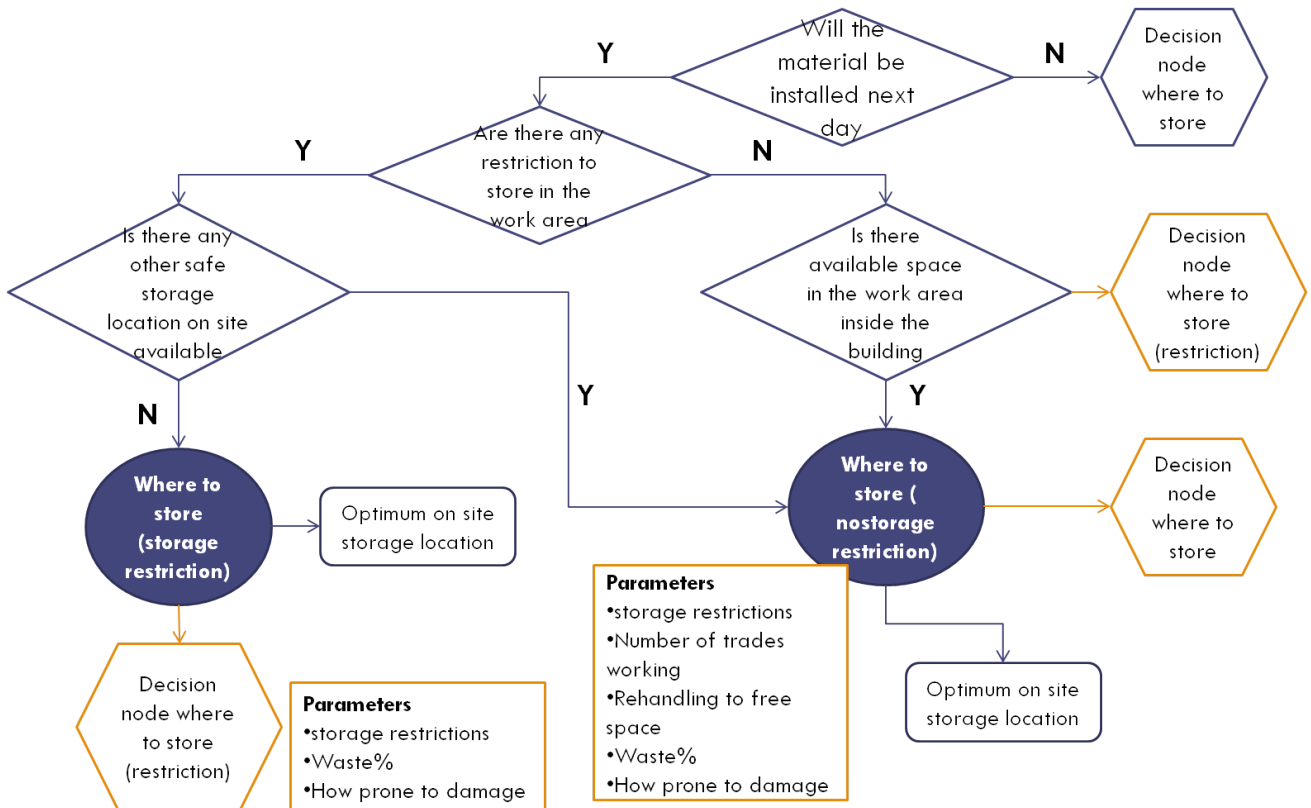


Fig 4.6 Where to store

- materials management problems highly impact general contractors, but are more critical for specialty contractors including electrical contractors.
- The electrical contractor needs to establish an effective materials management system to minimize problems that might arise if the activities related to materials management are not handled properly.
- Among these problems, the following are encountered: material shortages, misplacements, loss, and theft, which might result in increases in crew idle times, loss of productivity and delay of activities.
- Electrical contractors should implement an efficient material management system due to the fact that in most of the cases they are asked to squeeze their bids in order to keep the costs of project under budget.
- In such a case, failure to effectively manage materials could result in decrease in profit or even a monetary loss.
- In this describes the supply chain management related decisions considered in the study, a graphical description of the processes related to such decisions, which includes the parameters and alternatives for each decision.

4.2 SPARCS - SUPPLY-CHAIN PARAMETERS CLASSIFICATION SYSTEM

- The electrical industry needs a structured database design that can allow decision makers to review and categorize these parameters.
- This categorization could facilitate the storage and classification of the parameter information for future extraction and use.

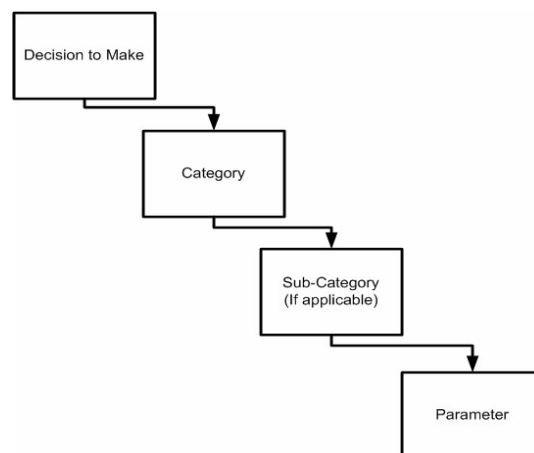


Fig 4.7 process

Table 4.1 Parameters

Parameter	Definition	Category
Lead Time	Time between the placement of an order and delivery to the construction site	Type of Material
Purchasing	The price of a particular material	Cost
Ordering	The cost of placing an order of material	Cost
Discounts	Any reductions in cost due to amounts bought or any other arrangement	Cost
Transportation	Cost of transporting the material from the supplier's location to the jobsite	Cost
Shortages	Cost associated with having less material available than required on the jobsite	Cost
Storage (Holding)	Cost of storing material on the jobsite for future use	Cost
Tracking	Cost of tracking material to avoid theft or losses	Cost
Re-handling	Cost of moving material around to free space or to bring it to the work area	Cost
Surpluses	Cost associated with having more material available than required on the jobsite	Cost
Backorders	Cost associated with material not available and being ordered by the supplier	Cost
Misplacement	Cost associated material misplaced and not available when needed	Cost
Damage	Cost associated with material being damaged by the weather, equipment, workers or other material	Cost
Loss	Cost of associated with material being lost	Cost
Theft	Cost of associated with material being stolen	Cost

Parameter	Definition	Category
Delays	Cost of associated with material not delivered when promised by the supplier	Cost
Capacity	The amount of material that can be stored on a particular location	Storage
Rent Fee	Cost of renting additional space for material storage	Storage
Location	Physical location of the storage facility	Storage
Security	How secure is the storage location with respects to theft of material	Storage
Progress of work	Work development and progression	Schedule
Productivity	Installation rate of material	Schedule
Uncertainty in schedule	The accuracy and possible changes in schedule due to uncertain events	Schedule
Work to be done	The work to be performed on a particular work day	Schedule
When to use material	Expected date for material installation based on schedule or actual work progress	Schedule
Extra work	Any additional work requested by the owner and not indicated in the contract documents	Schedule
Changes	Changes in the original work to be performed	Schedule
Quantity to install	Material quantities to be install based on the type of work to be performed	Schedule
Order to install	Material that is ordered for immediate installation	Schedule
Order to store	Refers to material being ordered to be stored for future use	Schedule
Location	Refers to physical location of the supplier	Supplier
Performance	Refers to the ability to supply material and in addition backorders expected	Supplier
Reliability	How trusted is the supplier with respects to delivery and availability	Supplier

Parameter	Definition	Category
Delays	Cost of associated with material not delivered when promised by the supplier	Cost
Capacity	The amount of material that can be stored on a particular location	Storage
Rent Fee	Cost of renting additional space for material storage	Storage
Location	Physical location of the storage facility	Storage
Security	How secure is the storage location with respects to theft of material	Storage
Progress of work	Work development and progression	Schedule
Productivity	Installation rate of material	Schedule
Uncertainty in schedule	The accuracy and possible changes in schedule due to uncertain events	Schedule
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Location	Refers to physical location of the supplier	Supplier
Performance	Refers to the ability to supply material and in addition backorders expected	Supplier
Reliability	How trusted is the supplier with respects to delivery and availability	Supplier

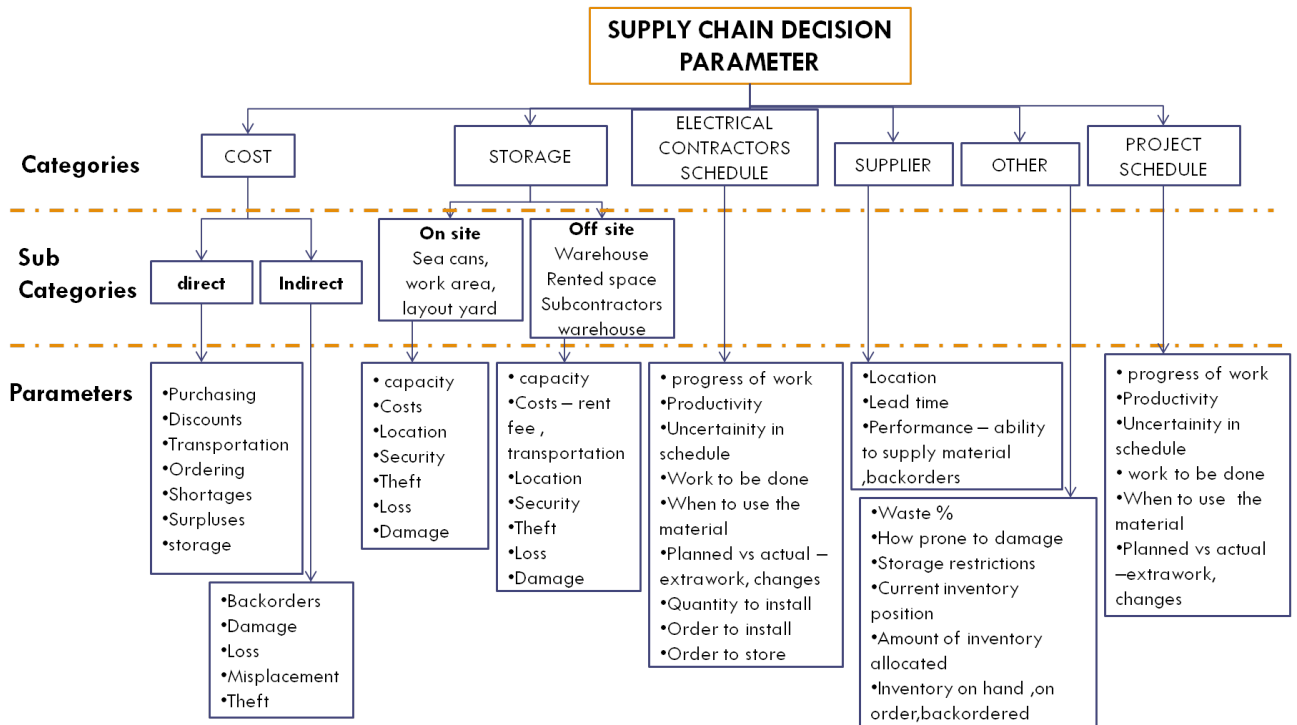


Fig 4.8 How much to buy decision

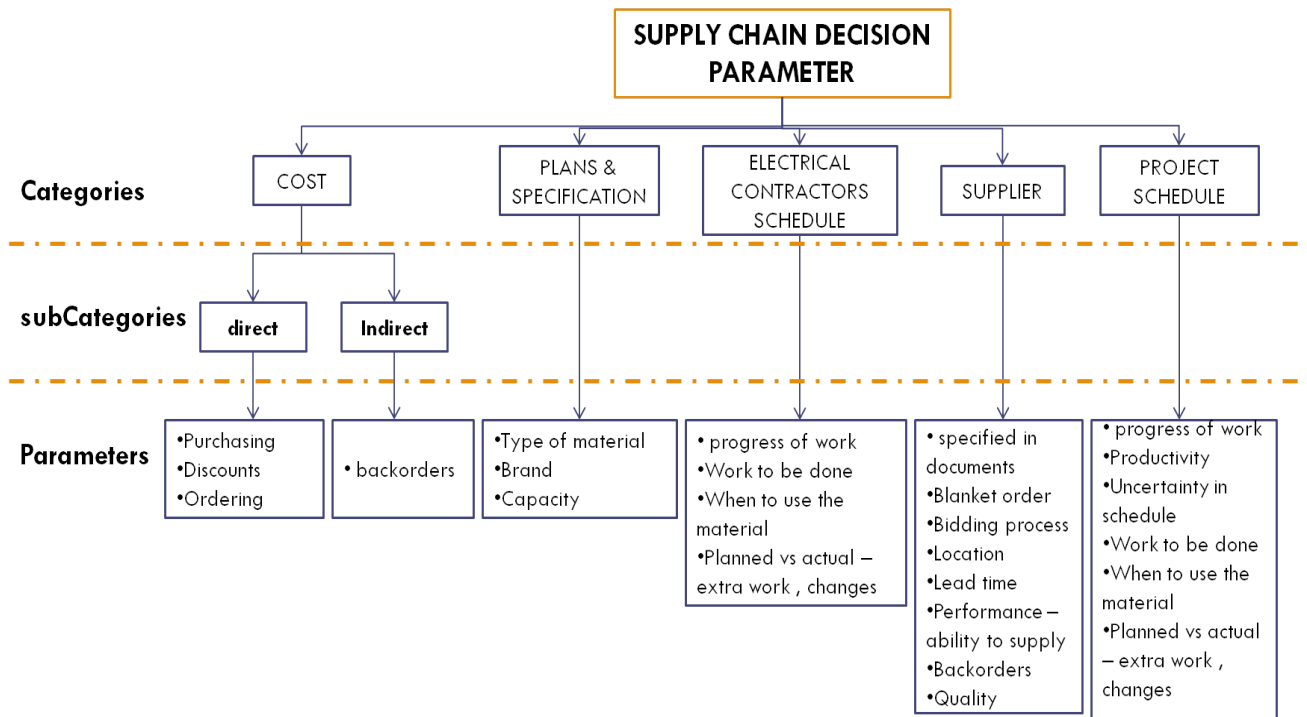


Fig 4.9 What material to buy decision

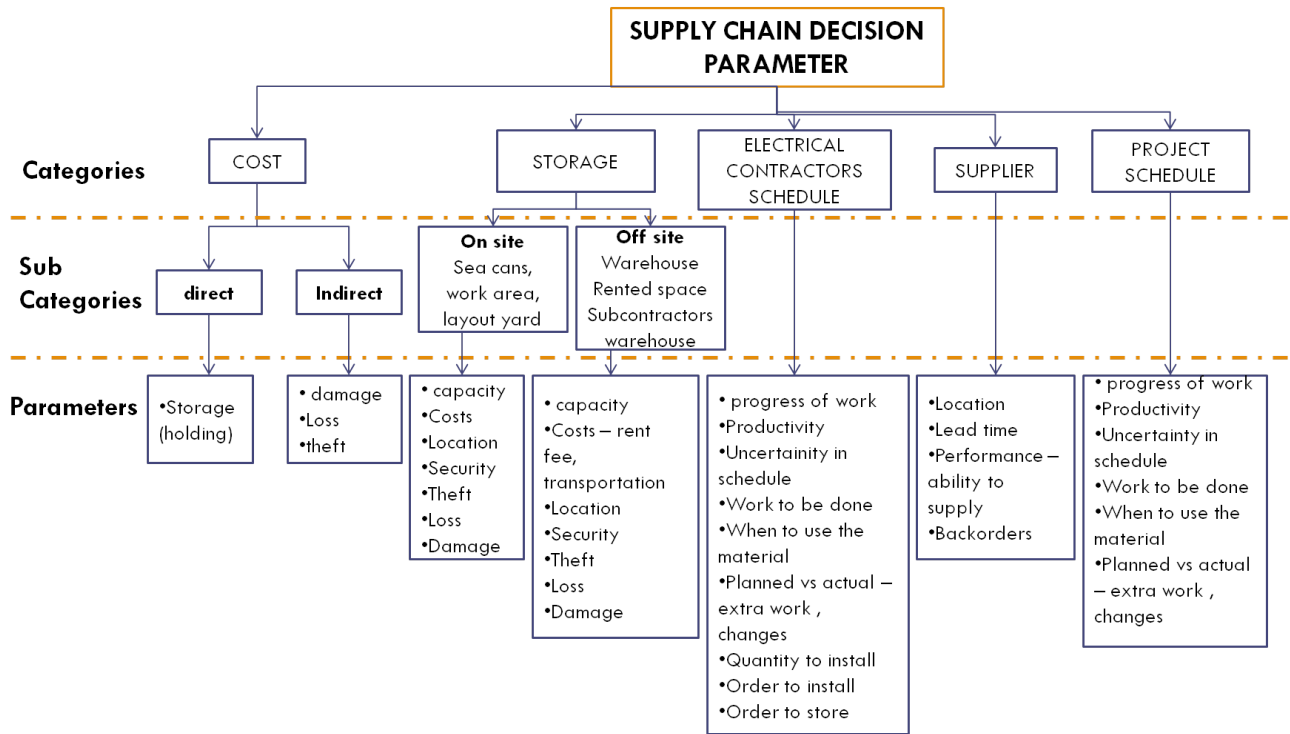


Fig 4.10 Where to deliver decision

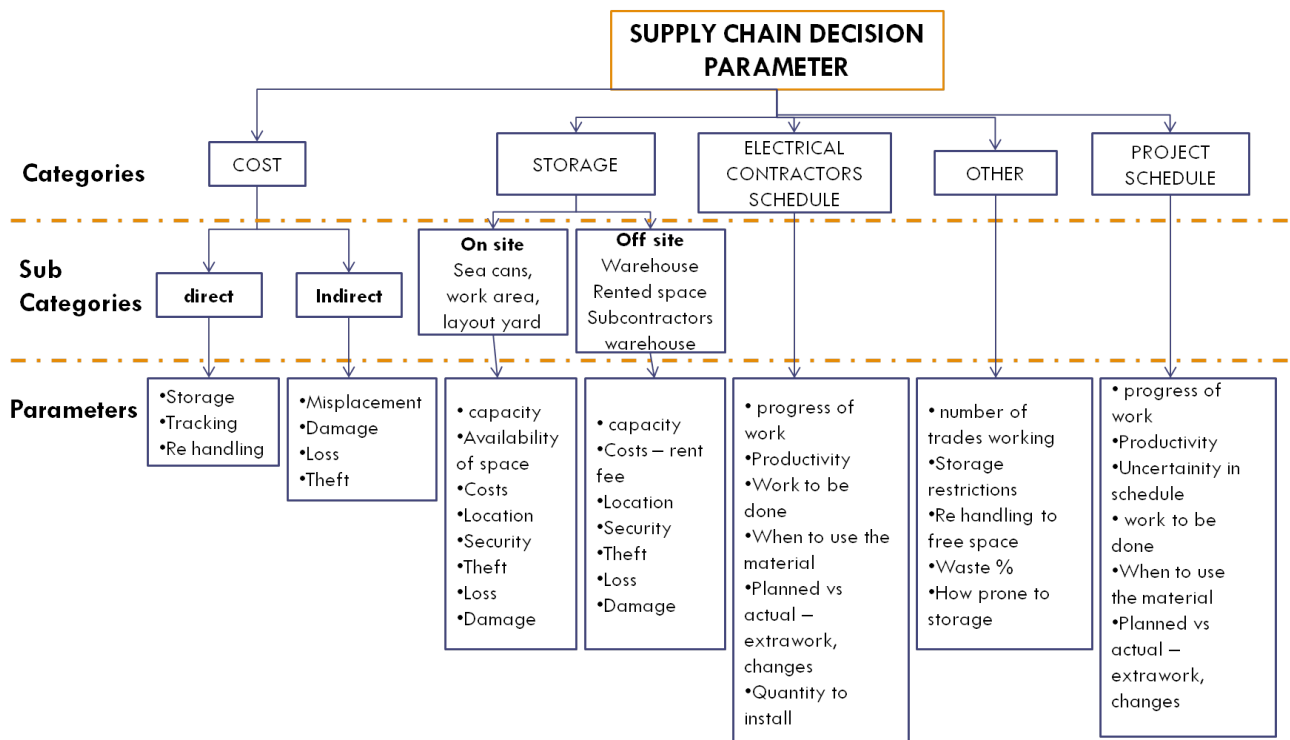


Fig 4.11 Where to store on site decision

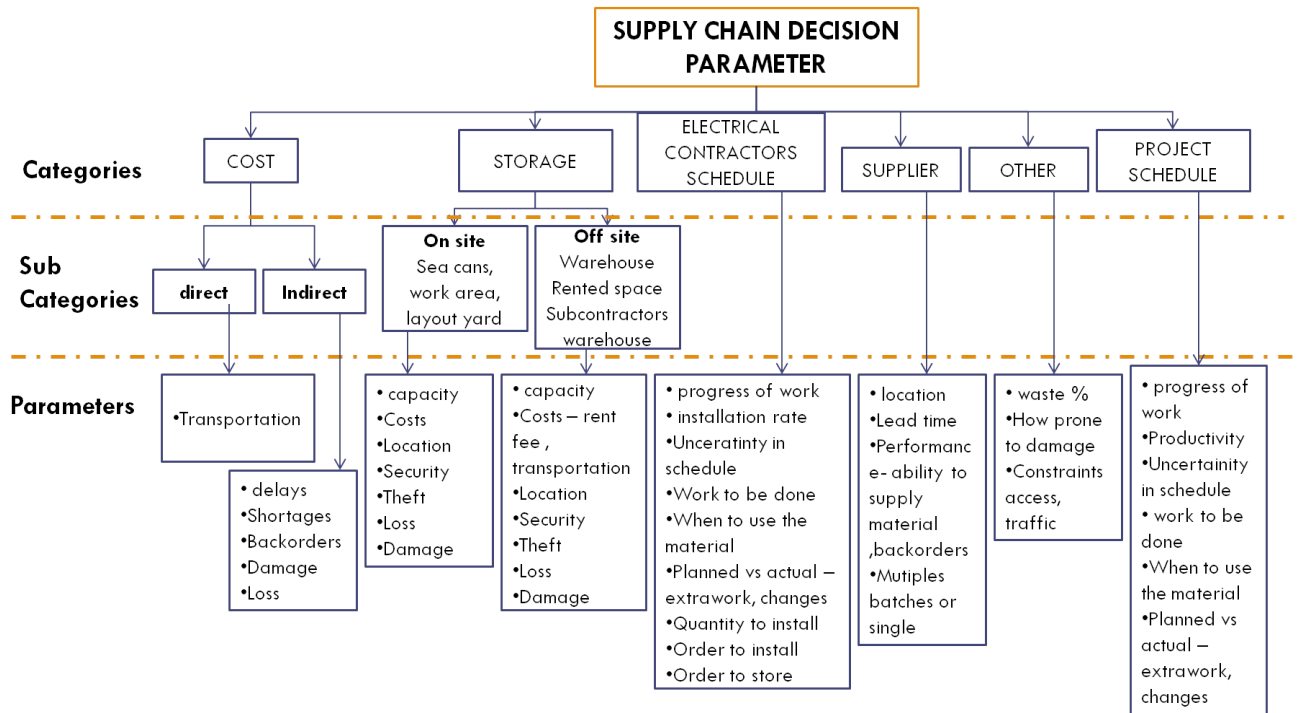


Fig 4.12 When to deliver decision

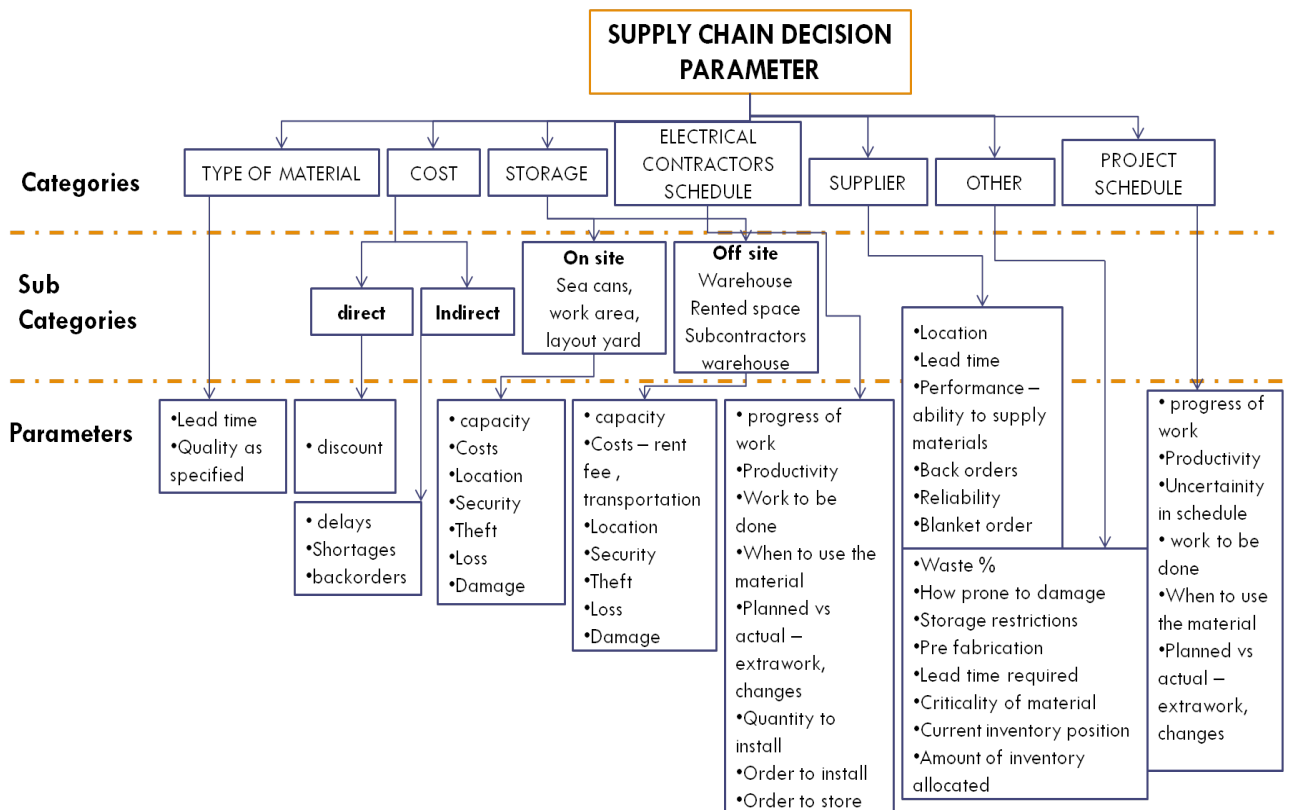


Fig 4.13 When to buy decision

- SPARCS, which is an acronym for Supply-chain PARAmeter Classification System.
- This classification hierarchy allows decision makers to classify supply chain parameters and organize them in a structured format, thus minimizing the time required for data extraction and reducing the tediousness of the current approach.
- The importance of developing such system was explained and the contribution of such system was described.
- The development of SPARCS fills the need for a structured model to categorize the parameters that need to be considered on the supply chain decision making process for the electrical contractor.
- SPARCS diagrams for all the decisions considered in the study were described and presented. For a more complete system design and model specification, a similar approach needs to be developed for alternatives and performance measures. However, the alternatives could vary between contractors and between the projects of a same contractor. Moreover, these alternatives could be input by the user when using the decision support model.

4.3 GENERAL RANKING

Major defects	design /planning	ordering	manufacture	assembly	factory test	packing / loading	transportation	unloading / storage	assembling the encloser	installing	power connection	labeling and marking	on site testing and commissioning
specification is not clear	x		x										
lack of coordination	x	x	x	x	x	x	x	x	x	x	x		
problem in price		x	x		x	x	x	x	x				x
dwgs were not clearly specified	x	x	x	x						x	x		
changes were not updated	x	x	x							x	x		
manufacture defect			x	x	x								
no proper check at factory			x	x	x								
poor transportation and package						x	x						
poor resource planning (no proper handling equip)						x		x					
poor quality of work /material not as per standard (no proper planning)			x		x			x			x		x
lack of knowledge					x			x				x	
brand may vary not as per specification		x									x		
weather constrain							x	x					
time constrain	x	x			x		x	x	x			x	x
lack of training								x	x	x	x	x	x
lack of inspection and checking					x			x	x	x	x	x	x
insufficient labour						x			x	x	x		
no proper purchasing team (delay in ordering)	x	x											
insufficient quantity		x						x		x			
space constrain(storage)	x							x					
Total	7	8	8	4	8	6	5	12	7	8	8	5	5
Ranking													

4.4 FMEA – FAILURE MODE EFFECT ANALYSIS

- FMEA can be applied as qualitative and quantitative method for failure analysis.
- An effective FMEA activity assists identification of potential failure modes and their effects based on experience with similar products, processes or system.
- It can be classified as three types; System FMEA, Design FMEA & Process FMEA due to the nature of analysis

In construction sites, hazards and risks evaluation table can be done by following;

- Create a major row for each component.
- Identify failure modes and establish a sub-row for each mode.
- Describe the effects on safety and system performance resulting from the failure. List the specific adverse outcomes.
- Determine occurrence value
- Determine severity value
- Determine causes of failure mode (if known): this includes environmental and/or operational stresses that increase the likelihood of the failure mode.
- Determine methods of detecting failure mode (if known): although this entry does not prevent a failure from occurring, it is important to discover that a failure has occurred. This column is used to present signs and symptoms that a component has failed.
- Suggest interventions: hardware modifications and/or compensatory actions to minimize effects.

Table 4.2 FMEA

GRADING	LEVEL OF SEVERITY	OCCURANCE	DETECTION VALUE		
1	uncertain	unlikely	certain	S	LEVEL OF SEVERITY
2	low	possible	high	O	LEVEL OF OCCURANCE
3	moderate	occasional	moderate	R	RISK VALUE
4	high	steady	low	E	CONTROL LEVEL
5	certain	certain	uncertain	F	DETECTION VALUE
				G	RRN VALUE
				H	ACTION TAKEN PRIORITY LEVEL

Table 4.3 FMEA for different phase

Phase	Problems	S	O	R	E	F	G	H
Material takeoff and identification	Not a good scope definition	4	2	8	moderate	3	24	
	Lack of communication	5	5	25	certain	1	25	
	Incomplete Drawings	4	2	8	moderate	3	24	
	Lack of conformance to requirements	4	2	8	moderate	3	24	
	Nonstandard specifications	4	1	4	low	4	16	
	Incomplete/ineffective meetings	3	2	6	moderate	3	18	
	Use of nonstandard items	3	1	3	low	4	12	
	Vague stated requirements	3	3	9	high	2	18	
	Ambiguities between plans and specifications	3	3	9	high	2	18	
	Not determining when and what materials are needed	4	3	12	high	2	24	
	Uncontrolled bid lists	2	1	2	uncertain	5	10	
vendor selection	Incomplete proposals	3	2	6	moderate	3	18	
	Time spent investigating non-qualified suppliers	3	2	6	moderate	3	18	

Phase	Problems	S	O	R	E	F	G	H
material procurement	unavailability of material	3	3	9	high	2	18	
	insufficient quantities of material	3	3	9	high	2	18	
	poor quality of material	3	2	6	moderate	3	18	
	Late Deliveries	4	2	8	certain	5	40	
	Late or incorrect of submittals	2	2	4	low	2	8	
	Late approval of submittals	2	2	4	low	2	8	
	Poor communication	3	4	12	certain	1	12	
	Lack of conformance to requirements	2	2	4	low	4	16	
	Unrealistic delivery dates	4	4	16	certain	1	16	
	Vague stated requirements	3	3	9	high	2	18	
	Re-handling of materials	4	1	4	low	4	16	
	Storage of materials	3	2	6	moderate	3	18	
	Lost of Materials	1	1	1	uncertain	5	5	
	Damaging	2	1	2	uncertain	5	10	

Phase	Problems	S	O	R	E	F	G	H
construction phase	Late deliveries	5	5	25	certain	1	25	
	Incorrect type of materials delivered	4	3	12	certain	1	12	
	Incorrect sizes delivered	4	3	12	certain	1	12	
	Incorrect quantities delivered	4	3	12	certain	1	12	
	Keeping track of material	3	2	6	moderate	3	18	
	Re-handling of materials	3	2	6	moderate	3	18	
	Storage of materials	3	2	6	moderate	3	18	
	Lost of Materials	1	1	1	uncertain	5	5	
	Damaging	1	2	2	uncertain	5	10	
	No supplier QA	2	2	4	low	4	16	
	Poor communication	5	4	20	certain	1	20	
	Receiving, handling and storage of unused materials	2	2	4	low	4	16	
	Can surplus be returned for credit?	3	3	9	high	2	18	

4.5 QUALITY TOOL

A method that provides organizations tools to improve the capability of their business processes. This increase in performance and decrease in process variation helps lead to defect reduction and improvement in profits, employee morale, and quality of products or services



Fig 4.14 objectives of 6 sigma

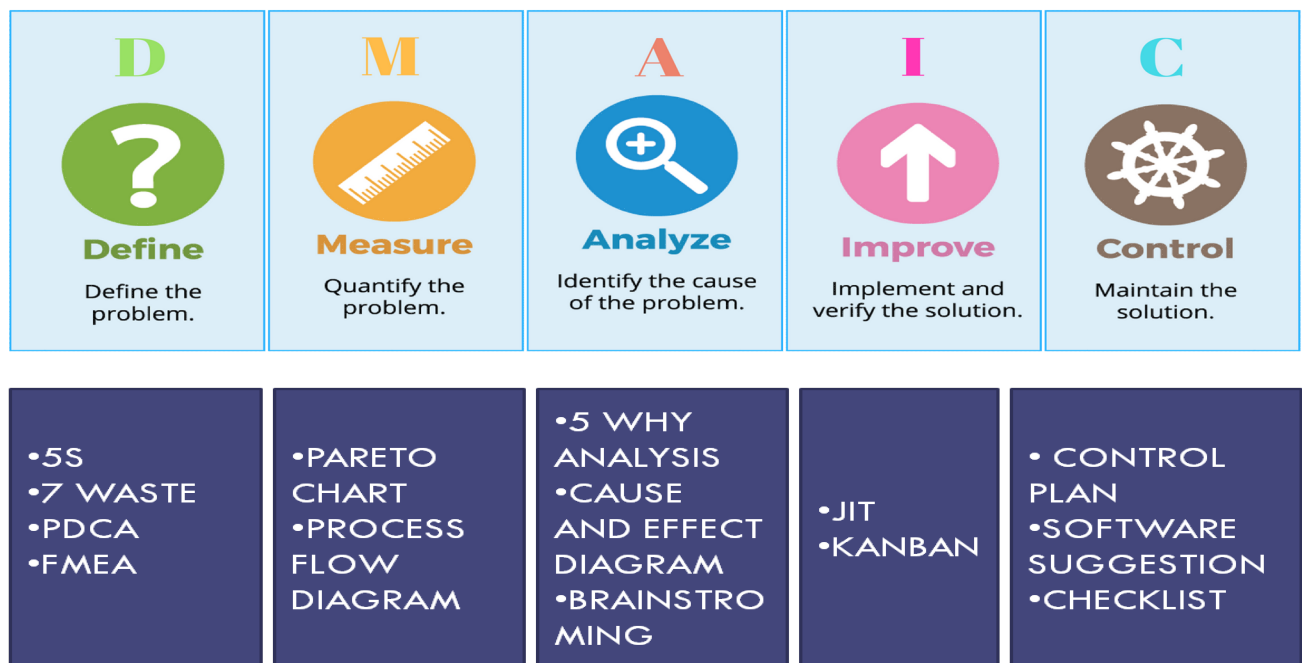


Fig 4.15 process of DMAIC

4.5.1. DG

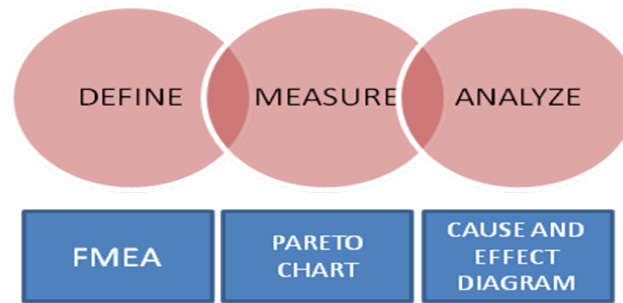


Fig 4.16 DG - DMAIC process

Table 4.4 FMEA for DG

Problems	S	O	R	E	F	G	H
dirt in filter	5	5	25	CERTAIN	1	25	
start stop key switch	3	2	6	LOW	4	24	
trip indication	3	3	9	MODERATE	3	27	
rain water entry in exhaust pipe	2	2	4	UNCERTAIN	5	20	
defect in pipe support	3	3	9	MODERATE	3	27	
loose cable connection	4	4	16	HIGH	2	32	
power leakage	3	4	12	HIGH	2	24	
earthing failure	2	3	6	LOW	4	24	
engine failure	1	2	2	UNCERTAIN	5	10	
battery failure	2	3	6	LOW	4	24	

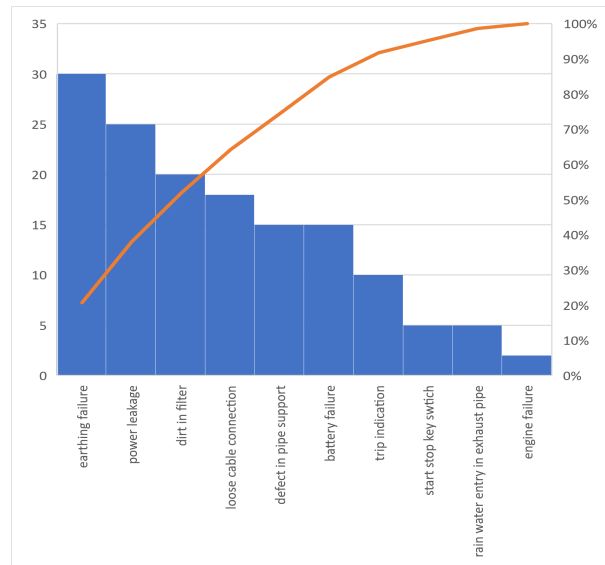


Fig 4.17 DG – pareto diagram

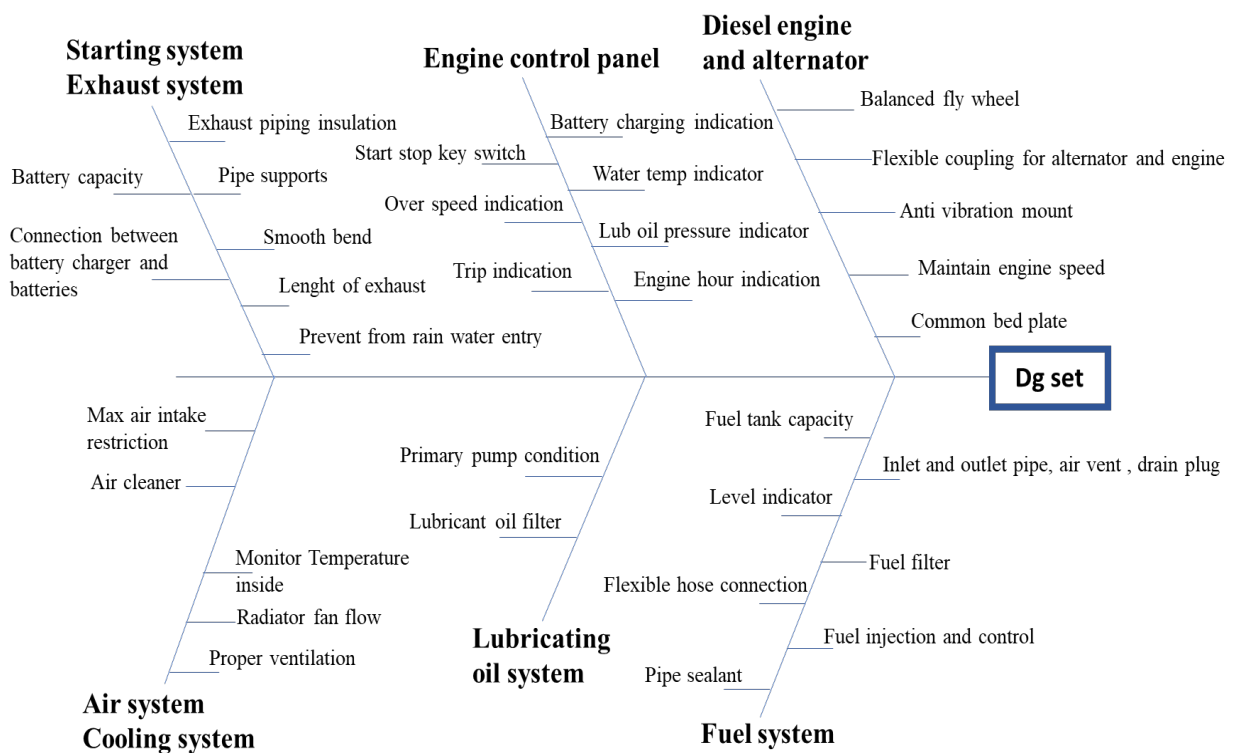


Fig 4.18 DG – analysis (cause and effect diagram 1)

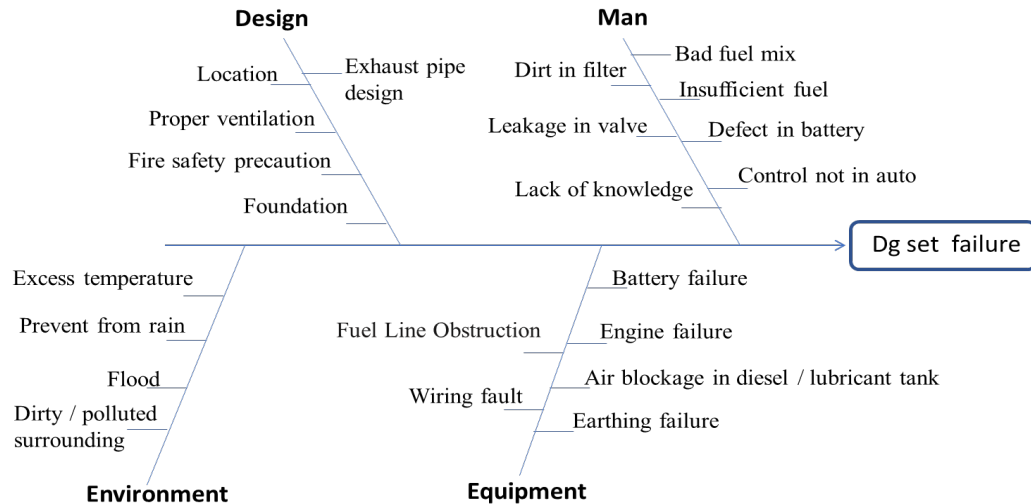


Fig 4.19 DG – analysis (cause and effect diagram 2)

4.5.2. LT panel

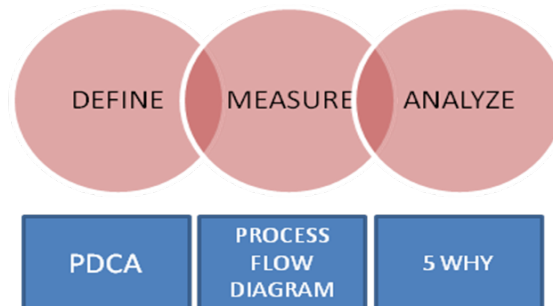


Fig 4.20 panels - DMAIC process

PDCA

- The Plan-do-check-act cycle is a four-step model for carrying out change. Just as a circle has no end, the PDCA cycle should be repeated again and again for [continuous improvement](#).
- The PDCA cycle is considered a [project planning tool](#).

PLAN	DO	CHECK	ACT
Compartment arrangement	• Circuit breaker compartment • Bus bar compartment • Instrument compartment	• Racking interlock • Close interlock • Close lock • Door interlock • Indication in compartment door	• Prevents machine failure due to sudden power cut • Continuous monitoring and checking
Planning /designing	• Foundation • Proper ventilation • Height • Material selection	• Ensure the panel installation checklist • Load check • Indoor ambient temperature • Material quality	• As per the installation guideline • Material must be in good quality
Cable connection	• Tightened bolt • Plan for cable entry and exist	• Loose or disconnected wires • Degradation of the cable sheath • Moisture in the insulation • Heating of cable	• Regular repair and maintenance • Fault indicator • Radar – know the velocity of the cable
Earthing	• Door earthing • Bus bar earthing	• Earthing switch in on position • Check the connection of bolts	• voltage regulation device • Fault indication

Fig 4.21 panels – pdca

Measure of panel

Using tool – process flow diagram

A Process Flow Diagram has multiple purposes:

- To document a process for better understanding, quality control and training of employees.
- To standardize a process for optimal efficiency and repeatability.
- To study a process for efficiency and improvement. It helps to show unnecessary steps, bottlenecks and other inefficiencies.
- To model a better process or create a brand-new process.
- To communicate and collaborate with diagrams that speak to various roles in the organization or outside of it.

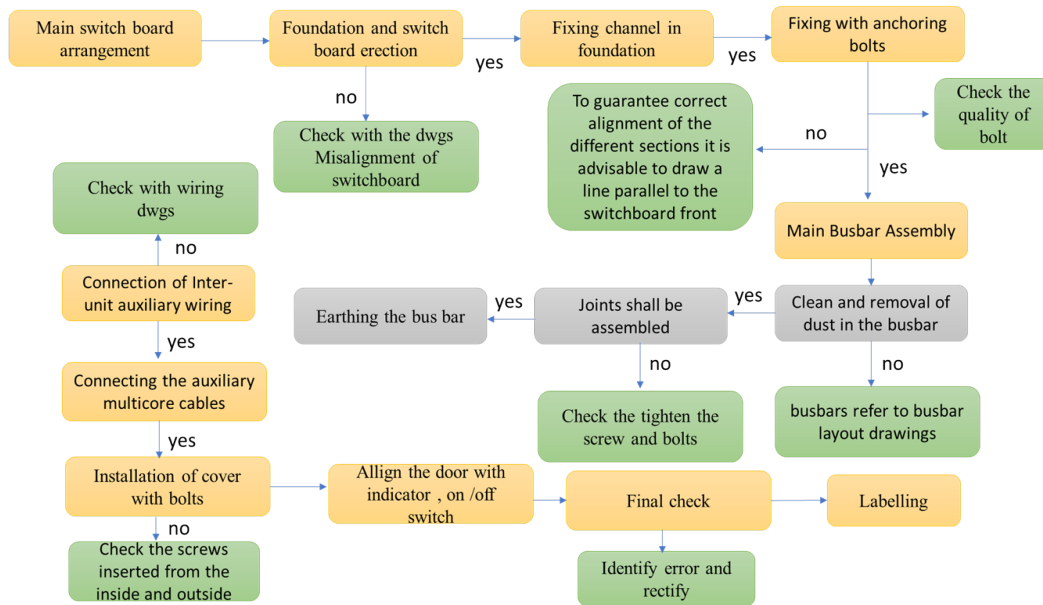


Fig 4.22 panels – process flow diagram

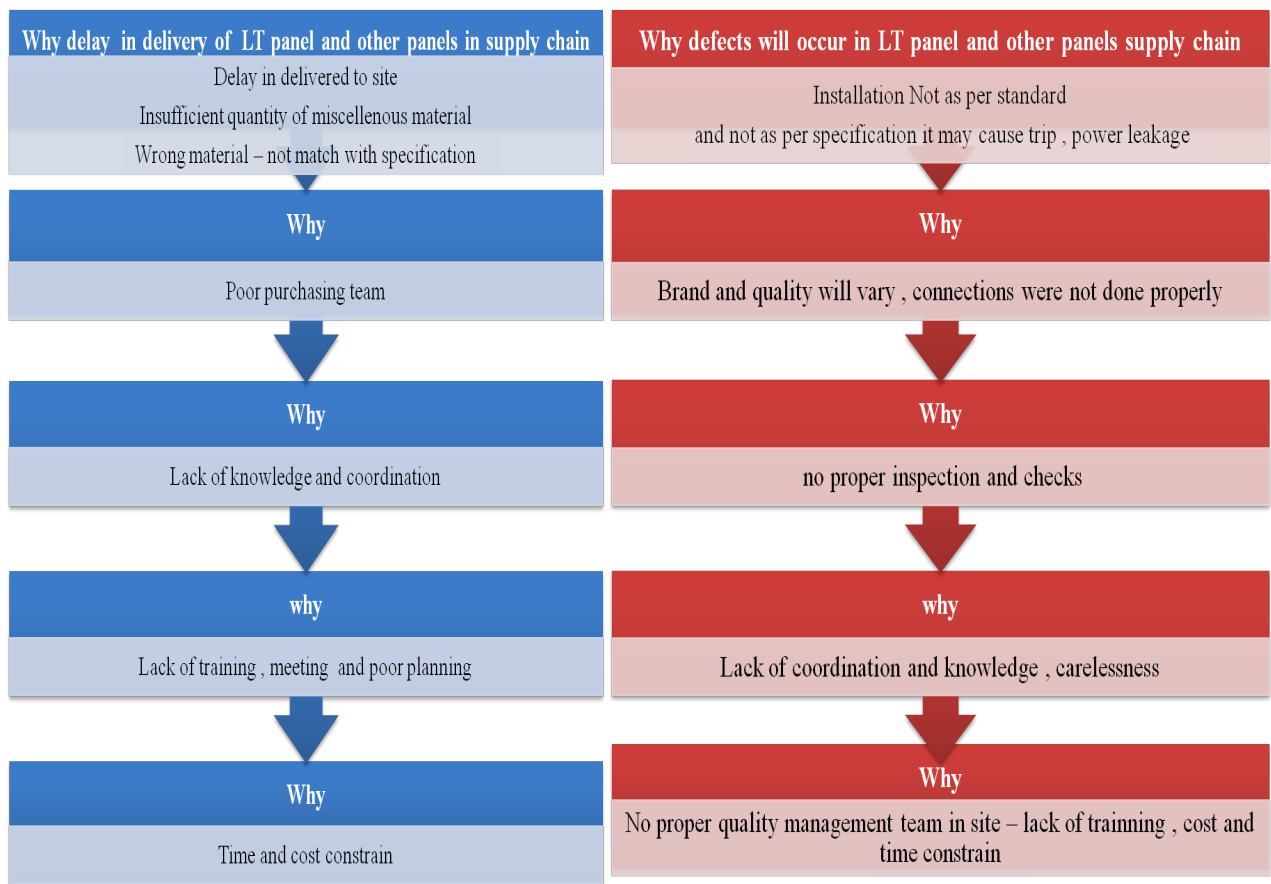


Fig 4.23 panels – 5 why analysis

4.5.3. bus bar

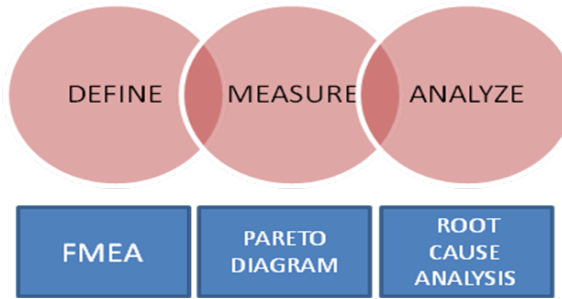


Fig 4.24 bus bar - DMAIC process

S.NO	Problems	S	O	R	E	F	G	H
1	Failure of insulation due to material deterioration	5	5	25	CERTAIN	1	25	Yellow
2	Failure of circuit breaker.	2	2	4	LOW	4	16	Green
3	earthing failure	3	3	9	MODERATE	3	27	Red
4	Flashover due to sustained excessive over voltages.	2	2	4	UNCERTAIN	5	20	Yellow
5	Errors in the operation and maintenance of switchgear.	3	3	9	MODERATE	3	27	Red
6	foreign object accidentally enter , moist , insects	4	4	16	HIGH	2	32	Red
7	power leakage	3	4	12	HIGH	2	24	Yellow
8	fire	1	3	3	LOW	4	12	Green
9	loss bolt ,no proper joints	4	2	8	MODERATE	3	24	Yellow
10	defect in clamps and supports	4	3	12	HIGH	2	24	Yellow

Fig 4.25 bus bar - FMEA

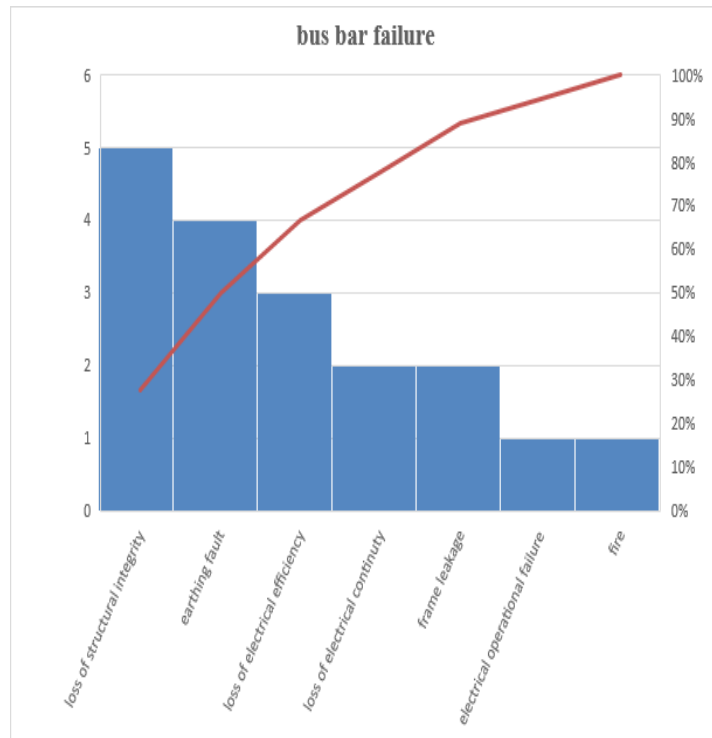


Fig 4.26 bus bar - pareto chart

Root cause analysis

Root cause analysis (RCA) is the process of discovering the root causes of problems in order to identify appropriate solutions. RCA assumes that it is much more effective to systematically prevent and solve for underlying issues

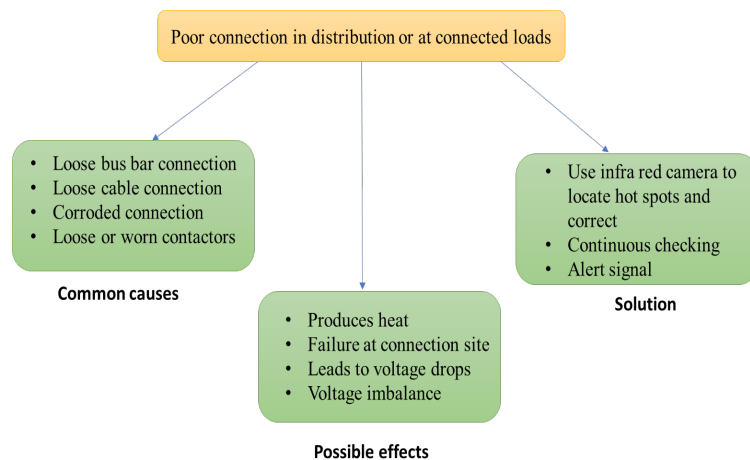


Fig 4.27 bus bar - root cause analysis

4.5.4. substation

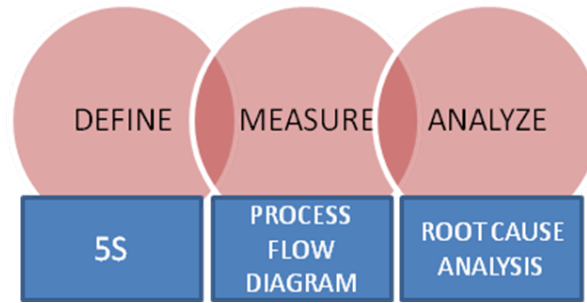


Fig 4.28 substation - DMAIC process

All elements are analyzed here according to the following criteria:

- 1) significance level - (the existing level and what activities have been taken?)
- 2) Note (Why is it important?) and
- 3) Problem solution (How to end problems and how to achieve the wished results?).



Fig 4.29 substation - 5s

Process Flow Diagrams (PFDs) are a graphical way of describing a process, its constituent tasks, and their sequence. A PFD helps with the brainstorming and communication of the process design. The [PFMEA](#) process needs a complete list of tasks that comprise the process under analysis. The level of detail can be decided by the team. Including more detail takes time, but it reduces the probability of missing Failure Modes.

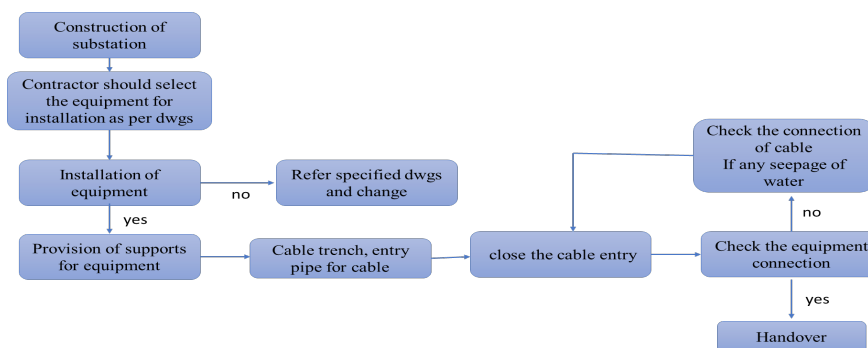


Table 4.5 5s tool for substation

Element	Level of significance	Risk elimination activities	Trouble shooting/ problem solving	Remark
sort	remove any excess and irrelevant elements	Mark critical points , fire safety precautions should be done properly	Unnecessary items are postponed or discarded. It reduces the waste of time looking for assets and parts.	Workplace productivity and quality are visible. Space, time, energy and money are better utilized.
set in order	place objects, machines and tools in the right place	After use, all the mentioned elements must be returned in order to avoid any risk. Easy to access and manage.	Prevents inventory loss, separate the correct from the defective products. Manipulating elements in the workplace is better.	Remaining production, elements that have no usable value and elements that are not part of the elements are eliminated.
shine	the worplace should be kept free and clean	Mandatory inspection of workplace after each activity performed.	Mark critical areas on which there could be undesirable occurrences/risks: dust, contaminated zone, water and oil leaks, inaccessible access to machinery	Tidy, clean, bright and controlled workplace provides proper training for workers.
standardize	Procedures for the operation, exploitation and maintenance of tools, equipment and machines are standardized	follow as per standards	The work surfaces must be clean, tidy and equipped with the most necessary materials, tools and machines. standards must be followed.	Elements quality, if any, are taken as the starting point.
sustain	Employees need to build up the habit of maintaining the workplace properly	Continuous improvement of working activities	Introduce discipline in the workplace by: preventing the accumulation of unnecessary items, returning tools and accessories to a defined location, cleaning work surfaces and dirty tools, monitoring machines during and after work.	Follow the stdard procedures with continuous training of employees in the workplace.

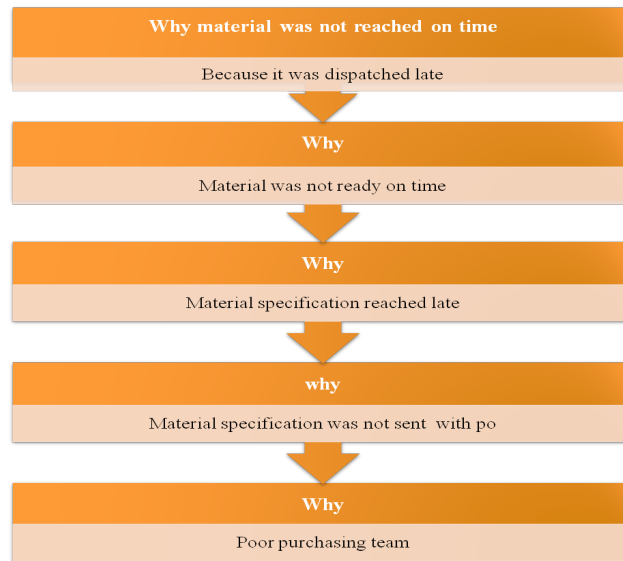


Fig 4.30 substation - 5 why analysis

4.5.5. Summary of analysis

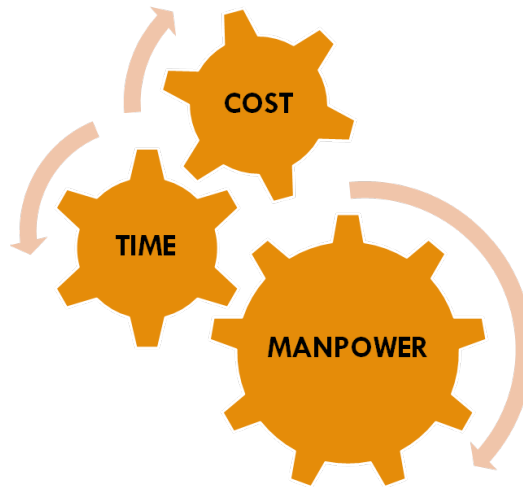


Fig 4.30 Three main categories

	TIME	COST	MANPOWER
DG	1) Delay in delivery 2) Changes were not updated properly (specification and dwgs)	1) Poor quality of materials and work 2) Increase in transportation cost	1) Damage while transportation 2) No skilled labour 3) Lack of communication
PANELS – LT,HT,DB	1) Delay in delivery 2) delay in placing order	1) Payment delay	1) Lack of communication 2) Poor coordination within stakeholders
BUS BAR	1) Poor planning 2) Changes were not updated properly (specification and dwgs)	1) Payment delay 2) Poor quality of materials and work	1) Damage while transportation 2) Lack of communication

Fig 4.31 summary for case study 1 – JIPMER campus

- Manpower – lack of communication is the major problem in case study 1 – JIPMER residence campus

	TIME	COST	MANPOWER
DG	1) Changes were not updated properly (specification and dwgs) 2) Lack of proper planning (uncertainty in schedule)	-	1) Damage while transportation 2) Poor coordination within stakeholders
PANELS – LT,HT,DB	1) Changes were not updated properly (specification and dwgs) 2) Delay in delivery	1) Payment delay 2) Poor quality of work / materials	1) Lack of communication 2) Lack of proper inspection
BUS BAR	-	1) Payment delay 2) Cost associated with material misplaced and not available when needed	1) Insufficient skilled labour

Fig 4.32 summary for case study 2 – HCL Madurai

- Time and cost are the major problem in case study 2 – HCL madurai

	TIME	COST	MANPOWER
DG	1) late delivery 2) Poor planning (cant meet the schedule)	1) More storage cost 2) Payment delay	1) Poor coordination within stakeholders
PANELS – LT,HT,DB	1) Delay in delivery(special items that might require more time to built) not as per schedule	1) Payment delay 2) Poor quality of material /work 3) Cost associated with material misplaced and not available when needed	1) Poor inspection 2) Poor planning (hard to unload – poor access)
BUS BAR	1) Specification are not clear (quantity were not match)	1) Poor quality of materials and work	1) Lack of communication 2) Poor inspection

Fig 4.33 summary for case study 3 – R & D block

- Cost is the major problem in case study 3 – R&D building

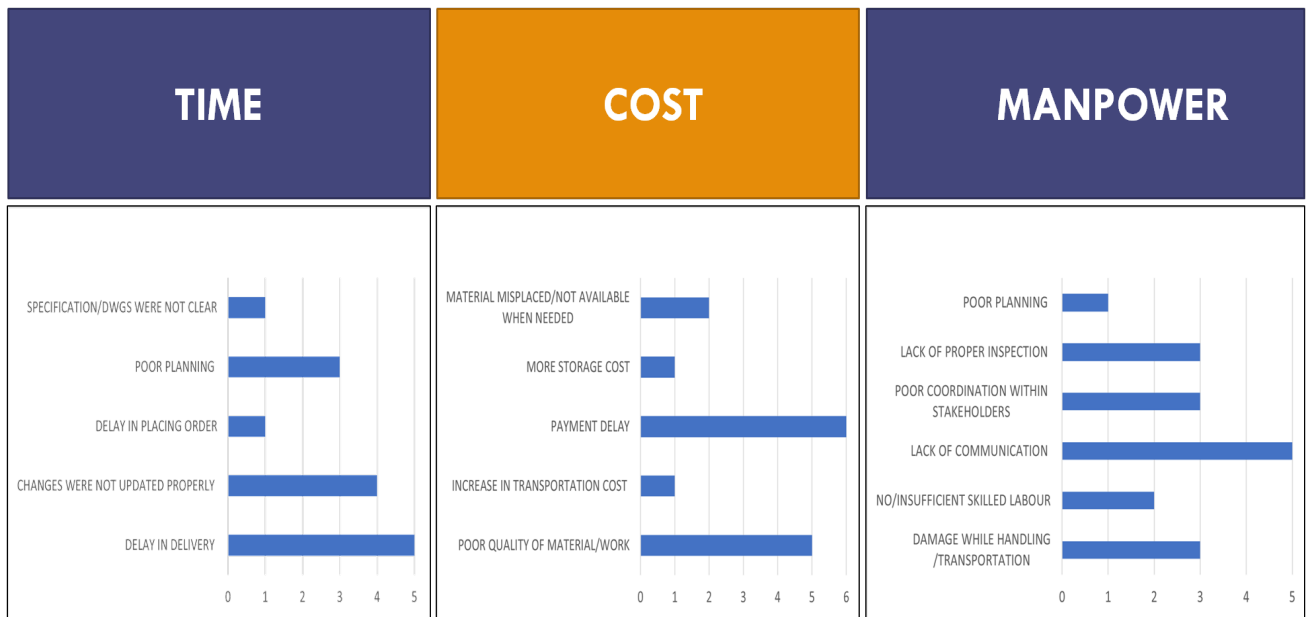


Fig 4.34 overall summary



Fig 4.35 improve tools

4.5.6. improve

communication plan

- A communication plan is a policy-driven approach to providing [stakeholders](#) with information.
- The plan formally defines who should be given specific information, when that information should be delivered and what communication [channels](#) will be used to deliver the information.

Table 4.6 communication tool 1

Activity	Stakeholders	Deliverables	Frequency	Owner	Priority	Preferred way to deliver	Notes and attachments
design/ planning /ordering	pm/electrical engineer /contractor /purchasing team	timeline updates, milestone review	as milestone have been completed	jipmer	medium priority - within 1-2 weeks of completing a milestone	email	include gantt shortand notes reasons for missed deadlines
execution	pm/electrical engineer /contractor	weekly status report	weekly - Monday @9am	jipmer	high priority - must provide weekly report	email/call	pm can help with special requests if needed
assembly / transportation	pm/electrical engineer /contractor /supplier	status update	weekly	jipmer	low priority - would like to be updated weekly but its flexible	in person meeting	mainly intrested in status of each task and timeline
execution	pm/electrical engineer /contractor	times review and updates	daily by EOD	jipmer	high priority	email	all team members are required to send updates by eod
inspection / execution /testing	pm/electrical engineer /contractor	list of blockers	as needed	jipmer	medium priority	team meeting	must meet with team when major blockers arise

Table 4.7 communication tool 2

DESCRIPTION	FREQUENCY	CHANNEL	AUDIENCE	ACTIVITY
project status updates	weekly	asana	all internal stakeholders and project team members	execution
virtual project team meeting	monthly	zoom /google meet	all project team members, stakeholders optional	execution
external stakeholders update	as needed	zoom /google meet	pm , project stakeholders	ordering , packing , transportation
milestone and deliverables updates	as needed	asana	project team	throughout scm
project checkins	daily	slack / mail	project team	throughout scm
outline client goals,establish budget & timeline, assign first milestone task	once / video coference	zoom /google meet	team members , key stakeholders and pm	project planning meeting
set daily goals, updated pm on milestone status	daily / in person	email	team members , pm	team touch base
summarize touch-bases outline achivements for the week and goals for the following week	weekly	email	team members , pm	team status report
summarize progress and next steps, updated timeline	bi weekly / weekly	zoom /google meet	pm , key stakeholders	stakeholder status report

Implementation plan

An implementation plan—also known as a strategic plan—outlines the steps your team should take when accomplishing a shared goal or objective. This plan combines strategy, process, and action and will include all parts of the project from scope to budget and beyond.

Benefits

- [Improved communication](#) between team members and key stakeholders
- Better organization and management of resources

- Increased accountability for everyone involved in the project
- More structured project timeline and daily workflow
- [Easier collaboration](#) between team members

How to develop an implementation plan

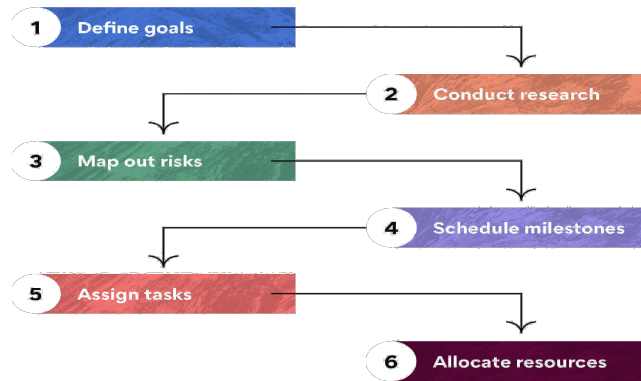


Fig 4.36 how to develop an implementation plan

Problems	Solution	Activities	Time to Implement	Responsible
specification / dwgs were not clear , changes were not updated	proper pre check should be needed , good communication within all stakeholders	design / planning	5days (planning stage)	architect / electrical engineer / pm
delay in ordering , no clear specs, dwgs	need proper coordination between stakeholders	ordering	continuous	pm / purchasing team
no proper check at factory , poor quality materials	proper inspection	assemble/ manufacture /factory test	5days (manufacture stage)	supplier /contractor
damage	need quality work	packing	1 day	supplier /contractor
damage while unloading	need proper resource planning	transportation	1 day	supplier /contractor
mishandling , mismatch with specs	proper training and inspection is needed	unloading /storage	weekly	pm/contractor / electrical engineer
not as per standards and dwgs	need proper training and inspection	installation	continuous	pm/contractor / electrical engineer
lack of inspection	need to follow TQM tools	on site test / inspection	1 day (testing)	pm/contractor / electrical engineer

Fig 4.37 implementation plan

Visual management

- Visual management is a form of communication used to give a snapshot of manufacturing operations.
- The goal of visual management is to translate shop floor processes and production statuses into easy-to-understand visual overviews.

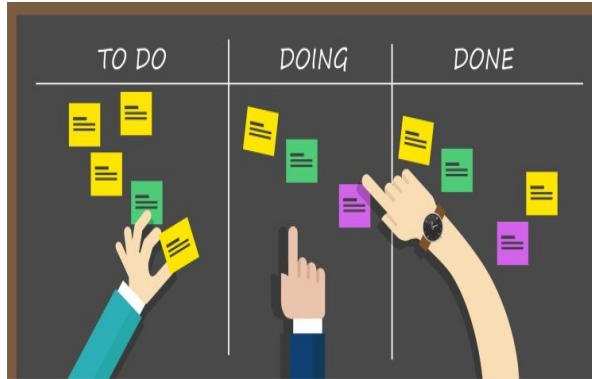


Fig 4.38 visual management

Benefits

- Improved process efficiency
- Reduced waste
- Safer workflows
- Inventory storage that matches production demands
- Higher team engagement

Big room meeting

- It allows teams to understand their impact across clusters or work groups. The Big Room also provides teams with the time to discuss project-wide concerns like budgets, hot topics, or global changes. The term Big Room refers more to the behaviors and actions of the team than the physical space

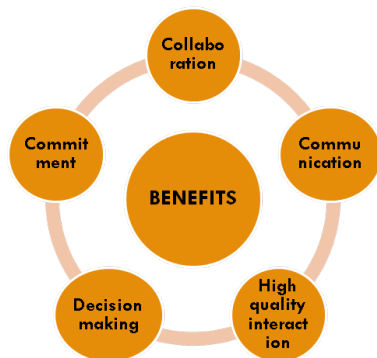


Fig 4.39 big room meeting

Kanban board

- The Kanban is usually used in the construction material procurement process by organizing orders, acting as a visual tool for the improvement of communication among all stakeholders, and insuring that the right amount of the right item is delivered at the right time.
- An effective Kanban system is more than just sticking post-its on a board. It is a mindset – a move towards productivity, organization, and eliminating waste through a steady flow of work.

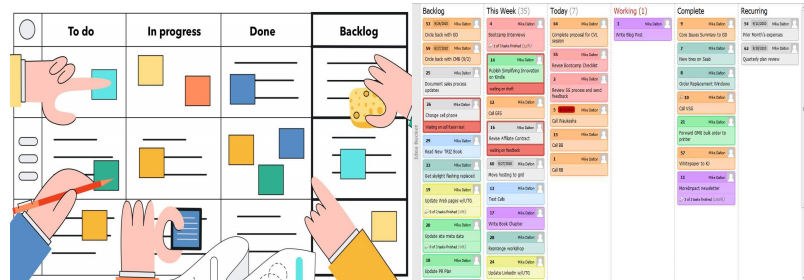


Fig 4.40 kanban board

Table 4.8 kanban board

To do	Doing	Done
PACKING	ASSEMBLE/ MANUFACTURING	DESIGN
TRANSPORTATION	FACTORY TESTING	PLANNING
UNLOADING / STORAGE		ORDERING
INSTALLATION		
ON SITE TESTING / INSPECTION		

Bottle neck analysis

- The bottleneck is in the Purchase Request Analysis sub-process, where more than 80% of purchasing time is consumed.
- It makes sense to invest time in the Purchase Request Analysis sub process as this would impact the quality of the purchase. However, that is not what buyers were doing.
- Study found that very little time was actually spent analyzing and designing a good purchasing strategy.
- Instead, purchase requests were being stuck precisely for the lack of analysis and the lack of a methodology that would help buyers get started in this process.
- When confronted with a backlog situation or with a project with a large number of items to purchase, buyers often have trouble figuring out the best way to approach such workload.

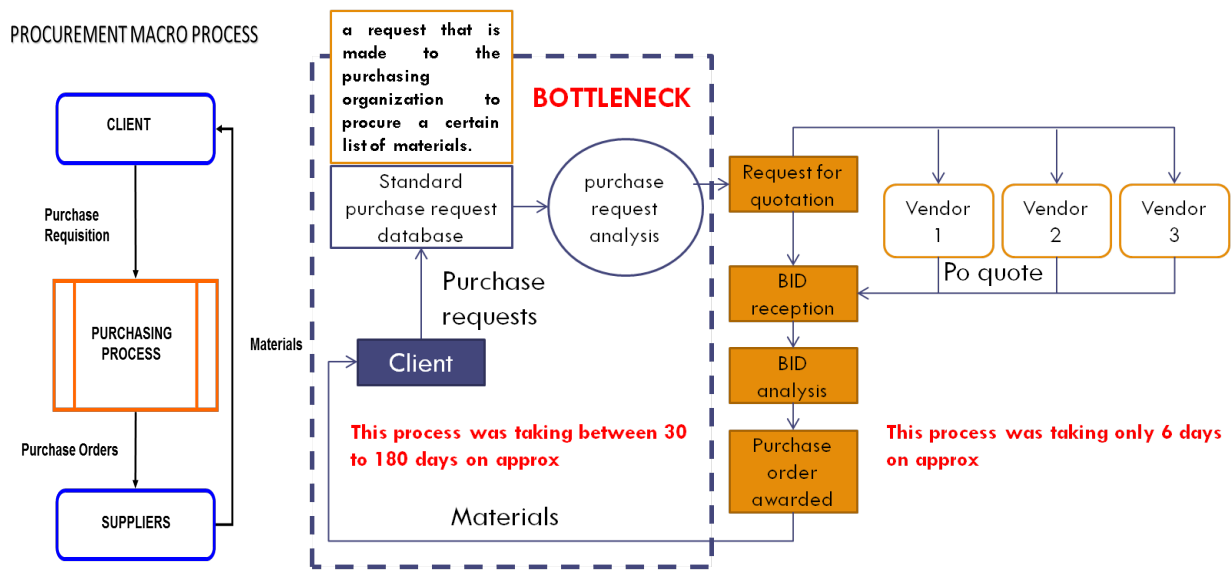


Fig 4.41 bottle neck analysis

Kaizen

- Kaizen is a Japanese term meaning "change for the better" or "continuous improvement."
- It is a Japanese business philosophy regarding the processes that continuously improve operations and involve all employees.
- Kaizen sees improvement in productivity as a gradual and methodical process.
- Lean or Kaizen in Construction is a production management-based approach to **project delivery to maximize value and minimize waste**.
- There are four key elements to Price Competitiveness:
- Material and Supplies
- Equipment
- Labor Productivity
- Overhead and Profit

Kaizen Newspaper

- A Kaizen newspaper is a document that speaks about the accomplishments till date. It contains a detailed account of what the objective is, what are the problems, who are responsible for solving the problems, the due dates and in what phase the Kaizen

Table 4.9 kaizen news paper

Task	Responsibility	Due	Status	Notes/Remarks
planning	pm, electrical engineer, consultant	6 days	completed	increase in time
ordering	pm, purchasing team, supplier	2 days	on process	delay in confirming

SIPOC

- SIPOC is another mapping tool used for analyzing Kaizen events in terms of Suppliers, Inputs, Process, Output and Customers. This cross-functional analysis helps in diagnosing work-flow problems which can be used for improving work procedures, eliminating zero-value activities and optimizing the process cycle time.

Table 4.10 SIPOC

SUPPLIER	INPUT	PROCESS	OUTPUT	COSTUMER

Kaizen or Lean tools have been applied in construction industry for many years now to improve quality, reduce costs and improve planning.

Various Kaizen tools used in construction are:

- The Last Planner System
- Target Costing
- A3 Problem Solving and Reporting
- PDCA
- Value Stream Mapping
- 5S (Sort, Straighten, Shine, Standardize, Sustain)

Value stream mapping

- Value stream mapping (VSM) is a tool used within the field of Project Management to visualize and improve the overall flow process of a product or service from raw material all the way to the customer.

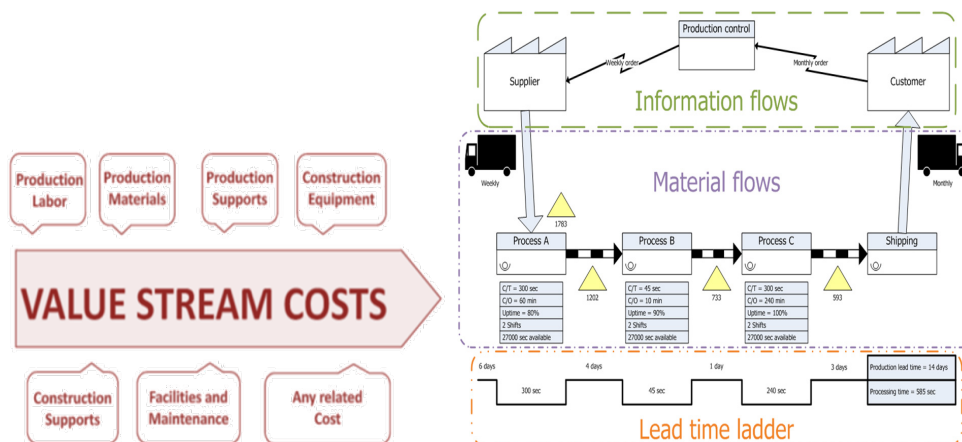


Fig 4.42 value stream mapping

Just In Time (JIT)

- Just In Time (JIT) inventory management is a lean methodology specially created for increasing organizational efficiency, decreasing unnecessary expenses related to inventory wastage and ensuring that goods are received only as and when needed.

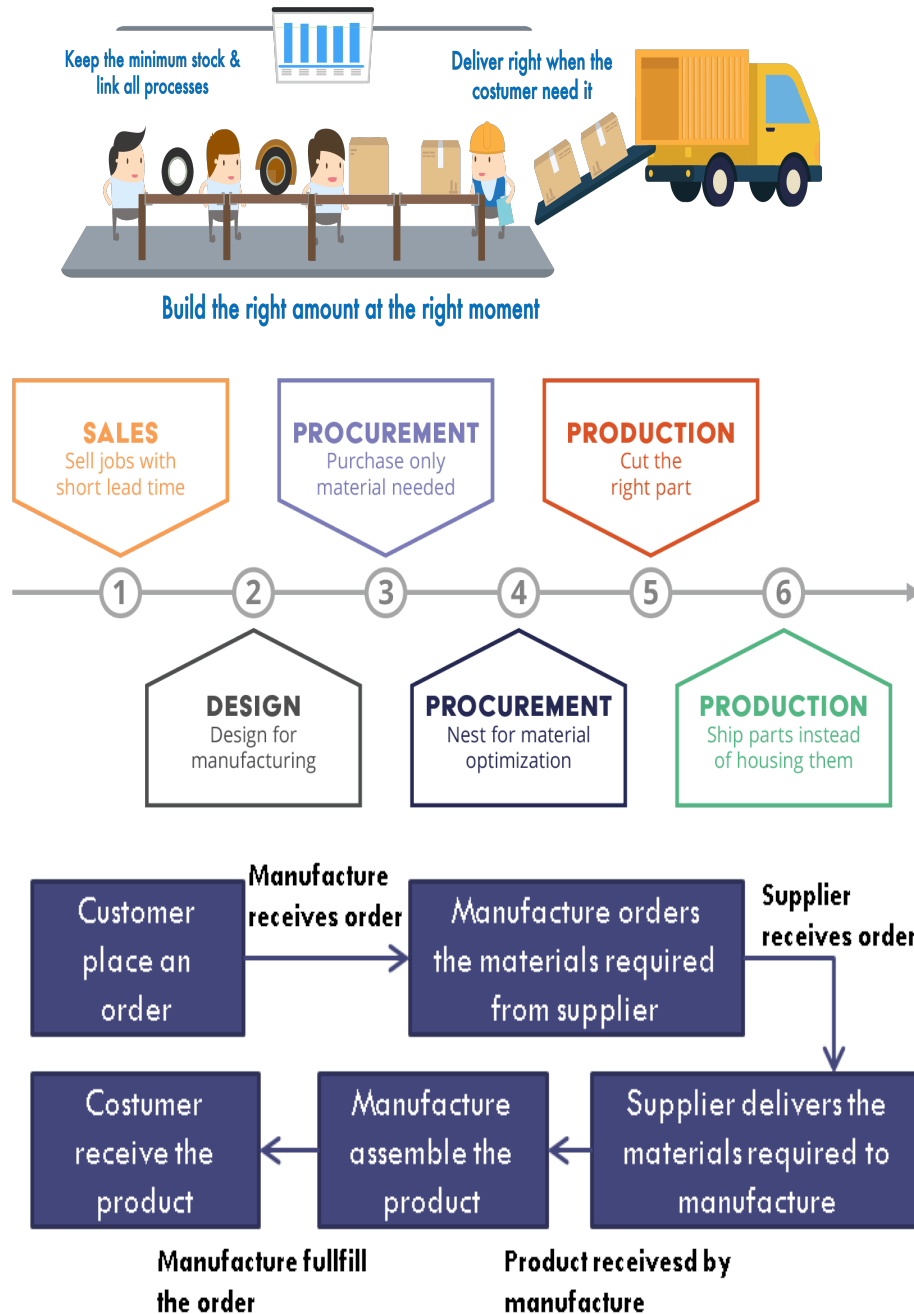


Fig 4.43 just in time (JIT)

4.5.7. control

4.5.7.1. Checklist

Table 4.11 checklist for DG

DG CHECKLIST					
ITEM	STATUS	REMARK			
Dg location and foundation			Cooling system		Electrical control panel and cable size and connection
Foundation , installation , space requirement details as per dwg			Remote radiator in primary circuit model		Required cable sizes for power cable with suitable glands
Is the site selection done which is away from dust /acid / chemical / fibers			Free space around it and platform mounting as per dwg		Check for requirement of local isolator panel at alternator end
Foundation size			Coolant specification		Auxiliary power supply for illumination in enclosure
Free space around dg			Raw water plumbing , valve,temp and pressure gauges		Auxiliary power supply for battery charger
Dg location open area or covered in shed			Structure and location of expansion tank		Auxiliary power supply for space heater
If the dg is located in covered area provide sufficient space between the air duct out and shed to facilitate air venting			Interlocking remote cooler with dg shut down		
Wind direction in line with acoustic encloser air flow. Wind barrier if required			Mcc panel required for dg auxiliaries like cooling tower,battery charger		Earthing
Exhaust piping			Flexible bellow / joint required to connect raw water lines		Earthing 4 pits — 2 for genset and 2 for neutral
Pipe Termination as per cpwd guideline			Water circulation pump selection		Breather pipe
Rain water entry protection			Cooling tower model		Breather hose should be extended out of the acoustic so that they oil from fumes don't get deposited on radiator /engine skin
Sealing of the exhaust pipe must be properly sealed			Free space around it, platform for mounting as per dwg		
Thermal insulation of the exhaust ducting			Fuel system		
Condensate drain valve to provided in exhaust ducting after silencer area			Disel engine driven generator set are generally designed to operate on astmd975 number 2 disel and shall meet the requirement of high speed diesel as per is 1460:2005		
			Tank capacity		
			Supply and return pipe , engine with flexible valve		
			Fuel system		

Table 4.12 checklist for LT panel

LT PANEL					
ITEM	STATUS	REMARKS			
Ensure the panel is thoroughly cleaned and no dust, loose screws etc present. All the covers are in place.			Check and record clearances, acceptable limits are:		Check all doors open and close properly. Door earthing provided.
Ensure that enough padlocks are available at site to lock all the feeders.			Behind the panel: < 200mm or >750mm for MCCB feeders, and > 900mm for ACB feeders.		Check all the components in the feeders are firmly fixed and labelled.
Ensure Mechanical interlock keys are provided.			Front of the panel: 1.2 mtrs		Panel is cleaned thoroughly, bolted covers have all the bolts tightened.
Ensure all cables are meggered.			Sides: 750mm		Bus bars are tightened with Torque wrench and marked with paint. Record torque values on a separate sheet.
Check the control supply is provided as per drawing. Measure the voltage.			Gland plate is firmly secured and all the bolts are in place. Gland plate is earthed.		Cable terminations are tightened with torque wrench and marked with paint. Record torque values on a separate sheet.
Switch on control supply and check:			All the glands are earthed.		Internal wiring is properly bunched and clamped, ferrules provided.
1. All the indicating lights are glowing,			Visually check for bruises / damages. Apply touch up paint on scratches.		Padlocking arrangement provided on all feeders.
2. Switch on and switch off breakers.			Panel is earthed properly at two points. Check tightness of the joint of the earth flat and earth terminal. The joint is tension-free.		Operate all the breakers, selector switches etc to check for proper operation.
3. Interlocks work properly.			Internal earthing connected to earthing bus.		
Make sure that the Panel Room GA drawing, shop drawings, factory test certificate are available at site.			Check the levelling of panel with spirit level.		
Ensure all the meters are calibrated and certificates available at site. Check with a calibrated hand held true RMS meter few random readings.			All the feeders have name plates on the doors. All cables are tagged. Cable and Bus chambers have labels.		
All the feeders confirms to SLD and GA shop drawing.					
Panel is placed as per room GA drawing.					

Table 4.13 checklist for bus bar and substation

ITEM	STATUS	REMARKS
Check tag #, voltage & current rating to drawing & data sheets		
Inspect entire assemble for damage or missing parts		
Check busbar insulators for damage or missing parts		
Check all busbar joints are bolted with high-tensile bolts		
Check all busbar are insulated and joints taped		
Weather proof & fire wall seals are installed		
Entire length of busduct is earthed by visible earth strap		
No openings in busduct section joints		
Space heaters checked & installed as per design		
Check megger test & phasing of busbars		
Check high potential test & record readings		
Final check inside busduct prior to closing		
Check busduct sufficiently supported		
Inspect assembly, tightness, levels, etc.		
Inspect all bus-bars and bolted electrical connection.		
All braces and supports adequate to handle of bus duct.		
Wall opening covered properly with fire resistance materials.		
Inspect all safety features.		
Check Control voltage		
Check circuit number and color code		
Inspect cables and glands		

SUBSTATION		
ITEM	STATUS	REMARKS
Location		
Opening		
Ventilation		
partitions up to the ceiling level		
Height		
Cable entry		
Turning radius of cable		
Prevent from storm water entering		
Floor level of substation		
Coordinate with stp and plumbing water tank		
Flooding consideration		
adequately drained in cable trenches		
Earthing		
Trenches and trench covers		
Fencing height		
sufficient safety signs		
precautions to minimize the risk of fire associated with the equipment		
name and emergency telephone number of the authorized personnel shall also be displayed at the substation		
instructions covering schematic diagram; requirements of switchgear interlocking		

4.5.7.2. software suggestion

Features of Supply Chain Mangement Software		ADVANTAGES OF SUPPLY CHAIN MANAGEMENT	
#1	Inventory Management	01	Reduced Costs and Wastages
#2	Order Management	02	Increased Production Efficiency
#3	Billing Systems	03	Improved Process Reliability
#4	Warehouse Management	04	Quicker Forecasting
#5	Shipping and Tracking System	05	Enhanced Collaboration
#6	Forecasting System	06	Better Tracking, Collection, and Analysis of Data
#7	Real-Time Analytics and Reporting Dashboard	07	Stringent Quality Maintenance and Control
#8	Third-Party Integrations	08	Stronger Relationship Building (suppliers, developers)
#9	Supplier/Vendor Management Toolkit	09	Unmatched Customer Experience
#10	Analytics and Reporting Dashboard	10	Reduced Supplier Risk
#11	Customer Request/Return Management	11	Superior Inventory, Warehouse Management

Fig 4.45 software features and advantage

1- ZOHO CREATOR , INVENTORY, FLOW, ANALYTICS (manage inventory, monitor operations, optimize your supply chains, vendor relationships)

Optimize inventory

- Inventory management is a distributor's biggest pain point.
- In this supply chain app lets us maintain control over every unit of stock in your warehouses, without the need for an outdated clipboard accounting system.
- Add and update inventory details such as purchases, sales, and products sold on the go.
- Keep track of distributed stock, and schedule notifications about low stock levels.

Accelerate inter-warehouse stock transfers

- Track the movement of goods with multi-warehouse inventory management.
- Set priorities at the product level, route orders based on available stock and generate reports for specific warehouses in seconds.
- Don't let tedious middleman communication delay your shipments.

Consolidate your contacts

- Maintain an online contact database to manage relationships with vendors, retailers, and contract manufacturers across your supply chain.

- Manage retailer details such as names, contact numbers, and email addresses, and easily access them using search filters, like location or shipment history.

Fast-track order handling

- Establish a smooth process flow, from issuing a sales quote to fulfilling an order.
- Track order statuses across the value chain with the help of unique IDs.
- With workflow automation and cross-channel integrations for end-to-end order fulfillment
- it can save time and boost overall productivity across the board.

Monitor sales operations

- Always be in the know with a centralized hub to monitor and regulate your sales channels.
- Record details of every sale without hassle.
- And retailers can view sales records and invoice amounts for any transaction, as well as the amount receivable and existing balances.

Simplify bookkeeping

- Automate payment workflows and standardize accounting throughout the supply chain.
- Generate invoices automatically for every transaction with customers and suppliers, and email them with a single click.
- Easily record the billed amount, paid amount, credits, and the payment type, whether receivable or payable.

Go mobile

- For every app you access on your computer, there's a fully optimized native one waiting for you on your smart phone.

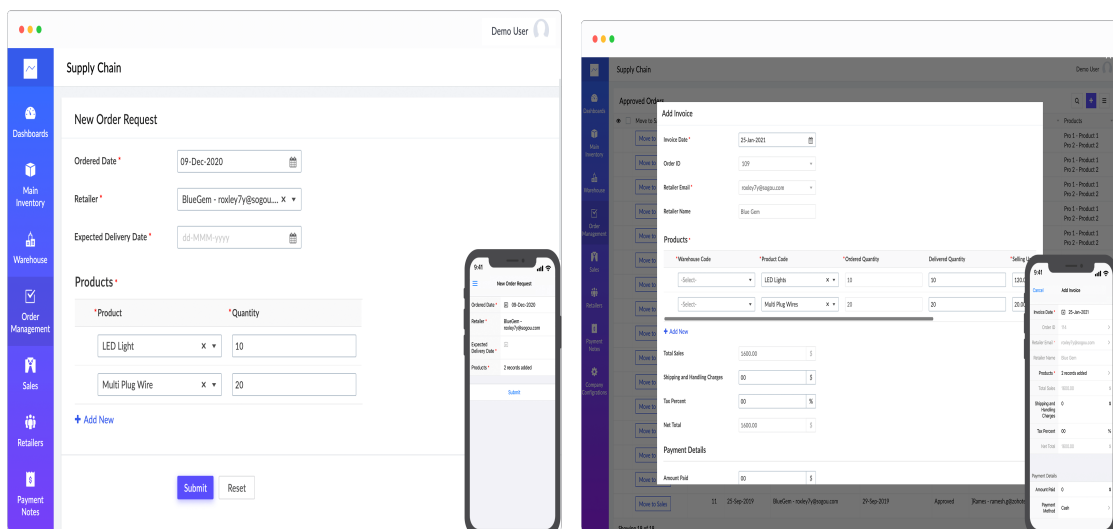


Fig 4.46 software 1

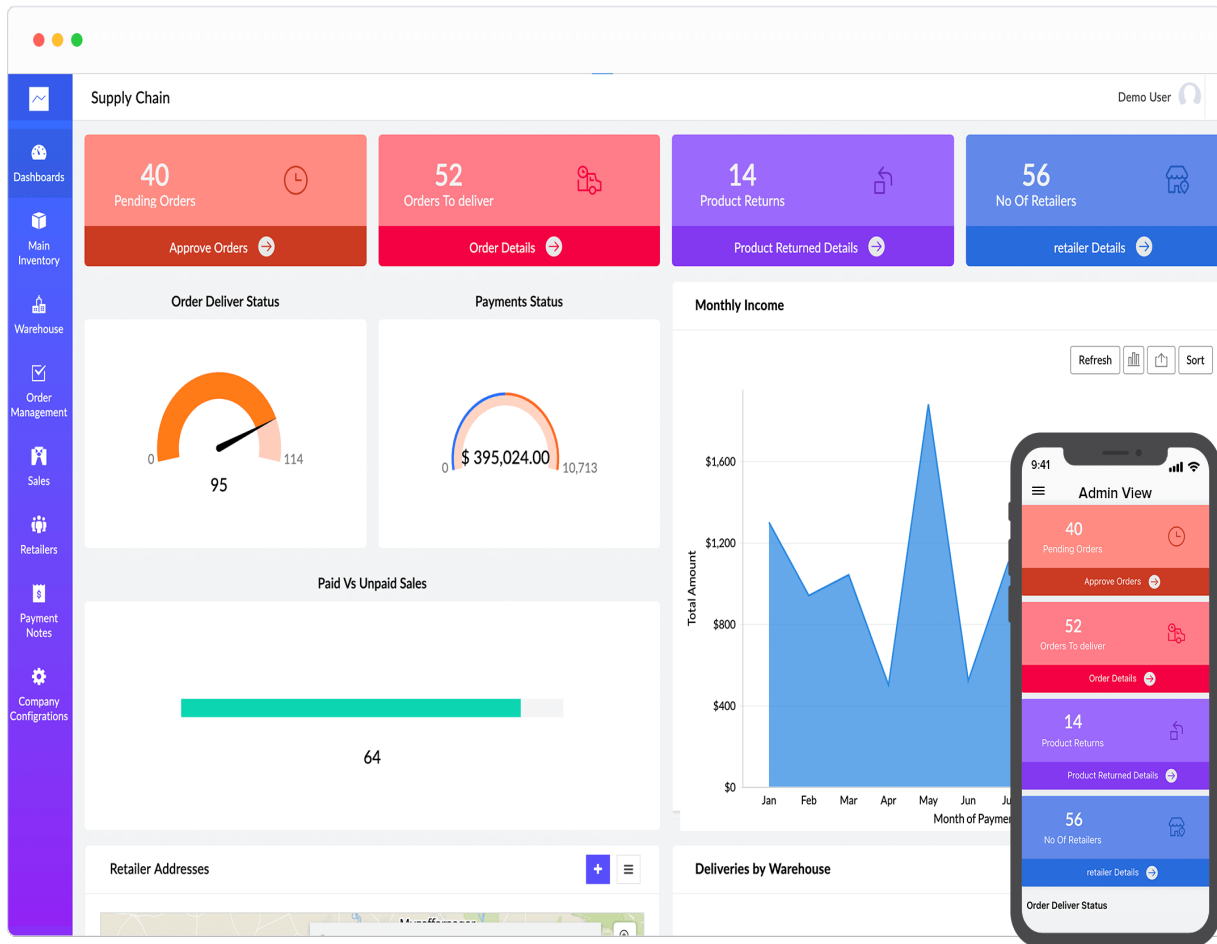


Fig 4.47 software 1 dashboard

2 - NOVADE LITE

(all in one – improve stakeholder coordination , checklist , changes were updated easliy)

Good bye to

- Communication breakdowns
- Costly delays, avoidable rework, quality issues and critical safety issues from outdated drawings
- Lugging around hard copies of drawings on-site
- **One Platform** – access, upload, view and share the latest project drawings such as site maps, floor plans or designs from anywhere
- **Real-time Visibility** – update drawings in real-time to keep everyone on the same page
- **Precise Location** – attach drawings or pin them to Tasks and Forms and mark them up to easily locate them on site

Access

- Ensure you always have the latest drawings in the palm of your hand

Location Pinpoint

- Locate Tasks and Forms accurately on a drawing

Organise

- Organise folders so you always have the right document at the right time

Portable

- Access all your project drawings from any mobile device on or off the field

Reduce rework costs

- Reduce rectification costs from miscommunication
- outdated drawings, and save time hunting for the latest drawings

Communicate and collaborate

- Work as one team with teammates, suppliers, subcontractors and even clients with everyone working on the latest drawings: Get everyone working on the same channel – No more texts, group chats or emails

Work with precision

- Build confidently with detailed drawings – pin relevant tasks and forms in exact locations
- Easy and intuitive – create, assign, schedule and prioritise tasks with ease
- Rich content – to add photos, documents, drawings, comments
- One place for all jobsite tasks – makes it easy to hit your deadlines, streamline workflows, and schedule resources to reduce downtime and bottlenecks

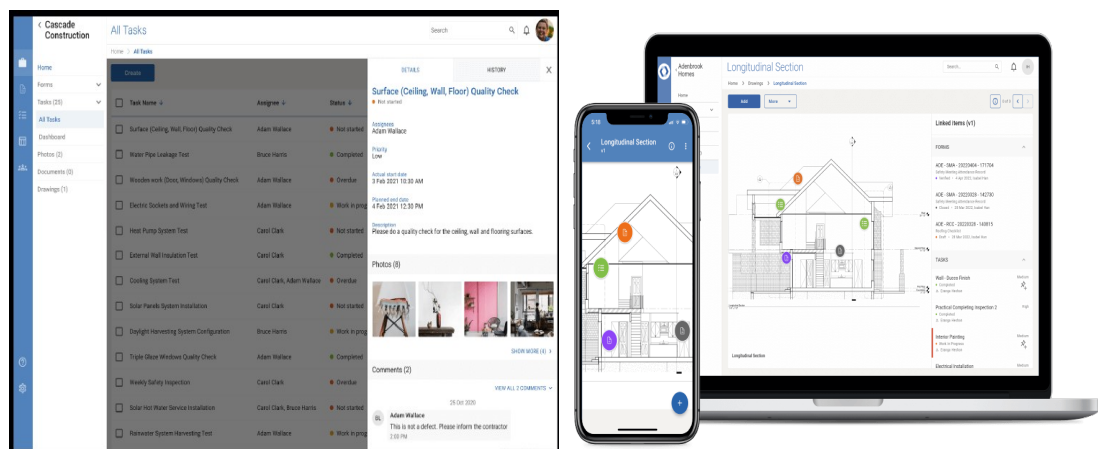


Fig 4.48 software 2

- Tasks Dashboards – allow you to monitor trends, improve productivity and reporting, streamline workflows
- Insights – across all your jobsites for effective project and task management
- Keep track of project status
- Get an accurate picture of what's happening in the field with real-time task updates on one construction job management tool

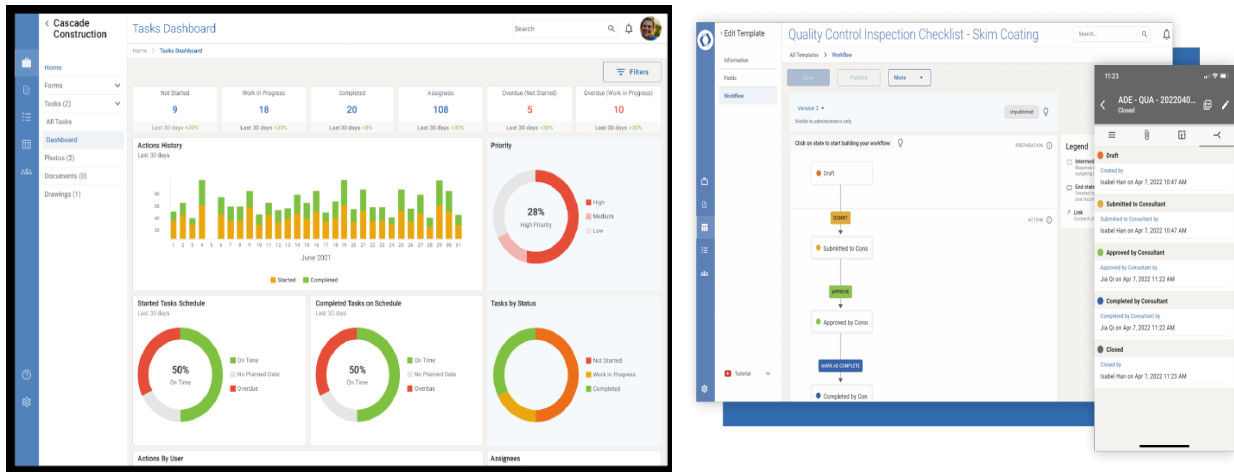


Fig 4.49 software 2 – dashboard

Checklist

- Capture all your inspection data easily from any mobile device
- Simplify all your inspections with a snap – speed up approvals when you annotate your inspection forms with photos



QA

"Makes conducting Building Control inspections so much easier – I'm able to capture data with my phone and even annotate photos with additional information."



Construction & Site Managers

"Digital sign-offs saves me so much time"

"All my forms are stored and filed in the construction app. Fast and easy digital sign-offs on my mobile device saves me so much administration time. We are able to manage quality and safety of subcontracted labour with everyone on the same construction management software."



Construction Project Managers

"I'm able to reduce downtime because I have full visibility of everyone's tasks and job progress, changes in our supply chain and deliveries – all in real time with one single construction job management app."



Project Managers

"I have full visibility on the team's tasks"

"I'm better able to control scheduling and dependencies because I have visibility on tasks and changes in deliveries. I'm also able to keep track of daily reports, logs and all project information in one single construction app."

CHAPTER 5 CONCLUSION

- Efficient material management is crucial for the success of any construction project and can be the deciding factor between a successful project and a project full of delays and claims.
- Better material management methods and decision models are needed to improve the electrical contractor's current practices, thus increasing efficiency and minimizing costs.
- An effective material management system is essential to avoid material shortages, misplacements, loss, and theft which might result in increases in crew idle times, loss of productivity and delay of activities.
- Electrical contractors should implement an efficient material management system due to the fact that in most of the cases they are asked to squeeze their bids in order to keep the costs of project under budget. In such a case, failures to effectively manage materials could result in decreases in profit or even a loss.
- The primary goal is to have the material needed, in the amounts needed, with the quality required, and the time that they are needed. Most electrical contracting companies have a material management system that serves their needs, although it could be improved.
- A fully integrated approach will better improve communication and minimize gaps in information flow among all the parties and departments involved.
- for this using two live case study and questionnaire survey while this gather data about supply chain and total quality management in electrical services , it gave the clear picture about SCM and TQM
- and then collected data are analysed through quality tools with the help of DMAIC for shortlisted three main equipment like DG, PANELS (LT,HT,LV,DB), BUS BAR .

- concluded collected data through three major constrain such as – cost , time, manpower according to this checklist and software suggestion to improve the SCM in TQM
- Standardization of the material management system could be a step forward in improving the system and eliminating some of the bottlenecks.
- The research presented in this document aimed at designing an integrated system of decision- support tools and SPARCS for material procurement for the electrical contractor.
- An integrated approach for material procurement provides better decisions on what to order, how much to order , where to deliver and quality of the order

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