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# Application of Supply Chain Tools for Improvement in Construction Material Management

Prathamesh Vijayrao Kale, Pranav Lende

PG Student, Department of Civil Engineering, G. H. Rasoni University, Amravati, India

Professor, Department of Civil Engineering, G. H. Rasoni University, Amravati, India

**ABSTRACT:** The generic methodology offered by SCM contributes to better understanding and resolution of basic problems in construction supply chains, and gives directions for construction supply chain development. Supply chain management (SCM) is a concept that has flourished in manufacturing, originating from Just-In-Time (JIT) production and logistics. Today, SCM represents an autonomous managerial concept, although still largely dominated by logistics. Previous initiatives to advance the construction supply chain have been somewhat partial. The practical solutions offered by SCM, however, have to be developed in construction practice itself, taking into account the specific characteristics and local conditions of construction supply chains. Construction supply chain management's potential for contributing to profitability. Construction supply chain has gained significance because of the increasing number of potential complex private and public sector construction projects. In the construction process costly delays in materials, equipment's, and services erode profits. Construction supply chain management through the integration and coordination of materials, information, and money flows between the various project partners resolves delays and offers a new means of increasing profitability. CSCM's emphasis on information sharing and communications fosters cooperation and collaboration among supply chain members. This study on assessment of supply Chain Management (SCM) in improving material management in the Indian Construction Industry in Pune district is focused on identifying the challenges of construction supply chain management (CSCM) for effective project delivery and also to identify the CSCM practiced in curtailing challenges in the construction industry in Pune.

**KEYWORDS:** CSCM, Construction Supply chain management, material supply, profitability, under-budget

## I. INTRODUCTION

### 1.1 GENERAL:

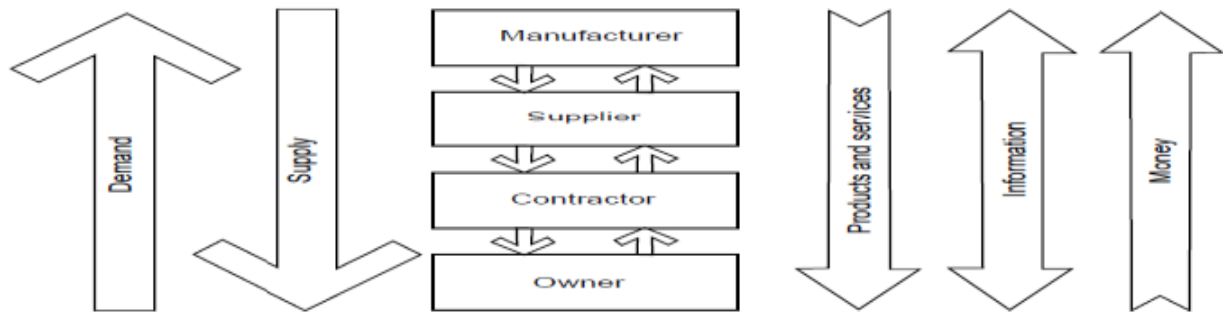
The construction of bridges, highways, schools, housing developments, hospitals, apartment buildings, manufacturing facilities, and levies has led to an explosion in construction knowledge. Supply Chain Management can be defined as the management of flow of products and services, which begins from the origin of products and ends at the product's consumption. It also comprises movement and storage of raw materials that are involved in work in progress, inventory and fully furnished goods. The main objective of supply chain management is to monitor and relate production, distribution, and shipment of products and services. This can be done by companies with a very good and tight hold over internal inventories, production, distribution, internal productions and sales.

#### 1.1.1 Background:

Supply chain management (SCM) is a concept originating from the supply system by which Toyota was seen to coordinate its supplies, and manage its suppliers (Womack et al. 1990). In terms of lean production, SCM is closely related to lean supply (Lamming 1996). The basic concept of SCM includes tools like Just-In-Time delivery (JIT) and logistics Management. The current concept of SCM is somewhat broader but still largely dominated by logistics. Until now, in construction, initiatives belonging to the domain of SCM have been rather Partial covering a subset of issues (e.g., transportation costs) in a limited part of the construction supply chain (e.g., the construction site). In most cases, the issues are regarded from a main contractor's point of view (e.g., Asplund and Danielson 1991, Wegelius- Lehtonen et al. 1996).

### 1.1.2 What is supply chain? What is supply chain management?

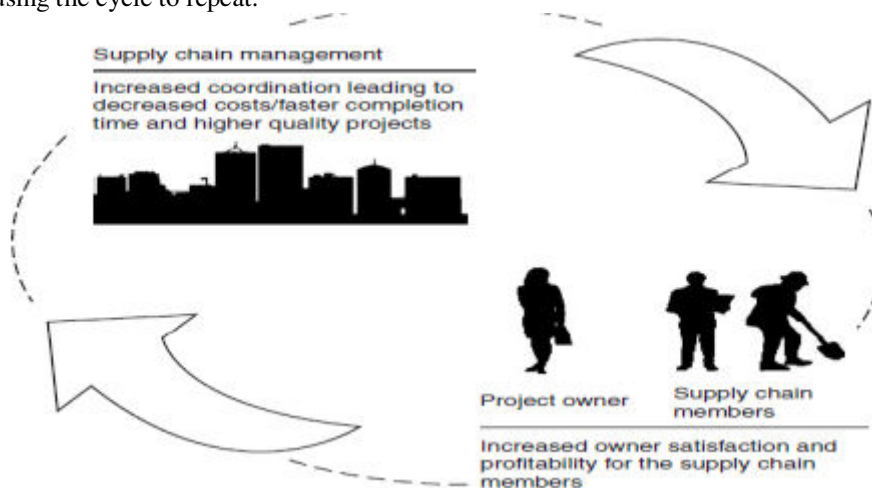
The term “supply chain” refers to a series of interdependent steps of activities or processes (sometimes sequential and sometimes overlapping) as well as flows between them, supported by infrastructure (people, equipment, buildings, software, etc.) [e.g., Simchi-Levi et al. 2007; Fine and Whitney 1996]. These flows express real or forecast customer demand going in one direction, and supply going in the other direction in order to fulfil that demand. Figure 1.1 outlines the general directions of these flows.



**Figure 1.2:** shows examples of supply & demand with flow of product/services, information & money in supply chain (Philip kamensky, Glenn barad, iris D. Tommenlion)

Supply chain management is the combination of art and science that goes into improving the way your company finds the raw components it needs to make a product or service, manufactures that product or service and delivers it to customers.

The satisfied project owner in turn rewards the supply chain with loyal contracting power, allowing profitability to be transferred back down throughout the supply chain. This in turn fosters further supply chain integration and responsiveness, causing the cycle to repeat.



**Figure 1.3:** shows circular benefits of construction supply chain management (W.C. Benton, Jr. & Linda F. Mchenry)

### 1.1.3 Benefits of using Supply Chain Management-

Following are the major advantages of supply chain. The key benefits of supply chain management are as follows:

1. Develops better customer relationship and service.
2. Creates better delivery mechanisms for products and services in demand with minimum delay.
3. Improves productivity and business functions.
4. Minimizes warehouse and transportation costs.
5. Minimizes direct and indirect costs.
6. Assists in achieving shipping of right products to the right place at the right time

**1.2 MATERIALS MANAGEMENT** can be defined as a system responsible for the planning and controlling the flow of materials. It defines materials management as a system for planning and controlling to ensure the right quality and quantity of material and equipment are specified in a timely manner. Materials Management is a key business function that is responsible for co-ordination of planning, sourcing, purchasing, moving, storing and controlling materials in an optimum manner so as to provide a pre-decided service to the customer at a minimum cost. Materials management comprises of series of processes of which a storage management is part. These processes include planning, purchasing, logistics, handle and stock and waste control.

### 1.3 SITE STORAGE

As storage being the first step in material management and failure to accommodate materials result in poor productivity and waste. Effective site and space utilization is a fundamental to material management. Materials stored on site can either be small or valuable and large or bulk storage item. All these items have the means of storing them on site. Small and valuable items are stored on racks or bin systems and similar items are kept together in a lockable store. Large or bulk storage items are kept within a lockable fenced compound.

### 1.4 STORAGE OF CONCRETE MATERIALS

Storage of material as the provision of adequate space, protection and control for building materials and components held in the site during the construction process, defines storage of materials by including the handling of the materials as part. Handling and storage of materials involve the unloading of materials such as steel with a crane, driving a truck loaded with concrete blocks, carrying bays or materials manually; and other materials such as drums, barrels and timber. It provides a continuous flow of parts and assemblies through the workplace and ensures that the materials are available when need.

### 1.5 CLASSIFICATION OF CONSTRUCTION MATERIALS

Studies have categorized construction materials in terms of how they appear, thus either in their raw state or finished product. These classifications are as follows;

**i. Raw materials:** These categories represent the original state of the materials and are the materials which are normally in its natural process. They are not affected so much by the weather and pilferage; and most at times bulky in nature. Consumes a lot of space when not properly planned well at the site. Chippings (gravels) and sand are examples;

**ii. Factory goods:** These categories deal with those items which have passed a series of processes and the end point are to pick and install. They are normally well packaged and most of them are off the shelf items. Examples include cement, ceramic items (closets, bath, basin, tiles) and ironmongery;

**ii. Workshop finished items:** They are the semi-finished product, thus slight works will be done on them before using. They are normally with their standard measurements and those materials are normally expensive since any default on it will create for it replacement. Examples include glass, timber, roofing materials, etc.

### 1.6 EFFECTS OF IMPROPER STORAGE AND HANDLING

The effect of improper storage location is also an issue and that can lead to poor productivity and waste. The effect of purchasing materials early may lead to capital tied up and interest charges incurred on the excess inventory of materials and to top it all, materials will deteriorate during storage and be stolen. It shows that an effective storage system should be operated with the planned activities of construction and revealed the building projects, procurement of materials should be well documented while location for materials should be made in good time; and materials should be delivered according to the programme of work. Improper storage and handling of materials have made a lot of project stack along the way and costing the client.

### 1.7 GUIDELINES FOR THE STORAGE OF CONCRETE MATERIALS

There are number of building materials used in the construction industry, most of them go waste during the storing process that materials form the bases of every project and occupying about 50% -60% of the cost of the entire project. Wastage in the storing of these materials have very big negative impact on the project.

### 1.8 RESEARCH PROBLEM:

Supply chain management (SCM) is a great opportunity for the construction industry primarily to reduce cost and time, and thus improve profitability. SCM principles seem to have much strength to smoothen and integrate the construction processes. The supply chains in construction could be divided into two major groups as materials chain and the construction chain, which would help to separate the procurement and management operations. However, both chains are linked through a SCM database, which is further linked with the central project database. This would ensure the smooth flow of information within the different chains and results in increased collaboration within the supply chain partners. Hence to adopt these benefits of SCM, this study is aimed to apply SCM tools for material management on a site selected for case study analysis.

### 1.9 RESEARCH AIM AND OBJECTIVES:

The main aim of this research was to study the effect of poor storage of concrete materials on construction firms in Pune and to develop guidelines for the proper storage of such materials in the building industries

To fulfil this aim the following objectives will be achieved:

1. To identify the problems while transferring the materials from place of origin to place of usage.
2. To identify the materials resources management practice that the contractors use
3. To identify the mode of storage of concrete materials on site
4. To identify the effect of poor storage of concrete materials on the contractor in the construction firms in the Pune.
5. To find out the way of cost reduction of materials.

## II. LITERATURE REVIEW

### 1) SulafaBadi , Niamh Murtagh (2019), Green supply chain management in construction: A systematic literature review and future research agenda:

The author researched on the green supply chain management in construction. The main aim of the author is to described in terms of publication outlet, date of publication, geographic setting, methods used, tools and techniques, conceptual definition, the role of stakeholders and practical implications. Research on green supply chain management in construction has been growing in recent times but to date has not been systematically brought together.

### 2) Zhaojing Wang , Hao Hu, Jie Gong , Xiaoping Ma , WuyueXiong (2019), Precast supply chain management in off-site construction: A critical literature review:

The author studied on the precast supply chain management in off-site construction. The study done by the author was to create a taxonomy to properly classify existing studies in precast supply chain management so as to reveal research gaps and suggest future research opportunities.

### 3) Po-Han Chen, ThanhChuong Nguyen (2019), A BIM-WMS integrated decision support tool for supply chain management in construction:

The author researched on the supply chain management in construction using BIM-WMS integrated decision support tool. Author aimed to support tool that integrates building information modeling (BIM) and web map service (WMS) for the source selection of sustainable construction materials. Selection of construction material sources is an important issue in construction supply chain management. This affects not only the shipping cost and schedule of a construction project, but also its environmental impact.

### 4) Hassan Younis , BalanSundarakani , Barry O'Mahony, Green Supply Chain Management and Corporate Performance: Developing a Roadmap for Future Research Using a Mixed Method Approach:

The literature is reviewed on green supply chain management and corporate performance for developing the roadmap for future research using a mixed method. The author investigates the relationship between green supply chain management (GSCM) practices and corporate performance (CP) using a sequential mixed methods research design. Research. on the impact of the implementation of green supply chain management practices on corporate performance is still inconclusive.

### 5) YueZhai, RunyangZhong, George Q. Huang (2018), Buffer space hedging and coordination in prefabricated construction supply chain management:



The author researched on the construction supply chain management by buffer space hedging and coordination in prefabricated. The aim of the author is to coordinate scheme and to solve a buffer space hedging (BSH) issue in the prefabricated construction supply chain management (PCSCM).

6) **Muhammad Farooque , Abraham Zhang , Matthias Thüerer , Ting Qu ,Donald Huisin(2019), Circular supply chain management: A definition and structured literature review:**

The author researched on the circular chain management which integrates the philosophy of the circular economy into supply chain management, offers a new and compelling perspective to the supply chain sustainability domain. There is increasing research interest. However, a review of the extant literature shows that a comprehensive integrated view of CSCM is still absent in the extant literature.

7) **Mochamadagungwiwo, elizar, (2017), supply chain management strategy for recycled materials to support sustainable construction:**

The main of the author was to determine supply chain management strategy for recycled materials to support sustainable construction. The concept of sustainable construction is the wise use of resources, the fulfillment of the future needs. This study by the author shows the strategies of field implementation. Thus attested by the low scores attained in green building certification. To support the sustainable construction in relation to supply chain management for materials, which have not been implemented well in Indonesia.

8) **FabiolaNegreiros de Oliveira , Adriana Leiras , Paula Ceryno (2019), Environmental risk management in supply chains: A taxonomy, a framework and future research avenues:**

The author researched on the chain supply management risk to environment. The main aim of the author was analyses both external and internal factors of environmental risk and their impact on supply chain management, as well as the mitigation strategies through the literature study. Where the recent environmental scandals and accidents bring to light the negligence of the environmental issues by supply chains.

9) **Zhaojing Wang, Tengyu Wang, Hao Hu, Jie Gong, XuRen, Qiying Xiao, Blockchain-based framework for improving supply chain traceability and information sharing in precast construction:**

The author researched on the blockchain based framework for improving the supply chain management in precast construction. The author determines the framework to extend the applications of blockchain in the domain of construction supply chains. As precast supply chain management often faces challenges such as fragmentation, poor traceability, and lack of real-time information.

10) **Alda Yoshi UemuraReche, Osiris Canciglieri Junior, Integrated Product Development Process and Green Supply Chain Management: contributions, limitations and applications:**

The literature is reviewed on the Product Development Process and Green Supply Chain Management. The main focus of the author was to identify the main bibliographical references that deal with integrated product development process (IPDP) models for the green supply chain management (GSCM).

### III. METHODOLOGY

#### 3.0 INTRODUCTION

This paper describes the approach in which the research is to be carried out. It describes how the information of the method was obtained, selection of the sample size, data collection and how the data is being handled. This paper also enlightens the review of the methodology and also description of the sample processes and techniques. The statistical method for the analysis of the data is also discussed.

#### 3.1 RESEARCH DESIGN AND METHODOLOGY

Research design describes the overall plan for obtaining answers to questions being studied and for handling some of the difficulties encountered during the research, It is also defined in some perspective as the strategy or plan to solve a research problem. Research design takes in the action plan from making something meaningful thus take the action for getting from 'here' to 'there' where 'here' is defined as the initial set of set of questions to be answered, and 'there' is some set of conclusion about these questions which involves a couple of major steps, thus collection of data and analysis of these relevant data.

### 3.2 SOURCES OF DATA

The sources of data gathered for this study were depended on both primary and secondary data. Primary data was made up of the actual information or first-hand data obtained from the site survey, observations, interviews and questionnaires. Secondary source of data was obtained using relevant books, research reports, journals and magazines. The type of research approach is the triangulation, which involves the use of both qualitative and the quantitative approaches.

### 3.3 SELECTION OF DATA COLLECTION METHOD

There are different means of collection of data. It depends on a number of factors and it included+ field of study, availability of information, time of study, characteristics of the respondent, location of the study and many more. The purpose of the study is the most at times the paramount. Data collections are normally done in so many ways and may be obtained by either a primary source or secondary source or both.

### 3.4 DESIGN AND DEVELOPMENT OF QUESTIONNAIRES

Generally, the design of the questionnaire was based on collection of information from construction firms registered with the public university in Western and Central Regions of Pune. This was on the basis of what was to be achieved thus the aims and objectives. Relevant literature also helped in the administering of the questions. All personnel on the construction site were possible respondents to the questionnaire.

**3.4 DISTRIBUTION OF QUESTIONNAIRES** Geographically, the study was carried out exclusively in pune and the questionnaires were developed and personnel handed over to the contractor or the representative. The questionnaires were to target twenty-five (25) construction firms in the institutions. The class from Works and Housing is D1K1 and D2K2.

### 3.5 RESEARCH POPULATION AND SAMPLING TECHNIQUES

#### 3.5.1 Research population

Research population as the totality of a well-defined collection of individual or object that have a common binding characteristics or traits. It can also be defined as a large collection of individuals or objects that is the main focus of a scientific query. The research covers a population of twenty-five (25) respondents made up of construction firms.

#### 3.5.2 Sampling

It is the process of selecting a portion of the population to represent the total population. Sample group is always a subset of the target population. It is important to select a sample group because is less costly and time saving than collecting information from a larger group of respondent. Each sample unit should have the same characteristics to allow for generalization of the result to represent the target population. There are two types of sampling techniques, namely, probability and non-probability sampling. The type considered in the study is the non-probability sampling.

##### 3.5.2.1 Non-Probability

Sampling the sampling technique where the samples are gathered in such a way that it does not give the individual in the population equal chances of being selected. The choice of sample group is left to the researcher and the issue of bias sometimes arose. There are different types of this technique but the one adopted is the purposive sample and the snowball technique. Purposive sampling technique because is the only means where the target group can be reached so easy and the study is also bounded by time; and above all the sample is not so big. Snowballing was used since some of the contractors helped in locating the other contractors in the same institution.

### 3.6 CRITERIA FOR SELECTING RESPONDENT

Non-probability sampling technique includes convenience, consecutive, quota, purposive and snowball sampling. The purposive sampling technique was used to select D1K1 and D2K2 local construction firms registered. In all twentyfive (25) contractors were available and was taken as the population. The population was also taken as the sample size and was used in the analysis since all respondent were responsive.

### 3.7 DATA ANALYSIS

The data collected from the questionnaire was screened, edited to ensure consistency and readability. This was done by determining the average response of each individual from the different companies. The software used for the analysis was the Statistical Package for Social Science (SPSS) and Microsoft excel. Quantitative analysis approach was used in

the data analysis and interpretation since the research is exploratory. It was final summarized in the form of charts and tables and was also involved in the categorization and ranking to reach various conclusions.

#### IV. RESULT AND DISCUSSION

##### 4.1 OVER VIEW

This paper analyses the data collected from the twenty-five respondents in which the respondents were randomly chosen from various construction firms. This paper deals with the analyses and discussion of the storage practices of reinforced concrete materials of contractors in the construction firms in Pune.

##### 4.2 DEMOGRAPHIC/ BACKGROUND INFORMATION

This section presents background information on various respondents. The background information included the respondent role in the construction industry, number of years in practice and the respondent's classification of works

##### 4.2.1 Role in the construction industry

The purpose of this question was to know the respondents position in the firm. They were to indicate whether they were building contractors, quantity surveyors, site supervisor or project manager. Table 4.2.1 shows a summary of the roles of respondents in the construction industry. The table clearly shows that 24 percent of our respondents were building contractors while 28 percent were quantity surveyors. A substantial percentage of 40 percent were site supervisors and the remaining project managers. This clearly justify the fact that site supervisors are easy to come across with while on site and are also willing to answer the questionnaire.

**Table 4.2.1: Role of respondents in the construction industry**

Role	Frequency	Percent (%)	Cumulative (%)	Frequency
Building Contractors	6	24.00	24.00	
Quantity surveyors	7	28.00	52.00	
Site supervisors	10	40.00	92.00	
Project managers	2	8.00	100.00	
Total	25	100.00		



**Fig 4.1 Role of respondents in the construction industry**

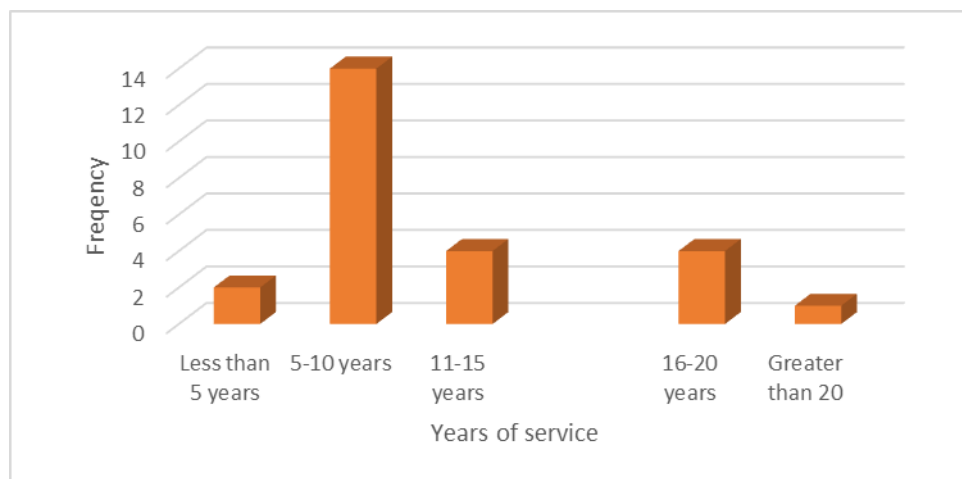
##### 4.2.2 Number of years of practice of respondents

Table 4.2.2 below shows a summary of respondent's years in service. The purpose of this background information was to know the level of experience in their sector. This information will give relevance to the quality of answers given out by the respondents. Also if respondents have gained more experience from working with their respective companies, it

is likely that they are well vexed in storage practices and processes of reinforced concrete and this will validate their response that is needed for this study.

**Table 4.2.2: Respondents years of service**

Years of service	Frequency	Percent (%)	Cumulative Frequency (%)
Less than 5 years	2	8.00	8.00
5-10 years	14	56.00	64.00
11-15 years	4	16.00	80.00
16-20 years	4	16.00	96.00
Greater than 20	1	4.00	100.00
Total	25	100.0	

**Fig 4.2 Respondents years of service**

#### 4.2.3 Classification of work

Table 4.2.3 represents the summary of analyses of the classification of work of our respondents. This question shows the class of the respondent's company. Majority of our respondents (20) were under the D1K1 class which represents 80 percent. The remaining respondents (5) represent D2K2 contracting companies. This shows that our respondent's bases were mostly high profile construction companies.

**Table 4.2.3 Classification of work**

Classification of work	Frequency	Percent (%)	Cumulative Frequency (%)
D1K1	20	80.00	80.00
D2K2	5	20.00	100.00
D3K3	0	0.00	100.00
D4K4	0	0.00	100.00
Total	25	100.0	

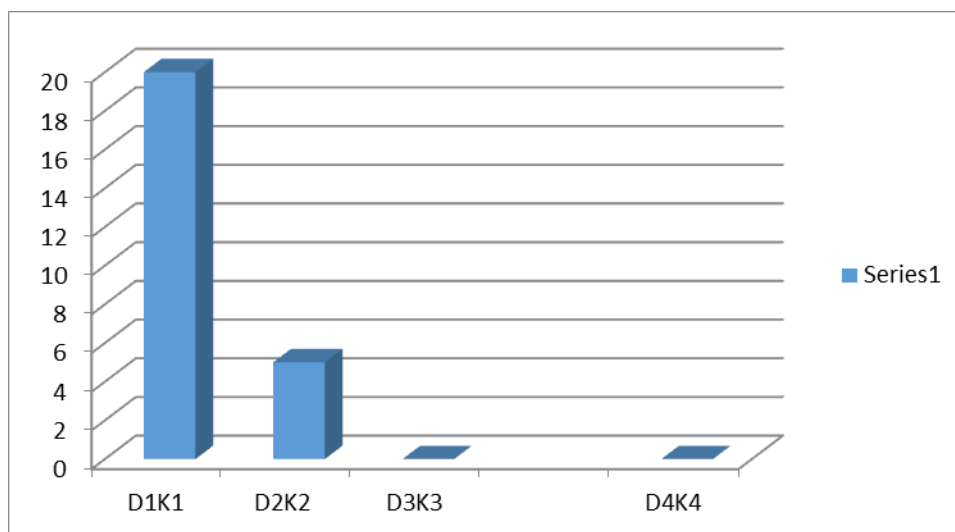


Fig 4.3 Classification of work

#### 4.3 PRESENTATIONS AND DESCRIPTIVE ANALYSIS OF DATA

##### Storage of reinforced concrete materials in the construction industry

The section of the questionnaire gave respondents the opportunity to show by indicating on a five point Likert scale, the material management practices, how specific concrete materials are stored and the effect of poor storage of materials on the construction industry.

##### 4.3.1 Material management processes

Material management as a system for planning and controlling to ensure the right quality and quantity of material and equipment are specified in a timely manner. Material management comprises with a series of processes of which a storage management is part.

**Table 4.3.1b** below employs the use of Relative Importance Index (RII) to rank the most widely used material management process

Table 4.3.1b: Material management processes

ITEM	Material management processes	Total	$\Sigma W$	Mean	RII	Ranking
1	Planning	25	91	3.64	0.73	1 <sup>st</sup>
2	Purchasing	25	90	3.60	0.72	2 <sup>nd</sup>
3	Handling	25	81	3.24	0.65	3 <sup>th</sup>
4	Stock and waste control	25	81	3.24	0.64	4 <sup>th</sup>
5	Logistics	25	72	2.88	0.58	5 <sup>th</sup>

Table 4.3.3a: Effects of improper material management

ITEM	Effect of poor storage	Total	$\Sigma W$	Mean	RII	Ranking
1	Ineffective cash flow	25	94	3.76	0.45	1st
2	Project duration	25	89	3.56	0.42	2nd
3	Security	25	86	3.44	0.41	3rd
4	Low production level	25	84	3.36	0.40	4th
5	Working space	25	79	3.16	0.38	5th
6	Double handling	25	75	3	0.36	6th

## V. CONCLUSION

This paper summarizes the issues addressed throughout the study. It begins with a summary of how the research objectives were achieved, followed by contributions of this research to knowledge. The paper concludes with recommendations for further research that can be conducted based on the conclusions and limitations of the study. This research was initiated with the primary aim of identifying the effect of poor storage of concrete materials on construction firms in Pune and to develop a guidelines for the proper storage of such materials in the building industries. In order to achieve the stated aim, three research objectives were set in Section 1.4. Objective 1 was achieved mainly through literature reviews. Objectives 2 and 3 were achieved through the literature reviews and the survey questionnaires, which were conducted. Below are discussions on how the objectives were achieved. The report demonstrated that with effective material management, firms can save a substantial amount of money and makes more profits out of it. The storage of concrete materials is very important since it forms about 25% - 35% of the entire materials needed in the construction. Therefore proper management of this material will go a long way to benefit both the client and the contractor and the economy as a whole.

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