

# Workflow Optimization of Material Management Process by Digital Adoption in Indian Residential Projects

Sadhayadharshni C, M. Kranti Kumar



**Abstract:** To analyze the present day's material management process and the extent of digital adoption in the workflow; to identify the shortcomings in the present day's practice; and to formulate digital inclusive framework to manage materials. Objectives 1 & 2 is achieved through 3 step process – Literature review to identify the related shortcomings (factors) and online/ web search to explore available technology; Survey(s) to assess the real time status on the factors, to identify more practical difficulties and the extent of digital adoption in the workflow; Interviewing seasoned professions to gather data in detail with respect to material. Objective 3 is achieved by comparison and analysis of the findings. Validation of the framework to assess the potential effects – Partial validation is performed as part of this study. Workflow involved in construction material management is optimized via framework. Autodesk Revit, MS Project, and MS Access are the 3 platforms proposed to be part of the framework that suits every phase of the process like Quantity survey and Estimation, Procurement Planning, Inventory, Purchasing and Store Management. Partial framework - MS Project has been validated and the results are – Ability to map the data efficiently; Precised Budget & material requirement identification resulted in an increase of 1% cost in the overall project budget; Easy Cross verification; Easy documentation; Data driven decision making; Multi - dimensional data visibility. The studies in the past have stressed on the benefits of digitalization and the willingness of construction sector in adopting the same. 2019, 2020 and 2021 studies have explored individual digital platform such as MSP, Primavera, and Revit in terms of part functions involved in material management. Whereas there is no study stating the order of workflow between these platforms for complete material management. Also, the studies in the past failed to identify and address the shortcomings related to the digital adoption. Hence, this study proposed a framework that determines the order of the workflow involved in material management between these digital platforms with an aim to optimizing the workflow.

**Keywords:** Material Management, Digital Adoption, Ms Project, Residential Developments

## I. INTRODUCTION

Building materials differ from manufacturing materials in that they are more varied, less uniform, and less standardized as well as having different demand characteristics. At every stage of the MM process, material planning and scheduling should be

understood [1]. Decreases in productivity and financial losses were usually attributed to lack in the supply and flow of construction materials. To minimize the detrimental impacts of a material shortage or an excessive amount of material inventory on site, material acquisition and storage on construction sites must be carefully planned and implemented. Management system ensures that the right kind and amount of supplies are properly chosen, efficiently acquired, dutifully delivered, and securely handled on site in a timely way and at a proper affordable cost [2].

The construction sector is currently very interested in digitalization, which is supported by the large number of created ICT solutions. BIM, digital meetings, and web-based project platforms have all been around for a while [3]. Though digitalization was a proposed solution and various ICT systems are available, the degree of implementations is scarce. Organizational culture is also a significant factor in preventing its stakeholders from discovering the true potential of digitalization. To enable greater digitization and the efficacy of digital technologies, it is vital to reengineer and digitally convert processes in construction projects and organizations [4][20]. Primavera and MSP are the predominantly used project management softwares. Primavera P6 is more efficient with its features, assists in better tracking, less time consuming and it requires less paperwork than conventional method [5][20][21][22]. Like Oracle Primavera, MSP is a contemporary digital tool for project management. Resources can be well-defined (Work, Material and Cost), and can be shared among projects. Scheduled works are executed depending on the availability of resource as predefined in resource calendar. Being it a Microsoft product it is user friendly compared to primavera [6]. As per the Inventory Analysis by a recent study, it can be concluded that the controlling inventory is very useful in controlling the cost of any construction project. Using MS Project increases the efficiency in management of inventory by saving cost and time [7]. Resource-loaded schedules are considered as foundation for better planning and offers important insights into the projected financial success of projects. Nonetheless, most schedules are not resource-loaded. Due to a lack of information, most project managers struggle to create realistic plans [8]. Resource loading can be done using both Primavera and MSP, but the steps involved in loading resources varies. MSP is relatively easier to use and extracting required insights. Also, primavera is relatively expensive tool. On the other hand, MSP is more affordable and accessible to a wide range of users [9].

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Using BIM tool – Revit, with a complete and detailed 3D model of the building, accurate quantities can be derived in no time. Mapping back the quantities with respect to building is much simpler task. Also, change management happens efficiently because, with modification in model, quantities get updated automatically [10]. To explore horizons further, a survey was conducted to track the user’s perspective of BIM in managing inventory and 63.6% of respondents believed, BIM based inventory management will give effective outcomes beneficial to Indian construction industry [11]. Followed by that, a case study attempted to mimic a 5D BIM process by combining several information dimensions, such as time scheduling and cost estimation, with a 3D model. To assess the benefits, viability, and constraints of the applications. It involved 6 stages of process, including quantification and cost estimation. The findings concluded that the modelling effort, interoperability, information output, and constraints had an impact on the extent of practicality of 5D BIM. On the other hand, the study also demonstrated that 5D BIM considerably decreased the technical barrier for customers to engage in construction projects, boosting the clients' happiness with the works by bridging the gap between clients' perceptions and the real results of the construction [12] [18][19].

The studies so far failed to furnish details such as – Predominantly used digital technologies in managing materials; Phases at which utilization is being done and Shortcomings in utilization of digital technologies. These details are essential to define the present day’s MM process and the extent of digital adoption. Also, with respect to MM, though there are numerous digital technologies available, no framework or procedures are established yet by correlating with the process, eliminating the shortcomings of digital adoption. Hence this study aims to formulate a digital inclusive framework to optimize the workflow involved in MM. Successful workflow optimization will decrease expenses, the likelihood of errors, and the amount of time needed to complete tasks [13]. The most obvious advantages of workflow optimization are productivity and efficiency in terms of better customer connections, data-driven decision-making, and more team visibility. A good process can also lessen human error [14].

## II. MATERIAL MANAGEMENT - INDIAN SCENARIO

Mostly Indian based studies mostly pertaining to the material management in varied typologies were alone reviewed to keep it much relevant to this study.

**Table I: Factors Identified from Literature**

Year	Context	Project Type	Factors - Shortcomings in MM
2013	Gujarat, India	Residential	Delay in Material Delivery
2015	India	Generic	Poor material handling No proper system of material procurement
2017	India	Residential	“Shortage of construction materials in the market and Improper scheduling”
2018	India	Residential	Shortage of materials on site Poor procurement planning
2019	India	Generic	Shortage of materials

2019	Urban region, India	Residential – Small & Medium scale	1) Material planning stage – Poorly defined roles and responsibilities, material stores located faraway from site and poor store layout. 2) “Vendor analysis” stage - Poor communication and coordination between building contractor and vendor/supplier 3) “Material purchasing” stage Local issues leading to delays and unavailability of materials 4) “Storage & inventory” stage Lack of access to contemporary tools and techniques for handling 5) “Supply & distribution” stage Damage of material on site and lack of onsite material control
2021	Case study – LMT tools Ltd., Pune	Industrial building by SCON	Deviation in quantities due to unavailability of RCC Design drawings Unavailability of material
2022	Somalia	Generic Small and med. scale	Shortage of materials during construction. Material cost fluctuation Delayed delivery of materials Over-ordering of materials Material usage without systematic control Difference in material specifications during construction. Theft of materials from the site. Insufficient storage space Use of faulty materials Poor use of advanced software

Shortcomings in MM (factors) identified from past 10 years of literature is listed in the table above and these are inferred through a common research methodology. Also, every study is confined to a particular region. These factors are categorized under 4 different phases involved in MM – Procurement planning, purchasing, inventory and storage, supply, and distribution on site.

**Table II: Factors Categorization – Literature Based**

<b>Procurement planning</b>	Poor procurement planning
	No proper system of material procurement
	Poorly defined roles and responsibilities
	Deviation in quantities due to unavailability of drawings
<b>Purchasing</b>	Poor use of advanced software
	Poor coordination & communication between contractor and material supplier
	Material cost fluctuation
<b>Inventory and storage</b>	Delay or unavailability of in materials due to local issues
	“Storage of materials in faraway from site, Poor store layout, insufficient storage space”
<b>Supply and distribution</b>	“Lack of availability of modern equipment and methods for handling”
	Shortage & unavailability of materials
	Deviation in material specification during construction
	“Lack of onsite material control”
	Damage of material on site
<b>Supply and distribution</b>	Theft of materials from the site.
	Delay in material delivery

### A. Confining the Region of Study

Demand for residential properties has surged due to increased urbanization and rising household income. India is among the top 10 price appreciating housing markets internationally [15].



Especially, the recent surge in demand is towards luxury segment and prefers ready to move in homes [16].

Q1 Y2022 witnessed significant momentum in residential real estate activity. Despite the temporary pause due to the COVID-19 pandemic, the new launches across the 7 cities have witnessed a 43% yearly rise in comparison with Q1 Y2021. Out of which, MMR & Hyderabad account for 51% of total launches in top cities; individually see a 59% & 71% yearly rise, respectively. New launches across the top 7 cities Hyderabad witnessed maximum new launches in the premium segment. Hyderabad is the only city to have the highest volume of new launches in the premium segment amongst all top 7 cities, comprising total share of 54% within the city’s overall new supply [17].

### III. RESEARCH METHODOLOGY

Methodology is developed after thorough review of literature and modeled according to this study as shown in the figure below to achieve the set objectives.

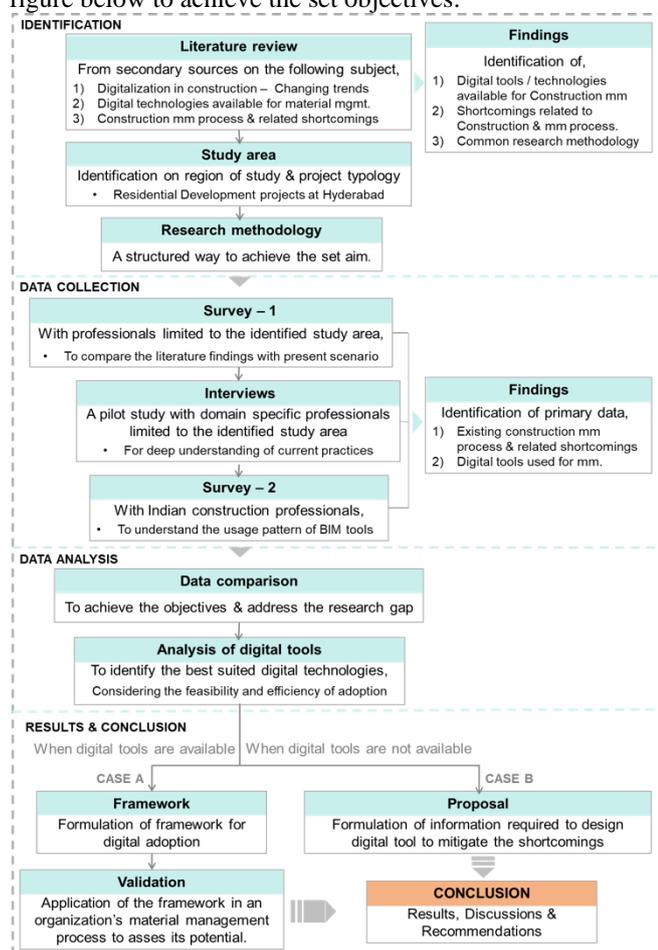


Figure 1: Research Methodology

**Objective 1 & 2** is achieved through three step process - First is through literature review of a decade old journals, articles, research papers, books, thesis, etc., to understand the background, status of research and shortcomings in MM (factors). Also, digital tools available in the market with respect to MM is explored through web/ online search. Next is survey(s) to assess the real time status on the factors identified from literature and to identify more real time practical shortcomings and the extent of digital adoption in the workflow. Because few of the factors mentioned in literature may got rectified and few shortcomings in conventional

practice may be yet to include literature. The last is, interviewing experienced professions of the related domain (Project manager, Planning Manager, Store manager, Procurement manager, etc.) to understand the present scenario better and much detail data on the shortcomings with respect to material.

**Objective 3** is achieved by comparison and analysis of the findings from previous steps of action. Considering the real time concerns and constraint, framework must be formulated to mitigate the shortcomings with the available digital solution (Tools/ Software). In case, if any shortcomings cannot be addressed with digital solutions available in market, proposals must be made. Finally, to validate the developed framework to assess the potential effects of the framework. Thus, the study concludes with the results of the validation, recommendations, and future scope.

### IV. DATA COLLECTION

#### Survey 1

**Intention** – To verify the inference from literature with the current practice and to understand the present scenario w.r.t digital adoption in material management.

**Target Respondents** – Construction professionals currently practicing in Hyderabad.

**Structure** –

1. Profile
2. Level of Agreement on the optimistic statements
3. Frequency of occurrence of the common issues identified through literature
4. Questions related to digital adoption that will help in addressing the gap identified from literature

#### Interview

**Intention** – To detail out the areas of concern identified from survey & literature w.r.t each material.

**Target Respondents** – Professionals of residential development projects at Hyderabad

**Structure** – Construction materials were listed in categories and for every item details like,

1. Source, aspects of procurement planning, risk, inventory planning, storage, wastage percentage and associated indirect cost
2. Percentage deviation observed in terms of cost and quantities
3. Efficient mode of handling within site
4. Quality related issues post construction and finally regarding software usage were recorded.

#### Survey 2

**Intention** – To assess the usage of BIM in Indian construction industry.

**Target Respondents** – Indian Construction professionals

**Structure** – Information on

1. Profile – Role & Location
2. BIM tool used
3. Phases of usage
4. Efficiency of BIM

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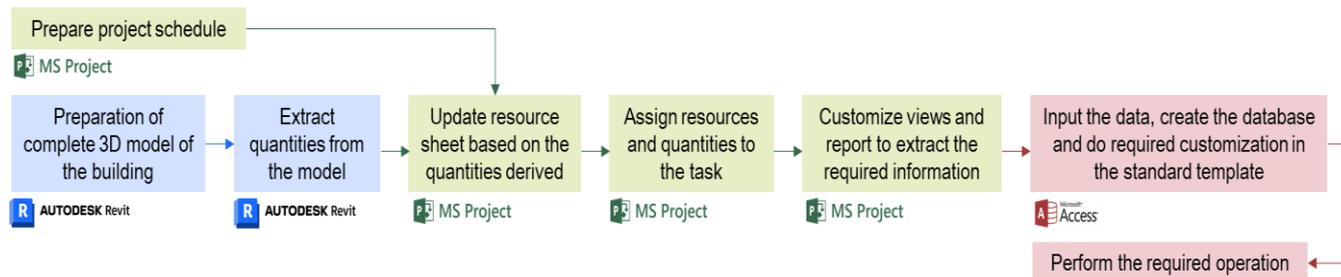
## V. FORMULATION OF FRAMEWORK

On analyzing findings from the literature and data collection with respect to digital adoption and its user’s perception, the framework should be simple, practical and efficient. Considering the identified constraints, digital technologies / software are proposed for the various phases of activities involved in MM process.

As said earlier, digital adoption is completely leveraging the available digital tools. Consideration towards the identified shortcomings resulted in re-examining the features and capability of software that is already in practice. Similarly, the proposed framework utilizes the digital tools that are already in practice.

**Table VI: Proposal**

Digital Tool	Phase of Utilization	Outcome	Benefits of Adoption	Status	Remarks
Autodesk Revit	Quantity survey and Estimation	1. Quantities of each material as a tabular form.	Accuracy, ability to map easily, and efficient change management	Proposal only. Efficiency is proven already [11]	Survey 2 aided in understanding the most prevalent BIM tool as Revit for designing and 3d visualisation. Detailed model would benefit said purpose
Microsoft Project	Procurement Planning	1. Resource loaded schedule 2. Month/ (customizable) wise requirement of each material in the form of graph 3. Resource form	User friendly interface, simple data input and import, customisable reports assists in decision making.	Proposed and validated using actual data of a project that falls within the defined scope of study.	Resource loading can be done in both the PM software but the steps involved in MSP is much easier to adapt. The organizations prefer MSP due to its user friendly interface was identified during the interaction with PM professionals.
Microsoft Access	Inventory, Purchasing and Store Management	1. Inventory list with rates 2. Vendor contact details 3. Stock control - items being stocked, their current stock levels, and track movements into and out of stock 4. Generation of PO & invoices	Economical and multiple tasking (able to do the works similar to a ERP).	Proposal only as the validation requires operational level application.	MSA is a part of Microsoft 365 - one of the basic mandatory tool which every user has installed in their personal computers / laptops. It is a database management system (DBMS) to help businesses manage the work.



**Figure 2: Digital Inclusive Framework**

## VI. VALIDATION OF PARTIAL FRAMEWORK - MSP

Actual data of a project that falls within the defined scope of study is used for application and validating the proposed framework. Resource loaded schedule of a high-rise residential development project is prepared using MSP. Procedure as follows:

1. Prepare a project schedule using MSP (which is the part of current practice).
2. In the view “Resource sheet” upload the materials, unit, and unit price.
3. Assign resources to each task. Multiple resources can be assigned to same task. Material quantity required for each task can be uploaded in the same step as well.

4. As the tasks are more in no. in the view, “Resource usage” quantities can be uploaded.
5. Also, the option “Details” can be choose to split window into two. By clicking on the task, the details will be shown below and the quantities can be entered there.
6. After uploading the relevant information, reports can be customized and generated as shown in the figure below.
7. As an end outcome, month wise requirement of each material can be extracted in the form of graph.
8. Adding necessary columns to the resource sheet, as show in table VII will produce a draft BOQ of the project.

Resource sheet forms the database, when assigning resources (materials) to the tasks. Column – “Cost” is auto generated based on the inputs feed in all the other columns.

**Table VII (a): Resource Sheet Generated in MSP – Resource Sheet View**

Resource Name	Type	Material Label	Initials	Standard Rate	Work	Cost
Site Levelling	Material	Sq.m	S	₹28.15	5,434 Sq.m	₹152,967.10
Resurveying And Marking Site Boundary	Material	LS	R	₹14.00	5,434 LS	₹76,076.00



Site barricading	Material	meter	S	₹2,827.40	2,827.4 meter	₹7,994,190.76
sample Pile test vertical load test	Material	LS	s	₹250,000.00	1 LS	₹250,000.00
Excavation	Material	Cu.m	E	₹286.85	273 Cu.m	₹78,310.05
Pile Casting 500mm dia	Material	meter	P	₹2,876.29	4,665 meter	₹13,417,892.85
Pile Casting 600mm dia	Material	meter	P	₹3,662.15	2,257.5 meter	₹8,267,303.63
pile test integrity test	Material	each	p	₹708.00	322 each	₹2,27,976.00

Table VII (b): Resource Sheet Generated in MSP – Resource Sheet View

Resource Name	Type	Material Label	Initials	Standard Rate	Work	Cost
Backfilling	Material	Cu.m	B	₹253.95	2,151 Cu.m	₹546,246.45
PCC	Material	Cu.m	P	₹5,660.45	354 Cu.m	₹2,003,799.30
Concrete M30 till plinth	Material	Cu.m	C	₹8,599.35	960 Cu.m	₹8,255,376.00
Concrete M30 stilt - 5 floors	Material	Cu.m	C	₹10,221.70	3,942 Cu.m	₹40,293,941.40
Concrete M30 6-9	Material	Cu.m	C	₹10,502.65	1,936 Cu.m	₹20,333,130.40
Concrete M30 10-terrace/ohts	Material	Cu.m	C	₹10,783.60	1,092 Cu.m	₹11,775,691.20
Shuttering - RW/CO	Material	Sq.m	S	₹804.20	20,333 Sq.m	₹16,351,798.60
Shuttering - PC	Material	Sq.m	S	₹307.95	676 Sq.m	₹208,174.20
Shuttering - SRS	Material	Sq.m	S	₹766.55	7,869 Sq.m	₹6,031,981.95
Shuttering - TRS/SW/OHT	Material	Sq.m	S	₹608.35	32,867 Sq.m	₹19,994,639.45
Reinforcement	Material	Quintal	R	₹8,966.15	9,130 Quintal	₹81,860,949.50
Masonry up to 5 floors	Material	Cu.m	M	₹6,994.16	1,818 Cu.m	₹12,715,382.88
Masonry 6-9 flrs	Material	Cu.m	M	₹7,136.16	1,456 Cu.m	₹10,390,248.96
Masonry 10-terrace	Material	Cu.m	M	₹7,278.16	825 Cu.m	₹6,004,482.00
Plastering Interior	Material	Sq.m	P	₹374.15	47,300 Sq.m	₹17,697,295.00
Plastering Exterior up to 2nd floor	Material	Sq.m	P	₹386.55	8,752 Sq.m	₹3,383,085.60
Plastering Exterior 4 floor	Material	Sq.m	P	₹532.15	2,838 Sq.m	₹1,510,241.70
Plastering Exterior 5 floor	Material	Sq.m	P	₹604.95	2,838 Sq.m	₹1,716,848.10
Plastering Exterior 6 floor	Material	Sq.m	P	₹677.75	2,838 Sq.m	₹1,923,454.50
Plastering Exterior 7 floor	Material	Sq.m	P	₹750.55	2,838 Sq.m	₹2,130,060.90
Plastering Exterior 8 floor	Material	Sq.m	P	₹823.35	2,838 Sq.m	₹2,336,667.30
Plastering Exterior 9 floor	Material	Sq.m	P	₹896.15	2,838 Sq.m	₹2,543,273.70
Plastering Exterior 10 floor	Material	Sq.m	P	₹968.95	2,838 Sq.m	₹2,749,880.10
Plastering Exterior 11 floor	Material	Sq.m	P	₹1,041.75	2,838 Sq.m	₹2,956,486.50
Plastering Exterior Terrace	Material	Sq.m	P	₹1,114.54	1,237 Sq.m	₹1,378,685.98
Waterproofing T&S	Material	Sq.m	W	₹406.24	186 Sq.m	₹75,560.64
Waterproofing	Material	Sq.m	W	₹516.62	2,662 Sq.m	₹1,375,242.44
Terrace weathering	Material	Sq.m	T	₹1,522.95	1,888 Sq.m	₹2,875,329.60
Granite Flooring	Material	Sq.m	G	₹2,677.90	2,261 Sq.m	₹6,054,731.90
Floor Tiling	Material	Sq.m	F	₹1,359.20	11,652 Sq.m	₹15,837,398.40
Anti-skid Flooring	Material	Sq.m	A	₹1,311.05	3,362 Sq.m	₹4,407,750.10
Skirting Tiles	Material	Sq.m	S	₹1,466.50	2,424 Sq.m	₹3,554,796.00
Granite Skirting / Dadoing	Material	Sq.m	G	₹3,105.50	720 Sq.m	₹2,235,960.00
Tile Dadoing	Material	Sq.m	T	₹1,063.00	9,632 Sq.m	₹10,238,816.00
Granite Counter	Material	Sq.m	G	₹418.85	330 Sq.m	₹138,220.50
Cutting in Granite Counter	Material	Each	C	₹808.15	132 each	₹106,675.80
Painting -AB Ext.	Material	Sq.m	P	₹166.86	25,928 Sq.m	₹4,326,346.08
Painting - AB Int.	Material	Sq.m	P	₹121.54	31,069 Sq.m	₹3,776,126.26
Painting - C Ext.	Material	Sq.m	P	₹168.00	1,218.11 Sq.m	₹204,642.48
Painting - C Int.	Material	Sq.m	P	₹145.00	16,236.96 Sq.m	₹2,354,359.20
Conduits	Material	meter	C	₹90.00	27,960 meter	₹2,516,400.00
Wiring	Material	meter	W	₹146.00	0 meter	₹0.00
Fixtures	Material	Each	F	₹57.38	0 each	₹0.00
Switches & Sockets	Material	Each	S	₹98.25	0 each	₹0.00
Precast lintel beams	Material	Cu.m	P	₹13,581.00	33.78 Cu.m	₹458,766.18

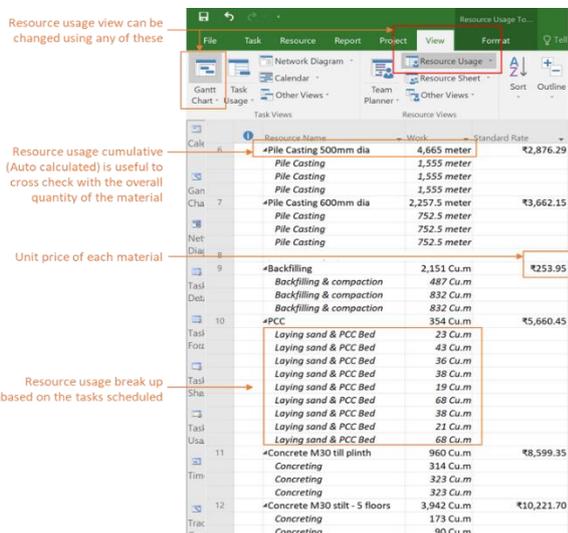


Figure 3: Resource Usage View in MSP

There are multiple ways to assign quantities to the resources. One such is resource usage view. Aggregate quantities are auto calculated and that will be useful in cross verifying with the quantities in BOQ. Options from the reports tab will be aiding in generating required data in the form of customizable reports. Each material required per month is extracted as report in the form of graph which will be highly helpful in analyzing the inventory requirements and plan it accordingly.



Figure 4: Reports Tab – MSP



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Resource loaded schedule is by product of the resource loading that aids in informed decision making.

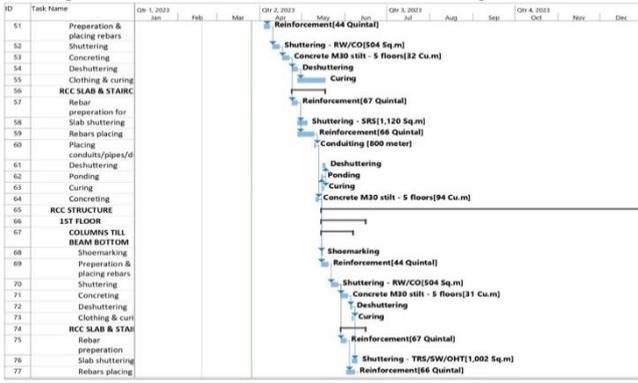


Figure 5: “Resource loaded Schedule” view in MSP

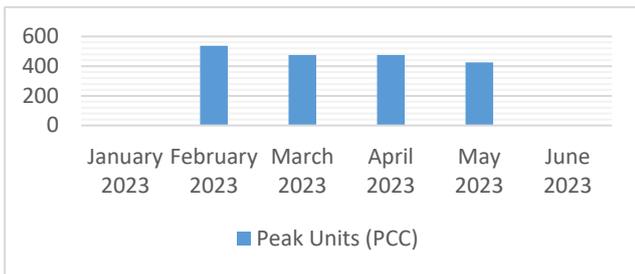


Figure 6: PCC Required Per Month in Cu. m

Here is the report generated from the MSP in the form of graph showing the material requirement of each month. Peak units – Aggregate of material required for the tasks assigned in that month. Also, this gives insight on number of months a particular material might require. By the end those particular months if the material is still in inventory, it can be tracked with either inefficient inventory planning that leaves in excess or the task requiring that material is still pending showing the delay in schedule. Similarly, for every material the graph has been generated.

## VII. RESULT AND DISCUSSION

### A. Comparison of Gathered Data Against the Baseline

**Objective 1** To understand the present day’s MM process and the extent of digital adoption in the workflow.

Table III: Present day’s Process and the Digital Tools Used

Phase	Present day’s mm process identified through survey & interviews	Digital tool / Software used
Procurement planning	Project durations – Schedule preparation considering productivity – Procurement schedules are back calculated	MSP / Primavera for project scheduling. Excel for other iterations.
	Planning team will be performing and the name of the team may vary with organization but the roles and responsibilities are similar	Team communication is through ERP few have in-house and few outsource.
	With respect to developer(s) procurement planning team is in house with some organizations and it is left to contractor in some by providing project schedule alone.	
Purchasing	Vendor discussions / Negotiations – Personal meetings.	E-Mails for communications
	Indent from site is raised and PO, PR are through vouchers got signed from planning team	ERP will be used to record all these.

	for approval and progresses.	
	Majority of items in shell and core, finishing materials like tiles, paint, etc are procured in large volumes. Except for interior materials like false ceiling, drywall partitions are procured when needed.	
Inventory and storage	Aging analysis for materials at storage. Reconciliation: Material In + Material Out = Consumption + Wastage	Excel / Google sheets for most of the iterations, reports on storage is generated from ERP.
	With respect to developers inventory planning and storage maintenance is in-house with some organizations and it is left to contractor in some orgs.	
	Storage issues in terms of availability of spaces is very rare but in terms of theft and poor handling do exist.	
Supply and distribution	Lack of onsite material control is prevalent only for supplies. Damage of material on site is often prone to tiles and pavements sometimes. Theft happens with wiring.	

**Objective 2** To identify the shortcomings in the present day’s practice

Ex – Existence Frequency. – Frequency

Table V: Shortcomings in the Present Day’s Practice

Phase	Shortcomings Identified through Literature	Survey Findings	Interview
		Ex	Frequen.
			Concerned Material
Procurement planning	Poor procurement planning	-	-
	No proper system of material procurement	-	-
	Poorly defined roles and responsibilities	-	-
	Deviation in quantities and Cost	✓	Often
	Poor use of advanced software		Excel/ Sheets, ERP are the software used
Purchasing	Poor coordination & communication between contractor and material supplier	✓	Sometime
	Material cost fluctuation	✓	Often
	Delay/unavailability of materials due to local issues	✓	Sometime
Inventory and storage	Storage of materials in faraway from site, Poor store layout, insufficient storage space	✓	Sometime
	Lack of availability of modern equipment and methods		Largely dependent on Excel for most of the calculations.
Supply and distribution	Shortage and unavailability of materials	✓	Rare
	Deviation in material specification during construction	-	Rare
	Lack of onsite material control	✓	Sometime
	Damage of material on site	✓	Often
	Theft of materials from the site.	✓	Sometime
Delay in material delivery	✓	Sometime	



- 1) 5-10% of material wastage is observed in – Pavements, stone, tiles, Electrical and plumbing items, Steel. Whereas wastage in other materials is between 2-3%
- 2) Indirect cost associated in these materials are 10% and above – Mivan, lifts, Tiles, Fabrications, Steel. Whereas indirect cost associated in other materials is within 3-5%.
- 3) Post construction quality issues are often found in flooring and services especially related to plumbing
- 4) Procurement planning Method and tools – Reverse calculation; Excel

**B. Addressing the Gap Identified from Literature Review**

- 1) List of predominantly used digital technologies – MSP / Primavera, MS Excel, ERP
- 2) Phases at which utilization has been done – Procurement Planning, Purchasing, Reconciliation, Storage
- 3) Weather digital technologies cater the intended process. – Yes
- 4) **Shortcomings in Utilization of Digital Technologies?**
  - a. Apart from buying, high cost associated with yearly subscription and renewal.
  - b. Server / network issues in using cloud-based software due to the location of construction site and unavailability of network. Which makes difficult to upload or download the required data.
  - c. Information support is weak in such situation.
  - d. Too many steps are involved in entering the data and difficulty in editing the data once entered.
  - e. Data storage costs are heavy nowadays.
  - f. Relying on an additional tech person to check for errors and maintenance issues increasing the unwanted downtime.
  - g. Despite many available software, in India still management persist physical approval and signature. This manually created vouchers and documents are pictured and documented digitally which is also a part of digital adoption identified from survey.

**Table VIII: Framework Vs. Shortcomings**

Benefits of adoption of framework	Mitigates the Shortcomings related to MM process	Mitigates the Shortcomings in digital adoption
Makes the procurement planning process composed and structured.	<b>Procurement Planning</b> - Poor procurement planning, No proper system of material procurement, Poorly defined roles and responsibilities, Deviation in quantities and Cost, Poor use of advanced software	Apart from buying, high cost associated with yearly subscription and renewal. Server / network issues in using cloud-based software due to the location of construction site and unavailability of network. Which makes difficult to upload or download the required data. Information support is weak in such situation. Too many steps are involved in entering the data and difficulty in editing the data once entered. Data storage costs
Establishes coordination between the project schedule and required material in appropriate quantities along with cost that helps taking informed decision.	<b>Purchasing</b> – Poor coordination & communication between contractor and material supplier, Material cost fluctuation, Delay/unavailability of materials due to local issues	Information support is weak in such situation. Too many steps are involved in entering the data and difficulty in editing the data once entered. Data storage costs
Helps identifying the periodic requirement of the materials in well advanced	<b>Inventory &amp; storage</b> – Poor store layout, insufficient storage space, Lack of availability of modern equipment and methods	Data storage costs

and assists in establishing a inventory and storage control accordingly.	<b>Supply and distribution</b> - Shortage and unavailability of materials, Deviation in material specification during construction, Lack of onsite material control, Damage of material on site & Theft.	are heavy nowadays . Relying on an additional tech person to check for errors and maintenance issues increasing the unwanted downtime.
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**VIII. CONCLUSION**

This study aimed to propose a digital inclusive framework for smooth and efficient MM process by optimizing the workflow. The concerns and constraints identified through data collection were the guidelines in formulating the framework. Formulated framework recommends the usage of - Autodesk Revit, MSP and MSA to optimize the workflow of the construction MM process. The proposed digital tools used in the said order and for the said purpose is expected to cater much efficiently. However, the validation of the complete framework is not performed as a part of this study. Only part of the proposed framework – MSP has been validated and the results are as discussed below.

- **Ability to Map the Data Efficiently** – Quantities required for each activity and the location of utilization can be easily mapped.
- **Précised Budget & Material Requirement Identification** – Compared to the availed project data, there was an increase of 1% cost in the overall project budget when planned in MSP. That was due to the task mentioned in the schedule, but the required material missed in BOQ listing.
- **Easy Cross verification**
- **Easy Documentation** – This reduces the load of handling fragmented documents.
- **Data Driven Decision Making** – Customizable reports keeps informed of the requirement.
- **Visibility** - Multi dimensional visibility to the data.

Despite the proven efficiency, to increase the rate of digital adoption, periodical training and development sessions for the constructional professional must be planned and conducted by their organizations to keep them aware of the current research trends, for being updated and get benefited collaboratively.

**FURTHER SCOPE OF RESEARCH**

Results and discussion on validation of a complete framework would be the ideal further step to support the study. Application in a project requires the intervention right after the designing stage till complete construction to identify the benefits, viability, and constraints of the proposed framework.

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# Workflow Optimization of Material Management Process by Digital Adoption in Indian Residential Projects

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