

Developing a Sample Web Application Model for Material Management

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Abstract:- Materials management is an important component of the construction field. As such, organizations need to understand the effects of proper materials management methods for the effectiveness of project execution. A properly implemented materials management system can achieve the timely flow of materials and equipment to the jobsite, and thus ensure improved work face planning, increased labour productivity, better schedules, and lower overall project costs. Materials are the major expense in construction, so minimizing procurement cost reduces the overall project cost. The basic aim of the project lies in revising the existing material management practices in construction sites which require manual efforts and paper works, by incorporating automation for real time monitoring as well as controlling of materials and developing a web application.

Keywords: Material management, construction, Web application, Automation for real time monitoring.

I. INTRODUCTION

A. General Background

In construction projects materials constitute major cost. Generally the cost of materials is up to 50% to 60% of total cost of the project. A small saving in material cost of even 5% by effectively managing materials can result in a large contribution. In every construction projects, material management is carried out to minimize the wastage of materials, damage of material, shortage of material, lack of storage space, and delay in supply of material.

B. Material And Supply Chain Management

Material management consists of mainly for processes i.e. planning, procurement and inventory. Materials planning, which is the key function of materials management, is closely related to project planning and control set-up. Both these work together to develop a plan for procurement and stocking of construction materials so as to provide the right quantity of materials of right quality at the right prices from the right sources to the sites at the right time. Thus, this research aims to develop a platform for the same.

A properly implemented materials management program can achieve the timely flow of materials to the jobsite, and thus facilitate improved work face planning, increased labour productivity, better schedules, and lower project costs. One of the main aims of material management is to provide an unbroken chain of parts for production of goods on time for the customer side; Supply Chain Management (SCM) becomes a vital sub part of material management.

C. AIM

The basic aim of the project is to change the existing material management practices in construction sites which require manual efforts and paper works, by incorporating automation for real time monitoring as well as controlling of materials and developing a web application. As a result, better outcomes are expected as of easing out the storage and retrieval of data related to materials and other operations.

D. Objectives

The project is carried out in order to satisfy the following objectives:

- To find out the relevance of automation in construction project management, especially in the control and management of materials, through literature reviews and questionnaire survey.
- To develop a sample web application model based on automation in material management.

E. Scope

Surveying the literature illustrates many instances and case studies of the drawbacks in the current practices of material management systems in the construction industries. As a result, incorporating Automation into the field of managing materials became the main objective.

A properly implemented material management system can lead to better control over flow of material, better project outcomes, reduced costs, improved productivity and quality to the whole of construction. A simple, user friendly and cost effective software thus developed can be made use by the construction companies, basically the small scale ones, for their managerial purposes.

II. LITERATURE REVIEW

The Webster' s dictionary defines materials as "the elements, constituents, or substances of which something is composed of or can be made". The target of material management is to ensure that materials are available at the time of use when needed; the material management system makes sure that correct quality and quantity of materials are selected, purchased, delivered, and handled on site in a timely manner and at an economical cost.

T. Phani Madhavi1, et al., (2010) They have done analysis on the work site was done with the previous knowledge of the material management, and new methodologies were implemented at work site, based on the current construction process. Understanding the problems that

occur at the work site due to, inventory, purchasing and on how materials are being handled at the work site were taken into consideration. Analysis was done on practices followed in purchasing and new concept of purchase requisition slip and tendering were introduced. Importance on how materials are properly procured at the site was also taken into consideration and new appropriate technological were introduced like RFID, PDA, which helped us in a proper scheduling, managing and financial control for proper scheduling and based on the materials importance, and on how they have to be released, ABC analysis and FIFO analysis were done.

Khyomesh V.et al., (2014) it's a study about the centralised material management and team co-ordination between the site and the organization. They point out that Proper control, tracking and monitoring of the system is required for proper material management and Awareness and accountability should be created within the organization. There is a need of an efficient MIS for integrating all aspects of material management.

Nawaj Kalim Hannurel.et al., (2013).They has studied the manually material management practices that are carried out in construction companies. But to achieve a profit, there is need to change process of material management. It reduces manual errors and it is easy to communicate. The main barriers of implementation of ICT are its high initial cost and lack of agreement amongst all the board of directors. The construction companies are using mostly the ICT techniques in planning and procurement stage while minimum in logistic and inventory stage. They conclude that profitability index is more than one and net present value of ICT tool is positive so it can be accepted.

Navon Roney, Berkovich, et al., (2005) They have said that the problem with materials management is the lack of up-to-date relevant information, hence the importance of monitoring the flow of materials and the data associated with them. The authors point out that a computer integrated materials management system can help in data collection, their organization, their analysis and their presentation to support real-time decision making.

Hemish kumar Patel et al., (2014) He has analyze the factors, which affect material management and inventory management. The factors are ranked on the basis of survey on construction firms in Gujarat and the factors are ranked in accordance with relative importance index technique and importance index technique. They concluded with analyzing important factor which affect material management misunderstanding of owner requirements by design engineer and factor which affect inventory management was a responsible official should authorize purchase.

Salah Uddin. K.M et al., 2015 A stochastic simulation and experimental study for reducing inventory cost and optimizing service levels in distribution of inventory was conducted to deal with inventory systems modeling and simulation to analysis the inventory cost of single item inventory in Bangladesh . The results show that a real inventory system can fully be monitored through a computer simulation.

Vincent Augiseau et al., 2016 Their studies on construction materials flows and stock, have improved the knowledge on stock accumulation and removal mechanisms and prospective modeling enabled partly to anticipate them. Research on flows and stock of construction materials has led to the development of a methodological framework. It has also allowed the conceptual framework for the analysis of socioeconomic systems to be completed, while supporting the implementation of some industrial ecology policies.

The information collected from existing literatures were used in evaluation of construction materials with the assistance of construction sector-based respondents. The proposed framework was validated with a case study company, and the results were compared to the existing literatures and to feedback from the respondents. Finally, the study concludes with an assessment of its own limitations along with the identification of some useful managerial implications; it sheds some light on future possible enhancements in the theme of sustainable construction in the context of UAE.

Mathew.J.Liberatore et al., 2001 His research focused on the use of project management software in the construction industry by drawing data from an empirical study of project management professionals. It was found that the number of activities in a typical project and the use of software for all active projects were the key determinants of the usage of specific analytical techniques. To maximize the impact on practice, development of new planning and control methods should include their integration into project management software.

Automation increases the productivity of the construction project, reduces the duration and laborious work, and increases the construction safety, increases the quality of work as compared to unskilled worker (Disha Gedam, 2015).

Edgar. M. Barriga et al., 2005 Lean inventory control systems and supply chain management techniques are applied to the current systems of the material handling industry and propose a new framework of material control systems as one of the system management tools. Thus a new material management system was developed from the generic material flow and control system currently used by the MH industry. The main benefit of the proposed new system was its ability to relate demand for material directly to the master production schedule MPS.

Rafael Sacks et al., 2007 A new tool was developed with which the gap between the desired functionality of control information systems and that provided in current construction practice can be identified. The tool can be used to identify the gaps in this area within individual companies, or at an industry level. The results of testing the tool with a select group of 26 professionals, serve to define research issues aimed at closing the aforementioned gap. Further, the relationship between strategic skills and performance is arbitrated by material supplier integration. Results of a dominance analysis also suggest which strategic skills are most likely to explain status integration, and performance.

Ricardo Antunes et.al, 2015 A theoretical framework was proposed in which the technology connects project stages—feasibility, design and construction activities, as well as proposes a flow of uncertainty to risk and the risk impact causing variability. This system structure representing the production provides a means to analyses the effects of interconnected elements in a micro and macro view.

Nawaj Kalim Hannure,et.al, 2014 To achieve a profit, there is need to change process of material management. By using Information Communication Technique (ICT), exact consumption of material, stocked material, and location of material can be obtained. It reduces manual errors and it is easy to communicate. The main barriers of implementation of ICT are its high initial cost and lack of agreement amongst all the board of directors. The construction companies are using maximum ICT techniques in planning and procurement stage while minimum in logistic and inventory stage.

Anirudh. P Akarsh et al., 2016 In India complaints of poor quality and unsafe practice of construction have been traditional problems which have to be rectified as the industry is at rapidly growing phase. Automation technologies have a promising potential which can overcome various barriers and enhances the efficiency and productivity of construction firms. The existing state of automation in Indian construction industry and stimulate the future potential of construction firms are discussed.

Yu-Cheng Lin, 2009 Interface management has got applications for building projects in construction phase. A construction Network-based Interface management (CNIM) concept and system for all project participants was presented as an interface-sharing platform. Network-based maps show the available interface events, problem descriptions and solutions in the interface management environment. The collection of interface events and problems for network-based map units in construction projects allows involved project managers and engineers to trace and manage most interface-related information. The observation results result showed that the CNIM system significantly enhanced progress in the process and management of construction project interface events.

Robin.G. Qiu et al., 2006 A construction logistics planning model was developed that at the same time optimizes the decisions of material supply and site layout in order to minimize logistics costs that include ordering, carrying, shortage, and layout costs. New methodologies were incorporated in the developed model to represent the interdependencies between material supply and layout decisions as well as to measure the impact of these decisions on project delays (Hisham Said, and Khaled El-Rayes, 2010).

A material flow management (MFM) system that controls and manages material flows on the shop floor is a key component of enterprise information systems. The authors propose a solution to the design and development of a scalable, reconfigurable, and distributed MFM system. Using the concept of Virtual Production Lines, production lines can be logically configured, and operated, respectively, in processing different families of products; MFM

modules/instances are accordingly created to control and manage material flows in corresponding production lines.

III. METHODOLOGY

The research project was carried out in different stages. Formulating the flowchart for the workflow of the model, coding was carried out to develop the application. Thereafter programming was done using the PHP framework, thus developing the intended web application model. Meanwhile, questionnaire was also prepared to aid for the field surveys to be conducted later on. The questionnaire survey was carried out with various builders along with the field studies, which aided as a market study too for the product model developed. Certain modifications were also made to the web application model developed based on the review received.

A. Questionnaire Survey

A detailed questionnaire is prepared as a part of the research. The questionnaire consisted of two sections mainly. The first section to be filled was regarding the company details are included. The second section consisted of open ended questions. The questions basically dealt with: the Current computerized techniques adopted and the material management methods adopted. The problems considered to be leading to the necessity of an automated system for materials were:

- Unavailability of materials
- Variation in quantity of material ordered and received
- Late material delivery to site
- Improper response from suppliers
- Delivery of incorrect materials
- Unnecessary piling up of stock in stores
- Carelessness in placing material PO on time
- Increased material wastage in sites
- Incorrect material quantity estimation to place order

And, the possible benefits of any such automated material management system were noted to be:

- Reducing the overall costs on project materials
- Better handling of materials
- Reducing duplication of material orders
- Timely availability of materials on site in the right quantity
- Improving labour productivity
- Complying to time schedule
- Complying to enhancement of quality control
- Improving follow up and monitoring of materials
- Better relationship with suppliers
- Waste reduction
- Reducing the space for materials on site
- Obtaining better price for the construction materials
- Reduce material transportation costs
- Better use of computerized technologies
- Considerable contribution in profit

B. Php Software

PHP is a programming language used primarily to

develop web applications (it is used in the ever-popular PHP-Nuke web portal software). It boasts compatibility with countless other protocols, such as CGI, and other programming languages, such as C++ or Python. PHP is an imperative, object-oriented programming language that can be used for applications ranging from general to specific.

One of PHP's greatest benefit is its compatibility with other programming languages, and indeed, even with concepts. If you want to do something with the language, you can likely do it. PHP can be used for any website idea or making your website work with any other piece of software in any other programming language.

C. The Project Control Cycle

Management, in general, involves setting objectives and then monitoring the performance of the system. The project control cycle can be illustrated as in fig.1.

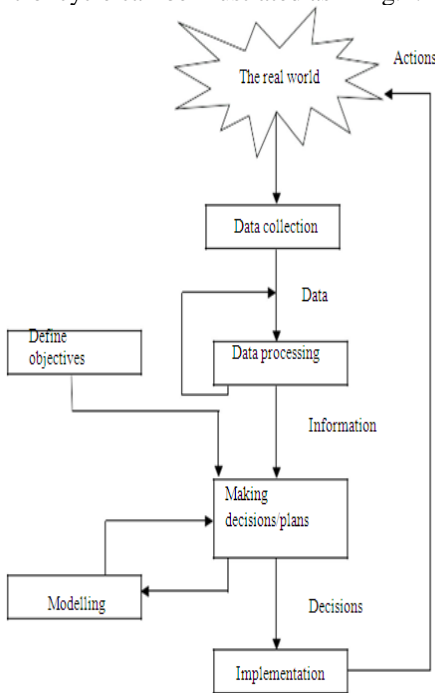


Fig 1:- Project Control Cycle

D. Modelling

Based on the findings from the literature and field studies conducted as a part of initial study, an integrative model for materials purchasing, supply and use, as well as the control of the entire process, will be recommended.

The determination of the type of material, quantity required and specifications require a thorough examination of contract documents, like the BOQ, drawings, preliminary vendor enquiries, etc. The materials provisioning process can be represented as a sequence as follows:

- Examination of contract documents to identify the items to be procured and the quantity.
- Float inquiry indents to locate supply sources and invite quotations from selected ones.
- Perusal of quotations received and suppliers' pre-

qualifications.

- Place PO and monitor the order execution.
- Pre and post-shipment inspections may be carried out as required.
- Close materials supply contract and inform the concerned sections like accounts, etc.

E. Criteria For Software Development

The criteria for a software system are as follows:

- The software must be relatively easy to install and operate. The input data must be easy to prepare, and the output reports must be understandable
- Data sorting is one of the base uses of computers
- It must be a fully tested system and should have a proven record
- The program should be flexible and have capacity for handling many types of application
- The database must contain all the necessary elements so it can be managed to generate the desired information reports
- The system must be economical in terms of installation, operation, and maintenance.

IV. RESULTS AND DISCUSSION

The research has tried to develop an effective automated material management model tool, which would be of use in local building construction projects. Questionnaire survey is also carried out retrieving the relevant factors from the literatures, in order to aid in a detailed study on the most prominent development in management, automation and also as a market study for the web application model developed.

A. Data Analysis

The factor analysis carried out generated some relevant outputs like: relative importance of factors, reliability of the questionnaire and checking of sampling adequacy. The inferences drawn are as follows:

Relative Importance Index

The Relative Importance Index is computed using the equation:

$$RII = \frac{\sum W}{A * N}$$

Where: W = weight given to each factor as response (ranging from 1-5)

A = highest weight (5 in this case)

N = total number of respondents

The results of the factor analysis carried out manually using the RII method are shown in tables.1

S.No	Problems which may lead to the necessity of an automated system for MM	RII
1	Unavailability of materials	0.72
2	Variation in material qty ordered and delivered	0.67
3	Late material delivery to site	0.72
4	Improper supplier response	0.54
5	Delivery of incorrect materials	0.72
6	Unnecessary piling up of stock	0.6
7	Carelessness in placing material PO	0.76
8	Increased material wastage in sites	0.63
9	Incorrect material qty estimation to place order	0.7

Table 1. RII values for first set of factors

The most important factors (problems which lead to the necessity of an automated management system) as per RII method, were found to be: carelessness in placing material purchase orders, late delivery of material, delivery of incorrect material etc. It could clearly be seen that these problems can be avoided by using the material management model developed in this project.

B. Conception of the Model

The major result obtained in this research is the web application model. The basic features or the criteria required for the model development have been included. The model was framed after the development of coding thus eliminating errors. Programming was carried out in PHP language for the front end and MySQL as the backend.

The application is designed in such a way as to be very simple and user friendly. The model has been developed focusing on the basic procurement practices carried out in construction sites and manage projects. The model helps in keeping a balanced inventory level at site, a level which can act as a cushion between supply and site requirements till supplies are received. It includes safety stocks presumption to cater for slippages in delivery schedules and also helps to know the details of the material supplied by the supplier and their current rates.

Features of the automated model for admin

Being web application, the output was run in one of the popular internet browsers, viz. Google Chrome. The automated material management model is provided with a series of controls which can be accessed by the admin (project manager or whomever in-charge of works) by logging in with his respective credentials. Fig.2. shows the log in page of the application.

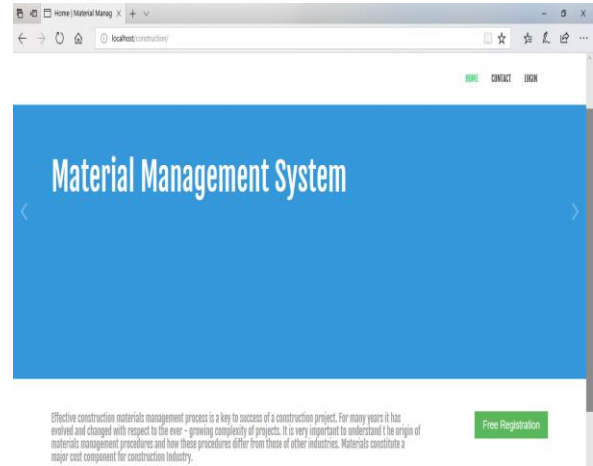


Fig 2:- Log in page of the application

The projects executed by the company can be added to the model as different modules. The projects can be added or deleted from the system as required, by making suitable changes to the programme. Each project is assigned to a site engineer by the admin. This division of model groups the works carried out by the organization and thus has a better control over the projects. Database has to be expanded according to the projects. The admin can access the home page, to different modules like material categories, suppliers, current rates of different dealers, on stock updates by site engineer and purchase orders, etc. The provision for handling multiple projects is shown in Fig.3.

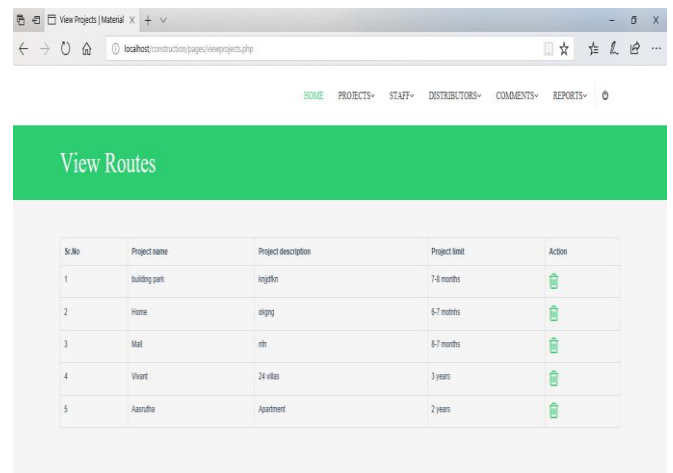


Fig 3:- Details of multiple projects under taken

The module ‘Categories’ can be accessed and the required materials can be added to the database along with the material details. Provision to allot respective category codes has also been included.

The details of the supplier for each material can be added by the purchase manager or the admin. Each supplier is provided with a username and password. The list of suppliers identified by the organization can be best viewed and the suppliers whose performance has been declined can be made inactive. Fig.4. shows the material suppliers module.

Sr.no	Material Suppliers	Material Name	Material Details	Price
1	greenhina	cement	ACC. Elite super 53 grade, Ultra tech.	389 - 400 per Bag
2	greenhina	steel	Kansal TMT Rebar, TMT, Kiscad TMT	42 - 55 per Kg
3	manoj	cement	ACC concrete plus	351 per bag
4	manoj	steel	TMT steel bars, High grade TMT bars, Ages TMT, Ages TMT Rebar	40 - 55 per Kg
5	manoj	M sand	M sand, Filling Sand etc.	1270 / TON
6	greenhina	W Proofing	Du Puit poly proof 100 LTR	1200 per 10 LR
7	Arun	cement	Acc. Elite super 53 grade, Naabur	350 - 400 per Bag
8	Arun	Calc Block	Concrete Block 4" x 8" 8"	70 - 120 per piece
9	Arun	Sand	M sand, filling sand etc.	1270 / TON
10	Arun	RMC	Ready mix concrete grade 100 - M 20, M30	4500 / cubic meter

Fig 4:- Material supplier details

From the field studies it was found that the order quantity and order period is estimated manually, but keeping in mind the concept of Just-In-Time. The required materials are ordered only as and when needed, with respect to the material usage, pace of activity progress, lead time, storage conditions, etc. No excess or shortage of material occurs. Thus, admin has access to feed the minimum stock level and the quantity of material to be ordered into the system.

The admin also assign Site engineers to the various projects undertaken and also he can evaluate the data such as site updates and other document send by the site engineer. The engineers will be given a username and password. The reports send by the engineers are evaluated and approved by the admin. Fig IV.4 shows the details of projects assigned to the engineers by the admin and fig IV.5 shows the details of reports send by the site engineers to admin.

Sr.no	Name	Phone	Email	Address	Project	Edit	Delete
1	ahmed	9879543201	ahmed@gmail.com	ahmed	building park		
2	ahf	9879543201	ahf@gmail.com	ahf	Home		
4	Arya	8247389502	arya@gmail.com	Palaikat, Kerala	Vihar		
3	Arun	9877950544	arun@gmail.com	mummalilad, palaikat, Kerala	Aashra		

Fig 5:- Projects assigned to site engineers

Sr.no	Engineer Name	Engineer Email	Engineer Phone	Project Name	Project Description	Project Limit	Report Details	Status	Action
1	ahf	ahf@gmail.com	9879543201	Home	sliping	6-7 months		pending	
2	Arun	arun@gmail.com	9877950544	Aashra	Apartment	2 years		pending	

Fig 6:- Site updates

• *Features of the automated model for Material suppliers*

The suppliers can also log in to the same domain with their respective credentials. The vendors can be selected on the basis of size, capability, past performance, market reputation, and if necessary, these may be confirmed by a visit to the vendor’s works. The key criteria for evaluating the potential of the vendor to deliver the right quantity of material at the right time may include: the quality of material, support services, professional competency and engineering skills. They can add the details of materials they supply and its rate. The any new materials can be added and deleted and also rates can be updated. They can view the purchase orders sent to them and can approve or rejected. The suppliers can also comment their opinion at the Comments.

Fig 7:- Adding material details

Features of automated model for Site Engineers:

The projects are assigned to the site engineer by the Admin. Site engineer can sign in by using their login id and password provided. They can view the details of the project under which they have assigned and all the material suppliers details. The site engineer can send their site material requirement and other information as report to the admin, which can be approved by the admin.

C. Highlights of the Model

The automated material management model is developed incorporating many features so as to make it more productive, user friendly and unique from its counterparts already available in the market. The major attractions of the model can be listed out as:

- Ability to handle the material details of multiple projects at a time Separate database for materials, suppliers, purchase orders and inventories
- Better Control on usage of materials and work .Projects can be completed as soon as possible due to less delay in material supply.
- Flexibility in setting the material quantities: to be ordered, minimum stock, minimum order, etc as generally these limits are set manually in majority of the construction projects
- Better interaction with suppliers by proper follow up, feedbacks and approval or rejection messages

- Better supplier management can be ensured by features like changing status, ratings Payment Reports can be obtained in printable formats
- Easy and digitized procurement options: online payment, etc
- Due consideration for material inspection as the material gets delivered and provision to store the details.

D. *Limitations Of The Model*

The developed web application model, which is in its nascent stage, has got many limitations with respect to its performance. Some of them are:

- Linking with BOQ could have automatically estimated the quantity of material required.
- Internet facility should be available at site without signal loss.
- Only purchase manager, Site Engineer and Material supplier have access to the system, amongst all project participants
- Not linked with the finance department, as material purchase also deals with accounts
- There is only a minimum scope for the builder side or the supplier side to portray their requirement and availability of materials, respectively, for each other to get known.
- The concept of tendering not included.

V. CONCLUSION

The research has examined material management practices on building construction sites. It was found that the material management field lacks utilisation of automation technologies and thus a simple web application model is put forth as the solution. The model is developed with the help of PHP framework (C# programming language for web form coding and MySQL server for database creation). The same is expected to ease out the material procurement practices in the current industry. Even though automation has got demerits, its advantages overwrite them.

A. *Recommendations*

The developed model is aimed for real time monitoring and controlling of the materials in the construction sites. Thus it is recommended to the residential building and commercial projects. Being cost-effective and user-friendly the model will be more useful for the project managers. As all the payments are getting digitized in the present scenario, this model will surely be of considerable significance in the construction industry, as it supports some of such latest advancements.

B. *Future Scope*

There is a huge scope for enhancing out the model's features in the future, so as to make it more productive. Further developments and enhancements on technical and performance features of the tool can be developed like inclusion of more project participants with varying visibility levels, inclusion of e-tender concept, etc. Yet another feature may be: developing this model's mobile application version to facilitate on-site data updating. Numerous other features may

also be added to make it simpler, more users friendly and cheaper than its existing counterparts

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