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A SYSTEM TO TRACK WORK PROGRESS AT CONSTRUCTION JOB SITES

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Abstract - To coordinate work effectively in a construction site, supervisors need to know who is doing what, where, and whether the work is progressing according to plan. Similarly, workers need to have clear instructions to execute the work effectively. Currently available solutions do not support information-sharing between the different participants in a construction site, resulting in decision bottlenecks and high coordination costs. In this paper we present a Work Tracking System (WTS) for construction. This system manages the information flows between project participants to support better communication about task scope, progress, and completion. The WTS automatically reports work progress and compares it to the original plan, allowing supervisors and workers to have a common understanding of the project status. We describe the implementation of the WTS system prototype, which leverages mobile devices and cloud computing to bring the technology to the field. We also present the feedback received from different participants in a mid-rise residential building project who evaluated the system. The evaluators liked the prototype's 4D visualization of the work performed, its facilitation of setting work priorities, and its support for accelerating decision-making. The feedback that we received also stressed the need to include filters that allow users to sort through information more efficiently and manage tasks at different levels of detail.

***Key Words*:** (work tracking system)

1.0 INTRODUCTION

On-site work needs to be coordinated by superintendents, foremen, subcontractors, and field workers to ensure that tasks are prioritized correctly, and that the work can be executed productively. Currently, work is coordinated during weekly or bi-weekly planning meetings. However, once the work is being executed, it is impossible for supervisors to know who is working on what task in what location, and what the task status is with respect to the plan. Since there is a substantial time lag between an issue being encountered in the field (e.g., quality, design, coordination, etc.) and supervisors being made aware of it, supervisors are likely to be making decisions based on outdated information. On the other hand, lack of clarity in the task status as well as the prioritization of tasks is not a problem that is faced by supervisors only. Timely communication about the task scope, materials, methods, and resources, is critical to avoid construction rework, which leads to wasted time, materials, and energy.

1.1 Methodology

The first step in the study is to identify the problem definition and to set aim and objectives of the study. To track the status of a task, the WTS needs to have access to key data about the task, such as: when the task started, when it was finished, and whether any issues were reported; so that the WTS can compare it to the plan. To collect this information in the most efficient way, we leveraged the principles of Power to the Edge.

Power to the Edge states that in a highly uncertain and dynamic environment, traditional methods of command and control break down. Instead, highly trained workers should be allowed to synchronize their actions based on a "command intent" established by managers. Information should be made available in a "publish and subscribe" model, where information is shared widely and workers can selectively browse the information which is useful to them. To implement Power to the Edge, we inquired about the information requirements of different project participants at the construction site to understand how the information flows could be made more efficient. We also relied on the task data supplied by the workers, decentralizing the work tracking operation, which is traditionally carried out by the supervisors (project engineers or foremen). To implement the WTS, we leveraged advances in mobile cloud computing technologies to manage the information flows and establish two-way communication between the users and the system.

Emerging commercial mobile solutions have centered their attention on visualization, tracking punch lists, and managing timesheets. However, these applications have not yet addressed the problem of work tracking at a task level of detail and integrating it with 4D visualization.

2.0 Work Tracking System (WTS)

Work Tracking System (WTS) In the first part of the research, we wanted to understand the information requirements from the different project participants in a construction site, to design a system that manages the information flows more effectively. Specifically, we wanted to know: what information is required by the different project participants to perform their job, and what information they have readily available or have to produce as part of their job. To understand this, we performed over twenty unstructured interviews with project managers, superintendents, project engineers, foremen, subcontractors, and field workers at three construction sites. We consolidated the responses around themes that were common across the interviews. An interesting observation was that there were many overlapping information flows between some of the project participants interviewed, which led us to consolidate them into one user type.

3.0 Development of a Project

3.1 Site Selection:

The following are the few factors which generally taken into account while selecting a site

- Location
- Climate of region
- Availability of raw materials for
- Cost and time frame
- Population of the region

The selection of a site for affordable housing should reflect the particular needs of the population that housing development will serve. An important consideration is the location of the property in relation to the services residents will need to access, such as shopping, medical, schools and transportation. Location of the site may also have a significant impact on the cost of project. In "Genetic Limited" we have found that they have a survey team. In the initial stage they visit the site and find if the condition is satisfactory according to their company policy. While selecting the sites they follow some of the criteria. Like-

- The land should be in a condition that no filling of land is required.
- The minimum land area should be 3600 SQ.FT.
- The location of the land should be in the prime location.
- The land should be undisputed

3.2 Soil Investigation.

Soil Investigation is carried out for designing a right type of foundation safely and economically, a designer must possess sufficient information about the physical properties and the arrangement of underlying materials. The field and laboratory investigations required to get this essential information is known as soil exploration.

A standard soil test report contains the following features.
Introduction.
Location & level.
General notes on sub-soil investigation.
Scope of the work.
Field investigation.

i. Drilling & recording.
ii. Standard Penetration Test (SPT)
iii. Disturbed sample collection.
iv. Undisturbed sample collection.
v. Ground water table.

Laboratory test.
Following tests should be conducted.

vi. Grain size analysis.
vii. Moisture content.
viii. Direct shear test.
ix. Specific gravity test.
x. Atterburg limit test.
xi. Density test.
xii. Unconfined compression test.
xiii. Consolidation test.

Determination of bearing capacity.
Determination of pile capacity.
Foundation recommendation.

3.3 Foundation Design

Design of foundations with variable conditions and variable types of foundation structures will be different, but there are steps that are typical to every design, including:

- Calculate loads from structure, surcharge, active & passive pressures, etc.
- Determine footing location and depth – shallow footings are less expensive, but the variability of the soil from the geotechnical report will drive choices
- Evaluate soil bearing capacity – the factor of safety is considered here
- Determine footing size – these calculations are based on working loads and the allowable soil pressure
- Calculate contact pressure and check stability
- Estimate settlements
- Design the footing structure – design for the material based on applicable structural design codes which may use allowable stress design.

3.4 Superstructure Design

Designing superstructures requires considering the pressure and force they will exert on the finished construction and balancing this to address concerns about safety and stability. The size of the superstructure is an important factor in base design, as the base of the structure must be able to support the entire laden weight. In building construction, there may be concerns about structural integrity in earthquakes and high winds. During designing Engineer should have a clear idea about the rules/codes like- BNBC, RAJUK & local rules etc. and apply them correctly.

The superstructure is also the highly visible part of a structure. For the purpose of determining the maximum stresses in any structure or member of a structure, the various loads have to be taken into account such as:

- Dead load of the structure
- Live Load of the structure

- Wind Load
- Seismic Load
- Temperature effects
- Loads during construction period

Once the required calculations for the structure are done, certain checks are performed to make sure that the structure remains durable, sound and stiff.

3.5 Project Planning and Management

Excellence in Project Management is achieved through a structured process that includes multiple phases:

- Initiating
- Planning
- Executing
- Monitoring and Controlling
- Closing.

The process balances the key project constraints and provides a tool for making decisions throughout the project based on stakeholder values, performance metrics, established procedures and project goals.

Effective project management includes strategies, tactics, and tools for managing the design and construction delivery processes and for controlling key factors to ensure the client receives a facility that matches their expectations and functions as it is intended to function.

Successful project delivery requires the implementation of management systems that will control changes in the key factors of scope, costs, schedule, and quality to maximize the investment. This section offers guidance for the entire team to successfully and effectively carry out a high performance building project.

3.6 Work Tracking System Prototype

To develop a first prototype rapidly, we decided to narrow the scope of the WTS to a set of core features that would allow us to provide the main functionality of the WTS. We focused on the features that were directly related to work tracking. The following were identified as core features:

- Task status dashboard showing
  - Task status (Future Activity, Started on Time, Has not started, Late Start, Delayed, Critical Delay, Finished on Time, Finished Late).
  - Task assignment (crews/specific people).
  - BIM element/Location o Planned Start, Planned Finish, Actual Start, Actual Finish.
- Create/Update tasks
- Visualization of the work performed.

3.7 Construction

When a project is executed on the site it has to cover up a sequential order from its initial stage to final stage. This generally includes:

- Site mobilization
- Drawing collection
- Proposed area check
- Pilling /Earth cutting
- Pile cap /Footing
- Column
- Grade beam
- Column
- Slab & beam
- Brick Layout
- Lintel & false slab
- Grill fitting & door floor fitting
- Grove cutting for electrical wire
- Inside & outside plaster
- Sanitary work
- Electrical wearing
- Tiles
- Paint
- Fitting Works

4.0 Overview of the WTS Web Application

The WTS was built as a web application to allow teams to access real time information in a decentralized manner. The web application was built using the Google App Engine Framework. This framework allows the developers to easily deploy their projects using Google's servers, provides powerful computing power as well as automatic scaling for their applications. The back end of the application was written in Python and Jinja was used as the template engine.

5.0 Conclusion

The aim of a civil engineer is to plan and design various types of structures. This will not be possible unless he involves himself in ground-oriented tasks. A project engineer is mostly responsible for implementing the structural design on ground. He needs to have depth of knowledge and foresight ness so that his project does not stuck up for material scarcity, manpower, any special equipment or any other project related problem like requirement of dewatering in an excavation pit. This should be also theoretically covered along with practical orientation.

In this research, we developed a novel system for managing on-site production by leveraging VDC, Power to the Edge concepts, the pervasiveness of mobile technology, and advances in cloud computing. The Work Tracking System (WTS) allows project participants to publish and obtain the needed information with minimum latency, by managing the available information in the project platforms and updating and synchronizing it. A prototype of the WTS system was developed and feedback was gathered about the advantages and limitations of implementing this prototype on a construction site. Some of the positive feedback highlighted the ability to visualize the work being performed using 4D models, and the usefulness of having updated information about task status to make decisions about work prioritization and resource allocation. The respondents also identified some limitations in the current version of the WTS. For example, they mentioned the need to develop advanced filters to sort task information using different criteria such as: subcontractor, area, assignee, and task status. This research uncovered gaps that need to be addressed for the ideal envisioned system to work. Current scheduling practices do not support data collection in a way that is meaningful for management. Master schedules and production schedules are disconnected, sometimes even using different systems. Since task progress is being measured using the production schedule, superintendents need to reconcile the production schedule with the master schedule to get a meaningful idea of the overall work progress. Most of the time, this process is cumbersome and superintendents rely on their intuition to judge work progress, which means that although the progress data are being collected, they are not converted into useful actionable information that can help managers make better decisions. Therefore, it is necessary to develop tools and methods that support better scheduling practices to facilitate data acquisition and processing. This will lead to better reports, which will support management in their daily operations. Similarly, although the WTS effectively manages the information related to work assignment, progress and completion, we still need to address some issues before Power to the Edge can be truly achieved. More effective filters need to be designed to prevent workers from being overloaded with information that is not contextually relevant, allowing them to "subscribe" to the information they need. Also, additional research is required to allow field workers access to richer work instructions, such as: installation instructions, checklists, tools lists, parts lists and access to updated drawings. Finally, we would like to reach out to a broader construction community to test our Work Tracking System prototype and send us feedback about it. This information will deepen our understanding of the advantages and limitations of the application, and help us clarify the requirements to develop future versions of the prototype.

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