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Whitepaper

Digital Transformation of the Material Value Chain

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Transformation of the Material Value Chain through Digital

Materials used in the Engineering & Construction (E&C industry) are typically classified into four categories: Reusables, Commodities, Consumables and Construction materials. The reusable category includes tools, personal protection equipment, and formwork, among others. Commodities encompass materials such as plant and machinery spare parts, lift gear, and trolleys. Consumables consist of fuel, lubricants/coolants, and abrasives. Construction material further can be classified into bulk (steel, cement, sand, aggregates, boulders, bricks, lime and silica) and non-bulk (cables, tiles, switches, piping, plywood, and paver blocks). Management of the materials value chain – right from receipt and storage, through consumption and ultimately, to periodic reconciliation and wastage management – is a complex process. It accounts for 60% of the cost of a typical construction project, making it a critical and valuable part of the whole project cycle. This paper explores how digital initiatives can enable better materials procurement, tracking, and reconciliation in the E&C industry.

Digital in Material Value Chain

This paper explains how digital interventions can help solve problems in major areas of the material value chain – sourcing and procurement, consumption tracking and wastage management, and reconciliation of both construction and reusable material at the end of the project schedule.

1. Sourcing and Procurement

Bulk construction material, as mentioned above, is typically procured from several vendors within close geographical proximity to the construction site. Aggregates and boulders are sourced from quarries in the site vicinity and transported in trucks and dumpers a few times per month, depending on site storage capacity and demand at various stages of the project.

Site storage can often be a challenge for linear projects such as highways and rail construction, hence procured in smaller batches, receipt of which is staggered to match demand. This presents a challenge to the planning team at remote locations as incorrect demand projections may delay material availability, thus delaying entire project schedules. Seasonal factors may also contribute to a delay in transport mechanisms and quarry activities at the source.

Analytics on data from similar historical projects, supplier databases capturing parameters like material lead times, supplier lead times, probability of fulfillment, and seasonality of material, as well as project data such as schedules and demand projections, can greatly enable better planning through accurate demand and availability forecasting. Insights from such analytics can bemade available to procurement teams at headquarter locations, enabling them to dispatch consolidated orders to quarries and suppliers, as well as share data-backed forecasts of material needs for advanced production schedule planning. This ensures timely material availability to the site, however linear or remote it is.

Additionally, GPS tracking solutions on vehicles carrying high-value materials for route optimization and logistics planning can help further enrich planning schedules to ensure on-time material receipt and reduced pilferage.

Site storage is also limited at non-linear sites (buildings, airports, factories), and material pilferage could be a major problem here. Although trucks and dumpers carrying bulk materials are weighed at either/both state toll booth weighbridges and/or site entry weighbridges, the possibility of pilferage remains high especially in-transit.

An analysis of over 5000 trucks across 150 construction sites by a construction major pointed to high variation in the unladen weights of some trucks to the tune of 500 kg to five tons, with abnormal variations of net weights against the unladen weight. Even differences in fuel levels within the fuel tank or structural changes to the body of the truck could not account for these huge variations. This pointed to one of the following scenarios:

1. Irregular placement of truck on weighbridge in order to manipulate the tare weight of the truck

2. Tampering of load cells on site weighbridges where these trucks were being weighed

3. Replacement of actual material with low-value items along transit

Digital solutions coupled with analytics were used to tackle this problem and thereby successfully reduce pilferage and manipulation of material receipt quantities, saving millions of dollars annually in material wastage across project sites.

Comparing the unladen weight of incoming trucks with expected/typical truck weights from an allowable weight variance table of similar model trucks, could be introduced as the first check at the site weighbridge. Additionally, employing digital, tamper-proof load cells that auto-detect calibration problems and inconsistencies in measurements across the bridge, can prevent material theft arising from tampering.

Spike chart analytics which detects real-time truck weight variation and distribution on the weighbridge, can enable easy detection of faulty placement and early identification of anomalies. Insights from such analytics, along with other data from purchase orders and vendor contracts, can enable vendor rationalization to ensure uniformity in rates per ton of similar material grades.

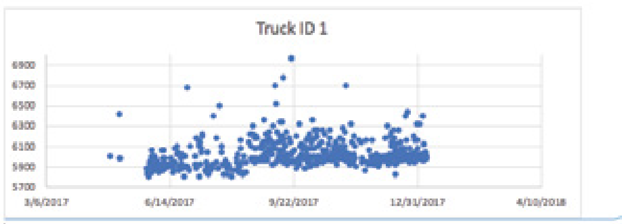


Figure 1: Analysis depicting variation in UW (Unladen Weight in kgs) of a truck across weeks

2. Consumption Tracking and Wastage Management

Lack of visibility into material availability, especially at large-scale construction sites in remote geographies, hampers not only future planning of project delivery schedules, but also makes maintenance and repair of completed structures cumbersome. RFID tagging proves to be an excellent solution especially for high-value materials like metal panels, façade elements, precast sections of tunnels, and steel rebars. RFID tags attached to such material right from fabrication/receipt on site provide real-time data as the material moves across the site to the point it is installed. Unique IDs enable faster traceability for reconciliation, damage reporting, replacement, and maintenance.

RFID tags also prove useful in tracking high-value and large machines/tools on a busy construction site. Issuance from stores is made easier through direct readers placed at store entry and exit checkpoints, removing the element of manual oversight and error from tools inventory management. Theft and misplacement of tools can be greatly reduced with RFID tagging. Fig. 2 illustrates this.

For reusable items like formwork and personal protection equipment, barcoding can be an effective solution. Issuance and return mechanisms of formwork can be greatly controlled in this way. It provides greater visibility into availability and reusability of formwork, reducing repeatable issuance, repurchasing, and wastage.

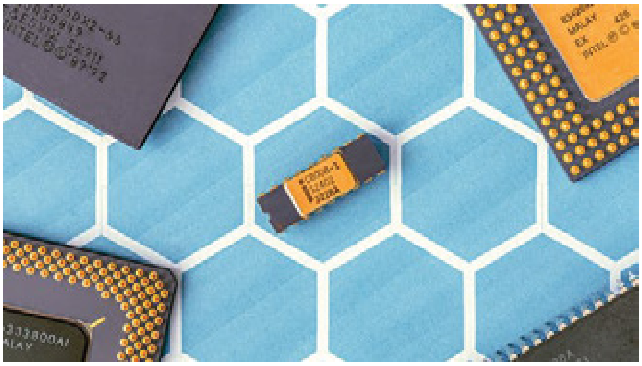


Figure 2: Barcoded /RFID-tagged tools

A subcontractor database, if captured and analyzed in a structured manner, can be used as a basis for evaluation of future subcontractor bids and for benchmarking cost estimations. These data-backed figures can place the company in a better bargaining position to negotiate and finalize payment rates. Logging of relevant vendor details like specialization, gang size, work feedback, productivity achieved, rates, etc. by project managers can provide reference points for hiring skilled and quality vendors in future, as per project requirements. This helps create a one-stop portal of collated and relevant vendor information of otherwise dispersed data that existed in the traditional system.

Onboarding vendors can be made more seamless through search engine-based mobile apps, allowing project managers to refer to the HR repository of all vendors hired in historical/existing projects and send out requests for engaging with preferred vendors via the app.

Advanced analytics can help correlate factors like productivity, gang size, core/non-core work percentages, ratio of skilled to unskilled labor, enabling better decision making. For instance, it may seem intuitive that fragmented and small, specialized laborers bring down the overall productivity because they require more investment of time and resources for their onboarding, management, payments processing, and retention. (Figure 4) Data analytics can not only provide proof of this hypothesis but also helps pinpoint problem areas to work on.

3. Reconciliation

Error-free and periodic material reconciliation is paramount to wastage reduction, budget management, and schedule adherence for construction projects of any scale. Errors creep in when the whole process is manually managed with manual measurements and stock record keeping. Additionally, given the nature of the construction site, accurately measuring stock consumption is very difficult on a daily basis. Digital interventions make the measurement process faster and error-free, especially the estimation of volume and weight of large aggregate stockpiles (as shown in Fig. 3) as well as counting of steel rebars, wooden logs, etc. typically used in construction. Laser stockpile measuring devices enable safe-distance measurement of large piles and faster computation of the volumes by a single person. Mobile applications can then be used to record the latest measurement and compare with previous measurements to decide on future plans as per project progress.

Mobile applications to count cross sections of steel rebars and wooden logs in stock and track consumption (as shown in Fig. 4) are useful in both faster process management and error-free reporting of stock quantity and volumes. This is because steel reconciliation is often complex, in that it relies on conversion of lengths to volume for stock keeping.

Figure 3: Aggregate stockpile measurement when digitized reduces error in reconciliation

Figure 4: Images fed into a counting /image analytics mobile application enable faster reconciliation at end of each month of project lifecycle

Application of QR codes from bulk material sourcing at quarries to measurement at source and destination site stores can provide end-to-end visibility into the movement of bulk material, providing automatic and accurate reconciliation at the end of the month, as illustrated by the process map in Fig. 5.

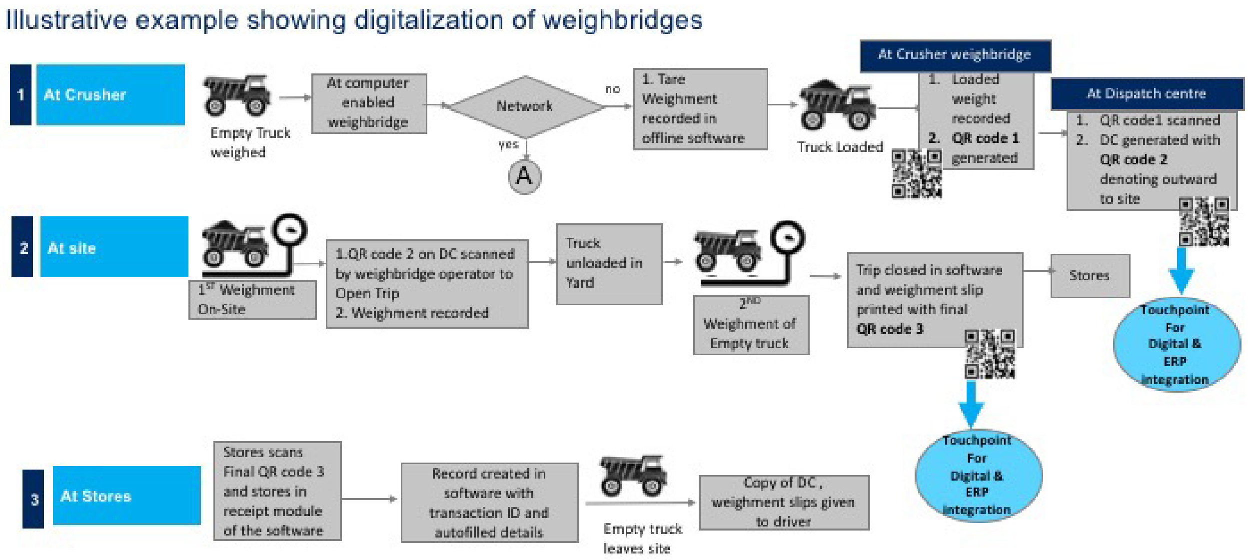


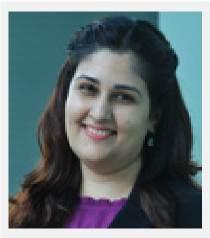
Figure 5: Digitalization of weighbridges across construction sites and source quarries eases reconciliation process by minimizing manual intervention and eliminating errors.

Conclusion

Adoption of digital solutions in a traditional industry like E&C is slow, considering the age-old affinity to paper-based bookkeeping and the manual nature of the overall process. Therefore, considerable effort must be put into training the workforce to use the digital solutions and mobile applications proposed in this paper. A culture of continuous adoption and change management led by "digital champions" is essential to increase the penetration of digital technologies into the construction industry, which serves as the backbone infrastructure of developing nations.

For an industry which is cost-sensitive, investment in new technologies may be a deterrent. It is important to keep in mind that these investments will accrue long-term benefits in terms of costs savings from improved digital material management, as well as increased customer satisfaction from better adherence to project timelines as material unavailability issues are digitally addressed.

About the Author



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Natasha leads the IoT Consulting practice at LTI, with deep domain knowledge in manufacturing and construction industry. She has rich experience in research and development in areas of remote condition monitoring of electrical equipment with over 9 years of work experience in the Manufacturing and Utility sectors. Natasha has a Masters degree in Electrical Power systems from the University of Strathclyde, UK.