NAC Executive Insights

Managing Materials During Engineering — Civil/Structural

Key Points

- This Executive Insight looks at the materials management during the various engineering phases.
- It describes an approach where the owner separately contracts with a designer and a construction manager.
- Responsibilities, activities, and workflow are described for the civil/structural discipline.
- Tracking, reporting, and reviewing forecast and actual engineered and bulk material quantities during the lifecycle of a project is a critical success factor for predicting and controlling project costs.
- Early variance identification allows for corrective action.
- Materials management activities are focused on large quantities, primarily bulk items.
- Material Take-Off (MTO) Allowance is the quantity for growth in estimated quantities of the bulk material.

Introduction

This Executive Insight looks at the management of materials during the various engineering phases and engineering support to construction. Responsibilities, activities, and workflow are described for the civil/structural discipline. The information here is most applicable to large process, power, mining, and industrial plants, but can be readily adapted for civil/structural projects such as large transportation or water projects.

General Responsibilities

Materials management during engineering falls under the overall purview of the project engineering manager. The project engineering manager is responsible for the overall coordination between the various engineering discipline leads and the materials manager, who at the earliest stages undertakes a materials planning function.

The engineering discipline leads ensure alignment of their specific disciplines to the project execution baselines and ensure materials are quantified, forecast, and controlled. Today's BIM (Building Information Modeling) is a significant enabler of this process. It enables essential real-time takeoffs as systems, structures, and components are included in the system. The various discipline engineers are the actual control points for managing materials during engineering, considering alternative system

designs and layouts. The growing presence of various AI-enabled design tools further facilitates this optimization process. Increasingly, discipline engineers will need to provide more focus on waste minimization, which will directly impact materials management during engineering.

Why Material Management During Engineering Is Important

Tracking, reporting, and reviewing forecast and actual engineered and bulk material quantities during the lifecycle of a project is a critical success factor for predicting and controlling project costs. Effective material management provides visibility to project engineering and management of any variance from the estimated quantities that have been established as part of the cost estimate baseline. Typically, the cost estimate baseline is associated with the front-end engineering design (FEED) estimate.

> FEED (Front-End Engineering Design) – basic engineering that is conducted after completion of a conceptual design or feasibility study

Early awareness of variances of design quantities provides project engineering, procurement, and management with the opportunity to evaluate the necessity for a deviation and possibly to consider other alternatives, depending on the stage of overall engineering efforts. Early variance identification allows for corrective action, updating of the material budget through an approved change, and incorporating any additional construction labor into the construction progress base. The later additions affect both earned value and earned schedule.

Tracking quantities at the appropriate work breakdown system (WBS) level ensures consistency and traceability to baseline estimate quantities. Quantities can be reported at the WBS level rolled up as required.

Typical Materials Tracked by Civil/Structural

Materials management activities are focused on large quantities, primarily bulk items. Typical materials in the civil/structural area that are tracked on process, power, mining, and industrial plants are reflected below.

Cost Account	Material Description	Unit of Measurement
CIVIL		
	o Excavation	Cubic yards / meters
	o Backfill	Cubic yards / meters
	o Area Paving	Cubic yards / meters

STRUCTURAL

o Piling	Each
o Engineered Foundations	Cubic yards / meters
o Fireproofing	Cubic yards / meters
o Structural Steel	Tons / metric tons
o Modules	Tons / metric tons
o Pipe Racks	Tons / metric tons

Material Management Work Process

During project initiation, scope definition, and conceptual engineering phases, an overall project execution strategy is developed with a contracting and material management plan. Material management responsibilities are established at this stage and materials are mapped to the developed WBS and construction work packages. Initial purchasing, expediting, logistics, material control, inspection and acceptance, and field management plans begin development at these early stages and preliminary bidder lists may be developed as part of market surveys conducted by procurement.

A control level schedule is issued as work moves into preliminary engineering and construction planning and the baseline is reviewed and validated by the discipline lead engineer against civil/structural requirements. This ensures completeness and reasonableness of assumptions. As preliminary engineering proceeds, a quantity control base is established for the civil/structural quantities to be controlled. Typically, those are the principal bulk materials reflected in the prior section. RFQs (Requests for Quotation) for any long lead procurements would be awarded near the end of preliminary engineering.

As design shifts into detailed design, quantity management activities commence. Trends and deviations are closely monitored and corrective actions are taken as needed. Any deviations are processed for formal approval and incorporation into periodic quantity reports, which include any then-current forecasts based on material quantity trends. Quantities are continuously reviewed against the established baselines and project level mitigation and corrective measures are taken.

During the final design phase, quantity management ensures that bulk material orders are consistent with estimates and any bulk over orders are per project execution plans and budgets. Material takeoffs from BIM model reviews are confirmed for completeness.

Engineering provides other material management support through the engineering phase and into receipt of materials at site. The assistance includes technical support in proposal evaluation, material take-offs on issued-for-construction drawings, vendor or fabrication inspection, and technical acceptance of materials received at the site or any on-site inspection, QA, or QC results.

Waste reduction is a key consideration in material management by engineering.

Material Take-Off (MTO) Allowances

A Material Take-Off (MTO) Allowance—the quantity for growth in estimated quantities of the bulk material and tagged items—is expressed as a percentage of the base quantity (net MTO) to account. It includes:

- allowances to cover extra work due to engineering quality (design development):
    - this results from the level of details of engineering design (50 percent complete or 100 complete).
    - miscellaneous fittings or quantities not reflected in design details.
- calculated as a percentage of direct quantity or costs calculations.
- applied to each material quantity and may be different for WBS elements at different stages of design development.
- percentage depends upon the level of project definition and can range from 1-25 percent.

In addition to allowances associated with design development and level of project definition, MTO allowances are provided for:

- wastage.
- loss of materials.
- breakage.

Summary

Control of project costs begins with control of the materials of construction. Reductions in project footprints result in significant reductions in civil/structural materials. Similarly, advanced modularization of structures and pipe racks have contributed not only to footprint reduction but also reduction in structural steel requirements. Integration of shipping bracing as part of module final design has reduced wastage and overall steel costs for projects.

Material management during design represents a significant cost control opportunity and relates to new BIM and AI-enabled technologies. Early supplier engagement with materials management provides opportunities for both significant cost and schedule savings. This is described in the Executive Insight, Procurement and Supply Chain — Introduction, that introduces this section of NAC Knowledge.

About the Author

Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.