Tec Empresarial
P-ISSN: 1659-2395; E-ISSN: 1659-3359

CRITICAL REVIEW OF CONSTRUCTION PROGRESS MEASUREMENT AND ACCURATE METHOD BY USING FIELD ESTIMATES

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ABSTRACT:

In Engineering, Procurement and Construction (EPC) projects, the construction phase is the largest and riskiest portion of Oil &Gas capital projects, comprising 35% to 50% of the total project cost. Thus, the construction portion is many times a game changer for the undertaking's good outcome and it is vital to have severe command over the construction stage to safeguard from project failures. Progress of the board in development projects assumes an imperative part in giving as-constructed data about the undertaking to the group for convenient navigation, where the measurement process carries a vital role in the timely decision-making process. In any case, progress data has not been constantly gathered through true sources, and commonly it is simply founded on a singular encounter or abstract decisions, which brings about a goal arranged choice methodology with an unpredicted achievement rate.

This research paper aims to outline a more accurate process that will revoke applying different measurement methods based on different approaches to overcome the problems using measurement based on field estimated quantities to portray realistic project status. The research covers the study of currently practiced approaches to establish an improved method that focuses on integrating work breakdown structure, schedule activities, estimates, and improved progress measurement methods based on field estimated quantities to monitor project progress all the more productively and really.

KEYWORDS: Progress measurement System (PMS), Engineering, Procurement and Construction (EPC), Field Estimated Quantities(FEQ),

1. INTRODUCTION

The competitive market situation, superior quality standards, stringent project delivery schedule, and cost-effectiveness techniques, introduce an altogether a set of challenges to Engineering & Construction (E&C) industry and also the emergence of COVID-19 added additional challenges for completing projects on time and within the budgets, where Projects have been considered as an important means to achieve organisations strategic objectives.

There is a clear noticeable shift from proprietor oversaw activities to CONTRACTOR oversaw projects, where the risk of time and cost has been transferred to Engineering & Construction (E&C) organisations along with responsibilities of engineering, design/detailing, procurement/delivery of materials and construction including commissioning under Engineering, procurement and construction (EPC) contracting method (EPC World Media Group, 2020). Under Engineering, Procurement and Construction (EPC) contracting model, Engineering & Construction (E&C) organisations largely depend on various expertise agencies, vendors and sub-contractors to perform the tasks, where the certain scope of work is being transferred along with uncertainties.

In Engineering, Procurement and Construction (EPC) contracting projects, Construction is the riskiest piece and most complex as it involves various interfaces. The construction part consists of 35%–50% of the total project cost in an Oil &Gas capital project and hence construction is often a deciding factor in the project. Designing and supply chain stages have their risks, however, they can't start to contrast and the extent of vulnerabilities that habitually portray construction projects (Ogunye, S., 2019). It is a matter of fact that well-established progress measurement for the construction phase is necessary for improved project success.

Project management information systems through defined data frameworks are being applied to construction projects for more proficient administration by gathering as-constructed data and supporting the decision-making process. Among the different sorts of as-constructed data, the task progress rate is one of the basic indicators that address the undertaking execution and progress state, and it helps convenient and exact direction by giving fundamental data that can be applied to project arranging and control as well as cost designing. In any case, the undertaking progress of the board has not been very successful, since it has not been founded on true information or rules, however, given abstract decisions and various measures reliant upon a singular's encounters or inclinations (Chin et al., n.d.).

Progress estimation is a key factor for productive project delivery. It evaluates the actual measure of finished work inside planned cost and labour execution at a predetermined phase of the task. A powerful progress measurement process facilitates accurate progress monitoring to enable early warning signs to outline structured work proceeding for product improvement. Different advancement estimating strategies are accessible and utilized for construction projects (Danku et al., 2020). The legitimate concentration and speed of development can't be monetarily achieved by impulse, however, require cautious and satisfactory preparation and control. Under the insecure, eccentric and exceptionally aggressive development business climate, progress and execution estimation is extremely basic for all classes of development associations, including clients, draftsmen, amount assessors, design and project workers. (Danku et al., 2020).

Successful project accomplishment requires a dedicated effort by the project team to carry out the various project activities simultaneously, and the project manager is responsible for organising the whole process being in a pivotal position. The project manager needs to keep up with the task organization and screen against slippages in cost, time and quality as long as necessary during the defined project duration. In accomplishing this, the project manager and construction manager rely vigorously on a solid observing framework that can give ideal motioning and timely alerting of project issues, whether they are genuine or potential (Memon et al., 2006). Hence it is very important to have stringent control over the project activities to protect from project failures. In construction projects, progress management plays a vital role in providing asconstructedd data for project planning, monitoring, controlling covering cost management risk management processes and other parameters of the project.

2. OBJECTIVE

This research paper aims to suggest an accurate progress measurement methodology by studying the silent points to be considered in progress measurement through earned value method by using site estimated quantities.

To perform the above, it examined various measurement techniques which are being currently practiced across the leading Engineering & Construction organisations, and how they could be applied contrastingly relying on the qualities of a work item and a project. Given the techniques, an advancement progress estimation system was created to give different estimation strategies, contingent upon work things and undertaking characteristics(Chin et al., n.d.). The proposed framework will support an improved progressed measurement process for the construction projects.

3. LITERATURE STUDY

3.1.PROGRESS EARNINGS IN CONSTRUCTION PROJECTS

By definition, "progress" alludes to the "advance toward a particular end." The level of "advance" for a construction project can be determined in various ways

Progress measurement is the process of evaluating and recording the status made on a task or project. It is a subjective (mathematical) estimation that can be determined in more ways than one. The means used to ascertain progress will rely upon the kind of work item, accessible advancement measurement instruments, business or client requirements, and other different project elements (ARESPRISM, 2022).

The measurement phase estimates the actual performance and compares it with planned or anticipated benchmarking data. The process enables the project team to understand the realistic performance of the task and to consider appropriate mitigation action (Wayne J. Del Pico, 2013).

Progress earnings and reporting is a critical management function for the successful delivery of construction projects and relies on physical data collected from the execution teams, which is being used to compare against actual work performed(El-Omari & Moselhi, 2008).

Managing a construction project is very challenging, due to its scale and complexity. It is essential to implement a progress measurement process to know the reality and to consider approaching actions in advance. (Ko et al., 2017)

Project progress review and control are one of the main undertakings of a construction project. All the project team members and functional teams need to be aware, in a convenient and precise way, of how the task is advancing, where they are currently in comparison to the initially set plans (Ref Figure-1), also to know whether deadlines are met, budgets are safely measured and followed (Memon et al., 2006).

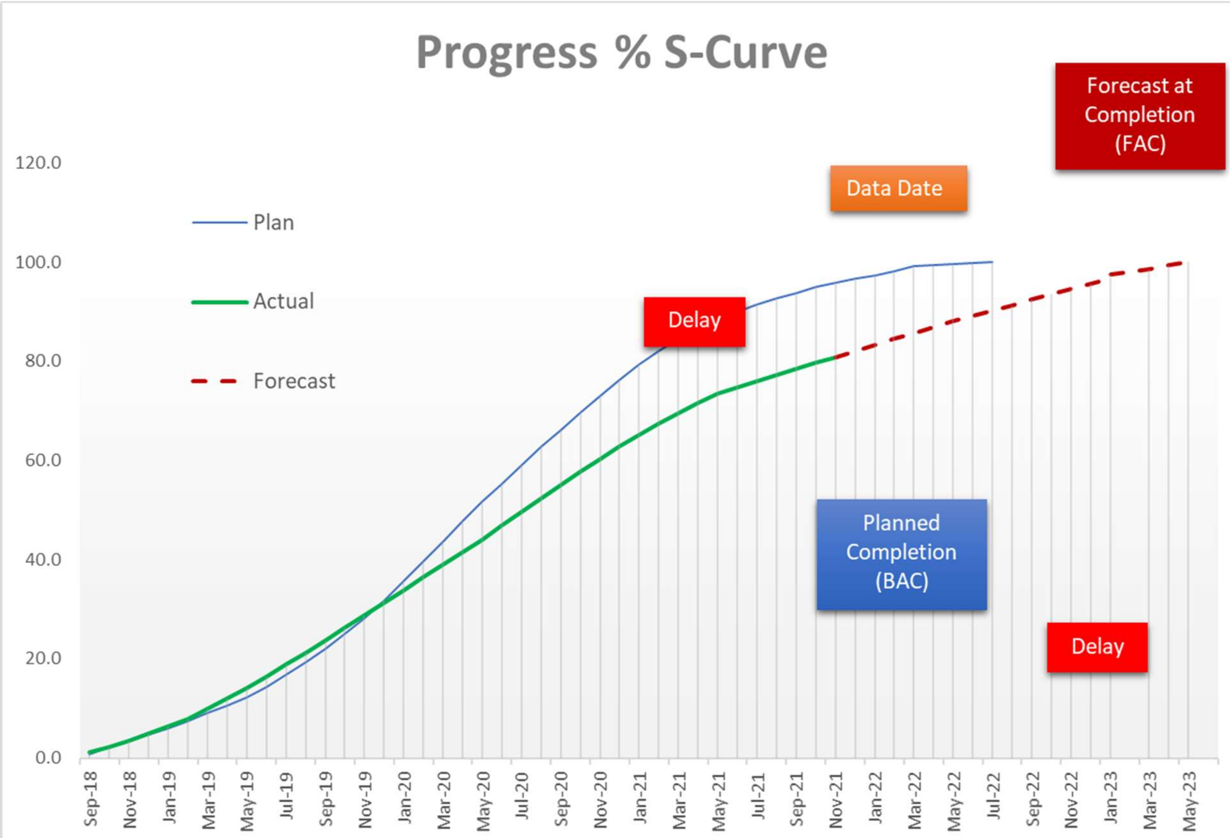

Figure-1:Progress S-Curve reflecting the actual progress behind the plan

Traditional approaches to gathering data on the advancement of development projects often involve human judgement, and significant expenses, and are excessively inconsistent to give supervisors ideal and exact control information.

Figure 1 shows "the traditional progress monitoring method and the progress reports are being updated to the agreed cut-offs, which are being tracked in most of the cases every week to roll-up on monthly basis as appropriate. These reports validate the project progress, comparing with planned work in terms of time and budgets, and also forecast the project finish date. These reports additionally referenced the constructability issues, quality issues including test results, contract changes remembering adjustment for plan and increment/decline in amounts, and forthcoming issues from progress gatherings.

This conventional development of the executives' framework furnishes a construction manager with different reports, for example, progress control, procured esteem the board and asset the board. The construction manager spends most of his time statusing these reports, instead of focusing on executing the tasks and considering timely decisions to maintain rubbest project delivery.

3.2.PROGRESS MEASUREMENT METHODS

Accurately measuring the project progress is always a challenging task, as there are many factors attributed to measuring precise progress. These factors like the type of measurement, data accuracy, maintenance goods records etc. Planning IT-enabled packages like Primavera P6 do not always support us in measuring accurate progress due to work complexity and each software has its advantages and at the same time certain limitations to manage under optimum concepts.

Inaccurate project progress will thwart your capacity to detect early advance notices in difficult situations ahead and to consider appropriate action to avoid project failures. Six common methods for measuring project progress are being practised to support measuring performance and work accomplishments. These methods are summarized in the "Project Control: Integrating Cost and Schedule in Construction,"(Wayne J. Del Pico, 2013). Let us review the below major progress review methods to provide the basis for a new approach to getting established,

3.2.1. Units Completed

The technique is clear and applies to sorts of assignments that include rehashed creation of effectively estimated units of work. Typically, an undertaking that is done more than once will in general take about a similar measure of time, assets and exertion, so following the unit finished functions admirably here. A simple example is "installing light fixtures" and each light fixture needs approximately the same amount of time. If we had 1000 apparatuses to introduce, we can just count the units introduced. For this situation, there is no emotional experience-based judgment included.

3.2.2. Incremental Milestones

This method is called the incremental milestone or steps method, the incremental milestones method is mainly used for cost accounts that involve subtasks and need to be completed in a sequence. For example, foundation laying consists of activities like blinding, formwork, reinforcement, concreting and backfilling which need to be progressed in a sequence to complete the entire task. To calculate the progress of the foundation, each progress step needs to be weightage with budgeted labour units that are required to complete the task. Each progress step is documented as a milestone and earns a certain predefined percentage of the total installation process. The percentages for each milestone may vary as per the task and prior agreement among stakeholders. To utilize the gradual achievement process, there would need to be an arrangement ahead of time concerning the proper rates of each of the subtasks. This technique won't permit guaranteeing steady advancement against sub-achievement.

3.2.3. Start/Finish

This technique is just centred around catching the beginning stage and the completing mark of the undertaking and in the middle between. This method is appropriate for short-duration tasks and clear in nature. Also, the method is the best fit for those where task work estimates are not available and it is difficult to collect percent complete progress data. The best example of this method of tasks such as "Testing, flushing, cleaning of piping spools. Majorly such tasks are one-time in general and short in duration. Various rules are being practised in the industry and may vary between the start and finish as briefed below….

- **50/50 Rule** – 50% on commencement and the remaining 50% on completion of the task.
- **20/80 Rule** – 20% on commencement and 80% on completion. This rule is being used to track higher value tasks and takes a slightly longer time to reach completion
- **0/100 Rule** – 100 percent progress earned on the task is completed. And we can say as milestone based, which is being used in procurement for inspections and clearances.

3.2.4. Cost Ratio

This approach is being implemented on a project that has tasks that tend to happen over a long period or the life of the project life cycle. Best fit for overhead costs and measured based on the budgeted allocation of dollars versus the labour hours of production. This technique allows contractors, the ability to earn value that is equal to the overall project percentage. For example, if the project progress is 25%, then the contractor earns 25% of the overhead and fees.

3.2.5. Experience/Opinion

This is the most emotional methodology with frequently no authentic validation to help the outcomes. This is completely different from above state scientific methods and is used for small activities like dewatering, filling the liquids/gases for testing purposes etc. It's not typically prescribed and will in general be viewed if all else fails because every individual encounter and assessment change from each other and can cause a struggle between proprietors, workers for hire, providers and sub-project workers/organizations. This opinion-based approach should be carefully executed and better avoided to the extent possible.

3.2.6. Weighted or Equivalent Units

This strategy is viewed as the best method and is the one that requires more exertion and reaches out to a more extensive information range. Tasks require a longer duration to execute and also contain multiple sub-tasks that will have various measurement progress steps with pre-defined weight points. The weightage points to each task or sub-task are generally weighted according to the estimated level of effort (in labour hours) or by the dollar value.

Let us consider an example to demonstrate this method (ref Table A) by measuring a structural steel package. Usually, structural steel is measured in tons and each sub-task has been completed, the weighted tons (units of measure) are then converted to the equivalent units of percentage complete of the overall project, by rolling up to weightage points assigned to each sub-task or the task.

Table A: Progress measurement of building a structural steel package

Weight (Tons)	Sub-Task	Unit of Measure (UOM)	Quantity	Estimated steel Wgt	Quantity completed	Earned Tons	% Complete
18%	Columns	Ton	100	90	50	45	50.0%
20%	Beams	Ton	120	100	40	33	33.3%
15%	Connections	EA	800	75	320	30	40.0%
12%	Cross Bars	EA	300	60	120	24	40.0%
12%	Connection Bolts	EA	200	60	65	20	32.5%
6%	Shims	%	100	30	35	11	35.0%
12%	Plumb and align	%	100	60	30	18	30.0%
5%	Punchlist	%	100	25	15	4	15.0%
100%	Total			500		184	36.8%

Earned tons to date = (Quantity completed) (Relative weight) (500 tons)/ (Total Quantity)

Percent complete = 184 tons/500 tons = 36.8%

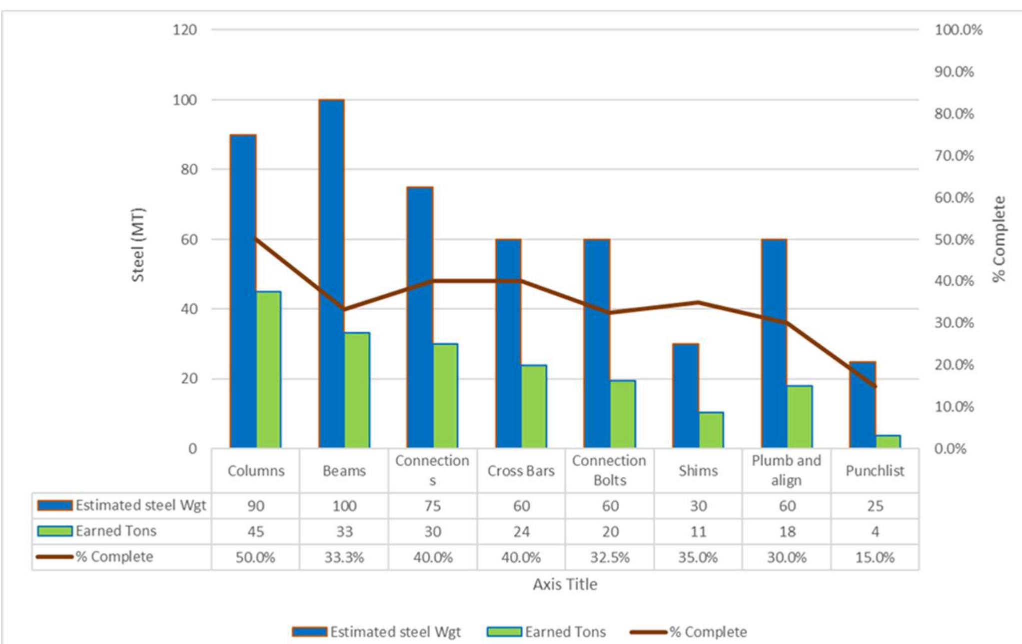

Figure-2:Graph represents Earned Weight against Estimated Weight, and also % complete

The above Figure-2 presents the comparison of Estimated weight, earned weight and progress percentage to illustrate, the balance work to be accomplished.

Above cited progress measurement aims to provide accurate progress of the project at any given point of time to the project teams to facilitate considering an appropriate action to mitigate if in case of any delays.

4. RESEARCH METHODOLOGY

4.1. CURRENTLY PRACTICED MODEL AND PROCESS GAP

The concept of progress management and various progress measurements practiced across the Engineering & Construction industry have been studied in its depth to understand through the project life cycle and illustrated the currently practiced model.

Having said that many approaches are being practised in the current complexity of project execution, there is always a defined model being practiced for construction projects by major organisations.

To define the currently practiced model, Data collected from various construction stakeholders . Contacted 96 functional experts, majorly consisting the project control professionals who performs the earned value progress measurement process.

	Experience Range					
Designation	**< 5 Years**	**5-10 Years**	**10-15 Years**	**15-20 Years**	**> 20 years**	**Total**
Project Managers				3	2	5
Construction Manager				4	2	6
Project Engineers	3	4	6	5	1	19
Sub-contracts Engineers		4	2	3	1	10
Project Control Manager			2	4	3	9
Project Control Engineer	5	6	8	5	2	26
Planning Engineers	6	4	6	4	1	21
Total	**14**	**18**	**24**	**28**	**12**	**96**

The below process (ref Figure-2) is being followed across various projects to get establish the progress measurement process, and process implementation is through work breakdown structure (Figure-3), schedules, weightage, systems, rules of credit (RoC), and earned value measurement.

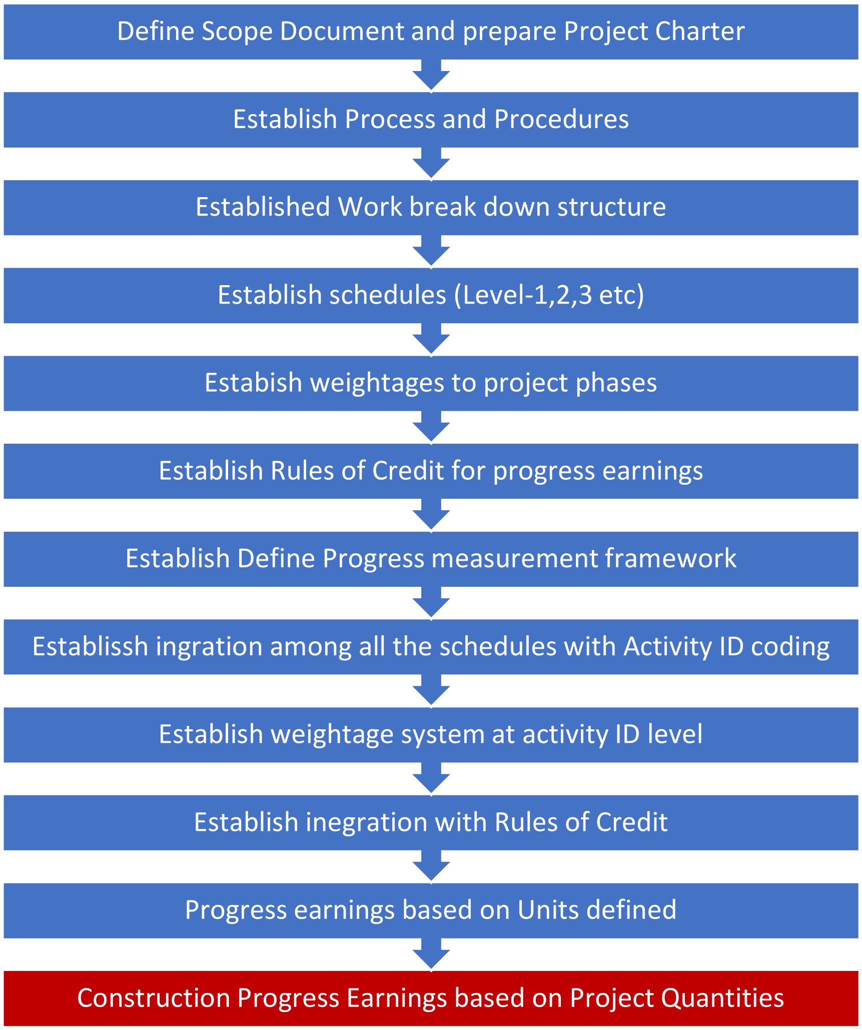

Figure-3: Project Progress Measurement Process Hierarchy

PHASE	Wtgs %
Engineering	**8.00**
Procurement	**54.00**
Construction	**35.00**
Temp. Works	*4.00*
Permanent Works	*29.00*
Pre-Commissioning	*2.00*
Commissioning & Startup	**3.00**
Commissioning & Startup	2.00
Handover (As-Built)	1.00
OVERALL	**100.00**

Typical Engineering, Procurement and construction phase weightages

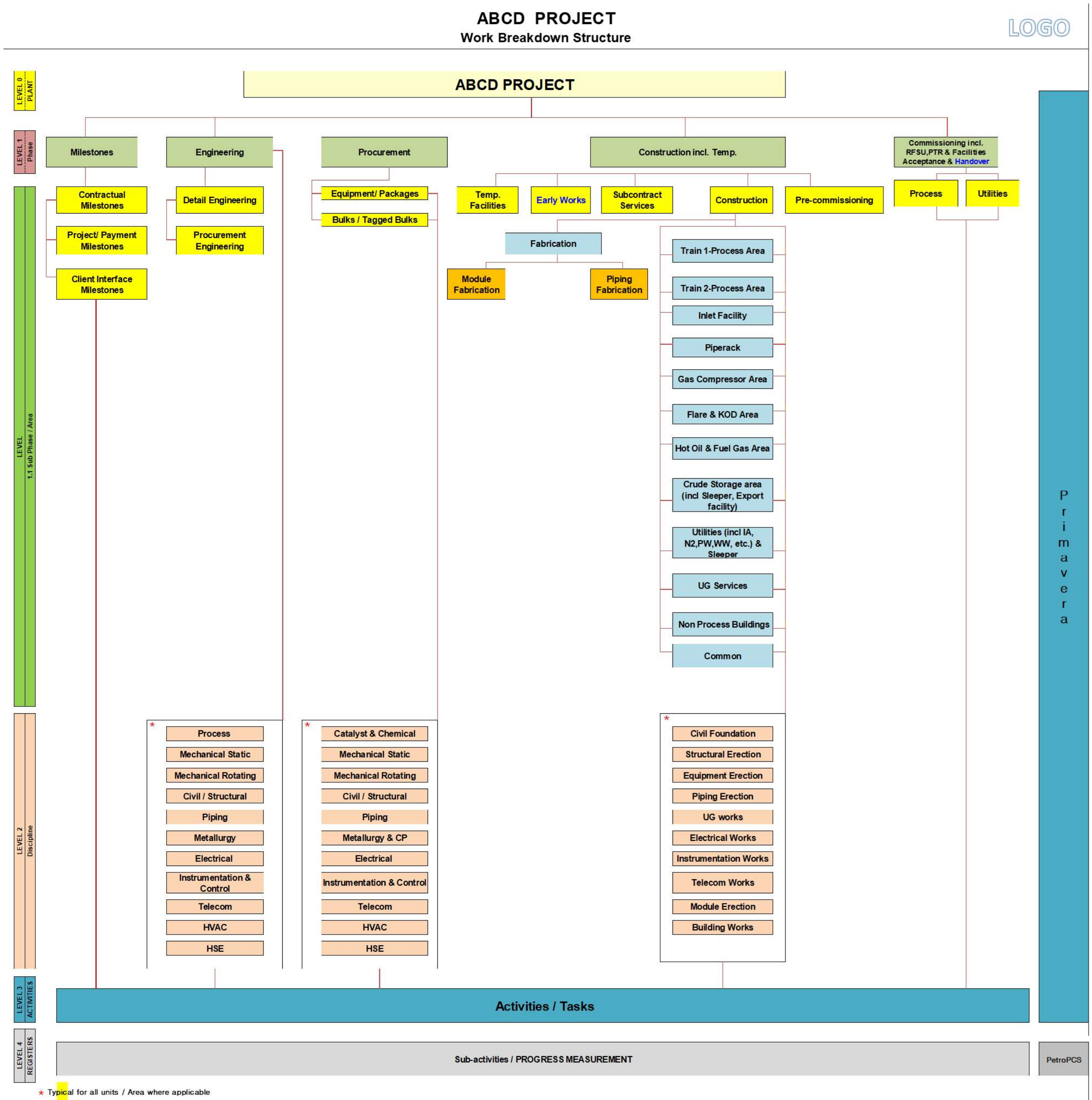

Figure4: Typical Work Breakdown Structure

There are various models and majorly the Engineering & construction industry organisations practice the below model which is a good model to roll up the progress, where still improvement is needed.

Each activity of the construction phase is weighted based on estimated cost or mna-hours practised across the industry *(Ref figure-6)*.

% Weight of an activity = Estimated cost or direct work hours for activity / Total Estimate

The construction progress will be based on weightings derived per Level-3 construction activity *(Ref figure-7)*. Estimated cost or direct man-hours will be the basis for deriving the weighting.

Construction progress will be measured based on Level-3 activity by calculating earned quantities/work hours. The earnings are based on construction "rules of credit" *(refer to figure-5)* at a later stage well before starting construction activities.

Ref. No	Activity	Units	Operation	Description	Weigtage % Period	Weigtage % Cumulative
CV1	Piling	Nos	001	Pile driving	90	90
		Nos	002	Cap Welding & Clearance	10	100
CV3	Tank Foundation		001	Excavation	15	15
			002	Ring Beam	40	55
			003	Compacted Fill	25	80
		M3	004	Bituminous Layer / Slab concrete	10	90
			005	Area clearance	10	100
CV5	Concrete Foundations		001	Excavation	10	10
			002	Blinding	5	15
			003	Shuttering	20	35
			005	Rebar	15	50
		M3	006	Concrete Pouring	35	85
			007	De-Shuttering	5	90
			008	Coating/Concrete Protection System	5	95
			009	Backfilling & Compaction	5	100
PI3	Piping Installation	ID	002	Fit up	20	55
		ID	003	Weld	35	90
		ID	004	NDE / QC Release	10	100
PI4	Pipe Support Installation	Ton	001	Erection	60	60
		Ton	002	Welded & Bolted-Up	30	90
		Ton	003	NDE / QC Release	10	100

Figure-5: Typical construction "Rule of Credit"(RoC)

					Cumulative				Weekly			
Discipline Code	Sub Area	Bdj. Wt.Points	Budg Man-hours	Weightage	RBL Plan %	Actual %	Variance %		RBL Plan %	Actual %	Variance %	
CS	Pits	14,266	21,905	0.52%	100.00%	99.64%	-0.36%					
CS	Civil ITR-A	5,962	9,155	0.22%	99.95%	63.07%	-36.88%					
CS	Civil Foundations - Tanks	24,681	37,895	0.90%	100.00%	100.00%						
CS	Civil Foundations - EIT/CP/HSSE	1,440	2,210	0.05%	100.00%	92.28%	-7.72%					
CS	EIT Duct Banks	9,144	14,040	0.34%	100.00%	100.00%				0.50%	0.50%	
CS	Erection - Piperack	59,009	90,610	2.16%	100.00%	98.69%	-1.31%					
CS	Fence & Gate Works	8,909	13,680	0.33%	100.00%	55.78%	-44.22%			0.23%	0.23%	
CS	Building - Finishing Works	23,511	36,104	0.86%	100.00%	13.16%	-86.84%					
CS	Grillage Works	49,509	76,020	1.81%	100.00%	100.00%	0.00%					
CS	Civil Foundations - EQ	150,046	230,400	5.50%	100.00%	99.59%	-0.41%					
CS	Civil Foundations - PS	83,307	127,920	3.05%	100.00%	97.43%	-2.58%					

Figure-6: Typical template to reflect Budget Man-hours, Budget Wt.points and Weightage

ABCD PROJECT

CONSTRUCTION PROGRESS ANALYSIS - Level-3 ACTIVITY LEVEL

Date: 12-Mar-22

ACTIVITY ID	ACTIVITY NAME	2042-AREA	2042-FIELD	2042-DISC	WEIGHTAGE ON PROJE	BLPLAN %	ACTUAL %	VARIANCE %
					100.00%	100.00%	69.43%	-30.57%
ABCDCC0010	Erection MP Compressor Outet KO Drum- Gas Compressor Area	Gas	C	MS	0.003%	98.67%	100.00%	1.33%
ABCDCC0050	Installation Tech Str (D1-D1B-TS07) Dehydrator - Train-1	Train1	C	CS	0.047%	100.00%	92.73%	-7.27%
ABCDCC0020	Installation Tech Str (D2-D2F-TS12)- Desalted Crude Flash Drum - Train-2	Train2	C	CS	0.101%	100.00%	94.57%	-5.43%
ABCDCC0070	Lightpole Foundation- Inlet Facility Area	IFA	C	CS	0.017%	100.00%	93.93%	-6.07%
ABCDCC0110	Pipe Support & EIT Support Foundations- Crude Storage Area	Crude Oil	C	CS	0.481%	100.01%	99.31%	-0.70%
ABCDCC0190	Pipe Support & EIT Support Foundations-Gas Compressor Area	Gas	C	CS	0.033%	99.89%	100.00%	0.11%
ABCDCC0210	Pipe Support & EIT Support Foundations-Train-2	Train2	C	CS	0.343%	100.00%	99.01%	-0.99%

Figure-7: Typical template to reflect Level-3 activity level progress

Area	Discipline	Disc_Description	Activity ID - Level 3	Level 3 Activity ID - Description	Act ID - Level 4 / 5	L-4 Description / Rules of Credit	ROC %	Level 3 - Weightage	Level 4 - Weightage	Progress % Last WK - Cum	Progress % Current WK	Progress % Cum ITD	UOM	BL ESTD- Qty	Actual Qty as of LW	Actual Qty Current Wk	Actual Qty ITD
								100.000	100.000	68.75%	0.68%	69.43%					
BL	CS	Modular Substation Buildings	ABCDCS1000	Piling - Substation Buildings		Piling - Substation Buildings		0.104		100.00%	0.00%	100.00%	Nos	33	0.0	0.0	0.0
BL	CS		ABCDCC0010		ABCDCC0010-01	Piling - Substation Buildings			0.104	100.00%	0.00%	100.00%				0.0	
BL	CS				ABCDCC0010-01-01	Pile driving	90%			100.00%	0.00%	100.00%	Nos	33	20.0	0.0	20.0
BL	CS				ABCDCC0010-01-02	Cap Welding & Clearance	10%			100.00%	0.00%	100.00%	Nos	33	20.0	0.0	20.0
T-1	CS	Civil & Structural	ABCDCS1280	Foundation Dehydrator Feed Pumps & Skid - Train-1		Foundation Dehydrator Feed Pumps & Skid - CP2-P-71101 A/B		0.070		100.00%	0.00%	100.00%		29		0.0	
T-1	CS		ABCDCS1280		ABCD1280-01	Pump Foundation - CP2-P-71101 A/B			0.070	100.00%	0.00%	100.00%				0.0	
T-1	CS				ABCD1280-01-01	Excavation	10%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1280-01-02	Blinding	5%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1280-01-03	Shuttering	20%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1280-01-04	Rebar	15%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1280-01-05	Concrete Pouring	35%			100.00%	0.00%	100.00%	Cum		44.5	0.0	44.5
T-1	CS				ABCD1280-01-06	De-Shuttering	5%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1280-01-07	Coating/Concrete Protection System	5%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1280-01-08	Backfilling & Compaction	5%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS	Civil & Structural	ABCDCS1110	Foundation Separator Water Transfer Pumps & Skids - Train-1		Foundation Separator Water Transfer Pumps & Skids - CP2-P-71102 A/B		0.022		100.00%	0.00%	100.00%		29		0.0	
T-1	CS		ABCDCS1110		ABCD1110-01	Skid Foundation - CP2-P-71102 A/B			0.022	100.00%	0.00%	100.00%				0.0	
T-1	CS				ABCD1110-01-01	Excavation	10%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1110-01-02	Blinding	5%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1110-01-03	Shuttering	20%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1110-01-04	Rebar	15%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1110-01-05	Concrete Pouring	35%			100.00%	0.00%	100.00%	Cum		14.1	0.0	14.1
T-1	CS				ABCD1110-01-06	De-Shuttering	5%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1110-01-07	Coating/Concrete Protection System	5%			100.00%	0.00%	100.00%			1.0	0.0	1.0
T-1	CS				ABCD1110-01-08	Backfilling & Compaction	5%			100.00%	0.00%	100.00%			1.0	0.0	1.0
GC	MR	Mechanical Rotating	CCNGCMR1010	Installation MP Gas Compressor with VFD Driven Motor- Gas		MP Gas Compressor with VFD driven Motor EQ Tag:- CP2-K-74002		0.305		70.00%	0.00%	70.00%		59		0.0	
GC	MR		CCNGCMR1010		CCNGCMR1010-01	MP Gas Compressor with VFD driven Motor EQ			0.305	70.00%	0.00%	70.00%				0.0	
GC	MR				CCNGCMR1010-01-01	Pre Installation - Clean/ mark/ shim	10%			100.00%	0.00%	100.00%			1.0	0.0	1.0
GC	MR				CCNGCMR1010-01-02	Rigging / Erection	45%			100.00%	0.00%	100.00%	MT		59.0	0.0	59.0
GC	MR				CCNGCMR1010-01-03	Preliminary Alignment	15%			100.00%	0.00%	100.00%			1.0	0.0	1.0
GC	MR				CCNGCMR1010-01-04	Bolting / Grouting	15%			0.00%	0.00%	0.00%				0.0	
GC	MR				CCNGCMR1010-01-05	Final Alignment & Inspection	15%			0.00%	0.00%	0.00%				0.0	

Figure-8: Typical template to reflect Level-4 sub-activity level progress

With ref to above Figure 7, the progress percentage is based on the quantity installed against the estimated quantity, where the progress percentage is applied against the budged weightage on the project. Weightage is based on man-hours in the construction, which is termed an effort. But many contractors/sub-contractors will downside for contractual obligations which will lead to wrong progress measurement.

Progress % = Installed Quantity / Estimated quantity

Weighted Progress = Weightage x Progress %

Due to advanced practices being implemented in Engineering & Construction Industry, there is a robust process has been implemented for progress measurement, but the accuracy is always questioned due to various individual interventions and contractual riders, which will lead to portraying inaccurate progress.

5. PROPOSED PROGRESS MEASUREMENT METHOD

The proposed method outline an accurate progress measurement methodology considering the Progress Measurement through the "earned value method based on site estimated quantities"

5.1. Progress Measurement through earned value method based on site estimated quantities

The progress earnings for each activity are based on engineering estimated quantities and which will be rolled up to the project phase and to further to project. The estimated quantities many times vary when compared with site installed quantities and hence measuring progress against the engineering estimated quantities is not accurate. This is a grey area in the construction progress measurement system in portraying realistic progress.

Interacted with various experts in understanding the measurement methods are being used for measuring the construction progress, where majority of the projects are using engineering estimates for earned value measurement process and field estimates are being used as minimum. Ref below figure-9.

		Measurement Method					
Designation	Assessors	Experience / Openion(Manual)	Based on Engineering Estiamate	Based on Field Estiamate	Incremental Milestones	Weighted or Equivalent Units	Total
Project Managers	5	2	2		1		5
Construction Manager	6	2	2	1	1		6
Project Engineers	19	3	9		4	3	19
Sub-contracts Engineers	10	2	3		3	2	10
Project Control Manager	9	3	4	1		1	9
Project Control Engineer	26	5	13	2	4	2	26
Planning Engineers	21	8	11	1	1		21
Total	**96**	**25**	**44**	**5**	**14**	**8**	**96**

figure-9 – *Measurement methods are in prctice*

However, while interacting with experts to understand the most accurate method for progress measurement, it is recommended to use progress measurement based on field estimates, ref figure-10 to understand the openions at stake holders level,

		Measurement Method					
Designation	Assessors	Experience / Openion(Manual)	Based on Engineering Estiamate	Based on Field Estiamate	Incremental Milestones	Weighted or Equivalent Units	Total
Project Managers	5	1	2	2			5
Construction Manager	6	2	2	2			6
Project Engineers	19	3	5	8	2	1	19
Sub-contracts Engineers	10	1	3	5	1		10
Project Control Manager	9		2	6		1	9
Project Control Engineer	26		6	14	4	2	26
Planning Engineers	21	3	6	8	2	2	21
Total	**96**	**10**	**26**	**45**	**9**	**6**	**96**

figure-10 – *Most prefereed Measurement method*

Not limiting to above expertise openions, conducted below analysis to know the accurate measurement systems to know more accurate measurement process.

Let us consider foundation activity to analyse the scenario, where foundation activity engineering estimate is 40 Cu.M for and while casting the installed quantity is 45 Cu.M due to site conditions.

Let us consider 20 Cu.M concrete has been poured and both the scenarios are as follows

Scenario 1: Activity progress based on an engineering estimate

Engineering Estimated Quantity = 40 Cu.M

Actual Installed Quantity = 20 Cu.M

Activity Progress = Actual Installed Quantity / Engineering Estimated quantity

= 20 / 40

= 50%

Scenario 2: Activity progress based on an engineering estimate

Field Estimated Quantity = 45 Cu.M

Actual Installed Quantity = 20 Cu.M

Activity Progress = Actual Installed Quantity / Field Estimated quantity

= 20 / 45
= 44%

Scenario 3: Activity progress based on an engineering estimate
Field Estimated Quantity = 35 Cu.M
Actual Installed Quantity = 20 Cu.M
Activity Progress = Actual Installed Quantity / Field Estimated quantity
= 20 / 35
= 57%

COMPARISON TABLE B

Scenario	Method	Type	UOM	Estimated Qty	Field Estimated Qty	Actual Qty	% Progress
1	Currently Practiced	Progress, as per engineering estimate	Cu M	40	Not used	20	50%
2	Proposed method -Case 1	Progress, as per the field estimate	Cu M	40	45	20	44%
3	Proposed method -Case 2	Progress, as per the field estimate	Cu M	40	35	20	57%

From the above table, it is very clear that the currently practiced is not as accurate as the proposed method and hence the proposed method based on field estimated quantities are more close to the real situation and hence portrays more accurate progress.

The above situation has been analysed based on one activity and where the project consists of many such activities. Hence overall impact on a project is huge and this is a real grey area in the construction progress measurement process.

To overcome this situation, the measurement should be based on Field Estimated Quantity (FEQ), instead of engineering estimated quantities. The below Figure-9 reflects the additional field with field estimated quantity (FEQ), which will be used as the basis of the earned value of the progress.

Area	Discipline	Disc_Description	Activity ID - Level 3	Level 3 Activity ID - Description	Act ID - Level 4 / 5	L-4 Description / Rules of Credit	ROC %	Level 3 - Weightage	Level 4 - Weightage	Progress % Last WK - Cum	Progress % Current WK	Progress % Cum ITD	UOM	BL ESTD- Qty	FEQ Qty	Actual Qty as of LW	Actual Qty Current Wk	Actual Qty ITD
								100.000	100.000	68.75%	0.68%	69.43%						
BL	CS	Modular Substation Buildings	ABCDCS1000	Piling - Substation Buildings		Piling - Substation Buildings		0.104		100.00%	0.00%	100.00%	Nos	33	0	0.0	0.0	0.0
BL	CS		ABCDCC0010		ABCDCC0010-01	Piling - Substation Buildings			0.104	100.00%	0.00%	100.00%					0.0	
BL	CS				ABCDCC0010-01-01	Pile driving	90%			100.00%	0.00%	100.00%	Nos	33	20.0	20.0	0.0	20.0
BL	CS				ABCDCC0010-01-02	Cap Welding & Clearance	10%			100.00%	0.00%	100.00%	Nos	33	20.0	20.0	0.0	20.0
T-1	CS	Civil & Structural	ABCDCS1280	Foundation Dehydrator Feed Pumps & Skid - Train-1		Foundation Dehydrator Feed Pumps & Skid - CP2-P-71101 A/B		0.070		100.00%	0.00%	100.00%		29			0.0	
T-1	CS		ABCDCS1280		ABCD1280-01	Pump Foundation - CP2-P-71101 A/B			0.070	100.00%	0.00%	100.00%					0.0	
T-1	CS				ABCD1280-01-01	Excavation	10%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1280-01-02	Blinding	5%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1280-01-03	Shuttering	20%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1280-01-04	Rebar	15%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1280-01-05	Concrete Pouring	35%			100.00%	0.00%	100.00%	Cum		44.5	44.5	0.0	44.5
T-1	CS				ABCD1280-01-06	De-Shuttering	5%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1280-01-07	Coating/Concrete Protection System	5%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1280-01-08	Backfilling & Compaction	5%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS	Civil & Structural	ABCDCS1110	Foundation Separator Water Transfer Pumps & Skids - Train-1		Foundation Separator Water Transfer Pumps & Skids - CP2-P-71102 A/B		0.022		100.00%	0.00%	100.00%		29			0.0	
T-1	CS		ABCDCS1110		ABCD1110-01	Skid Foundation - CP2-P-71102 A/B			0.022	100.00%	0.00%	100.00%					0.0	
T-1	CS				ABCD1110-01-01	Excavation	10%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1110-01-02	Blinding	5%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1110-01-03	Shuttering	20%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1110-01-04	Rebar	15%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1110-01-05	Concrete Pouring	35%			100.00%	0.00%	100.00%	Cum		14.1	14.1	0.0	14.1
T-1	CS				ABCD1110-01-06	De-Shuttering	5%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1110-01-07	Coating/Concrete Protection System	5%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0
T-1	CS				ABCD1110-01-08	Backfilling & Compaction	5%			100.00%	0.00%	100.00%			1	1.0	0.0	1.0

Figure-9: Proposed Progress measurement method for accurate construction progress

The proposed method allows us to calculate progress more accurately, at any given point of time in the project in facilitating an appropriate decision-making process.

5.2.SYSTEM IMPLEMENTATION

The improved process and proposed methodology require a disciplined approach to get implemented as currently used systems are compatible with the recommended changes.

6. DISCUSSIONS AND CONCLUSION

In conclusion, let us refer to the well saying quote "Planning is bringing the future into the present so that we can do something about it now- Alan Lakein".

This is possible by having the right status of the project at any given point on the project, and it may be ahead or behind the schedule. Having the right status allows the managers and team members to consider an appropriate decision protecting future threats to support in steering the project towards successful accomplishment.

Technology and modern construction practices have completely reshaped the construction management and measurement process over the past few years and made it easier for project controllers to streamline various construction processes where individuals frequently attempt to steer with an abstract methodology with frequently no verifiable validation to help the outcomes. This is completely different from above state scientific methods and is used for small activities like dewatering, filling the liquids/gases for testing purposes etc. It's not typically prescribed and will in general be viewed if all else fails on the grounds that every individual encounters and sentiment differ from each other and can cause a struggle between proprietors, project workers, suppliers and sub-contractors. The Experience or opinion approach should be carefully used and recommended to avoid it to the best extent possible.

The proposed method provides accurate progress through an agile scientific progress measurement approach with limited individual interventions. The approach is developed with an extensive experience in the industry and provides an advantage to the organisations to have an accurate project status for considering an appropriate decision.

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