VALUE-ADDED ASSESSMENT OF CONSTRUCTION PLANS

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ABSTRACT: In the purchase of a constructed facility, the buyer values those components that are in place when the user occupies the building. A task of placing or assembling such a component is therefore ''value-adding'' (VA). This paper presents a method to classify construction tasks as VA, contributory, or ineffective to assess the value-added by individual activities, as well as the aggregate value-added effectiveness of the construction plan. Current approaches to evaluate construction operations are based on limited examples rather than general rules. The proposed method presents a list of nine rules that are applicable to various construction trades. This paper provides for the value-added classification rules, specifies how to decompose activities for value-added analysis, and presents an illustrative test case. The proposed method can be used to assess the overall planned effectiveness of a detailed construction plan or the actual effectiveness of a construction operation. A case study of masonry wall construction indicates that the method requires significant understanding of the evaluated operation and task precedence relationships to classify activities properly. The use of this method for construction plan assessment enables a contractor to identify and potentially eliminate or reduce non-VA tasks, as well as predict the value-added effectiveness of a plan.

INTRODUCTION

In his book, *Competitive Advantage*, Porter (1985) states, ''In competitive terms, value is the amount buyers are willing to pay for what a firm provides them.'' In the purchase of a constructed facility, the buyer, or owner, values those components that are in place when the owner occupies the building. The tasks necessary to place these components are therefore value-adding (VA) in the owner's perspective. This paper presents a methodology for how to elaborate the detail of a plan to a level that is appropriate for assessing the value-added of each activity. Second, it presents a set of rules that project managers can use to classify tasks as VA, contributory, and ineffective.

Following this plan elaboration method and classification procedure, a manager can identify specific activities and attempt to reengineer them to either eliminate or at least have non-VA tasks performed less frequently. If the frequency of such non-VA tasks can be reduced, the effectiveness of the plan for the owner will be improved.

VA tasks are only part of the work completed during a construction operation. Maximizing the fraction of tasks that are VA increases the overall effectiveness in adding value during a construction operation. To facilitate this maximization, an accurate measurement method must be used. This paper proposes an extension to existing methods such as those described in Oglesby et al. (1989) and Thomas (1983).

Construction plans can be represented as a master schedule or a detailed schedule. Even a detailed critical path method (CPM) schedule usually does not indicate all of the tasks that compose an activity, but only shows the major activities themselves. For example, the activity ''build concrete column formwork'' does not indicate tasks such as ''drill hole for form tie.''

The value-added planning (VAP) method, which is used more commonly in manufacturing industries, requires the decomposition of activities into individual tasks that are solely VA, contributory, or ineffective. This paper is not about VAP as such, but rather describes a technique that can help users evaluate the effectiveness of plans for construction. Current CPM schedules generally include high-level activities that include some VA and non-VA tasks, so that further decomposition normally is necessary before evaluating the effectiveness of a plan. Contractors usually do this if they make detailed task plans for construction activities, including tools, materials, crew composition and assignments, procedure steps, safety precautions, and technical requirements.

The proposed value analysis technique can also be used to evaluate actual construction operations as well as construction plans. Detailed time-based records are required for such operational analyses. By operational analysis, a contractor can compare planned and actual value-added effectiveness, just as contractors now compare budget with costs.

The value-added assessment method requires only simple PC technology for task classification or VA effectiveness computation. Thus, there are no technical barriers to the implementation of the VA assessment method.

BACKGROUND

''Planned effectiveness'' is the estimated aggregate value productivity of a construction plan relative to other plans for constructing the same facility component. ''Actual effectiveness'' is the actual value productivity of the planned construction method when applied, as compared with the planned effectiveness. An earth-moving operation that employed wheelbarrows instead of trucks is a low planned effectiveness method. However, if this operation was performed without delays or the underutilization of manpower, it would be highly efficient and have an actual effectiveness that was higher than planned. Likewise, a construction method can be highly effective yet be performed inefficiently, resulting in lower actual effectiveness. For example, the best suited construction method could be chosen for an operation, yet low efficiency and effectiveness will result if the method is employed with delays or the poor utilization of resources.

Currently, contractors manage time and costs rather than the amount of value being added. As a result, time and cost are the evaluation factors for the effectiveness of a construction plan. These factors indicate the effectiveness of the overall construction plan but do not highlight particular areas of ineffectiveness where improvements could be made. We argue

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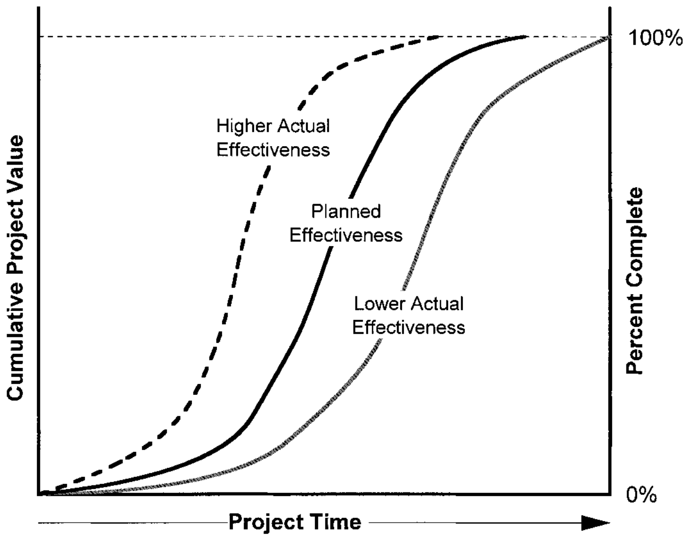

FIG. 1. Planned and Actual Value-Added Rates

that adding a new focus to the planning process—value for the building owner—contractors will then choose the most effective plans in the aggregate and identify and attempt to improve plan construction operations. Contractors will evaluate the effectiveness of planned processes before the project to eliminate individual non-VA tasks. This new focus may encourage contractors to be more innovative for more effective construction methods and to optimize the use of available resources.

Fig. 1 shows a simplified graph of the amount of value added during construction operations according to time. The solid line shows planned VA effectiveness, whereas the dotted lines show higher and lower possible outcomes as efficiency affects the planned operation. By considering both the effectiveness of a construction plan and the efficiency of its execution, a contractor could manage operations by objectively measuring VA efficiency during construction operation in comparison with the planned VA effectiveness. While these curves are similar in shape to construction cost ''S'' curves, as used in this diagram the curves represent the cumulative amount of value added during the project.

GOALS

The goals of this paper are to illustrate the application of value-added analysis in the construction industry, propose classification rules, and present initial validation of the method in actual construction projects.

METHODOLOGY

The output of the VA method is a numerical measure of a contractor's effectiveness and efficiency in meeting a customer's needs in the construction of a specified facility. To produce this output, all construction tasks must be classified as value-added, contributory, or ineffective.

VA tasks are those that add a permanent component to, or prefabricate a permanent component of the owner-specified facility. VA tasks are given a value-added effectiveness factor (VAEF) of 1. ''Contributory'' tasks are necessary for the execution of value-added tasks, but do not directly add value for the owner. For example, using current methods, formwork must be constructed for a concrete beam to be cast. To recognize the necessity of these tasks in the calculation of the efficiency factor, contributory tasks are given a VA effectiveness factor of 0.5. Ineffective tasks do not contribute to the final product and are therefore given a value of 0. Averaging

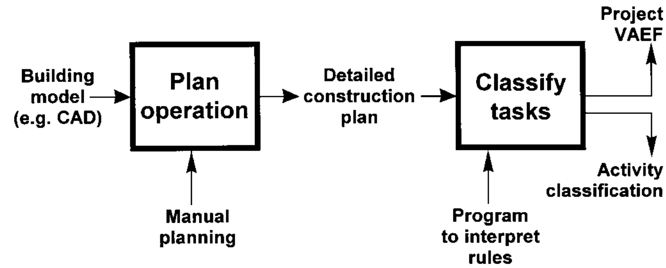

FIG. 2. Information Flow: CAD Model Data to VAEF

the factors assigned to each task with respect to time results in the overall VAEF for the construction operation. Theoretically, the VAEF can vary from 0 to 1.0. Most construction operations will fall in the range of 0.25–0.75, because construction operations normally involve some contributory and ineffective work.

To facilitate the comparison of data from various construction projects and researchers, a uniform classification technique must be created for objective evaluation. This method must not only be precise to ensure consistent results, but also be flexible to allow its application in diverse construction operations.

We created a simple set of VA classification rules to enable planners to classify tasks consistently with respect to value-added. Fig. 2 shows the information flow and interpretation that occurs between different stages of the design and construction planning process. An engineer uses information generated during architectural and engineering design to create a computer-aided design (CAD) model. The CAD model and selected construction methods form the basis for the creation of a detailed construction plan. A person could manually develop the detailed plan, but ideally a computer application will create the plan because of the large number of tasks required for VA classification. Classified tasks and their durations enable VA effectiveness analysis to produce an aggregate VAEF for a plan and a list of tasks that do not directly add value that the project manager can try to reduce or eliminate.

VIGNETTE: ACTIVITY—BUILD CONCRETE COLUMN

A simple example demonstrating the need for a standard methodology is the construction of a concrete column. The value added by each task in this construction operation could be different depending on who classifies the tasks: Owner, contractor, or layman.

Constructing a concrete column involves the fabrication of formwork and reinforcing steel, the placement of concrete, the subsequent stripping of forms, and all minor associated tasks. Tasks considered in this discussion are prefabricate the rebar cage, place concrete, drill hole for the form tie, bring the power supply to the workface, review the construction plans, sweep the construction work area, and idleness.

The facility owner values only tasks that add components to the final structure, for example, prefabricate reinforcing steel and place concrete. The owner finds no value in the following tasks: Drill hole for the form tie, bring the power supply to the workface, review construction plans, sweep the construction work area, and idleness. Though necessary for the construction of the column, drill hole for the form tie, bring the power supply to the workface, and review construction plans do not add a permanent component to the structure. Furthermore, the owner finds sweep the construction area and idleness unnecessary to the construction of the column.

In contrast to the owner's viewpoint, a contractor typically equates value with the cost to complete a project. As a result, the contractor may consider more tasks to be VA than the owner. Therefore, the contractor regards the following tasks as

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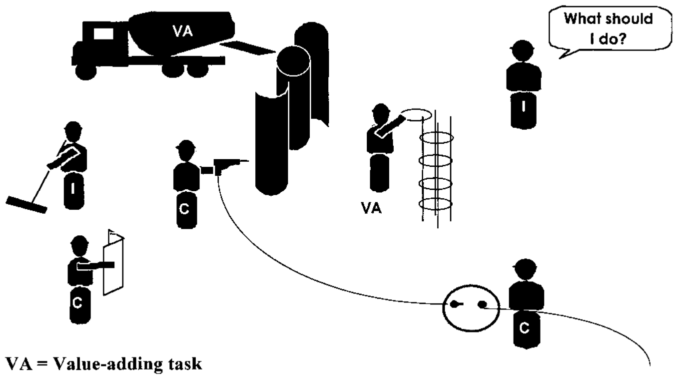

FIG. 3. Activity Snapshot

value-added: Prefabricating reinforcing steel, placing concrete, fabricating concrete formwork, bringing the power supply to the workface, reviewing construction plans, and sweeping the construction work area. Even rework and cleanup might be considered value-added tasks by the contractor because they are a normal part of construction operations.

Fig. 3 shows the classification of specific tasks in the construction of a concrete column, according to the proposed owner-perspective VA classifications. Value-added tasks include prefabricating reinforcing steel and placing concrete. Contributory tasks include fabricating concrete formwork and bringing the power supply to the workface. Ineffective tasks are sweeping the work area and idleness.

PAST RESEARCH

Oglesby (1989) and Thomas (1983) conducted research in operational analysis. Oglesby classifies tasks into three groups: (1) Effective work; (2) essential contributory work; and (3) ineffective work. Oglesby's method of classification uses examples rather than flexible rules, and defines formwork construction and material cutting as effective. Oglesby considers cleanup contributory. The method uses a weighted average to calculate a summary figure, the labor utilization factor, by giving the effective work a 1.0 weight and contributory work a 0.25 weight. Classifications assume the contractor's point of view; that is, if a task has a cost code associated with it, it is effective work.

Thomas (1983) uses 10 rules that are specific to placing reinforcing steel to categorize tasks into three classifications similar to Oglesby's. These rules do not address formwork and they classify material cutting as contributory. This paper specifies no point of view, yet orients more toward the owner's viewpoint on value than Oglesby's paper. Thomas' classification rules are not general enough to cover all tasks involved with building construction because Thomas analyzed a reinforcing steel placement crew. Thomas' method calculates labor utilization factor the same way as Oglesby, but uses a 0.5 factor for contributory work.

Superficially, the VAEF achieves the same results as Thomas' and Oglesby's methods, with minor differences. While Thomas' method refers to specific tasks, it cannot be easily applied to other trades because it lacks generality. Oglesby's method is more general, but does not specify the necessary level of detail required. Table 1 demonstrates the differences among the three methods of classifying the tasks illustrated in Fig. 3: The construction of a concrete column. The question marks in Table 1 represent areas of ambiguity within the classification method. Because Thomas's method does not provide general rules, ambiguity in the classification of formwork fabrication and cleanup results. Oglesby's more general rules,

TABLE 1. Comparison of Past and Current Methods

Task (1)	VAEF method classification (2)	THOMAS method classification (3)	OGLESBY method classification (4)
Fabricate rebar cage	Value-added	Effective	Effective
Pour concrete	Value-added	Effective	Effective
Drill hole for form tie	Contributory	?	Effective
Hook-up power	Contributory	Contributory	Contributory
Read plans	Contributory	Contributory	?
Sweep	Ineffective	?	?
Idle	Ineffective	Ineffective	Ineffective

however, are unclear in the classification of obtaining information and cleanup.

While our classification method recognizes contributory activity, the traditional manufacturing-based methodology for value-added analysis uses only two classifications: (1) Value-added; and (2) non-value-added (Beischel 1990) While this traditional method is appropriate for manufacturing and is widely used in process analysis, construction operations can be analyzed more accurately using the three classifications of the VAEF method. Because construction projects are built in place and without significant repetition, construction requires a higher fraction of contributory tasks than typical manufacturing operations. Manufacturing operations have the advantage of performing the same tasks repeatedly in the same location, allowing engineers to reduce the transportation of resources, the time spent obtaining information, and the amount of temporary setup. These are all contributory tasks prevalent in construction operations. To better represent the effectiveness of building contractors, the VAEF method gives a weighting to contributory tasks as well.

This paper expands and refines the work of past researchers by attempting to create completeness and provide applicability for the construction industry. Furthermore, this paper improves on past researchers' lack of clarity by providing a rule for the most detailed level of activity decomposition. The generalized rules presented in this research more explicitly define the classification of tasks for industry application than do the examples presented in past research. Examples of the nine classification rules and a test case provide guidance in the application of this method.

The OARPLAN paper (Darwiche et al. 1989) presents the technique of representing construction tasks in the form of object, action, and resource (OAR) along with an automatic construction planner. Both the OAR representation and the possibility of automatic construction planning are relevant to the VAEF method. The observer collects VAEF data in the OAR format. Table 2 lists the object, action, and resources of a group of tasks [for example, the entry reading (mortar, scoop, trowel) indicates that the worker scooped (action) mortar (object) with a trowel (resource)].

TECHNIQUE

The flowchart in Fig. 4 illustrates a methodology to decompose a construction activity into appropriate tasks and classify each task as value-added, contributory, or ineffective. The chart has nine decision nodes, which classify a task specifically into the corresponding outcome node if it meets the decision node's criteria. If the task does not fit the criteria, it is passed down to the next decision node and reconsidered. A task that reaches the ninth decision node is forced into the ineffective outcome node.

The value-added assessment technique enables different engineers to consistently classify the same tasks. In current practice no rules exist. Therefore, different engineers can come to different conclusions about the value-added effectiveness of a

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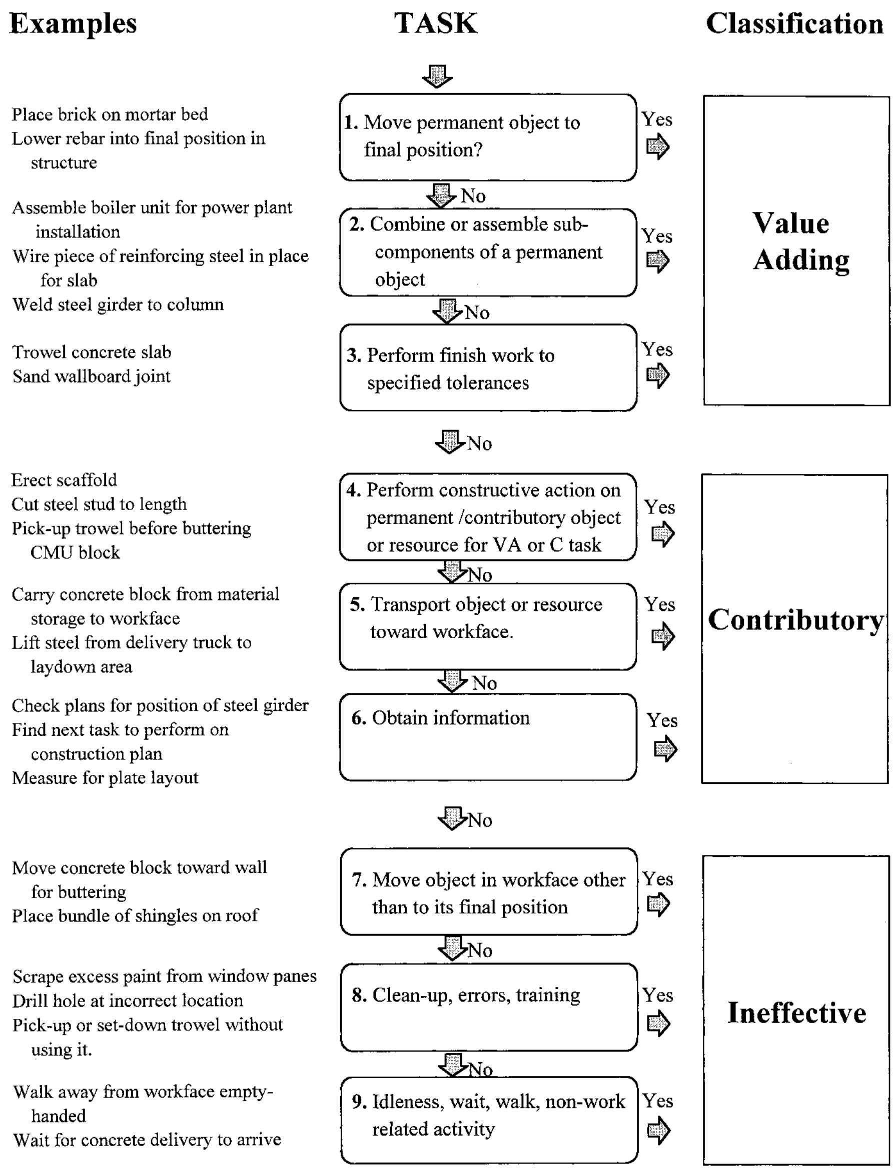

FIG. 4. Precedence List Flow Chart

given operation. For example, a class group project to evaluate a construction operation using Oglesby's technique resulted in widely varying results. Specifically, one student felt that she should classify training as effective work because she felt the operation could not be performed without it. However, an owner sees no value in employee training because training does not physically contribute to the facility. The owner would rather that employees arrived at the jobsite with prior training. The value-added assessment technique directly addresses training and classifies it as ineffective. The technique attempts to eliminate all such areas of ambiguity.

The flowchart in Fig. 4 illustrates a methodology to decompose a construction activity into appropriate tasks and classify each task as value-added, contributory, or ineffective, according to the rule list. The chart has nine decision nodes that classify a task specifically into the corresponding outcome node if it meets the decision node's criteria. If the task does not fit the criteria, it is passed down to the next decision node and reconsidered. A task that reaches the ninth decision node is forced into the ineffective outcome node. The nine rules depend on the location of that task in the work area.

Fig. 5 represents a simple version of a work area for the construction of a small concrete block enclosure. The structure or structure component, the workface, material preparation,

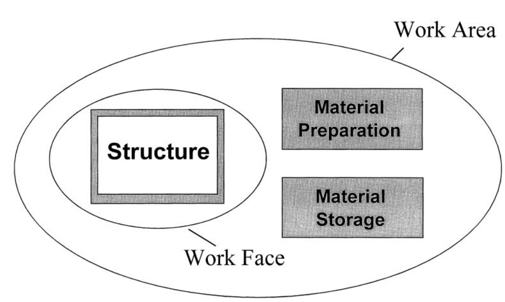

FIG. 5. Work Area Diagram

and material storage are located within a work area on the construction site. The work area may move during the construction operation. Reasonable distances, rather than strict dimensions, define boundaries.

Fig. 6 shows the inputs, output, resources, and information involved in the construction process. The VA classification rules consider the value to the owner of work done on permanent objects by individual tasks found in construction activity plans. Resources are those objects necessary for performing VA or contributory work that do not remain as part of the permanent structure.

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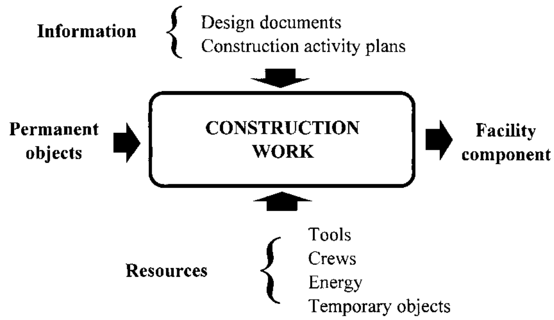

FIG. 6. Construction Process Model

AMPLIFICATION

This section describes rules that require further elaboration, and presents the rationale used in developing the rules that significantly differ from past work. Rules were developed by refining the classifications presented by researchers in past research, with a more detailed focus on value provided to the owner. A group of general rules replace the example-based methodology presented in previous papers.

Constructive Actions

Rule No. 4 requires the engineer to determine whether or not an action is constructive. A ''constructive action'' prepares a permanent object, contributory object, or resource for another contributory or value-added task. For example, a worker measures a steel stud, preparing to cut it to length. Measuring is a constructive action because it prepares the stud for another contributory task. Cutting prepares the stud for the value-added task of installation and is therefore also a constructive action.

Errors and Rework

Rule No. 8 addresses incorrectly completed tasks. The incorrectly completed tasks, errors, and the removal of the incorrectly completed components are first classified as ineffective work. Then all work necessary to correctly install or fabricate the permanent object or component, including repair and repetition of the task, are classified according to the VA effectiveness rules.

According to the definition of value-added work, only those tasks that add a permanent object to, or prefabricate a permanent component of, the specified facility can be considered as adding value for the owner. Therefore, the rules recognize the value-added effectiveness of correctly performed work, rather than the possible effectiveness of the tasks performed during the incorrectly completed work. Although the worker might perform the same tasks more quickly during rework because of the learning curve, a time-based average still reduces the efficiency of the construction operation because the method classifies initial incorrect work as ineffective in the overall VAEF calculation.

Classifying Movement Around Work Area

Tasks involving the movement of resources and personnel around the work area are difficult to classify. Four rules consider movement: Rule No. 1, move an object to its final position; Rule No. 5, transport objects toward the workface; Rule No. 7, move an object in the workface other than to its final position; and Rule No. 9, walk. Classification of tasks involved with transportation and movement are dependent on whether the worker moves the object or resource within the work area or the workface. The rules are applied in their numerical order, so that when a task that is related to walking or transportation requires classification, one must simply go through the rules and choose the first one that is appropriate.

Rule No. 1 includes a task such as pick a brick off a temporary pile in the workface and place it in its final position in a wall. This transportation distance is very short, as the workface is a small area that contains the short-term activities involved with the work.

Rule No. 5 includes all moves that bring material closer to the workface. Tasks that are undertaken to move improperly stored material out of the way of work generally don't fit into this rule because these tasks do not bring the material closer to the workface. This rule addresses the issue of work flow from storage areas to material preparation areas, and finally to the workface. Each move must bring the material closer to the workface for this work flow and all the tasks involved to be considered contributory. Therefore, the layout of the work area must place the material preparation area between the storage area and the workface. Rule No. 5 does not include walking empty-handed, for example, to return to the workface after transporting something.

Rule No. 7 classifies all moves within the workface that do not move an object to its final position as ineffective. This rule constrains the size of the workface by forcing the observer to limit the boundaries to a reasonable size, allowing all moves to be classified as either VA or contributory.

Rule No. 9 classifies all other walking as ineffective. Any transportation-related activity that doesn't meet the criteria of one of the three previously described rules will be classified as ineffective. Tasks included are walking empty-handed or carrying a resource away from the workface.

These four rules simplify the classification of transportation. They eliminate the need to recognize some moves as unnecessary, or to know the handling history of an object or resource that the worker moves. If the application of the rules required the observer to make decisions as to whether a move was necessary for an activity to proceed, the observer would have to be subjective and would risk improperly understanding the detailed site requirements. Similarly, the rules avoid the arbitrary classification of activities based on a fixed number of moves once an object had arrived on the jobsite. Both of these classification scenarios were considered when developing the proposed classification method. The rules consider continuation of a move toward the workface as contributory. Time-based averaging reflects the lower efficiency of continued moves.

TEST CASE

A simple case study of the actual effectiveness of masonry wall construction at a hospital project tested the applicability of the proposed evaluation method. Within the work area, three workers placed reinforcing steel, mortar, and concrete masonry unit blocks.

A videotape of the construction operation enabled an observer to record tasks at 5- and 10-second intervals, which is the required level of detail for application of the VA method in this case. A detailed analysis of $\sim$16 min generated 800 tasks. At each interval the observer recorded the object manipulated, the action performed on that object, and the resource used to perform the action (object, action, resource). The worker performing each task is an implied resource.

Once the data were recorded, the nine VA rules were applied to a sample time period. Table 2 shows the task data recorded for a 2:35 min portion, and the corresponding classifications and weight factors for each task. Worker No. 3 has a VAEF of 0.30 due to the large amount of ineffective tasks performed, such as clean, walk, and idle. By applying the value-added assessment technique to this operation, the low productivity of worker No. 3 is apparent. The contractor can now assess

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TABLE 2. Case Study Data and VAEF Calculation

Time (1)	Worker number 1 (2)	Rule (3)	Class (4)	Factor (5)	Worker number 2 (6)	Rule (7)	Class (8)	Factor (9)	Worker number 3 (10)	Rule (11)	Class (12)	Factor (13)
0:00:00	mortar, spread, trowel	1	VA	1.0	block, butter, trowel	1	VA	1.0	–, idle, –	9	I	0.0
0:00:05	block, pick-up, –	1	VA	1.0	block, pick-up, –	1	VA	1.0	block piece, align, trowel	4	C	0.5
0:00:10	block, place, –	1	VA	1.0	block, butter, trowel	1	VA	1.0	block piece, align, trowel	4	C	0.5
0:00:15	block, place, –	1	VA	1.0	block, pick-up, –	1	VA	1.0	block piece, align, trowel	4	C	0.5
0:00:20	block, align, –	3	VA	1.0	block, butter, trowel	1	VA	1.0	block piece, align, trowel	4	C	0.5
0:00:25	–, pick-up, level	6	C	0.5	–, pick-up, trowel	5	C	0.5	blocks, scrape, trowel	3	VA	1.0
0:00:30	–, pick-up, trowel	6	C	0.5	joints, scrape, trowel	3	VA	1.0	blocks, scrape, trowel	3	VA	1.0
0:00:35	joint, scrape, trowel	3	VA	1.0	joints, scrape, trowel	3	VA	1.0	joints, smooth, trowel	3	VA	1.0
0:00:40	–, place/read, level	4	C	0.5	mortar, scoop, trowel	1	VA	1.0	joints, smooth, trowel	3	VA	1.0
0:00:45	–, place/read, level	4	C	0.5	block, butter, trowel	1	VA	1.0	joints, smooth, trowel	3	VA	1.0
0:00:50	–, reposition/read, level	4	C	0.5	block, pick-up, –	1	VA	1.0	–, idle, –	9	I	0.0
0:00:55	block, align, –	3	VA	1.0	block, butter, trowel	1	VA	1.0	–, idle, –	9	I	0.0
0:01:00	–, set-down, level	6	C	0.5	block, pick-up, –	1	VA	1.0	block, align, level	4	C	0.5
0:01:05	–, set-down, trowel	6	C	0.5	block, place, –	3	VA	1.0	block, align, level	4	C	0.5
0:01:10	–, manipulate, line	4	C	0.5	–, pick-up, trowel	5	C	0.5	block, align, level	4	C	0.5
0:01:15	–, manipulate, line	4	C	0.5	block, tap, trowel	3	VA	1.0	block, align, level	4	C	0.5
0:01:20	–, take-out, ruler/pencil	4	C	0.5	joints, scrape, trowel	3	VA	1.0	–, walk, –	9	I	0.0
0:01:25	block, measure/mark, ruler/pencil	4	C	0.5	block, tap, trowel	3	VA	1.0	–, walk, –	9	I	0.0
0:01:30	–, put-away, ruler/pencil	4	C	0.5	joints, scrape, trowel	3	VA	1.0	–, walk, –	9	I	0.0
0:01:35	–, pick-up, trowel	6	C	0.5	mortar, mix, trowel	4	C	0.5	trowel, clean, –	8	I	0.0
0:01:40	mortar, spread, trowel	1	VA	0.1	block, pick-up, –	1	VA	1.0	trowel, clean, –	8	I	0.0
0:01:45	–, idle, –	9	I	0.0	block, butter, trowel	1	VA	1.0	trowel, clean, –	8	I	0.0
0:01:50	–, walk, –	9	I	0.0	–, idle, –	9	I	0.0	–, put-away, trowel	4	C	0.5
0:01:55	block piece, pick-up, –	5	C	0.5	block, butter, trowel	1	VA	1.0	–, walk, –	9	I	0.0
0:02:00	block, transport, –	5	C	0.5	block, butter, trowel	1	VA	1.0	–, walk, –	9	I	0.0
0:02:05	–, pick-up, hammer	5	C	0.5	block, pick-up, –	1	VA	1.0	–, idle, –	9	I	0.0
0:02:10	block piece, strike, hammer	4	C	0.5	block, place, –	1	VA	1.0	–, idle, –	9	I	0.0
0:02:15	–, set-down, hammer	6	C	0.5	–, pick-up, trowel	5	C	0.5	–, idle, –	9	I	0.0
0:02:20	mortar, scoop, trowel	1	VA	1.0	joints, scrape, trowel	4	C	0.5	–, idle, –	9	I	0.0
0:02:25	mortar, mix, trowel	4	C	0.5	block, tap, trowel	3	VA	1.0	–, idle, –	9	I	0.0
0:02:30	mortar, scoop, trowel	1	VA	1.0	joints, scrape, trowel	3	VA	1.0	–, idle, –	9	I	0.0
0:02:35	–, walk, –	9	I	0.0	joints, smooth, trowel	3	VA	1.0	–, idle, –	9	I	0.0
VAEF	—	—	—	0.61	—	—	—	0.89	—	—	—	0.30

Note: VA = value-adding; C = contributory; I = ineffective.

whether this worker's VAEF is due to the effectiveness of the construction plan or a result of poor plan implementation. In this case, the ineffectiveness indicates that the worker could have been either eliminated from this operation or given a different role in this activity. For instance, this worker could be shared with another team to better utilize the worker's time.

The case study indicated that application of the VA method requires significant understanding of the operation to properly classify tasks. Informed judgment by the observer is necessary to determine the actual purpose of a task. For example, the observer must understand the position of a permanent object indicated by the architectural design to determine if the worker placed the object in its final position. In addition, the application of this method in construction plan analysis demands a detailed plan. Finally, it is sometimes necessary to look at successor and predecessor tasks to correctly classify a particular task. For instance, if a worker picks up a tool to move it out of the way of work, the task (–, pick-up, trowel) should be classified as ineffective according to rule No. 8. However, if a worker picks up a trowel and then butters a block, the same task (–, pick-up, trowel) should be classified as contributory according to rule No. 6.

CONCLUSIONS

To facilitate comparison of data from various construction projects and researchers, we created a uniform method for objective evaluation. This method is not only precise to ensure consistent results, but also flexible to allow its application in diverse construction operations.

The nine simple task descriptions classify tasks into three classification groups. Therefore, construction personnel will be able to employ this method widely. The VAEF method does not require training regarding the classification definitions, but merely a simple understanding of the nine task groupings and the construction operation being evaluated.

With this method, construction activities must be decomposed into tasks that are purely VA, contributory, or ineffective. Doing so requires much more detail than a traditional construction plan. In addition, the value-added assessment method needs a crew-balancing technique to plan each worker's minute-by-minute tasks.

The value-added assessment technique enables different engineers to consistently classify the same tasks. Consistency in evaluation allows comparison of operations that are evaluated by different engineers, because it reduces ambiguity by providing a set of rules to objectively classify tasks.

Application of the method encourages recognition, understanding the reasons for, and, ultimately, reengineering the process to reduce non-VA tasks. Highly detailed planning, which the typical CPM construction schedule does not contain, facilitates the application of this method. The detailed activity plan includes a time-based list of each worker's tasks, defined by the object, action, and resource involved. Considering VA effectiveness raises the consciousness of non-VA tasks.

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Contributory tasks cannot be completely eliminated because construction involves manufacturing a single product at a single location, using varying workforces and resources. Because contributory tasks are such a significant part of construction work, the method will yield a much better representation of a contractor's effectiveness if a weighting is given to contributory tasks rather than if these tasks were considered ineffective.

This technique evaluates the effectiveness and efficiency of a construction method. Most techniques, such as stopwatch studies, only evaluate the output efficiency of a construction method, which does not allow the reengineering of the method prior to its execution. This method allows the differentiation of productivity problems between the effectiveness of a construction method and the actual effectiveness of its execution.

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