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ACTIVITY-BASED COSTING AND ITS APPLICATION TO LEAN CONSTRUCTION

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ABSTRACT

Activity-Based Costing (ABC) has been popular since the 1980s because it prevents cost distortions and provides a process view which traditional cost accounting cannot provide. Activity-Based Costing is based on a "flow view" in production theory in that ABC adopts two-staged costing, i.e., resources are assigned to activities and activities are assigned to cost objects. Lean construction comes from recognizing the limitations of current project management and applying "lean production" to the construction industry.

This paper presents an application of ABC and an example of applying ABC to construction, exploring the relationship between activity-based costing and lean construction. It shows that lean project control can encompass cost control by adopting an activity-based costing system.

KEY WORDS

Activity-based costing, resource-based costing, transformation view, flow view, and lean construction

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INTRODUCTION

Traditional cost accounting has been criticized for cost distortion and lack of relevance during the last 20 years (Johnson and Kaplan 1987). A new costing method, activity-based costing (ABC), was developed and has been advocated as a means of overcoming the systematic distortions of traditional cost accounting and for bringing relevance back to managerial accounting. A traditional system reports what money is spent on and by whom, but fails to report the cost of activities and processes (Miller 1996). Many organizations including petroleum and semiconductor companies in the manufacturing industry have adopted the new costing method.

There are two purposes of activity-based costing. The first purpose is to prevent cost distortion. Cost distortion occurs because traditional costing combines all indirect costs into a single cost pool. This pool is allocated on the basis of some resource common to all of the company's products, typically direct labor. Cost distortion is prevented in ABC by adopting multiple cost pools (activities) and cost drivers. The second purpose is to minimize waste or non-value-adding activities by providing a process view. This objective can be achieved by activity analysis with multiple cost pools (activities) and cost drivers.

Lean construction comes from recognizing the limitations of current project management and applying new production management called "lean production" to the construction industry. Koskela (1992) critiqued construction project management in that the traditional construction project management models construction as a series of conversion (value-adding) activities while new production philosophy improves competitiveness by identifying and eliminating waste (non value-adding) activities. He claimed that the construction industry should adopt a new production philosophy. It is an origin of lean construction.

Traditional project management is derived from an activity-centered[3] approach, which aims to optimise the project activity by activity assuming customer value is identified in a design phase (Howell 1999).

The focus on activities conceals the waste generated between connected activities by the unpredictable release of work and the arrival of needed resources (Koskela 19992). The purpose of traditional project control is to minimize the negative variance from pre-established (contracted) budgets and schedules (Halpin 1985, Howell and Ballard 1996). By contrast, the focus of lean construction is on work flow reliability. Managing the combined effects of dependence and variation is the first concern in lean construction (Howell 1999).

GOAL AND STRUCTURE

The goal of this paper is to present a method or applying ABC in construction and an example of applying ABC in construction, exploring the relationship between activity-based costing and lean construction.

The paper includes a review and evaluation of prior applications of ABC in construction. Then the paper presents a cost hierarchy and cost driver in application of ABC, and illustrates with an example. Finally the relationship between ABC and lean construction is presented.

[3] Activity in this context means schedule activity. It is different from activity in ABC.

RELATED WORK: APPLICATION OF ABC IN CONSTRUCTION

Efforts to apply ABC to construction were found in several papers, as ABC is a popular managerial accounting tool in the manufacturing industries.

Fayek (2000) linked the job-costing model with activity-based costing. He conceived a schedule activity as an activity in ABC. He proposed that costing each schedule activity and job is activity-based costing. However, a schedule activity in construction differs from an activity in activity-based costing because each schedule activity is a task or service that a contractor or crew is supposed to provide, as opposed one of several process steps involved in its execution or production. The 'activity' in ABC refers to the production process. The 'activity' in 'schedule activity' refers to the product of production processes, but neglects the processes themselves. Therefore, assigning costs to schedule activities in construction projects is not equivalent to activity-based costing.

Back et al. (2000) and Maxwell et al. (1998) linked process modeling and simulation with activity-based costing. They expanded the concept of activity following that of process modeling. However, their model uses only one resource driver such as time and does not recognize activity cost drivers. The model does not recognize a cost hierarchy either. Moreover, their model concentrates on field operations neglecting other elements in the value chain such as procurement, material handling, production, and hand-over.

Some accounting companies such as ABC Tech Inc. provide construction companies with ABC service (Matteson 1994, Antos 2000). However, application is limited to home office overhead costs.

CURRENT COSTING METHOD: RESOURCE BASED COSTING

At the heart of construction project accounting is the job costing system. In job costing systems, the cost object is an individual unit, batch, or lot of a distinct product or service called a job (Horngren et al. 1999).

> *"Job costing systems capture project expenses as they occur and allocate them to the physical and non-physical sub-elements of the project, namely sub-projects, by assigning them to cost accounts or work packages"* (Halpin 1985, pp.119).

These cost accounts (work packages) are the results of the project work breakdown structure.

However, it is found that resources are directly assigned to a cost account (a subproject) in direct costs. Each resource becomes an individual cost account in overhead costs as seen in Table 1. We use the term 'Resource-Based Costing' as opposed to Activity-Based Costing. RBC assigns costs directly to sub-projects, cost accounts or work packages defined in the work breakdown structures[4], as if the costs that arise in the execution of work packages also have their causes in those work packages. This traditional one-stage costing, in which resources are traced directly to products and services, is undertaken from the perspective of a "transformation view", which conceives production as a transformation of inputs into outputs. On the other hand, ABC uses two-

[4] A deliverable-oriented grouping of project elements which organizes and defines the total scope of the project (PMI 1996)

stage costing, tracing resources to processes then assigning processes to products and services. ABC assigns costs to the processes involved in those work packages, thus potentially revealing problems in the reliability of work flow, the causes of which may be removed from where their effects become visible. In this regard, activity-based costing (ABC) reflects a "flow view", which conceives production as a flow of materials and information consisting of transformation, inspection, moving, and waiting (Koskela 1999).

Cost Code	Description	Cost Code	Description
100	Clearing and grubbing	700	Project administration
101	Demolition	01	Project manager
103	Earth excavation	02	Construction supervision
104	Rock excavation	701	Superintendent
240	Concrete, poured	01	Foreman
01	Footings	02	Permits and fees
02	Slabs on grade		
03	Beams		
04	Columns		
05	Walls		
06	Stairs		
260	Concrete forms		
01	Footings		
02	Grade beams		
04	Columns		
05	Walls		
270	Reinforced steel		
01	Footings		
05	Walls		

Table 1: Example of Cost Accounts (Halpin 1985)

APPLICATION OF ABC IN CONSTRUCTION

There are two possible perspectives in the application of ABC in construction: the home office perspective and the project perspective.

From the home office perspective, the objective is to assign project-related home office overhead to different projects as shown in Figure 1. The scope of the activity-based costing system is limited to project-related home office overhead. A simple illustration with regard to prevention of cost distortion is the assignment of material procurement costs to different projects. The current practice is to distribute those home-office overhead costs on the basis of contract amount or direct labor hours (Holland and Hobson 1999). In an activity-based costing system, costs are assigned based on an appropriate activity cost driver such as the number of procurement instances.

From the project perspective, all costs are to be assigned to jobs/work packages except general administrative costs and direct material costs as shown Figure 2. (General administrative costs are not assigned because there is no rational basis for the assignment/allocation. There is no need to assign direct material costs since they can be directly costed to each job.) ABC from the project perspective include: 1) assignment of overhead costs to each work division, area, or individual building and 2) cost visibility as

to where the costs accumulate in the business process. ABC can provide accurate costs for each project by preventing cost distortion. Besides ABC can provide detailed activity costs data, by which different procurement routes or different strategies can be compared[5]. We include direct labor costs in the scope of the activity-based costing system (and thus, to be assigned or allocated based on cost drivers) because construction direct labor costs often include activities which can be categorized in manufacturing overhead costs; e.g., material handling. Therefore direct labor costs conceal non-value-adding activities such as rework. In manufacturing applications of ABC, direct labor costs are usually excluded because they do not contain such activities.

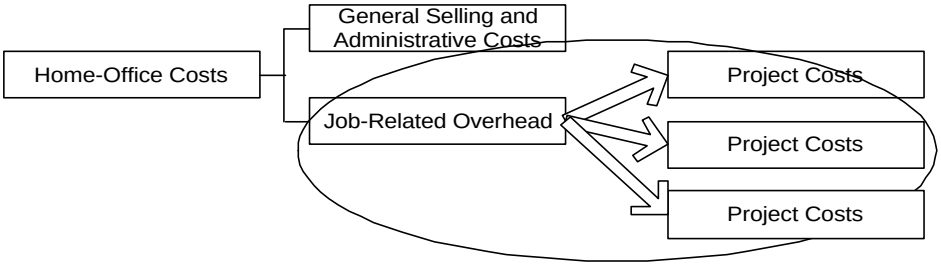


Figure 1: Assigning Home Office Overhead to Projects (Home-office Perspective)

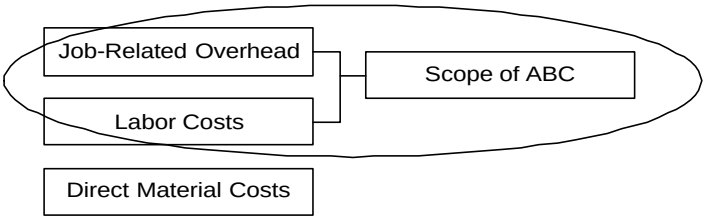


Figure 2: Scope of Activity-Based Costing (Project Perspective)

COST HIERARCHY

> "*A cost hierarchy categorizes costs into different cost pools on the basis of the different types of cost drivers (or cost allocation bases) or different degrees of difficulty in determining cause-and-effect (or benefit-received) relationships*" (Horngren et al. 1999, p142).

ABC system in manufacturing commonly uses a four-part cost hierarchy (output level costs, batch-level costs, product-level costs, and facility-level costs) to identify cost allocation bases or cost drivers (Horngren et al. 1999).

Output unit-level costs are defined as resources sacrificed on activities performed on each individual unit of a product or service (Horngren et al. 1999). Manufacturing operating costs such as energy and repair that are related to the activity of running machines are output unit-level costs. In construction, construction operating costs such as

[5] Such usage of ABC in project preparation is possible only after activity data on different channel or strategies is attained.

direct labor hours and equipment depreciation fall into this category because the cost of the activity increases with each additional unit of output produced.

Batch-level costs are defined as resources sacrificed on activities that are related to a group of product units or services rather than to each individual unit of product or service (Horngren et al. 1999). Setup costs and procurement costs are examples of batch level costs in manufacturing. In construction projects, the term "batch" is not familiar whereas unit cost is commonly used. This research assumes that construction projects have four different types of batches: procurement batch, delivery batch, task batch (process batch), and hand-off batch (transfer batch).

Procurement batch costs include the costs of placing purchase orders, receiving materials (when the entire quantity of materials purchased through the purchase order are delivered in a single batch), and paying suppliers (when they are to be paid based on the entire procurement batch rather than on incremental deliveries). These costs are batch-level costs because they are related to the number of purchase orders placed rather than to the quantity or monetary value of materials purchased.

Delivery batch costs include the costs of delivery from contractor's warehouse to site. The costs are costs incurred after receiving materials. These are batch-level costs due to the same reason. They can be included in task level costs if the delivery costs are proportional to the number of work packages.

Task is a unit of assignment released to a production unit and a unit of commitment planning made by a Last Planner (Ballard and Howell 1994, Choo et al. 1998, LCI 2000). *Task batch* can be interpreted as a process batch in manufacturing terminology because a production act is implemented once a task is assigned. Task batch costs include set up costs, quality inspection costs internal to a production unit (work group to whom assignments are made), and commitment planning (production unit control) costs.

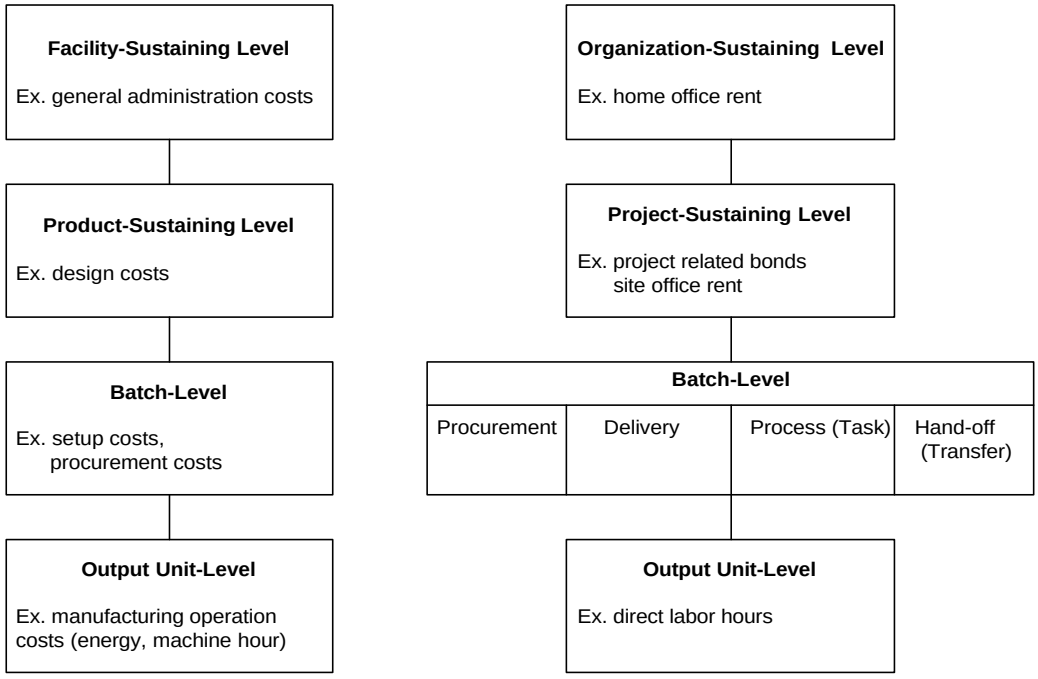
A *hand-off batch* is a quantity of intermediate product released to the next production unit or internal customer in a production chain. Hand-off batch level costs include external inspection.

Differentiating batch types has not only a cost accounting purpose (identifying a cost allocation base) but also a production management purpose. Ballard and Howell (1998) pointed out that construction projects lack production control. Making people use the batch concept promotes consideration of production control in project management.

Product sustaining costs are defined as resources sacrificed on activities undertaken to support individual products or services (Horngren et al. 1999). Design costs and engineering costs are examples of product sustaining costs in manufacturing. This research uses the term "project sustaining costs" similar to production sustaining costs for use in construction projects. Project sustaining costs include general planning, scheduling, and cost control. Some activities may occur at the home office and some at site offices.

Facility-sustaining costs are defined as resources sacrificed on activities that cannot be traced to individual products or services but support the organization as a whole (Horngren et al. 1999). This research uses the term "organization sustaining costs" similar to facility sustaining costs. Home office general administration costs fall into this category.

Figure 3 shows the cost hierarchies for manufacturing and construction.



(a) Manufacturing (Horngren 2000) (b) Construction

Figure 3: Cost Hierarchies

COST DRIVERS

> *"A cost driver is defined as any factor or event that causes a change in the cost of an activity"* (Raffish and Turney 1991).

The cost driver is at the heart of activity-based costing. A cost driver in ABC is defined more specifically as an allocation base of costs to activities (Horngren et al. 1999). The major distinction between traditional cost accounting and ABC is that ABC uses multiple cost drivers to assign activity costs to products or services (Cokins 1996). The final output of an activity-based costing is cost driver information (Miller 1996). Understanding the causal relationship between an activity and its cost driver enables management to focus improvement efforts on those areas that will produce the best results (Miller 1996). Because causal relationship can change according to situation, cost driver for an activity can change. Therefore it is required to check and update the activity data to make sure that appropriate cost drivers are being used. As that being said, please note that cost driver example shown in Table 4 is one of many options.

EXAMPLE

DEF Construction, Inc has an industrial project (D-890) consisting of five different buildings in which form and rebar work is done direct-hire (using its own employees). Suppose that D-890 is a cost-plus project. A new project manager recognized that the current costing method does not accurately assign costs for each building and neither

provides nor promotes a process view. He persuades the company to adopt a new costing method.

Current Method: Resource-Based Costing

Table 2 shows the information that the current method can provide. Costs are categorized into each resource type: labor, superintendent, and manager. Table 2(a) shows the information when direct material costs and direct labor costs are integrated whereas Table 2(b) shows the information when they are presented separately.

Job	Description	Costs
	Direct Cost	
10	Form, Foundation Building 01	$ 11,000.00
20	Form, Foundation Building 02	$ 6,000.00
30	Form, Foundation Building 03	$ 3,800.00
40	Rebar, Foundaiton Building 01	$ 10,400.00
50	Rebar, Foundaiton Building 02	$ 5,200.00
60	Rebar, Foundaiton Building 03	$ 3,800.00
	Subtotal	$ 40,200.00
160	Supervisor (1)	$ 5,500.00
170	Project Engineer (2)	$ 9,000.00
180	Project Manager (1)	$ 7,500.00
190	Warehouse Guard (1)	$ 3,500.00
200	Helper (2)	$ 4,000.00
	Subtotal	$ 29,500.00
	Total	$ 69,700.00

(a)

Job	Description	Costs
10	Form, Foundation Building 01 (Material)	$ 3,000.00
20	Form, Foundation Building 02 (Material)	$ 2,000.00
30	Form, Foundation Building 03 (Material)	$ 1,500.00
40	Rebar, Foundaiton Building 01 (Material)	$ 8,000.00
50	Rebar, Foundaiton Building 02 (Material)	$ 4,000.00
60	Rebar, Foundaiton Building 03 (Material)	$ 3,000.00
	Subtotal	$ 21,500.00
100	Form, Foundation Building 01 (Labor)	$ 8,000.00
110	Form, Foundation Building 02 (Labor)	$ 4,000.00
120	Form, Foundation Building 03 (Labor)	$ 2,300.00
130	Rebar, Foundaiton Building 01 (Labor)	$ 2,400.00
140	Rebar, Foundaiton Building 02 (Labor)	$ 1,200.00
150	Rebar, Foundaiton Building 03 (Labor)	$ 800.00
	Subtotal	$ 18,700.00
160	Supervisor (1)	$ 5,500.00
170	Project Engineer (2)	$ 9,000.00
180	Project Manager (1)	$ 7,500.00
190	Warehouse Guard (1)	$ 3,500.00
200	Helper (2)	$ 4,000.00
	Subtotal	$ 29,500.00
	Total	$ 69,700.00

(b)

Table 2: DEF Construction Cost Report Using RBC (Project D890)

Some observations on the current method:

(1) Overhead costs are not usually assigned to each building. Therefore, it is hard to get accurate costs for each building. If the owner wants to segregate overhead costs into different buildings, the company uses direct labor cost as an assignment base (Sommer 2001) as shown in Table 3. However, assignment of overhead costs with direct labor costs does not provide accurate costs for each building because costs that have little relations with direct labor hours are assigned by direct labor hours, causing cost distortion. As a result, managers do not have accurate information on where profits and losses arise, or where opportunities and needs for waste reduction exist with a cost report.

(2) As shown in Tables 2 and 3, the current method doses not provide a process view because costs for each resource are categorized in terms of resources rather than activities/process steps.

	Building01	Building02	Building03	Total
Direct Material	$ 11,000.00	$ 6,000.00	$ 4,500.00	$ 21,500.00
Direc Labor	$ 10,400.00	$ 5,200.00	$ 3,100.00	$ 18,700.00
Total Direct Costs	$ 21,400.00	$ 11,200.00	$ 7,600.00	$ 40,200.00
Total Overhead				$ 29,500.00
Assignment %	55.61%	27.81%	16.58%	
Overhead	$ 16,406.42	$ 8,203.21	$ 4,890.37	$ 29,500.00
Total	$ 37,806.42	$ 19,403.21	$ 12,490.37	$ 69,700.00

Table 3: Overhead Assignment (Allocation Base: Direct Labor Hour)

Activity-Based Costing

The first step in ABC is to define cost objects. Suppose that there are six cost objects: formwork building 01, formwork building 02, formwork building 03, rebar building 01, rebar building 02, and rebar building 03.

Suppose that the results of activity analysis are as shown in Table 4. For example, an activity "Receive Rebar" costs $1,280 and the number of receipt in a month was 4. The unit rate for the activity is $320 because the number of receipt is selected as a cost driver ($1,280 / 4 = $320). Direct labor costs are included in the scope of activity analysis because DEP construction performs form and rebar work with its own employees.

			The Number of Activity							
Process Costing	Cost Driver	Hierarchy	Bld01 (Form)	Bld02 (Form)	Bld03 (Form)	Bld01 (Rebar)	Bld02 (Rebar)	Bld03 (Rebar)	Total	Unit Rate
Setup (Mobilize)	No. of Setup	Task Batch	2	1	1	2	1	1	8	$ 100
Receive Form	No. of Receipt	Procurement Batch	1	1	1				3	$ 350
Receive Rebar	**No. of Receipt**	**Procurement Batch**				**2**	**1**	**1**	**4**	**$ 320**
Form Moving (Warehouse to site)	No. of Moving	Delivery Batch	3	2	1				6	$ 67
Rebar Moving (Warehouse to site)	No. of Moving	Delivery Batch				3	2	1	6	$ 50
Forming	Direct labor hour	Unit	190	90	30				310	$ 41
Insert Rebar	Direct labor hour	Unit				60	30	15	105	$ 32
Rework (Form)	Direct labor hour	Unit	0	0	30				30	$ 41
Rework (Rebar)	Direct labor hour	Unit				0	0	10	10	$ 32
Inspection (Form)	No. of inspection	Hand-off Batch	2	1	2				5	$ 240
Inspection (Rebar)	No. of inspection	Hand-off Batch				2	1	2	5	$ 180
Procurement	No. of purchase order	Procurement Batch	0.33	0.33	0.33	0.33	0.33	0.33	2	$ 1,400
Progress Payment	No. of payment	Procurement Batch	0.33	0.33	0.33	0.33	0.33	0.33	2	$ 1,100
Q/A (Quality Assurance)	No. of NCR	Hand-off Batch	0	0	1	0	0	1	2	$ 2,750
RFI (Request For Information)	No. of RFI	Task Batch	2	0	0	1	0	1	4	$ 1,050
General Supervision	Proportional to Direct Labor Hour	Project	43%	21%	12%	13%	6%	4%	%	

Note: NCR stands for Non Conformance Report

Table 4: DEP Activity Data (D-809)

The overhead rates developed in Table 4 can now be used to assign process costs to cost objects as shown in Table 5.

	Bld01(Form)	Bld02(Form)	Bld03(Form)	Bld01(Rebar)	Bld02(Rebar)	Bld03(Rebar)	Total
Direct Material (1)	$ 3,000.00	$ 2,000.00	$ 1,500.00	$ 8,000.00	$ 4,000.00	$ 3,000.00	$ 21,500.00
Process Costing							
Setup (Mobilize)	$ 200.00	$ 100.00	$ 100.00	$ 200.00	$ 100.00	$ 100.00	
Receive Rebar	$ 350.00	$ 350.00	$ 350.00				
Receive Form				$ 640.00	$ 320.00	$ 320.00	
Form Moving (Warehouse to Site)	$ 200.00	$ 133.33	$ 66.67				
Rebar Moving (Warehouse to Site)				$ 150.00	$ 100.00	$ 50.00	
Forming	$ 7,790.00	$ 3,690.00	$ 1,230.00	$ -	$ -	$ -	
Insert Rebar	$ -	$ -	$ -	$ 1,920.00	$ 960.00	$ 480.00	
Rework (Form)	$ -	$ -	$ 1,230.00	$ -	$ -	$ -	
Rework (Rebar)	$ -	$ -	$ -	$ -	$ -	$ 320.00	
Inspection (Form)	$ 480.00	$ 240.00	$ 480.00				
Inspection (Rebar)	$ -	$ -	$ -	$ 360.00	$ 180.00	$ 360.00	
Procurement	$ 416.67	$ 416.67	$ 416.67	$ 416.67	$ 416.67	$ 416.67	
Progress Payment	$ 333.33	$ 333.33	$ 333.33	$ 333.33	$ 333.33	$ 333.33	
Q/A (Documentation)	$ -	$ -	$ 1,750.00	$ -	$ -	$ 1,750.00	
RFI	$ 2,100.00	$ -	$ -	$ 1,050.00	$ -	$ 1,050.00	
General Supervision	$ 5,334.59	$ 2,666.80	$ 1,530.43	$ 1,597.28	$ 795.14	$ 527.76	
Process Costing Total (2)	$ 17,204.59	$ 7,930.13	$ 7,487.10	$ 6,667.28	$ 3,205.14	$ 5,705.76	
Total (1) + (2)	$ 20,204.59	$ 9,930.13	$ 8,987.10	$ 14,667.28	$ 7,205.14	$ 8,705.76	$ 69,700.00

Table 5: ABC Cost Report (D-809)

Observations:

(1) As shown in Table 6, costs for each of the three buildings are different using ABC (activity-based costing) versus using RBC (resource-based costing). Building "01" is overcharged because the current method assigns overhead costs in proportion to direct labor hours, causing cost distortion.

	RBC				ABC		
	Direct Material	Direct Labor	Overhead	Total	Direct Material	Process Costs	Total
Building 01	11,000	10,400	16,406	37,806	11,000	23,872	34,872
Building 02	6,000	5,200	8,203	19,403	6,000	11,135	17,135
Building 03	4,500	3,100	4,890	12,490	4,500	13,193	17,693
Total	21,500	18,700	29,500	69,700	21,500	48,200	69,700

* Unit: $

Table 6: Comparison of RBC and ABC (D-809)

(2) Activities and their costs are shown in ABC cost reports (Table 5) whereas only resource types and their costs are shown in RBC cost reports (Table 2). ABC provides managers with a process view as to where the costs accumulate and at what rate. For example, information such as an average cost for each receipt of

rebar or cost for each RFI can be known. Therefore managers can focus on the area where the improvement is needed.

ABC AND NON-FINANCIAL INFORMATION

Managers can get a different information channel (non-financial information) other than cost information. Quality information such as the number of inspection failures can be an example. However, ABC converts non-financial information to cost information. Dollar is a media with which all managers and workers can communicate each other. It can be said that ABC provides a frame in which various non-financial information can be utilized. Information that is converted to a dollar value has more impact on human behavior than other information.

IMPLEMENTATION: MOVING FORWARD

As seen from the above example, managers can get accurate cost information on each work division or each building, and get a process view by using ABC.

The research needs more case studies on actual construction projects. In case studies, a researcher will participate as a consultant in an active way. The researcher will teach engineers a detailed procedure for implementing ABC and encourage them to test that procedure on their own projects. For a case study, one general contractor's project without direct-hire work and several direct-hire projects will be selected and tested. Note that the research will test the implementation of ABC only on several cost accounts during a specific time frame instead of a whole project. ABC reports will be discussed with professionals in comparison with previous cost reports. Discussion will focus on the opportunity that ABC reports provide.

CONCLUSIONS

The paper deals with only the use of the information during implementation of the project. Of course, the information can be used in the preparation of the project. Choosing an alternative in procurement channel or subcontract selection can be an example. However, such use in the preparation of the project can be possible only after activity cost data is available. Therefore setting up a new costing system and its use during the implementation is to be accomplished first.

This paper showed an example of the application of ABC in construction and its potential benefits compared with RBC. Theoretically ABC is based on a "flow view" of production theory in at least two ways: First, process-based costing assumes that resources are assigned to activities (processes) and activities (processes) are assigned to pieces of projects whereas resource-based costing assumes resources are directly assigned to pieces of projects/ products. Second, the purpose of process-based costing is not only preventing a cost distortion but also providing a process view, thereby helping reduce or eliminate wastes or non-value-added activities.

In conclusion, lean project control can encompass the cost control by adopting an activity-based costing system.

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