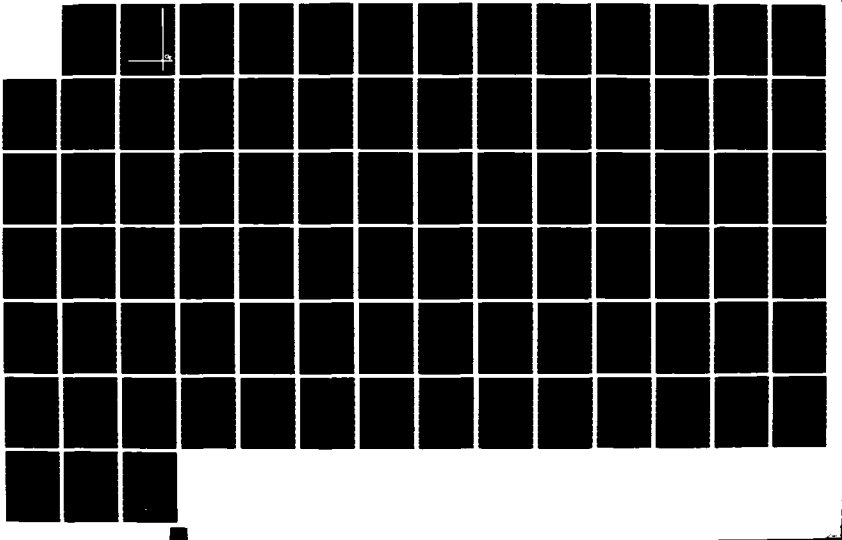
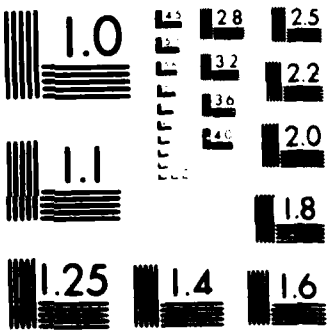
AD-A172 427 PHYSIOLOGICAL AND MANAGEMENT FACTORS AFFECTING FIELD PRODUCTIVITY(U) GEORGIA INST OF TECH ATLANTA SCHOOL OF CIVIL ENGINEERING A D AYARS AUG 86 1/1

UNCLASSIFIED F/G 5/1 NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

PHYSIOLOGICAL AND MANAGEMENT FACTORS AFFECTING FIELD PRODUCTIVITY

A SPECIAL RESEARCH PROBLEM

PRESENTED TO

THE FACULTY OF THE SCHOOL OF CIVIL ENGINEERING

BY

ARTHUR D. AYARS, JR.

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

GEORGIA INSTITUTE OF TECHNOLOGY

AUGUST, 1986

GEORGIA INSTITUTE OF TECHNOLOGY
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
SCHOOL OF CIVIL ENGINEERING
ATLANTA, GEORGIA 30332

PHYSIOLOGICAL AND MANAGEMENT FACTORS AFFECTING FIELD PRODUCTIVITY

A SPECIAL RESEARCH PROBLEM

PRESENTED TO

THE FACULTY OF THE SCHOOL OF CIVIL ENGINEERING

BY

ARTHUR D. AYARS, JR.

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

GEORGIA INSTITUTE OF TECHNOLOGY

AUGUST, 1986

PHYSIOLOGICAL AND MANAGEMENT FACTORS
AFFECTING FIELD PRODUCTIVITY

BY

ARTHUR D. AYARS, JR.

APPROVED:

8/12/86
DR. LELAND S. RIGGS

8/12/86
DR. ROOZBEH KANGARI

8/12/86
DR. W. RODRIGUEZ-RAMOS

ACKNOWLEDGEMENTS

My deepest thanks to Sherry and the kids and family; the ones who really count.

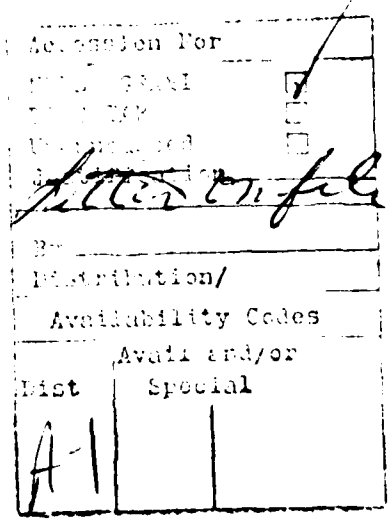


TABLE OF CONTENTS

PAGE

LIST OF TABLES AND CHARTS

CHAPTER I

PRODUCTIVITY CONCEPT

1.0 Introduction

Simply stated, Productivity is the measure of work produced during a unit of time. During construction, it is valuable to compare actual or expended quantities with estimated or budgeted quantities; the purpose of which is to accurately measure progress and ultimately to control the construction project parameters of time and money. When comparing quantities, the conclusions reached are only as good as the data collected. In this regard, information collection techniques may vary from project to project to better suit the project size, type and complexity. One approach for measuring construction progress is to determine project status through the earned value system.

1.1 Earned Value System

To utilize the earned value approach, the project is broken down into work task control accounts. These accounts are uniquely defined and contain resources programmed in the planning and budgeting process. These control accounts are different from the financial accounts which record expenditures during the construction process. The earned value accounts contain the total budgeted resource units

required to accomplish the particular work task. The resource unit used in the control account is either dollars or man-hours.

For example, control account A may contain 1000 man-hours associated with performing a concrete pour. This figure is the estimated quantity based on experience gained from previous projects or other information sources and constitutes the best guess of quantities that will be needed to perform the task in the allotted time. As construction proceeds, these resource units are expended. At desired time intervals, in-the-field assessment is made to determine actual work-in-place figures. From this sampling, the actual expended resource units are compared with the total budgeted resource units in the control account. This ratio gives the earned percentage to date. The earned value for the completed work is computed by multiplying this ratio by the budget cost for the account as follows:

$$\text{Earned Value} = (\text{Total Budget Value}) \frac{(\text{Amount of work completed})}{(\text{Total for Control Acct})}$$

This technique applies to all individual control accounts and may be used to render earned value(% complete) for the entire project as well.

$$\%\ \text{Complete} = \frac{\text{Total Man-hours or Dollars to Date}}{\text{Budget Man-hours or Dollars}}$$

Measuring the amount or work completed, and thus

productivity, may be accomplished using various discrete or subjective methods.1

1.2 Productivity and Earned Value

The earned value approach to work statusing gives a current reading to management of construction progress. From a comparison of the earned value and the estimated progress at a particular time, management will make conclusions regarding the worth of original project estimates and productivity. After trending and forecasting analysis is completed, possible corrective action may be taken to adjust project schedules and budgets accordingly.

Therefore, productivity becomes paramount with respect to project success. Productivity is intimately involved in answering the questions "Where are we now?" and "When will we finish?". The question of "Where are we now?" is usually the easier of the two to answer since known techniques are available for measuring the amount of work completed to date. But, accurately forecasting project completion is uncertain since the events of the schedule have not yet occurred. Management can project completion based on the progress to date, but there is always the risk that the productivity of the remaining work may be affected adversely by unforeseen circumstances. If productivity declines, this will require additional labor man-hours to accomplish the same unit of work. The earned value of the project at a particular time will be less than desired since the actual

work-in-place per man-hour is less than expected. However, labor costs will be at the estimated rate. Ultimately, this means less profit to the company due to higher labor costs and may pose a potential threat to timely project completion and cause cash flow problems.

It is evident that being able to accurately estimate the productivity of crews is crucial to a successful project bid and schedule. Because of this, great care should be exercised by management in reviewing those productivity factors which impact upon field productivity.

1.3 Objective

The objective of this report is to identify and examine some of the physiological and management factors that should be considered by project management in assessing labor productivity in the field. Methods of measuring job site productivity will be presented as well as an analysis of one company's approach to measuring and improving productivity based on those factors.

1.4 Scope of Research

Chapter II addresses the physiological factors affecting the construction worker. It details the role that the individual's physical condition and metabolism play in determining worker fatigue. The influence of environmental conditions on the worker is reviewed as is task difficulty.

Chapter III deals with those factors management may control. This includes the decision making process at all levels of project management and also addresses utilizing field personnel in establishing job policy. Leadership by management and the communication with and motivation of personnel is discussed as they affect productivity.

Chapter IV examines methods of measuring job productivity and presents an analysis of a large industrial company's system used for measuring productivity incorporating the factors discussed in Chapters II and III.

Chapter V presents conclusions and recommendations for further study.

CHAPTER I ENDNOTES

[1] Neil,J.,article "The Earned Value System".

CHAPTER II

FACTORS AFFECTING WORKER PHYSIOLOGY

2.0 Worker Physiology

Worker physiology encompasses the physical conditions affecting the worker during the performance of a physical task. These conditions include the worker's metabolism and age, physical task characteristics and the job environment. These conditions have a direct influence on the productivity of the worker. For this reason, it is important that management be concerned about these factors.

2.1 Worker Metabolism

The energy control process within the body allows the body to convert food into kinetic and chemical energies. About 25% of the energy produced from the chemical breakdown of food is available for muscular work. The amount of work the body performs is determined by measuring the amount of oxygen utilized. The oxygen uptake value is converted into kilocalories of energy expenditure. This is the metabolic rate. During the initial phase of exertion, the body functions without oxygen(anerobic), but eventually the metabolic rate stabilizes. The worker who is more

aerobically physically fit will find work tasks less tiring.1

As a result, each construction worker has his own unique capacity for performing work depending on his state of health and nutrition. The individual's age has a significant effect upon his metabolic rate since the oxygen uptake rate decreases with age.2

2.2 Physical Task Characteristics

The worker is affected by three aspects of a physical task. These include task difficulty, task duration and required work posture.

2.2.1 Task Difficulty

Task difficulty is defined as the energy expended per unit of time in performing a task. Research has developed a relative ranking of tasks according to difficulty. Where truck driving may require approximately 1.6 kcal/min, a worker hand sawing may expend 9.0 kcal/min. For general construction, a laborer expends about 6.o kcal/min. Task difficulty varies with the physical requirements of the task.3

It should be noted that research in this area is non-conclusive since individual differences may affect the results. For example, worker motivation will impact upon the production rate of the individual.

2.2.2 Task Duration

Work tasks that require a higher energy expenditure can not be performed for as long as tasks requiring a lower energy expenditure. In general, a person of average physical fitness can work continuously for 50 minutes of each hour during an 8 hour day.4

2.2.3 Posture

This aspect of worker performance is often ignored in studying job productivity. It is believed that discomfort experienced by a worker due to maintaining a certain posture is as equal a limit on productivity as is the actual physical activity performed. Management should consider this factor when crew assignments are made. Assigning the same personnel to perform repetitive tasks may become counter productive.5

Research by Corlett indicates that seven rules should be used in minimizing loss of efficiency in workers. They are:

1. The worker should be able to maintain an upright and forward facing posture during work.
2. The task should be visible with the trunk upright and the head either upright or inclined slightly forward.
3. The back should be supported during sitting work. The weight of the body should be supported equally on both feet during standing work.

Ideally, the task should permit the worker to adopt any of several equally safe and healthy postures without reducing productivity.

4. Work should be performed at a height below shoulder level. Even occasional exertion of force above the shoulder level should be avoided. Where light hand work must be performed above the shoulder level, upper arm rests must be available.
5. Work should be performed with the joints at about the midpoint of their range of movement. This is particularly important for the joints of the neck, trunk, and arms.
6. Muscular force should be exerted so that large (groups of) muscles can be used. The direction of motion should be parallel with the involved limbs.
7. When repeated use of muscular force is required, the task should be designed so that the worker can use either arm or either leg.6

2.2.3.1 Evaluating Posture Effects

Several methods may be used to study posture on the job. One successful method used in industry is the Ovako Working Posture Analysis System(OWAS).7

This rating system considers the position of the worker's back, arms and legs. A three digit code is

assigned based on posture as follows:

Back(first digit)

1. Straight
2. Bent
3. Straight and Twisted
4. Bent and Twisted

Arms(second digit)

1. Both arms at or below shoulder level
2. One arm at or above shoulder level
3. Both arms above shoulder level

Legs(third digit)

1. Weight on both legs, straight
2. Weight on one leg, straight
3. Weight on both legs, bent
4. Weight on one leg, bent
5. Weight on one leg, kneeling
6. Body being moved by walking
7. Both legs hanging free

Workers were questioned regarding their comfort when working in a particular posture. From the responses a four category system was developed for use in realizing current and possible future problems in the efficiency of the worker. The four posture categories are:

Class 1. Normal postures that do not need any special

attention except in some special cases.

Class 2. Postures that must be considered during the next regular check of work methods.

Class 3. Postures that need consideration in the near future.

Class 4. Postures that need immediate attention.

A system such as OWAS has been found to be useful to management in improving labor productivity.

2.2.4 Back Injury

It is a fact that back problems increase with age. Most problems result from degeneration of the disks located between vertebrae in the spine. These disks may become misalligned and cause inflammation and pain in the spinal nerve.8

Statistics compiled by the National Safety Council indicate construction workers have more back injuries than other workers. A California survey of workers who perform physical tasks follows.

California

Occupation	%of Workers	% of Back Injuries	Relative Risk
Mining	.4	.7	1.75
Construction	3.7	7.1	1.92
Manufacturing	20.1	26.4	1.31
Transportation/ Public Util.	6.1	10.5	1.72
Wholesale/Retail Trade	22.8	21.1	.92
Finance,Ins., Real Estate	5.8	1.8	.31
Services	20.4	14.3	.70
Government	20.7	18.1	.87

Back injury to the worker results in lost productivity and higher medical costs for the company. One way to reduce these negative aspects is through physical training. Exercises such as running and sit-ups strengthen muscles and help to minimize the opportunity for back injury.

Proper lifting and carrying techniques also reduce back injury. Proper lifting methods include two principles. When lifting objects from the ground, the worker should use

his leg muscles by squatting. When pushing a heavy object, initiate horizontal movement by using the body's momentum. Inherent in these two principles are six common factors. They are correct position of the feet, straight back, arms close to the body, correct hold, keep chin tucked in and use of body weight.

2.3 Environmental Conditions

Workers' physiology is affected by ambient temperature, altitude and air quality. A worker performing in a humid climate of extreme heat will react much differently than a worker in a breezy, 70 degree environment. Consequently, productivity expectations will vary greatly with each situation.

2.3.1 Body Temperature

Internal body temperature is controlled by a process called "thermoregulation". This involuntary control system can maintain the body temperature within one-half degree with lower readings in the morning and peak values in the late afternoon.9

Thermoregulation requires that, over a short time period, the heat gain and loss by the body are equivalent. The body can adjust to ambient temperature in three ways: adaptation, acclimation, and acclimatization. Adaptation is a genetic adjustment to a condition. Acclimation refers to physiological responses to temperature variations. For

example, acclimation includes sweating or shivering. Acclimatization includes enduring changes in physiological mechanisms that allow the worker to perform in an extreme environment. It is significant to note that the body can adjust well to hot climate temperatures, but is unable to maintain a stable body temperature when dealing with ambient temperatures below 78.8 degrees Farenheit.10

2.3.1.1 Effects of Heat on the Worker

Construction in extremely hot climates can pose a dangerous threat to a labor force. To prevent heat stress in an individual, it is essential that the body's temperature be controlled by the intake of salt and water during the course of work.

A proper balance of salt and water in the blood allows the individual to remove excess body heat through sweating. An average construction worker may lose one liter of sweat per hour during an eight hour day. This extensive fluid loss will result in personality as well as physical changes which affect the workers' efficiency and production on the job.

According to research by Adolph and Marriott, a water deficit of 2% of body weight leads to thirst, reduced urine output, irritability, and aggressiveness. A deficit of 6% or greater results in a reduction of mental and physical capacity. A salt deficit of one-half gram per kilogram of body weight will cause giddiness, mild cramps, and

eventually fainting. Chronic salt deficiency is marked by continued worker weight loss. Because of these hazards, OSHA regulations contain provisions for salt and water on the construction site.11

Worker acclimatization in a hot environment varies with the individual. Some workers adjust well to high ambient temperatures while others cannot. The acclimatization process usually occurs over a one to ten day exposure period. This period is reduced when people perform physical work in the heat. Research by Horvath and Shelley found that for each hour worked in a hot environment, acclimatization provides for another four hours of effort. This result is apparently independent of the worker's age. Some degree of acclimatization is lost if the individual is removed from the heat for a period of time. A one week break from working in a hot environment may require four days of exposure for the worker to re-adjust.

2.3.1.2 Effects of Cold on the Worker

As stated previously, a worker is unable to maintain a stable body temperature when performing in colder climates. The potential effects of the cold must be carefully considered as a threat to the individual's health and efficiency.

Internal heat loss to the cold produces shivering and an increase in metabolic rate by a factor of 3 to 5. The sense of touch is reduced significantly in colder

temperatures. This results in numbness and a loss of sensitivity and dexterity in the worker. Performing tedious and highly skilled tasks by the individual become much more difficult during cold conditions. A loss of hand strength usually follows and is normally not recognized by the individual. As such, production will decline also.12

2.3.2 Effects of Altitude on the Worker

It has been proven that individual production diminishes at higher altitudes. Unlike the effects of temperature, acclimatization may require several generations to adjust to higher altitudes and equal that of the native people.

At higher altitudes, the individual experiences a decrease in maximal aerobic capacity. The relationship is linear, however the slope of the line varies with the worker's time of acclimatization, weight loss and possibly the individual's physical condition. Since the metabolic rate of the worker is adversely affected, work production is decreased since greater rest periods are necessary because of decreased energy production.13

2.3.3 Effects of Air Quality on the Worker

The production of the worker is affected most by the air contaminants of carbon monoxide and ozone. Carbon Monoxide bonds with the hemoglobin in the blood about 200 times more readily than oxygen. This causes a reduction in

the absorbed oxygen supply and the individual's work capacity. This effect occurs when carbon monoxide binds with only 5% of the body's hemoglobin. A reduction in the work capacity is equivalent to the individual working harder at a task than normal requiring additional rest or slower unit production.14

Ozone adversely affects lung ventilation during work. Construction workers who weld experience reduced breathing rate and volume. This causes a loss of work capacity in the individual. Tests indicate that a worker in Los Angeles, on a smoggy day, suffers a 10% decrease in work capacity.15

2.4 Summary

Limitations exist in any construction effort. There are physiological and environmental factors which degrade worker capacity. The effects result in added costs to the project. As such, management must be aware of and strive to mitigate those conditions which could adversely affect project planning and scheduling.

CHAPTER II ENDNOTES

[1] Helander, M., "Human Factors/Ergonomics for Building and Construction", New York: John Wiley & Sons, Inc., 1981.

[2] Astrand, I., and Rodahl, K., "Textbook of Work Physiology", New York: Mcgraw-Hill, 1970.

[3] Helander, pp.119.

[4] Michael, E. D., Hutton, K. E., and Horvath, S. M., "Journal of Applied Physiology", 1961.

[5] Corlett, E. H., "Posture: It's Measurement and Effects", Birmington, England: University of Birmington Dept. of Engineering Production, 1979.

[6] Ibid.

[7] Karhu, O., Kansi, P., and Kuorinka, I., "Applied Ergonomics", 1977.

[8] Adams, R. L., Cauthen, D. B., Neidre, A., and Washburn, K. B.,"Current Prescribing", 1977.

[9] Helander,M.,Ibid.

[10] Helander,M.,Ibid.

[11] Adolph, E. F.,"Physiology of Man in the Desert",New York: Wiley, 1947; Marriott, H. L.,"Water and Salt Depletion", Springfield, Ill.:Thomas, 1950.

[12] Helander,M.,Ibid.

[13] Wagner, J. A., Miles, D. S., Horvath, S. M., and Reyburn,J. A.,"Journal of Applied Physiology: Respiratory, Environmental, and Exercise Physiology",1979.

[14] Horvath,S. M., Raven, P. B., Dahms, T. E., and Gray, D. J.,"Journal of Applied Physiology",1975.

[15] Helander, M.,Ibid.

CHAPTER III

MANAGEMENT FACTORS INFLUENCING PRODUCTIVITY

3.0 Role of Management in Productivity Research

Most productivity research has focused on technological advances which assist the worker on the job in improving his output. Complex technology has created an atmosphere where the investigation of management's impact upon project flow has been neglected.

3.1 Management Defined

In discussing the influence of management upon field production, this paper will identify and examine those factors which may be controlled by management decisions. Chapter II discussed the worker's susceptibility to various limiting physiological and environmental conditions. For purposes of this paper, management is defined as the individual or group of personnel who provide the decision making capability for the organization. Therefore, management includes the foreman as well as all his seniors in the organization.

One distinct difference between management and the worker is that management does not perform any physical tasks associated with constructing the project. Management

decisions normally affect some aspect of the project schedule or method of construction and as this paper will discuss, these decisions often impact upon the emotions and attitude of the worker.

3.2 Worker Satisfaction and Productivity

It has been often said that people perform better doing jobs they enjoy. From this it could be argued that management plays an important role in making a job more or less satisfying for the worker through policy making. Management faces a significant challenge in motivating workers who perform repetitive and boring tasks.

A 1975 study on job satisfaction revealed nine components which should be considered when management desires to improve job productivity.1 These components directly relate to the productivity factors to be discussed in subsequent sections of this chapter. The nine job characteristics are:

1. The employees must know that they are important to the organization, and that they are involved with the organization
2. The employees should interact with clients, customers and co-workers directly
3. The jobs should be enlarged to include challenge, variety, wholeness and self-regulation
4. The employees should participate in the making

of decisions regarding their jobs

5. Compensations should be tied to performance
6. Pay, fringe benefits, safety, and working conditions should be at least adequate
7. Channels of communication and authority should be kept simple
8. Resources should be at the worker's disposal to reduce frustration associated with getting the job done
9. Methods improvements should be instituted with the employee's participation

Not all of these components are applicable to the construction worker in the field. Personal contact with clients and customers is practically never present. Such contacts are almost exclusively handled by management. To do otherwise would cause confusion and it would be inappropriate for construction personnel to discuss design or financial matters with the customer. It is also appropriate to question whether the average construction worker is seeking a challenge and self-regulation.

Components five and six were developed by Frederick Taylor, the Father of Scientific Management, who proposed that compensation be based on individual productivity.2 Unfortunately, the bonding of labor into unions and the resulting wage agreements has all but negated individual motivation based on compensation.

Components four and seven through nine offer the greatest opportunity for management to increase productivity. These four components will be discussed as the following management factors:

1. Leadership
2. Participative Decision Making
3. Planning, Scheduling, and Communicating
4. Motivation

3.3 Management Factors

Management of people is one of the toughest jobs possible. A manager must repeatedly confront the personal problems of his personnel and assist in solving them while striving to attain productions goals. He must make honest evaluation of those who work for him and recommend promotions or dismissals accordingly. In a world of numbers and quotas, he must be ever conscious of the individual values and emotions of those he manages. Production often depends on the individual worker's perception of management and the role it plays in determining his well being and future.

The four management factors all affect productivity by creating an atmosphere where management is viewed as either an adversary or supportive ally.

3.3.1 Leadership Factor

Managers are usually conditioned to concentrate on weaknesses in the organization. This is important if problems are to be minimized. However, often this creates a business relationship with subordinates where criticism is a way of life. It is fairly common for the worker to consider management to be engrossed in numbers and insensitive to the difficulties of getting the done.

This perception of management is often quite accurate. Many managers are more task-oriented than people-oriented. Managers tend to follow an autocratic managerial model in which workers are considered lazy and incompetent.3 As a result, such managers overlook strengths while focusing on individual weaknesses.

In the purest sense, leadership is providing direction to an organization so that a task or goal may be achieved. Inherent in this definition is the responsibility and authority given to the leader to accomplish his goals. In leading, the leader must be concerned with the development of personnel assigned to him. This aspect of leadership is frequently neglected incident to the efforts associated with achieving production.

Studies indicate that leaders fail to develop subordinates for the following reasons:

-Managers are chosen for their technical expertise and have little training in human relations

-Managers prefer to hire proven managers thereby

avoiding the difficulty involved in developmental training

-Managers are interested in furthering themselves and have little interest in training subordinates

-Managers prefer to avoid the painful confrontations of human behavior. Performance reviews often lead to hostility although one on one reviews are the most effective way of learning

-Managers build their own strengths and often feel threatened by capable subordinates

-Managers are not familiar with an individual's abilities and prefer to choose a carbon copy of themselves when promotion opportunities arise

These leadership shortcomings do not foster continued growth and profitability within the company.

3.3.1.2 Leadership Styles

Often managers fail to recognize that employees today are different from those of a generation ago. They are better educated and less likely to blindly follow the orders of the boss. They look for leaders who are skilled in interpersonal relations as well as technical skills. This group also seeks personal growth as well as monetary objectives.

There are an infinite number of management styles, but the most successful are those which build strength within

the organization. A manager controlling in this way is less concerned with personal status than with the organization. He realizes that workers who are supported and trained to their potential become the most productive. A leader who trusts his personnel and creates a positive environment also fosters motivation with the unit.

A leader may teach and develop skills in subordinates in two ways. First, by showing them proper procedures for solving problems and second, by giving subordinates special assignments and providing guidance as appropriate. For real growth, a leader will provide a problem-solving environment for employees which offers opportunity for subordinates to achieve goals and experience a sense of progress within the organization. Such techniques allow for close observation of the individual so that a better understanding of an employee's skills is achieved.

3.3.1.3 Human Relations and Successful Leadership

Successful leadership may not always mean that goals and objectives are achieved. The leader of an organization must often choose which path to take to success. Although he may not always be successful, a true leader is always able to inspire others to give their all to accomplishing a task.

As previously stated, a good leader is aware of the needs of his personnel. A word of recognition to a subordinate can have long lasting effects to the

organization. Although he will not be admired by all, a good leader will enjoy the respect of those who work for him.

Foremost, a leader should appear to be human to subordinates. The qualities of a leader who is a "good people person" are found in the way he relates to those he directs. He should be genuinely interested in his people and considerate of their limitations and feelings. He should be ready to assist them in resolving problems beyond their control or authority. In day to day operations, a leader should speak openly and friendly and call people by name. He should be quick to praise and exhibit a sense of humor with patience and humility.

Being a leader should not be cause for trying to win a popularity contest. But, a leader or manager who abuses his power ultimately loses the respect of those he controls. This leads to low morale, crew friction, loss of motivation and lower productivity.

In leadership, the method of implementing a decision may be just as important as the decision itself. In construction, a manager should be alert to the impact a policy decision may have on production. These decisions may have to be implemented regardless, but a manager should consider them in advance.

3.3.2 Participative Decision Making Factor

In the last decade, no other management concept has

received as much attention as that of participative decision making. Research found that the delegation of decision making to lower levels of construction management, as done in other industries, was already occurring. It was also found that when participative decision making stops, supervisors and especially workmen lose their enthusiasm toward construction work resulting in a decline in productivity.5

Participative decision making may be defined as making decisions in consultation with the lower levels of management and workmen. The process creates honest communication with accessible managers resulting in the development of subordinates. As previously cited, an improvement in morale and productivity also occurs.

3.3.2.1 The Foreman's Involvement in Methods Selection

A survey of 26 construction foremen asked "Does management restrict you in your work capacity?". Only three of these mentioned any restrictions and were quick to explain that these restrictions were peculiar to a particular job estimate or effort by project managers to reduce costs. One plumbing foreman stated that "Sometimes there are easier or different ways to do a job, but management figured it this way and wants it done in this specific manner". Some foremen also commented that some companies will restrict a foreman if his capability is in doubt. Occasionally, companies use established procedures

regarding construction methods to be employed which interfere with the progress of work.6

However, the foreman's role was found to vary considerably on nuclear power plant construction projects. In this field, foremen have little decision making authority and are restricted to executing orders and pushing for production. Construction methods are chosen by a bureaucratic group without consulting the foremen. Supervisors and workmen complain of the lack of responsibility for their work. These workers also feel void of any challenge in their work because of the detailed direction given to them in performing a task. Construction under these conditions leads to less enthusiasm in the foremen and crews who frequently spend much of their time waiting for decisions. One foreman stated that "Powerhouse work is hard to get interested in, and productivity is always at the lowest level when compared to other jobs in a given area".7

3.3.2.2 The Foreman's Involvement in Field Suggestions

The survey indicated that most upper level management personnel seek suggestions from the foremen. Management often prods the field to render suggestions and requires foremen to attend planning meeting to obtain different ideas that could make work safer and less costly. Project managers noted that often a program to reward suggestions does not exist.8

Often, the superintendent is the focal point for suggestions from foremen. For example, the superintendent for the general contractor hears recommendations and suggestions from the plumbing or carpenter foreman. Therefore, the superintendent inherently becomes involved in evaluating suggestions affecting various subcontractors. A good superintendent must be open minded to all suggestions. He may be the real key to improved productivity and project managers should learn to routinely tap into this information source.9

Most foremen feel that management responds to suggestions from the field that make construction work safer and less costly. Furthermore, management is willing to try something new if the foreman's approach is logical and it is economically feasible.

3.3.2.3 The Foreman's Involvement in Policy Making

Companies with effective management use field personnel to develop policies rather than relying on strict orders passed down from upper management. Job policy includes almost any work or rest activity occurring on the job. Project managers first related job policy to coffee breaks since coffee breaks are not stipulated in some union agreements. Foremen are required to control coffee breaks during the work day. Crew size is another decision that is usually controlled by the foreman. Project managers prefer that foremen attempt to prevent fluctuations in the crew

size because these changes make work less productive than having a constant work force for the project duration.

It should be noted that foremen participate with management only to a limited degree when a superintendent is supervising the foreman.

Since foremen are responsible for establishing and controlling coffee breaks, numerous schedules are developed and often become part of the company policy. For example, one company's policy may be:10

-Strict time periods must be adhered to
-Coffee must be in thermos bottles and close to the craftsman work area
-Laborers or apprentices cannot be sent to diners or lunch wagons
-Workmen should not group together since this tends to lengthen a break

Many foremen would like to have coffee breaks become part of a union agreement to relieve them of this responsibility.

Union regulations is a significant aspect to consider when job policies are determined. It is important that the foreman participate with management in preventing any misunderstanding on management's part regarding union requirements. An infraction of a rule could result in a serious setback in construction progress. A foreman who allows work to proceed in violation of a union rule may be

subject to disciplinary action.11

3.3.2.4 Summary of the Foreman's Role

It is evident that successful construction companies relate to the field when developing new policies. Management must realize that valuable suggestions will come from experienced field personnel resulting in increased productivity. This information is especially useful in planning a project. Another benefit is improved relations between management and the field. A company where management allows upper field personnel to make some decisions will realize fewer personnel problems and increased motivation in the worker.

In general, the closer the job foreman is to the decision making level the more successful the effort.

3.3.2.5 Journeyman's Involvement-Delegation of Authority

Delegation of authority from foreman to journeyman may not always be included in management regulations. Usually, such decisions are made based on individual circumstances and may not occur with any particular consistently. Interviews with foremen in the electrical and mechanical trades indicate a willingness to have crew members make decisions regarding construction methods. They feel that the usual four years apprentice program, with on-the-job training, qualifies many crew members to perform quality work without continuous supervision.12

Carpenter foremen expressed some reservation in this area. The difference results from having a lower percentage of qualified journeymen carpenters. On the west coast specifically, the construction expansion during the last twenty-five years and the resulting need for carpenters, has provoked an increase of journeyman carpenters without formal training. Therefore, foremen are often hesitant to allow journeymen to use their own methods to accomplish a task.13

Delegation of authority by the foreman may be done by making one journeyman responsible for the group. The foreman will then check progress occasionally to ensure quality, but in such a manner that crew confidence is not impaired. Additionally, the foreman may pair a more experienced crew member with a less experienced one. The amount of delegation depends on crew experience, task difficulty and job specifications. Often, the foreman must delegate authority so that he is free to do paperwork, plan and layout future work or order materials. Foremen who control and train their crews by delegating authority, make their own jobs easier while providing the company with a more knowledgeable and efficient labor force.

3.3.2.6 Journeyman's Suggestions

Foremen are generally open to suggestions from workers. However, foremen differ in attitude regarding the value of such suggestions. Some foremen openly solicit ideas and opinions from the crew while others listen

unenthusiastically. Regardless, the collective opinion is that crew participation makes the work easier and increases crew output.14

3.3.2.7 Participative Decision Making Not Always Used

Participative decision making enhances worker satisfaction and is essential in achieving a project schedule and budget. As discussed previously, large construction projects such as nuclear power plants often suppress decision making at lower levels. This effect creates a negative reaction in the worker and frustration may be great. The following comments from field personnel reflect this.

> Foreman #1
> "I'm used to working on a job where I make a lot of day-to-day decisions. But, it isn't like that on a big job like this. All I really do is order my crew to do this or that. There's no room for responsibility."15
>
> Foreman #2
> "On a small job you know what you're doing. You know how it fits in. You can look ahead to proplems and make corrections on the spot. But on a big job like this, you don't really know why you're doing something. So if you come to a problem, you have to wait until someone tells you what to do."16
>
> Journeyman #1
> "I'd like to be able to show management why some of the decisions just don't work in the field. They might be fine on paper, but that's not the same. If they could see more what it's like on this end, maybe they could make better decisions."17
>
> Journeyman #2
> "If you are just working because somebody says that you have got to do this and do it this way, it is harder to have a real interest. However, if you

> understand what you are doing, and you are interested in it, you are going to accomplish much more and do a better job."18

Field personnel want an answer or solution as soon as possible. Having to seek approval from someone not in the field is cumbersome to production oriented people. It is felt that the authority and responsibility to solve problems should be at the lowest possible level considering the experience and training level of the people involved.

As stated previously, large projects do not provoke decision making at the lower because of the bureaucratic nature of the organization. But, utilizing people on the field may be the only solution to avoiding passing the problem up the ladder creating lengthy time delays to progress. Supervisors and foremen must be qualified and appointed to make decisions. And, management must be willing to delegate authority and remove some control from their level.

An improvement in the area of participative decision making will have significant impact upon job satisfaction and morale thereby having a positive effect upon production.

3.3.2.8 Conclusions

Decision making belongs with the foreman, and when appropriate, at the journeyman level. Interviews with these two groups indicate that most foremen are given the proper authority to control the project at their level. It is apparent that often this authority is not fully recognized

by the individual until it is revoked. Yet, comments regarding job satisfaction and personal success usually involve actions where independent action is involved. Soliciting ideas from journeymen occurs to a much lesser degree than with foremen. There is room for management growth in this area.

The construction industry is unique in the way decision making takes place. Usually, individuals have little input to management which tends to prevent the development of an improved work environment. This is especially evident in the super construction projects. A management move toward giving an appropriate portion of project details and responsibility back to the field would reward all involved.

3.3.3 Planning, Scheduling and Communications

The effects of the physiological factors discussed in chapter II are unique in that the labor force does not feel any particular malice toward them. However, management is always responsible for it's actions. Most inefficiencies may be attributed to variables within the control of project management.

Some aspects of achieving high job productivity are so basic as to be almost irrefutable. Planning begins with knowing and understanding what needs to be done. The next task is to determine how available resources are to be scheduled to complete the project within the allotted

timeframe. This schedule must then be communicated to the various levels within the construction organization. Any break in the communication network may result in a project delay.

The ability of management to foresee and appreciate potential problems will directly impact on job productivity. Most construction management personnel support this statement, but field observations indicate only a minority may claim success in mastering planning, scheduling and communication skills. Frequently, managers do not make the effort to fully apply the skills they possess. The following discussion will focus on the potential impact of this problem upon labor productivity.

3.3.3.1 Productivity Observations in the Field

Observation of the construction process is a valuable way of assessing management effectiveness. Interviews with crew members and conclusions reached regarding job communications usually offer a substantial report of how workers spend their time. Unfortunately, why time is wasted is not as easily identified. Additionally, project management is not often willing to assist in researching this area since some self blame may be present.19

A study of Pacific Power and Light projects revealed that construction workers spent 29% of the work day waiting and only 32% on direct labor.20 Such statistics may foster erroneous conclusions by management regarding the labor

force. One may conclude that workers lack self discipline and work only when directly ordered to do so. This one sided view totally ignores that management may not possess the talent required to plan, schedule and communicate guidance to the field.

A study of management's impact upon productivity was conducted by Logcher and Collins.21 This study showed that production increased with the amount of on site management and coordination. It was also discovered that home office caused field delays provoke a magnified ripple effect in the field. These conclusions readily show the potential impact of management on field production.

3.3.3.2 Worker Motivation

The connection between management direction and field efficiency is not well documented. Most available information regarding motivation is based upon worker interviews which reflect frustration with management's control of the project. Some responses regarding this issue cite material availability, unnecessary movement of personnel and not having a central location for material or fabricated work.22 The subject of motivation will be reviewed in greater detail in a subsequent portion of this chapter.

3.3.3.3 Teamwork Concept of Planning

One of the areas that may make a significant

improvement in productivity is that of management's awareness of their role in establishing a positive work environment. It should be management's goal to foster a team spirit among all levels of the organization from management down into the field. To do this, top management must strive to establish a framework for success founded on well thought out goals. These goals must be supported through the dedication of resources and then clearly communicated to all players on the team.

The teamwork concept begins before or during the estimating process. This is the time for estimators and job site managers to discuss project constraints and discuss available construction options.

Subcontractors and suppliers must be included in the scheduling phase as soon as possible. Identification of needed equipment and supplies creates a sense of commitment to the team. Additionally, it is paramount that input be solicited from the people who do the construction. By soliciting their input, the schedule will be realistic and well received during execution. This aspect will assist in motivating the workers to perform at a peak level since they will feel informed and enthused.

3.3.3.4 Planning and Communicating on the Job Site

As mentioned previously, construction foremen generally are granted significant control on the site. However, an interview of eight foremen on commercial building projects

in a positive, supportive environment then the productivity level will reflect this fact. Therefore, management should seek to identify those factors which the worker feels affects his ability to be productive.

A study at five nuclear power plants identified five common problems which are instrumental to worker motivation.24 They are:

-Materials availability
-Tool availability
-Rework
-Overcrowded work areas and delays due to crew interference
-Inspection delays

3.3.4.1 Materials Availability

Over 50% of the tradesmen sampled agreed that this problem is paramount in its impact upon job productivity. It is estimated that there is an average loss of 6 to 8 hours per week per man because of material non-availability.

Tradesmen were asked to identify the source of this difficulty. Most attributed the problem to insufficient numbers of handling equipment or labor to transport materials from the warehouse or storage area; improper material on site and lack of proper planning by management. Most workers stated that delays are inevitable when a crane is used. Often, the movement of large quantities of rebar require other trades to stand idle while waiting for necessary material.25

The paperwork associated with the requisitioning process is another complaint. It was agreed that documentation is important for control, but that too much emphasis is placed on obtaining the "proper" signature. This often requires a lengthy search to locate the correct person.26

Another complaint is that the wrong material is delivered to the site. Many crews believe that the warehouse or storage areas are disorganized and that persons issuing the material are not acquainted with material location. Some attribute this problem to having different trades working in the issuing capacity. These personnel are unfamiliar with various material types and are not skilled in operating the material retrieval system.

The premier reason that materials may not be available on the site is because of inadequate time between design and construction. In this case, the time required for shop drawings and submittals exceeds that figured in the project schedule. This is clearly a detail to which management must attend.27

Another problem that management should be alerted to involves theft of materials from one crew by another. This may happen when it is inconvenient for one crew to draw the material from stock. There is also friction between day and night shifts regarding material ownership. These problems are normally not detected by the material control system.

3.3.4.2 Availability of Tools

Not having tools readily available results in an estimated loss of 3.4 to 5.08 hours per man per week. This problem consistently ranks as a contributing factor of low productivity on the job. Worker complaints address tool quantity, quality, and maintenance.28

The problems associated with tools are similar to those discussed regarding materials. Interestingly, the foremen often inspire theft of particular tools by the crews. According to surveys, they encourage crew members to secure a particular tool in advance of a work task even if this means taking it from another crew if necessary. This is the result of not having a sufficient number of tools on the job or not managing them in such a way that crews have access to them when needed. It is common practice for a worker to hoard a certain tool for his own use. Such occurrences result in work being attempted with improper tools; a common reason for job related injury.

Management must carefully consider the quality of the tools utilized by it's labor force. Safety must be stressed from the top down. Most managers would agree with this, however serious measures must be instituted to ensure a low risk work environment.

3.3.4.3 Rework

This problem is the last of the three worst factors affecting worker motivation and productivity. Approximately

5 to 8 hours per man per week are lost because of poor workmanship or planning.29

Most workers feel that change orders provoke the largest amount of rework. Change orders occur frequently late in the project at the customer's request. This is frustrating to crews because a sense of progress is thwarted and this tends to breed resentment toward management for improper planning. However, management may be innocent of such accusations. In an effort to maintain a good working relationship with the customer and make a profit, management has little choice but to accommodate the owner. In this area, management should strive to communicate to the lower levels the reasons for sudden changes. This would assist in creating a positive feeling toward the changed work and would put management in a supportive light with labor.

The crews complain that repetitive construction does not possess consistent design traits. Inspectors may require that scaffolding be built and rebuilt do to their own lack of knowledge as to what is required. However, an experienced foreman on the job should be involved with such incidents before they become a problem. Perhaps the real problem is lack of good supervision on the site.

The greatest amount of rework is due to poor design. The labor force desires to do something the first time and do it right. Management's challenge is to devise a system which mitigates the problems before they get to the field. Ultimately, this will improve morale, productivity, and

profit.

3.3.4.4 Delays Due to Crew Interference

Not all workers complain about interference from other crews. The worst situation is among the electrical and mechanical trades. The average weekly loss in productivity due to waiting and crowded work areas is approximately 8 hours per man.30

Crews are usually idle because of improper planning or scheduling. It is particularly bad when a series of critical activities becomes stalled because one crew is affected by material or priority changes. Management needs to make realistic appraisals of task difficulty, material needs and time for completion.

Overcrowded working conditions are a result of the physical conditions of the site/project layout and the density of workers within a given area. This becomes very significant on an industrial project where heavy piping or machinery is to be installed. Often design overlooks this aspect of construction and to the worker it occurs again and again. In one case, installation of a piping system could only be accomplished using mirrors to allow the worker visual orientation of what his hands were doing.31

One way management might anticipate such situations is by constructing a model to assist in the pre-construction phase of the project. An overcrowded work site results in lost efficiency and management should carefully review the

costs associated with work actually performed and that lost because of decreased efficiency.

3.3.4.5 Inspection Caused Delays

Inspections affect the mechanical trades the most while carpenters have little complaint regarding this matter. Weekly productivity losses vary from 2 to 4 hours per man. Most workers complain that ill-trained inspectors require complete compliance with the specifications. They feel that a more experienced inspector would realize quality work without such a detailed review. A significant effort by the worker resulting in a slight increase in quality does not seem reasonable to most crew members. A particular complaint in this area regards the setting of reinforcing bars for concrete pours.32

CHAPTER III ENDNOTES

1 Katzell,R.A., Yankeloich,D. et al.,"Work Productivity and Job Satisfaction", Report to the National Science Foundation,New York: The Psychological Corporation,1975, Chapter II.

2 Drewin, F.J., "Construction Productivity", New York: Elsevier Science Publishing Co., Inc., 1982.

3 Haffey, B.T., "Developing the People Who Can Replace You",Administrative Management.

4 Ibid.

5 Borcherding, J.D., "Participative Decision Making in Construction", Journal of the Construction Division,ASCE, Vol.103, No.CO4., Dec.,1977.

6 Ibid.

7 Ibid.

8 Ibid.

9 Ibid.

10 Ibid.

11 Ibid.

12 Ibid.

13 Ibid.

14 Ibid.

15 Ibid.

16 Ibid.

17 Ibid.

18 Ibid.

19 Olson,R.C., "Planning, Scheduling, and Communicating Effects on Crew Productivity", Journal of The Construction

Division,ASCE, Vol.108, No. CO1, Mar.,1982.

20 Strandel, M., "Productivity in Power Plant Construction," AACE Transactions, 1976.

21 Logcher, R., and Collins, W., "Management Impacts on Labor Productivity", Journal of the Construction Division, ASCE, Vol.104, No. CO4, Proc. Paper 14235, Dec., 1978, p.447.

22 Olson,R.C.,"Applying Behavioral Science Concepts to Improve Motivation and Productivity on a Construction Job Site", Engineering Research Center, University of Nebraska, Lincoln, NEB., Feb., 1978.

23 Borcherding, J.D., Ibid.

24 Borcherding, J.D., and Sebastian, S.J., and Samelson, N.M., "Improving Motivation and Productivity on Large Projects", Journal of the Construction Division, ASCE, No. CO1., March, 1980.

25 Ibid.

26 Ibid.

27 Ibid.

28 Ibid.

29 Ibid.

30 Ibid.

31 Ibid.

32 Ibid.

CHAPTER IV

METHODS OF MEASURING JOBSITE PRODUCTIVITY

4.0 Purpose

Chapters II and III presented various physiological and management factors which affect worker productivity. Collectively, these factors form a working environment for the labor force. Management must be interested in assessing productivity at various stages of construction within that environment on each project. From this, production trends are developed and conclusions made. It is then management's responsibility to to analyze these conclusions to determine the reason and significance of specific productivity factors on the job. From this knowledge, future projects may be planned more efficiently.

This chapter will present five methods of measuring productivity on the job. A field study is then reviewed which shows application of such methods and what conclusions may be reached regarding project management. Next, a detailed analysis of a company's productivity measuring system is presented incorporating the productivity factors presented in chapters II and III.

4.1 Problems in Measuring Productivity

4.2.1 Work Sampling

Work sampling is a method which provides insight into worker performance rather than work in place. It is a discrete picture of the job at some particular time. Because of this, work sampling is best suited for analyzing long term projects where sufficient data may be accumulated to identify weaknesses.

Work sampling consists of observing a particular task or activity and classifying the worker's behavior into various categories. These categories may include working, waiting, talking or resting and may be further defined as desired. The locations of the various activities to be studied must be mapped out by project phase. Then representative samples are achieved by sampling at everytime of day, each work day and during each project phase. It is best to have different observers monitor each crew.2

One advantage of this method is that it enables the analyst the opportunity to develop a general impression of the entire project. For example, inordinate waiting time by a crew suggests a problem with resource management or project scheduling. Work sampling techniques also identify problems requiring immediate attention such as the need for overtime work by a particular trade. A disadvantage of this method is that it does not distinguish between effective and ineffective work. Low quality work or rework is not readily identified by sampling.3

4.2.2 Time-Lapse Photography

Time-Lapse photography is used to study activities which are high cost and low productivity. This process is expensive and time consuming and should be carefully considered before using it. If properly utilized, this method supports a detailed productivity analysis.

A unique advantage of time-lapse photography is that a permanent record of the operation is made and may be reviewed repeatedly. The data may be reviewed jointly by management and the work crew so that problems may be solved much easier through direct communication. Perhaps the greatest advantage is that this method will identify work as being productive or just busy work. One disadvantage is that camera placement limits coverage of the site.4

4.2.3 Cost Estimates

Project cost estimates may be used in conjunction with cost reports to assess project productivity. Cost comparisons must be based on the estimated costs for an activity measured against the actual costs for the activity for a given crew size. This will allow a day by day measure of project productivity.

This approach relies on good cost estimates. This is a drawback to many construction companies since job bids are often padded with that extra cost not readily identified with a particular activity. Then if the actual costs exceed

estimated costs, management must question whether the estimate is too low or productivity was lacking.5

4.2.4 Key Activities

This method selects key construction activities found in all construction projects for use in assessing productivity on a particular project. The measured productivity of these key activities is used to draw conclusions about the entire project. This method has its shortcomings. One being that the performance of an activity on project A may be much easier than on project B. Because of safety, design, physiological or management reasons, productivity may vary. Another negative is the tendency for management to neglect the job in areas other than the selected activities.6

4.2.5 Ratings

This method is based on rating the construction supervisor, usually the foremen. A Stanford University study measured the four characteristics of ability to meet costs, productivity level, ability to work under pressure and administrative ability. Each characteristic is graded on a 1 to 4 scale with 4 being the highest. This method is very useful in comparing managers on the same organizational level. This method is easy and places emphasis on management who sets the theme for good productivity. One drawback of this method is that assigned ratings are

affected by the subjective judgement of the evaluator.7

4.3 Field Study Using Key Activity/Modified Work Sampling

One study involved observation of asbestos tile laying on five different jobs.8 Laying tile in open areas was chosen as a key activity representative of the tile laying process. This key activity was then broken into productive and non-productive work categories for use in the work sampling technique. This technique was modified because observers remained on site throughout the day instead of only taking a "snap shot" of the job. However, this provided a better evaluation of the project.

The observation of the job included noting when employees arrived and left the job site. The job time of the workmen was documented as productive or nonproductive with productive time being that directly involved with laying tile. Notes were kept regarding supervisor presence and any comments made.

4.3.1 Results

The results show the importance of management to production. Physiological factors were not relevant in this case because of the controlled environmental conditions. The results indicate a correlation between management and productivity as follows:9

1. Significant differences in work rate and

productivity are possible on different jobs.

2. Work rates were not affected by the size of the area available to the worker. This is probably due to the low density of workers within the area.

3. Daily on-site management had a significant impact on the productivity at a given site.

4. There is a correlation between home office caused delays and lost field productivity. The loss of productivity in the field was greater then that in the home office. This is a ripple effect.

5. There is some evidence to suggest that increased breaks causes a loss of momentum on the job.

6. The use of the telephone as a way of communicating with the crew appears to be effective.

Such a study may yield useful information to be implemented in new management policies. The job with the highest productivity offered a competitive bonus for increased output over a period of time. In companies where job security is tied to performance, workers are much better informed regarding their required performance level and even what the company needs to make a profit.

4.4 Profile of Company X

Company X is a large industrial firm operating on an international scale. The magnitude and nature of its operations are of such size that it requires a construction

division for its various plants. This construction division is responsible for the efficient construction of facilities through maximizing field productivity. To this end, the construction division operates a Field Labor Control System(FLCS) to measure and improve performance in the field.

4.4.1 Company Objectives of a Useful Measuring System

The four company objectives of a productivity measuring system are listed below:

1. Improve Management Control
2. Determine Intervention Impact
3. Provide a Motivational and Communication Tool
4. Is Cost Effective and Dynamic

4.4.1.1 Improve Management Control

Company Objective:

The thrust of improving management control is pointed at costs and manhours. To this end the system must be realistic and useful at the construction site. Goals must be set and performance measured against these goals. The system must be understood by all and assist in the communication process.

Comment:

This objective reflects an interest in two particular

management factors discussed in Chapter III. Those of participative decision making and planning, scheduling and communicating. By having the FLCS accessible to the field, field personnel are able to discuss problems more readily with management personnel. This is an important step toward establishing a sense of expectation in the labor crews. By doing so, a more positive work environment is created. From this communication at the field level, planning and scheduling become a natural benefit. Decision making at the lowest level is a highly desirable situation since it frees upper management for other tasks.

4.4.1.2 Determine Intervention Impact

Company Objective:

The FLCS must recognize the effects of management strategies, methods, tools and equipment and contract arrangements on productivity.

Comment:

As discussed in Chapter III, worker motivation and productivity are adversely affected by the lack of tools or required material on the job. This company is aware of the significance of resource management and desires to minimize lost production because of such delays. This attitude reflects experienced leadership, another important management factor. By monitoring worker motivation and avoiding unnecessary interruptions, management is exhibiting good leadership qualities to the organization.

4.4.1.3 Provide a Motivational and Communication Tool

Company Objective:

The FLCS must allow all levels to participate in setting goals and know their performance quickly. This company feels that labor productivity is a function of management productivity since 2/3 of lost time is attributable to management.

Comment:

This objective really addresses all 4 management factors discussed in Chapter III: leadership; participative decision making; planning, scheduling, and communicating; and worker motivation. It is particularly significant to note that this company believes in keeping all levels advised of their progress. This gives each worker a feeling of team spirit and responsibility.

4.4.1.4 Cost Effective and Dynamic

Company Objective:

The system must be responsive to the goal-setter user or it will be useless.

Comment:

Any system must allow for feedback from decisions so that improvements can be recognized and implemented. This objective allows for change and flexibility, an integral part of a successful management scheme. Otherwise, the FLCS is nothing but a paper system without real meaning.

4.5 Company X and Productivity Factors of Construction

The chart shown on page 59-1 lists eleven factors which Company X feels are significant and must be considered in implementing the Field Labor Control System. It is interesting to note that each factor is weighted relatively equal.

Of the eleven factors, only two deal with worker physiology. What is termed weather would include rain, temperature, air quality and altitude. In most cases, only rain and temperature would be included in productivity estimates. However, work conducted in a heavily smogged atmosphere has been shown to decrease worker productivity by about 10%. Construction in a hot climate may require special attention to provide sufficient water and salt at the jobsite. Cold climates may require space heating for workers. Extreme temperatures conditions will result in lower productivity because of acclimatization problems and loss of dexterity in workers' hands and feet.

Another physical aspect of construction is job conditions including type of work and task difficulty. Installing an intricate piping system in a cramped mechanical room will affect worker efficiency and attitude. This situation becomes a demotivator to the individual. Specialty contractors must be particularly aware of this.

Company X feels that management is responsible for 67% of all delays on the job and the remaining factors support

GENERAL FACTORS GOVERNING CONSTRUCTION PRODUCTIVITY

	WEIGHT %
WEATHER	10
MANPOWER AVAILABILITY	10
WORKER SKILL LEVEL	10
SUPERVISORY EFFECTIVENESS	10
METHODS AND EQUIPMENT	10
SIZE OF PROJECT & COMPLEXITY	9
JOB CONDITIONS & LABOR ATTITUDE	10
CONSTRUCTION SCHEDULE	6
MATERIAL AVAILABILITY	10
DELAYS & WORK AREA CONGESTION	10
OTHER	5

this viewpoint. Manpower availability affects direct labor, but also becomes a demotivator to workers. Crews waiting for additional manpower represents a loss of about four man hours per week. It's obvious that unskilled workers will not perform as efficiently as skilled personnel. This problem is one that company leadership must be involved with. Training subordinates requires top management attention and policies should reinforce training in the field. There is an associated safety risk with having unskilled workers on the job. Job costs, reputation and motivation may be adversely affected.

Supervisory effectiveness encompasses technical and management skill and leadership qualities of trust and delegation of decision making to the lowest competent level. The best supervisors encourage ideas from subordinates thereby supporting participative decision making on the job. The value of the foreman should always be recognized. He is the force that makes things happen in the field. In this capacity, Company X may have underestimated the weighted value of this factor.

Methods and equipment certainly may play a major role in job costs. On one project, an innovative approach to excavation bracing saved the contractor one million dollars. Admittedly, deciding which methods and equipment to employ may not be that controversial, but soliciting ideas from the field on a regular basis is important to an individual's pride and labor-management relations. As studies indicate,

recommendations from foremen and journeymen when appropriately evaluated by management, pay large dividends in the planning and scheduling phase. Management teams which foster a spirit of contribution are proven to be more successful.

Project size and complexity is given only a 9% weight factor by Company X, but should probably be higher. Project size and complexity affect management's span of control. The addition of personnel or subcontractors on the job have a direct impact on how decisions are made. In section 3.3.2.7, a discussion of nuclear power plants examined the difficulty that foremen have in getting an answer on how to proceed. Because of the nature of the construction which requires such tight specifications, the large super projects are managed at the top and frustration among field personnel runs high.

The construction schedule is the backbone of project execution. Company X weighs it lower than other factors. This is because, the schedule is only as good as the information used to structure it. If properly developed using inputs from all sources, a meaningful schedule will result. The schedule integrity will remain unless changes or resource availability is affected.

Material availability accounts for many construction delays. As discussed in section 3.3.4.1, this problem causes a loss of 6 to 8 man hours per week per man. Research also indicates that this is a premier factor in

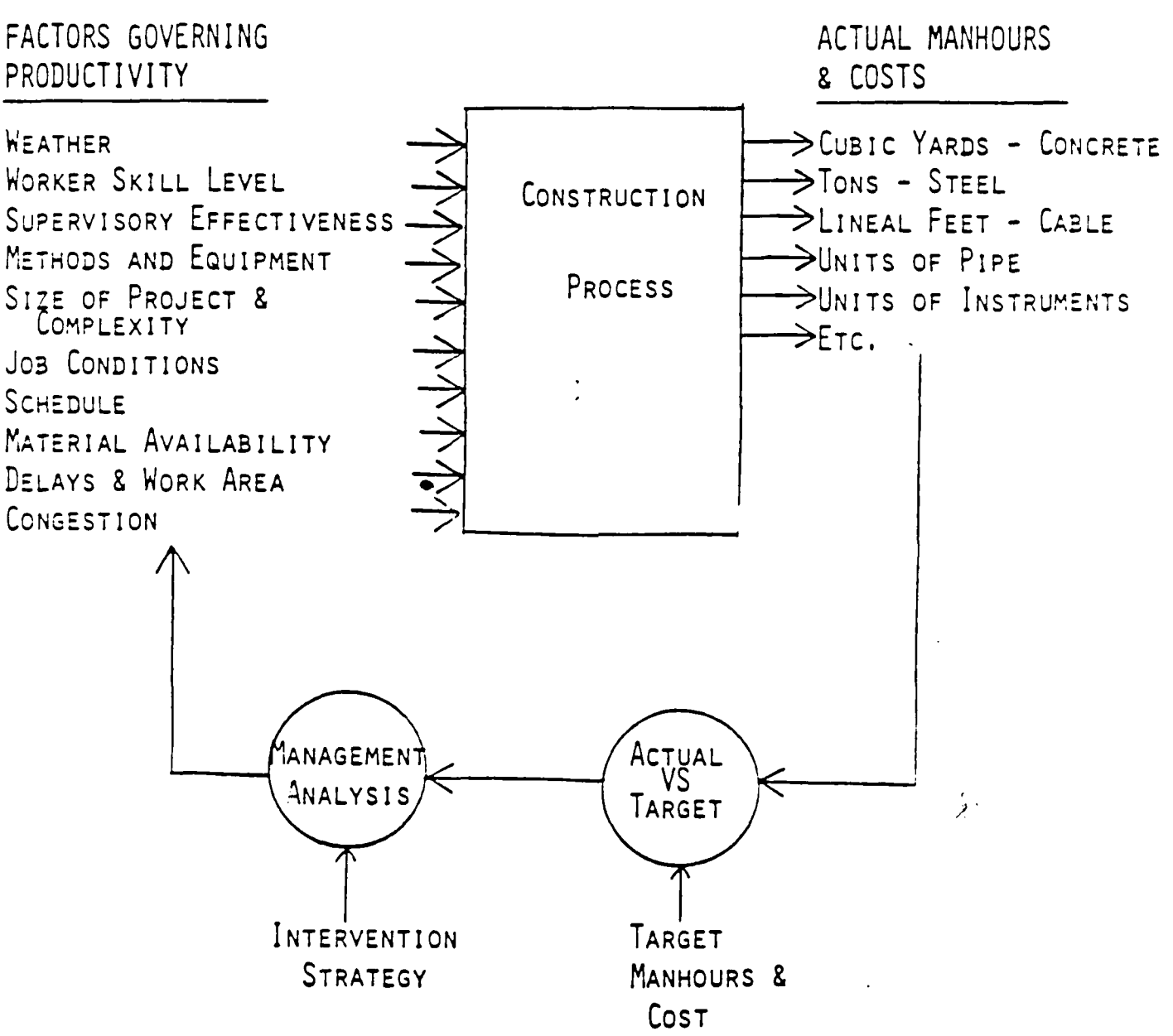
adversely affecting worker motivation and management's image. Material delivery problems affecting facility completion also have a severe impact on company reputation. As a result, most contractors employ a material expediter to track needed materials.

Delays other than those due to material, tool or labor shortages, may occur due to work area congestion. This is particularly significant in the mechanical and electrical trades where competition for access to a particular construction area exists. Congestion occurs when worker density is too high for a given area. Discussion presented in section 3.3.4.4 revealed that weekly production losses may reach 4 to 6 hours per man. A contributing factor to this problem is that coordination is left to the subcontractors. Ultimately, the prime is responsible for the job and he must review the subcontractor's schedules for reasonableness.

4.6 FLCS Operation

A sound management system must possess a feedback capability. As shown on page 62-1, Company X has developed FLCS as a feedback system. At time of project estimation, the project productivity factors are considered. Historical costs, field experience and other data sources are tapped to arrive at reasonable productivity target estimates. During construction, actual manhours and costs are compared with the target values. Variances are analyzed by management

FLCS OPERATION



including superintendents, foremen and crews. Based on the analyses, intervention strategies are employed. For example, analysis may indicate low crew productivity due to insufficient worker skills causing low motivation in the crew. Management's strategy may be to institute special training, hire more personnel or shift personnel. Under this approach to problem solving, a ready reference of options for a particular problem may be generated. This could then be automated or put into an expert system for use by several management levels.

The FLCS system enables management to check the productivity level on a regular basis. The frequency of reporting depends on the effort required to collect the data. Company X utilizes the key activity method of measuring productivity. As discussed in section 4.2.4, the key activity method monitors select activities which represent overall project productivity. Company X monitors from 14 to 16 key labor activities which account for approximately 75% of project direct labor cost. This provides management with a tool for tracking the activities with the most significant costs. However, care must be taken to monitor other critical activities on the schedule. Page 63-1 provides a breakdown of various types of work that is used as key activities for progress monitoring.

Trend charts are then developed for these key activities which provide management with data in time to note deviations and take corrective action. Examples of

-SAMPLE PROJECT-

TYPE OF WORK	% OF DIR LAB & FLD MAT'L
GENERAL FACILS	4
EQUIPMENT FNDS	6
BUILDINGS	11*
EQUIP INSTALL	6
INSULATION	6
ELECTRICAL	9*
INSTRUMENTS	7*
PIPING	48*
OTHER	3

	100%

* 4 ITEMS = 75% OF LABOR & FLD MATERIAL

these trend charts are shown on pages 64-1 through 64-3. These trend charts reflect current and forecasted amounts for units, manhours and dollars.

Another important part of FLCS is the "Quantity Summary" sheet. This weekly report on crew productivity keeps them advised of their productivity level not only for the week, but the total project as well and is a vital part of good communication techniques as discussed in section 3.3.3.4. Company X management teams have made these reports simple so that the information may be readily grasped. A standard measure of one hour per unit is used for crews to assess their efficiency. A sample "Quantity Summary" sheet is shown on page 64-4.

FLCS renders detailed information to management so that the earned value approach to managing the project resources of labor and money may be used. Units of cost per unit installed or cost per man hour are used to monitor progress.

4.7 Benefits of the FLCS System

Company X has realized seven important benefits from the FLCS system. They are:

-It provides a means of goal setting
-Increased awareness of cost on all levels
-Measurement against goals
-Trend Analysis
-Motivational and Communication Tool

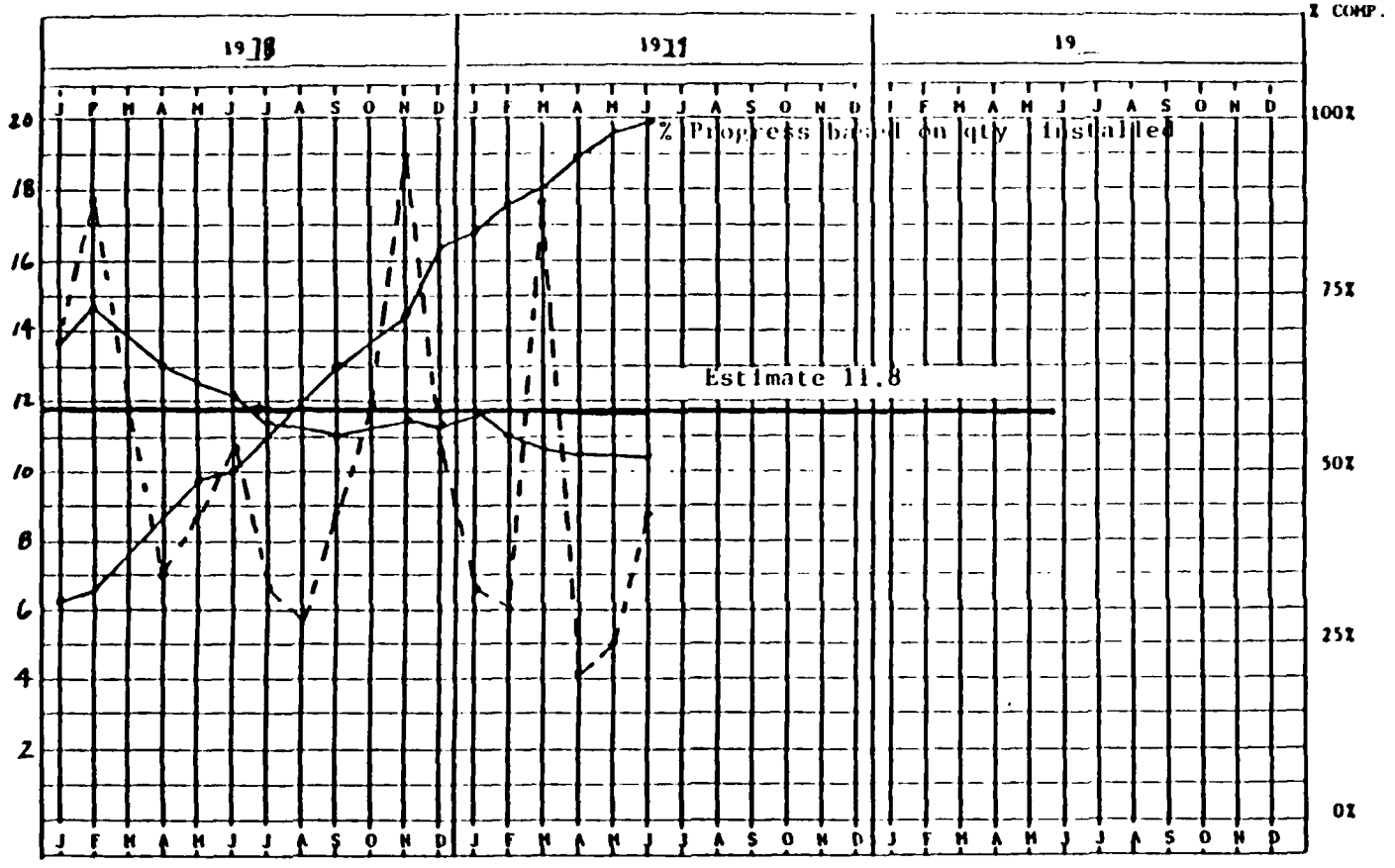
Date 1-4-77

Project 6313

FIELD LABOR CONTROL SYSTEM

Building Concrete

PROGRESS REPORT



I-49

QUANTITY			MANHOURS			DOLLARS	
Current Estimate	1620	CY	Current Estimate	16960	M.H.	Current Estimate	123.0M$
Forecast At Comp	1620	CY	Forecast At Comp	16960	M.H.	Forecast At Comp	114.0M$
Placed This Period	0	CY	Exp. This Period	0	M.H.	Exp. This Period	0 M$
Total Placed Todate	1620	CY	Total Expended	16957	M.H.	Total Expended	113.5M$
Original Budget	1450	CY	Original Budget	17208	M.H.	Original Budget	129.1M$

NOTE: Includes formwork & resteel

_ _ _ _ _ _ _ Incremental

_____ Cumulative

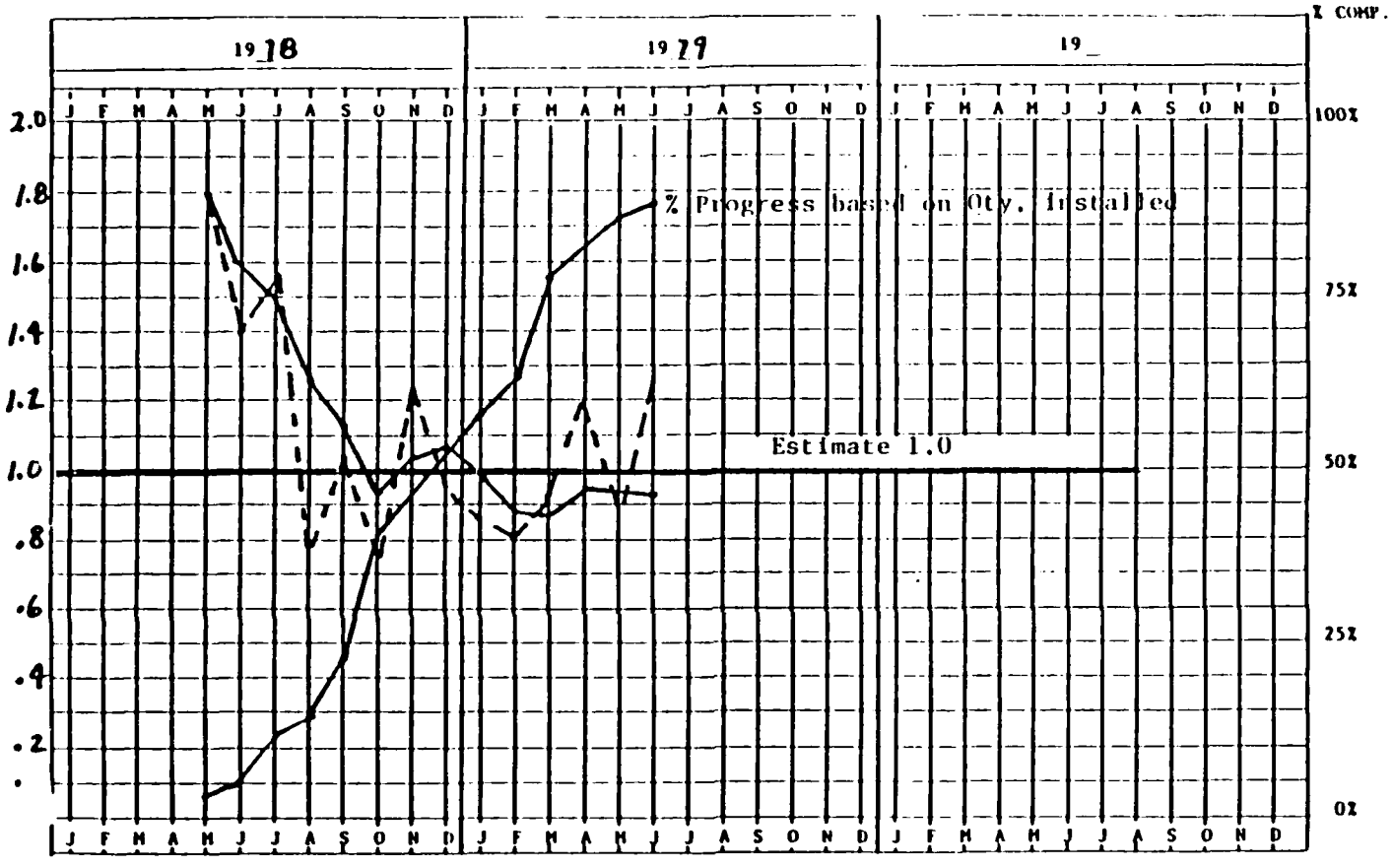
FIELD LABOR CON..OL SYSTEM

Date 3-79

Project 7408

PROGRESS REPORT

Above Grade Pipe Erection



MANHOURS PER SEU

64-2

QUANTITY			MANHOURS			DOLLARS	
Current Estimate	18500	SEU	Current Estimate	18500	M.H.	Current Estimate	1665.0M $
Forecast At Comp	18500	SEU	Forecast At Comp	17575	M.H.	Forecast At Comp	1564.2M $
Installed This Period	925	SEU	Exp. This Period	1178	M.H.	Exp. This Period	107.2M $
Total Installed Todate	16300	SEU	Total Expended	14996	M.H.	Total Expended	1319.6M $
Original Budget	22300	SEU	Original Budget	22300	M.H.	Original Budget	2007.0M $

_ _ _ _ _ Incremental

_____ Cumulative

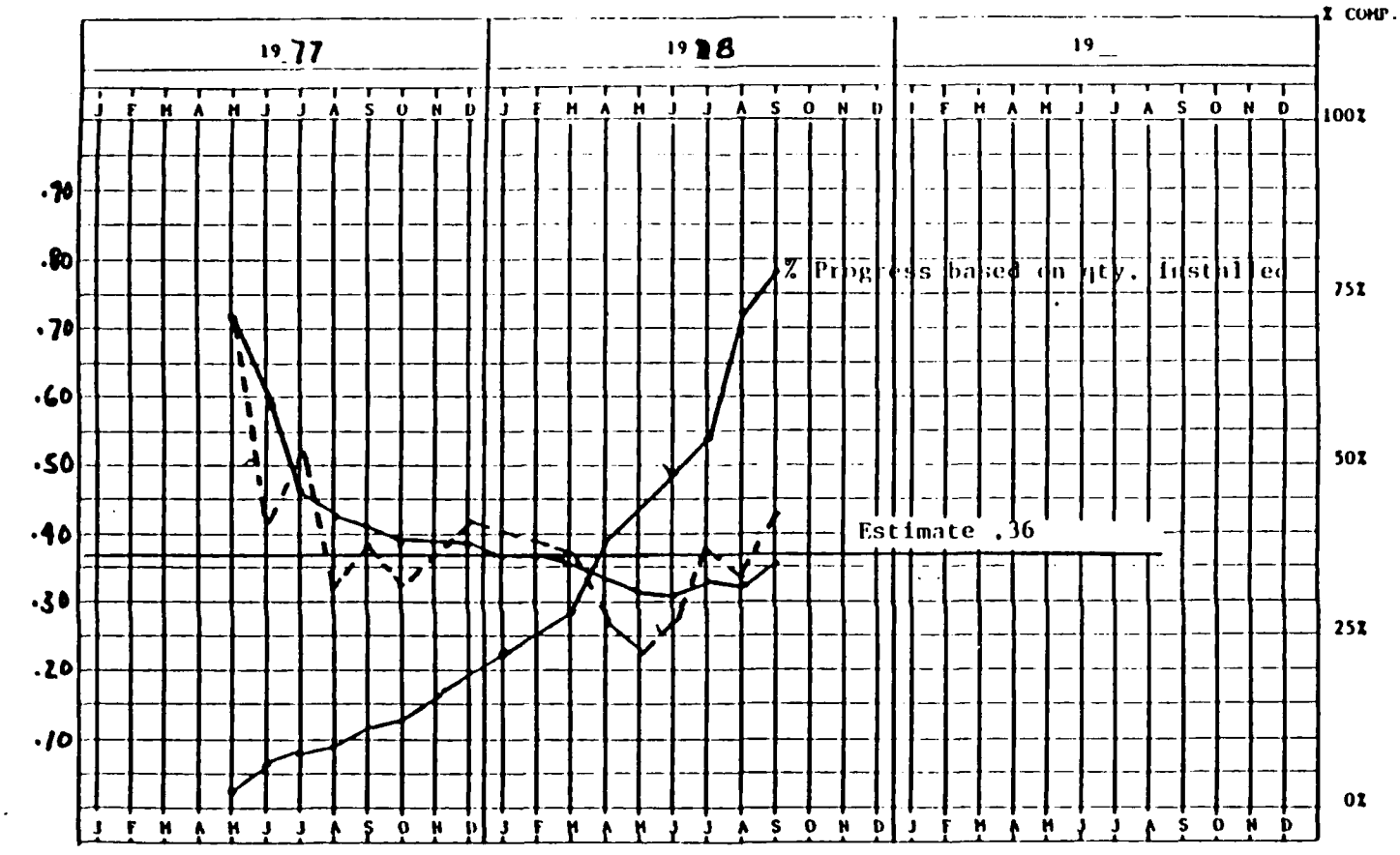
FIELD LABOR CONTROL SYSTEM

Date 10/1/78

Project 5631

Electrical Conduit

PROGRESS REPORT



64-3

QUANTITY			MANHOURS			DOLLARS	
Current Estimate	43000	LF	Current Estimate	15480	M.H.	Current Estimate	143.2 M$
Forecast At Comp	43000	LF	Forecast At Comp	13760	M.H.	Forecast At Comp	125.2 M$
Installed This Period	2150	LF	Exp. This Period	903	M.H.	Exp. This Period	8.4 M$
Total Installed Todate	33000	LF	Total Expended	9100	M.H.	Total Expended	90.6 M$
Original Budget	49000	LF	Original Budget	18620	M.H.	Original Budget	172.2 M$

_ _ _ _ _ _ Incremental

_____ Cumulative

PROJECT _____ TWC 4040 Building Concrete WEEK ENDING _____

UM CY

QUANTITY SUMMARY BY DA

DA	PROJECTED QUANTITY	THIS WEEK			TOTAL TO DATE		
		QUANTITY	HOURS	HRS. PER QUANTITY	QUANTITY	HOURS	HRS. PER QUANTITY
TOTAL							

STANDARD _____

-Provides data analysis of influencing productivity factors

-Reasonable system cost

-Generates reports tailored for easy assimilation by field personnel

The FLCS system passes information down through the organization. This enables crews to know where they stand on production and costs. Because of the feedback nature of FLCS, it is possible for management to recognize problems early and intervene as appropriate. Because the information flow is intact, FLCS plays a positive role in worker motivation.

4.8 Comments on Company X

Company X represents a successful, aggressive business concern. Development of the FLCS system is indicative of the quality leadership present in the company. Company X is attuned to today's worker. As discussed in section 3.3.1.2, the better educated employee is interested in why and who not just what. They are interested in the participative aspect of their job. Company X is careful to include them in the planning and scheduling function. As a result, this company enjoys high motivation and productivity.

It is a trademark of success, that Company X recognizes and implements the various factors of production.

CHAPTER IV ENDNOTES

[1] Helander,M.,pp.304.

[2] Ibid.

[3] Ibid.

[4] Ibid.

[5] Ibid.

[6] Ibid.

[7] Ibid.

[8] Logcher,R.D.,and Collins,W.W.,"Management Impact On Labor Productivity", Journal of the Construction Division, ASCE, Vol.104, No. CO1, Mar., 1978.

[9] Ibid.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

5.0 Summary

Chapter II reviewed worker physiology and metabolism and the susceptability of the labor force to environmental conditions. The impact of temperature, altitude and air quality was discussed. The nature of task difficulty and posture as they affect the worker's ability to perform work was examined.

Chapter III reviewed various management factors including leadership; participative decision making; planning, scheduling and communication; and motivation. The qualitities of a successful leader were discussed as they apply to today's worker. The relatively new idea of participative decision making was examined. This approach opens the decision making process to the lower levels of the construction organization.The ingenuity and effectiveness of workers at the foremen and journeymen level was detailed by reviewing project interviews and studies. Planning, scheduling and communication was investigated using the teamwork concept. The impact that experienced field

personnel might have on planning a project was discussed. Finally, common items which affect the worker's morale and motivation were identified. These include material and tool availability, rework and delays.

Chapter IV cited problems in measuring jobsite productivity and common methods used in the industry today. Methods examined include work sampling, time-lapse photography, cost estimates, key activities and ratings. A field study using key activity and modified work sampling techniques was presented. Next, a review of a Field Labor Control System currently in use in the industry was analyzed. The operation and benefits of this system were discussed.

5.1 Conclusions

Construction productivity is a difficult subject to study and reach consistent results. What is true on one job may not be relevant on the next. It was concluded that conventional techniques of measuring productivity do not always provide complete information regarding why various productivity factors affect a project.

The nature of the construction industry today is that historical costs often include unexplained inefficiency costs. Management's challenge is to investigate the relationship between decision making and production. Modern technological advances continue to make work forces smaller. In some ways, this development will tend to reduce the

aware of the worker's need for pride and accomplishment

-All management levels support the training of subordinates

5.2 Recommendation For Further Study

There is vast potential in management learning to utilize the talents of those they manage. Traditional views regarding the worker need to be challenged and new management styles implemented. The worker today is much better educated and possesses many innovative ideas based on experience. Management structures need to be formed which allow clear communication from the field regarding scheduling and methods of construction. The impact of leadership and motivation on productivity has not been fully appreciated within the industry. The impact of automated office systems on inter-personal relationships and communication as they affect coordination and project planning should be examined.

Chapter II discussed the physiological factors affecting productivity. Some attempts to estimate productivity losses under varying environmental conditions have been made. However, abundant research information suitable for use by the industry does not exist. Third world countries offer ample opportunity to gather data pertaining to human capabilities under harsh physical

conditions and limited resources. From this, perhaps a better understanding of the social pressures associated with productivity could be realized. It would be appropriate to explore the role of education and motivation in improving productivity. Finally, the real benefit of productivity on a national level could be explored. This might involve weighing the negative social aspects against the benefits of an increased standard of living.

BIBLIOGRAPHY

1. Adams, R. L., Cauthen, D. B., Neidre, A., and Washburn, K. B.,"Current Prescribing", 1977.

2. Adolph, E. F.,"Physiology of Man in the Desert",New York: Wiley, 1947; Marriott, H. L.,"Water and Salt Depletion", Springfield, Ill.:Thomas, 1950.

3. Astrand, I., and Rodahl, K., "Textbook of Work Physiology", New York: Mcgraw-Hill, 1970.

4. Borcherding, J.D., and Sebastian, S.J., and Samelson, N.M., "Improving Motivation and Productivity on Large Projects", Journal of the Construction Division, ASCE, No. CO1., March, 1980.

5. Borcherding, J.D., "Participative Decision Making in Construction", Journal of the Construction Division,ASCE, Vol.103, No.CO4., Dec.,1977.

6. Corlett, E. H., "Posture: It's Measurement and Effects", Birmington, England: University of Birmington Dept. of Engineering Production, 1979.

7. Drewin, F.J., "Construction Productivity", New York: Elsevier Science Publishing Co., Inc., 1982.

8. Haffey, B.T., "Developing the People Who Can Replace You",Administrative Management.

9. Halpin, D. W., Woodhead,R.W.,Construction Management,John Wiley&Sons, Inc., Canada,1985.

10. Helander, M., "Human Factors/Ergonomics for Building and Construction", New York: John Wiley & Sons, Inc., 1981.

11. Horvath,S. M., Raven, P. B., Dahms, T. E., and Gray, D. J.,"Journal of Applied Physiology",1975.

12. Katzell,R.A., Yankeloich,D. et al.,"Work Productivity and Job Satisfaction", Report to the National Science Foundation,New York: The Psychological Corporation,1975, Chapter II.

13. Karhu, O., Kansi, P., and Kuorinka, I., "Applied Ergonomics", 1977.

14. Logcher, R., and Collins, W., "Management Impacts on Labor Productivity", Journal of the Construction Division, ASCE, Vol.104, No. CO4, Proc. Paper 14235, Dec., 1978,

p.447.

15. Michael, E. D., Hutton, K. E., and Horvath, S. M., "Journal of Applied Physiology", 1961.

16. Neil, J., article "The Earned Value System"

17. Olson,R.C.,"Applying Behavioral Science Concepts to Improve Motivation and Productivity on a Construction Job Site", Engineering Research Center, University of Nebraska, Lincoln, NEB., Feb., 1978.

18. Olson,R.C., "Planning, Scheduling, and Communicating Effects on Crew Productivity", Journal of The Construction Division,ASCE, Vol.108, No. CO1, Mar.,1982.

19. Strandel, M., "Productivity in Power Plant Construction," AACE Transactions, 1976.

20. Wagner, J. A., Miles, D. S., Horvath, S. M., and Reyburn,J. A.,"Journal of Applied Physiology: Respiratory, Environmental, and Exercise Physiology",1979.

END

11-86

DTIC