ABSTRACT

Title of Document: EVALUATION OF WAYS TO RECOVER LATE CONSTRUCTION PROJECTS

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Delay in construction projects is a common issue. Considerable percentages of projects fall behind schedule causing damages to almost all involved parties.

Owners may experience losses due to postponed completion dates and Contractors may face liquidated damages. Even Architects and Engineers may face additional challenges resulted by delays.

In this thesis possible solutions to compensate delays before reaching the estimated end of a project have been studied. Effective usage of the remaining time to completion of the project has been the main concern, and advantages and disadvantages of each solution are studied.

EVALUATION OF WAYS TO RECOVER LATE CONSTRUCTION PROJECTS

By

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Preface

Considerable percentages of projects are falling behind schedule and if a project is finished on time it would count as a success. In fact in an on time project nothing is done but what was planned originally and everyone would appreciate a project manager whose project has been finished on time.

On the other hand it is common to be late in schedule. This could vary from few days to unacceptable long delays. Delay could be caused by General Contractors, Subcontractors, Suppliers, Owners and Architect/Engineers and almost everyone involved in a construction project.

Depending on the nature of each late project there could be a different remedy and any of the suggested methods or combination of them may be selected. In small projects the strategy is usually determined by experienced superintendents based on their intuitive ideas. In large construction project the magnitude of financial losses is larger and the project manager should carefully analyze the situation to determine what action should be taken.

When a delay occurred unlike working with computer applications, there is no way to rewind the time and go back to the first day and redo the project by the correct strategy, but there are ways to use the remaining time effectively to compensate as much as possible and possibly finish the late project on time. This thesis looks to the problem from different perspectives and suggests effective ways to bring back late projects to the planned schedule.

To

Dad and Mom

I could never be who I am without your cares.

My heart is always with you.

To

My wife Laleh with all my love.

Thanks for your support in all our sweet life.

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1. Chapter One - Critical Factors Affecting Schedule Performance

In this chapter several construction projects in the United States and different countries are studied as sample projects. In each project the affecting factors are identified and the common problems are selected.

1.1. Schedule based on incorrect assumptions

A recent study commissioned by the National Society of Professional Engineers (NSPE) concludes that about half of construction projects today are behind schedule. As a result of this study, there is some finger pointing. However, it seems everyone has a piece of the fault.

Also, there is little gained from recriminations since, everyone wants the same thing: an on-time and on-budget project with safety and quality excellence. Additionally, each stakeholder in construction wants to do a great job personally and thus, be rewarded accordingly with more work at a higher margin. So, there is a great chance we can get a better result with a little focus. That is, a majority of all projects on schedule.

It is important to understand that a CPM schedule is a critical piece of information with which Contractors and Owners manage. However, the Critical Path Method is only as good as the quality of consecutive plans, forecasts and short horizon schedules over the life of the project. So, those use the CPM must proactively plan, forecast and schedule (short horizon) in great detail based on true and accurate information. To seek a greater knowledge into the process of these three processes is the first step of many. Today, it is doubly important to understand planning, forecasting and short term scheduling processes. Again, a major study has concluded that approximately half of today's project schedules are in distress.[1] This explains why it is important to schedule based on correct assumptions.

1.2. Indian construction projects[2]

Based on a study on Indian construction projects it is known that over 40% of Indian construction projects are facing time overrun ranging from 1 to 252 months. Fifty five attributes are known to be responsible for impacting performance of the projects. These attributes were then presented to Indian construction professionals in the form of a questionnaire. Statistical analysis of responses on the attributes segregated them into distinct sets of success and failure attributes. Factor analysis of sets of success attributes and failure attributes separately grouped them into six critical success factors and seven critical failure factors. In order to understand the extent of contribution of these factors on the outcome of a construction project, a second stage questionnaire survey was also undertaken. The analyses of responses of the second stage questionnaire concluded that there are two success factors and one failure factor as described below.

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[1] Stevens, Matt. Half of Today's Projects are Behind Schedule. 21 January 2008. 28 April 2009 <http://www.allbusiness.com/construction/construction-overview/6365405-1.html>.

[2] Jha, K. C. Iyer and K. N. Critical Factors Affecting Schedule Performance: Evidence from Indian Construction Projects. August 2006. 28 April 2009 <http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=JCEMD4000132000008000871000001&idtype=cvips&gifs=yes>.

1.2.1. Main success factors

Followings are two main factors that were concluded to have the most affect on the success of the Indian projects.

- **Commitment of project participants**

As explained later, intrinsic motivation of the project participants has the most affect on project performance. This as will be mentioned later explains the engagement theory and how intrinsic motivation could bring success to the entire project team.

- **Owner's competence**

Although the owner usually is not present in construction field and even in most sophisticated projects handful of owner's personnel are present in jobsite, the project is strongly influenced by owner's competence and cooperation with the General Contractor and Architect/Engineer. Even the design built projects are highly dependent to owner's competence. In another word, a project never begins without an owner and never is completed without owner's presence.

The two above mentioned success factors contribute significantly in enhancement of current performance level of the project. The extent of their contribution has, however, been observed to vary for a given level of project performance.

1.2.2. Main Failure Factor: Conflict among project participants

Conflict can work like both sword and shield. In early stages of project team development, conflict can be a very useful tool to encourage the participant to resolve the issues. Basically not having conflict means that either there is no problem at all or no one cares to resolve the issues. Not having any problem is almost impossible in the construction industry and every project may have its own problems. If conflict doesn't exist because of ignorance of project participants, the project will be in danger. In a project, problems should be resolved as soon as possible; otherwise they will extend to the entire life of the project and become the main failure factor of construction projects.

1.3. Capacity Constraints of subcontractors and suppliers in Construction Schedule in the United States[3]

Many project schedules drive the projects to serious variations in project completion date only by wrong assumptions of subcontractors and suppliers' capacity. The time-cost trade-off and its resource-oriented extensions are incapable of representing the capacity costs and constraints of subcontractors and suppliers. These methods are incapable of representing the effects of site conditions on productivity, which in turn affects the capacity choices of subcontractors.

In a study on 15 subcontractors and suppliers, it is been found that the capacity of subcontractors and suppliers often are not considered as a constraint.

According to my own experience in construction fields most of the subcontractors pay more attention to win the bid rather than beeing able to finish it on time. The

[3] Fischer, William J. O'Brien and Martin A. "Importance of Capacity Constraints to Construction Cost and Schedule." J. Constr. Engrg. and Mgmt. Volume 126, Issue 5 ((September/October 2000)): pp. 366-373.

problem becomes worse when there is no financial bond between the General Contractor and the subcontractor.

Experienced Project managers not only pay attention to the ability of subcontractor but also carefully study the amount of work each bidder is involved. Obviously a busy subcontractor who is already under another owner's pressure can not meet the schedule of a new project and will bring delay and poor quality of work to the project.

1.4. Major problems in renovation projects in Finland [4]

In a study on Finland construction projects it has been found that beside the technical skills required in construction projects, it is also important to have skilled personnel in order to coordinate the diverse efforts of the many people involved. There are inevitable problems encountered in the course of a construction project, such as unexpected additional work, defective work, structural failure, cost overrun and accidents. Other problems include:

• Inaccurate project financial rewards and reports.

• Overcharges and costly practices.

• Excessive requirements and scope management issues.

• Excessive change order costs.

[4] Marja Naaranojaa, , and Lorna Uden. "Major problems in renovation projects in Finland ." Building and Environment Volume 42, Issue 2, (February 2007,): Pages 852-859 .

• Project funding not aligned with project plans.

• Government compliance issues.

• Inconsistent facilities-management processes.

• Non-user-friendly and inefficient project management systems.

• Occupant requirements unfulfilled.

• Claims and disputes.

• Uninsured property and casualty losses.

This comes as no surprise because the construction projects involve interdisciplinary aspects consisting of Communication Sciences, Public Administration, Construction Engineering, Information sciences and Industrial Economics. People involved in the construction business have seen projects where costs have exceeded the budget, where the timetable has been drawn out causing disadvantages for the project and where the end results proved to be useless. The costs of these projects must be paid as capital expenditures or rents.

The study on renovation projects in Finland has identified following common problems in all projects:

1.4.1. Lack of decision-making process

Parties do not know who is responsible and who takes care of what especially the role of the end user is. The reason why a decision cannot be made depends on the process of decision making itself. The difficulty in making decisions is generally attributed to obtaining the information on which the decision is based, being certain that the data used to determine the decision were correct, that it was in the correct order of importance. Not all the needed data were available at the time.

1.4.2. Lack of time for planning

Shortening time to complete tasks or marketing a product has been one of the most critical factors to the success of a business in many industries. As a result, companies have sought methods that can ensure a faster product development. Most industries focus on product cycle time reduction through concurrent development. Construction projects are not an exception. There has been increasing pressure from clients to fast-track construction projects. However, when a project is fast-tracked without proper planning, it can lead to failure or delay of the project. Since construction has a physical manifestation, a construction rework is normally perceived to have a larger impact than change. As a result, construction projects tend to avoid rework on problematic tasks by changing the scope of the work, especially under time constraints.

1.4.3. Difficulty in updating regulations

To protect public safety and welfare, legislators and various government agencies in Finland periodically issue regulations that influence the construction process, the operation of constructional facilities and their disposal. In the construction industry, there are regulations on how things should be built and authorities are controlling how things are done. The construction professionals need to know several rules. They also have difficulties in remaining up to date about all the new rules. The construction field is also a rather conservative field. New ideas are discussed long before they are used. Even asking what the end user wants is sometimes seen as risky because it may create higher expectations and can increase the costs.

1.4.4. Updating regulations in United States

In the United States we are facing increasing number of regulations each year as well. The following figure illustrates the rapid increase in regulations and laws since 1900 till 2007. As shown every 40 years the number of regulations is almost doubled every 40 years.

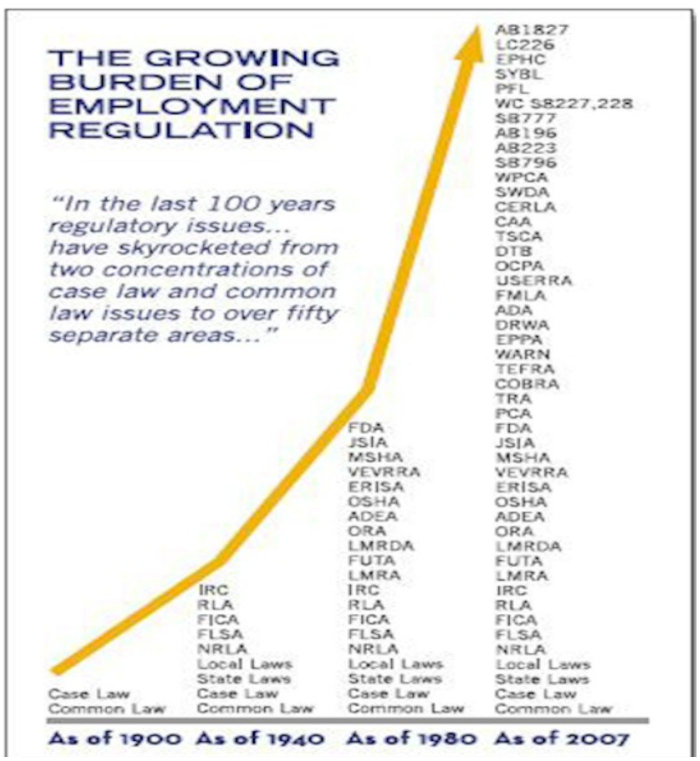

Figure 1 – Increasing number of regulations within recent years[5]

[5] Network, Total HR. 28 April 2009 <http://totalhrmgt.com/>.

As shown in 1940 only a handful of regulations were governing the entire construction industry. Still some big projects completed in early 20th century that are counted as huge projects in the world of construction. The Golden Gate Bridge and Empire State Bridge are examples of biggest projects in 1930s.

The Golden Gate Bridge[6] was the longest suspension bridge span in the world when it was completed during the year 1937, and has become an internationally recognized symbol of San Francisco and California. Since its completion, the span length has been surpassed by eight other bridges. It still has the second longest suspension bridge main span in the United States, after the Verrazano-Narrows Bridge in New York City. In 2007, it was ranked fifth on the List of America's Favorite Architecture by the American Institute of Architects.

Figure 2 – Golden Gate Bridge completed in 1937[7]

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[6] Wikipedia. Golden Gate Bridge. 28 April 2009 <http://en.wikipedia.org/wiki/Golden_Gate_Bridge>.

[7] Jr., Rich Niewiroski. The Golden Gate Bridge and San Francisco, CA at sunset taken from the Marin Headlands. 28 April 2009 <http://en.wikipedia.org/wiki/File:GoldenGateBridge-001.jpg>.
Network, Total HR. 28 April 2009 <http://totalhrmgt.com/>.

The Empire State Building[8] has been named by the American Society of Civil Engineers as one of the Seven Wonders of the Modern World. The building and its street floor interior are designated landmarks of the New York City Landmarks Preservation Commission, and confirmed by the New York City Board of Estimate. Excavation of the site began on January 22, 1930, and construction on the building itself started symbolically on March 17 and the building was officially opened on May 1, 1931.

Figure 3 – Empire State Building completed in 1931[9]

The two mentioned projects are examples of possibility of early completion of sophisticated project without limitation of regulations.

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[8] Wikipedia. Empire State Building. 28 April 2009 <http://en.wikipedia.org/wiki/Empire_State_Building>.

[9] Wikipedia. Empire State Building by David Shankbone.jpg. 28 April 2009 <http://en.wikipedia.org/wiki/File:Empire_State_Building_by_David_Shankbone.jpg>.

1.4.5. Users do not know what they need

Each project in the construction industry is unique. Users have different needs that must be made known to the designers. However, in reality, users seldom know what they need, making it difficult for designers to specify what users need. In addition, the time span from the first need specification to realization of the project is often very long and about 5–10 years, in public construction projects. The success of the project depends on getting the users' needs identified. If users have no idea of what they need, it is very difficult to plan in advance what to do in the project.

1.4.6. Lack of trust

Trust is vital in a construction project, as many people from different organizations work together. The ability to rely on people to do what they say they are going to do impacts everybody and the way they work. Trust is about reducing risks and uncertainty through better communication. There is generally a lack of trust present in construction projects. It is very difficult for members of the project to obtain information from another person. It would appear that no one seems to be willing to share information and pass it on. Some members of the project have actually failed to understand the language used in the construction activities. Many of them found it difficult to accept a viewpoint different from their own, making it impossible to discuss alternative solutions.

1.4.7. Lack of risk assessment

Projects frequently start without proper planning or risk assessment being taken into consideration. It is taken for granted that projects have been well planned and it is known in advance how much the deadline may overrun or cost increase or exceptional events that may occur. Because of the complexities involved in a construction project, there are always risks involved. Construction projects possess more risks than other industries. The risk factors in construction projects include: labor disputes, poor financial controls, bad weather, faulty design, cost overruns, quality problems and even natural disasters.

1.4.8. Failure to learn from successful projects

It is generally acknowledged that much of the knowledge of construction companies resides in the minds of the individuals working within the domain. Although a project has been completed successfully, it is rare that the intent behind the decisions is recorded or documented. This is hardly surprising, given that it requires complex processes to track and record the thousands of ad hoc messages, memos, conversations and phone calls that comprise much of the information.

Another problem is that data are not managed as it is created. Instead it is only captured and archived at the end of the construction. The people who have the knowledge about the project have most probably left by this time, making it impossible to retain the required knowledge.

It would be good to have some way of finding what worked and what failed. However, there is no record of any past case studies or lessons learned that the designer or the participants can refer to in their work.

1.4.9. Resistance to use of Information Technology (IT)

Recently new technologies have been used to support construction projects. Computer aids have improved the capabilities of generating quality designs as well as reducing the time to produce alternative designs. The most dramatic new technology in the construction industry is that of the Internet and Corporate Intranet. The Internet has been used as a means of faster collaboration among professionals on a project, to communicate for bids and results, to procure necessary goods and services. This should ideally result in more effective collaboration, communication and procurement. Although construction quality and cost can be improved with the adoption of new technologies which have been proven to be efficient from both the viewpoints of performance and economy, many of the participants in the project were very suspicious of the use of technology to support the project. Some even refused to use emails.

According to my own experience in the United States some trades especially those performing as subcontractors, still prefer to fax the letters and not use the email. I am still receiving shop-drawings which are developed by hand.

1.4.10. Lack of change management

Change affects all forms of human activity and construction projects are no exception. Change happens all the time in construction. Many projects are conceived, designed and planned many months or years before they are constructed. No one can predict what would happen in the months and years ahead, no matter how well the project is originally thought out. When change is required in construction projects, it involves many different people: architects, engineers, surveyors, contractors, sub-contractors and suppliers and so on. Changes must be properly managed in construction projects; otherwise, missed dates and claims for damages will inevitably follow. Change is a risk. It is important that the risk of change is borne by those best able to manage that risk.

There are inevitable changes that may be made in a project. It has been observed that there was no facility for participants to handle changes. Although changes needed to be made, the information is seldom passed on to those who should have it. This creates resentment among people because they do not know what is happening. Even though they receive the information about the changes, often they are not told why changes were made or necessary.[10]

[10] Marja Naaranojaa, , and Lorna Uden. "Major problems in renovation projects in Finland ." Building and Environment Volume 42, Issue 2, (February 2007,): Pages 852-859 .

2. Chapter Two - Methods of evaluating the progress in a project

2.1. Understanding Construction Schedule Delays [11]

It is probable that most construction projects will incur some sort of a delay before they are completed. An even greater probability exists that once a delay has occurred, a claim for financial damages by either the owner or contractor will arise.

Generally speaking, assertion of damages from a delay requires that the contract completion date be extended. A delay may or may not extend the overall schedule for completing the entire scope of the contract. When using a method referred to as Critical Path Scheduling (CPM), delays of an activity off the critical path do not extend the schedule until the entire float (slack time) is consumed.

A delay may merely have the potential for extending the contract completion date. As such, work is accelerated by either a decision by the contractor or a directive from the owner to complete part of the work in less time than was originally planned. If the delay that caused the acceleration was the owner's responsibility, the contractor may have a claim against the owner for increased performance costs. Those costs are typically a result of overtime or shift premiums, material expediting, and labor inefficiencies.

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[11] David A. Norfleet. Understanding Construction Schedule Delays. 01 02 2004. 28 April 2009 <http://www.callpie.com/articles/articles/17/1/Understanding-Construction-Schedule-Delays/Page1.html>.

Delays are defined and categorized differently depending on the type, reason and the impact of the delay. It is important to understand these categories in order to determine who may be responsible and whether damages may be sought.

There are three types of delays:

1) Independent delays occur in isolation and do not result from a previous delay. The effect on the total project duration usually can be calculated.

2) Serial delays occur solely as the result of an earlier, unrelated delay to preceding work. For example, winter weather causes the delay in the installation of a HVAC system solely because an earlier labor strike pushed the work into the winter season.

3) Concurrent delays involve two or more events. Taken alone, either of the events would cause a delay in the project schedule, but if either of the delays had not occurred, the schedule would have been impacted by the other delay.

There are also three categories of delays used in determining delay damages:

1. Inexcusable delays are caused solely by the contractor or its suppliers. The contractor is generally not entitled to relief and must either make up the lost time through acceleration or compensate the owner. This compensation may come about through either liquidated damages or actual damages, providing there is no liquidated damages clause in the contact. Liquidated damages are generally expressed as a daily rate that is based on a forecast of costs the owner is likely to incur in the event of late completion by the contractor.

2. Excusable, non-compensable delays are caused by third parties or incidents beyond the control of both the owner and the contractor. Examples typically include acts of God, unusual weather, strikes, fires, acts of government in its sovereign capacity, etc. In this case, the contractor is normally entitled to a time extension but no compensation for delay damages.

3. Excusable, compensable delays are caused by the owner or the owner's agents. An example of this would be the late release of drawings from the owner's architect.[12]

To find out what needs to be done to compensate delays, current status of a project has to be determined. There are several tools to monitor the progress of the project.

2.2. Variance and Earned Value Calculation

As shown in the following chart the earned value and the schedule value can be obtained from the project S-Curve. The earned value can be a good index to show the deviance in the early stage of the project. Earned schedule can represent the variance any time even near the completion of the project.

[12] David A. Norfleet. Understanding Construction Schedule Delays. 01 02 2004. 28 April 2009 <http://www.callpie.com/articles/articles/17/1/Understanding-Construction-Schedule-Delays/Page1.html>.

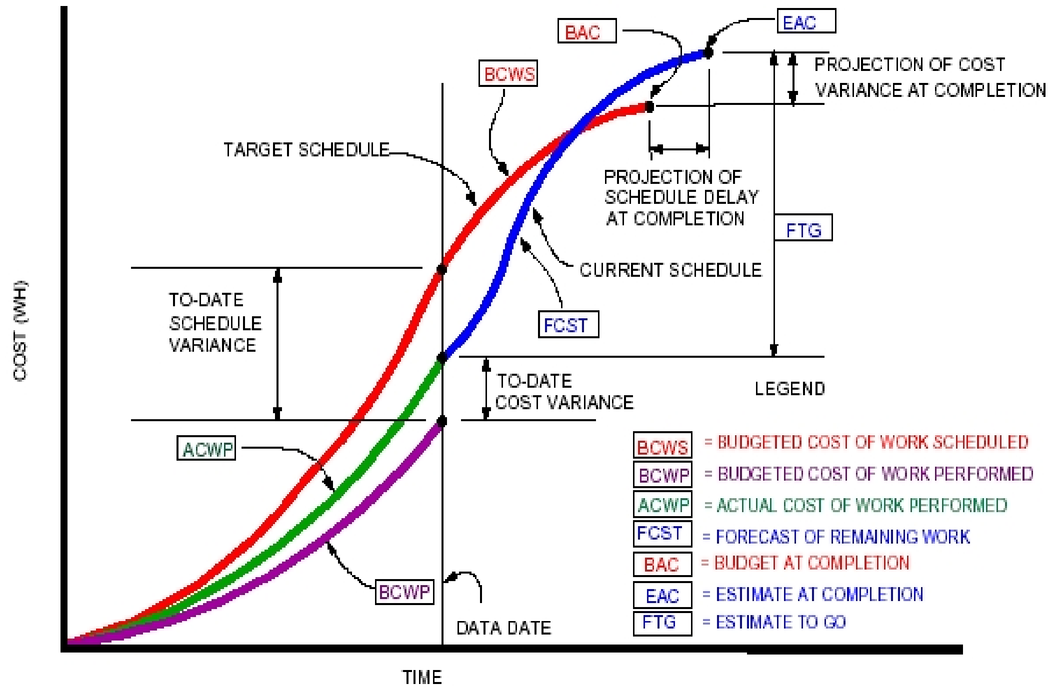

Figure 4 - Earned value and other monitoring indexes[13]

An important factor in calculating the mentioned indexes is that the activities should be considered as they are supposed to be accomplished in network diagram. It is observed that in some cases activities which are scheduled to be completed in future are completed earlier and are counted as a part of earned value. This can mislead both the owner and the contractor and deviates the indexes from the real value.

2.3. Monthly and weekly reports

The other way to track the progress of a project is to study the monthly and weekly reports. Some projects may not have numerical data to be used to calculate earned value. In those cases the completion of units or consumed time or any other possible

[13] Corporation, Ball of Gold. Earned Value. 28 April 2009 <http://www.ballofgold.com/content/execcontrol.htm>.

measuring tools can be used to calculate the completion of a project. Once the completion is been calculated by extrapolation it can be projected to future to see if the project could be finished on time.

2.4. Study cost reports and self performing

Cost reports can be used as a guideline to evaluate the cost deviance of the project. The goal is to compare the estimated cost at the time of bid to the real costs at the time of construction. Since the bid estimate is developed based on realistic assumptions, any major deviation could raise a flag to check the reason of cost over run or possibly lower cost.

Same theory can be applied to the planed schedule. In day to day reports all activities have to be monitored and deviation from planned schedule should be carefully checked. Big delays can be prevented in early stages if corrective actions are taken to prevent development of the delay to the bigger stage.

Three sets of activities should be monitored carefully:

2.4.1. Activity on the critical path

These are definitely the most important activities to monitor and smallest delay in these activities would delay the entire project. The critical path activities can be located in two or more critical path at a time. In that case delay in each critical activity may cause the other critical paths to become non critical path.

2.4.2. Activities with low float

These are activities with one or two days float which any accidental delay may consume their short float and extend the delay to the entire project. Compared to the critical path activities, these activities are in lower importance, but they may potentially become a critical activity as a result of any change or sudden delay.

2.4.3. Activities near critical path

These are activities which are predecessor to the activities on critical path. They may have big floats but should be paid attention to. The importance of the near critical activities are lower than the low float activity, but a sudden unexpected event can easily consume even the long floats and eventually delay the entire project.

Beside these important activities, any change in the project scope may bring new activity to the schedule that is located in the critical path since appearance.

The following example of bar chart diagram illustrates the three important kinds of activities in a sample chart.

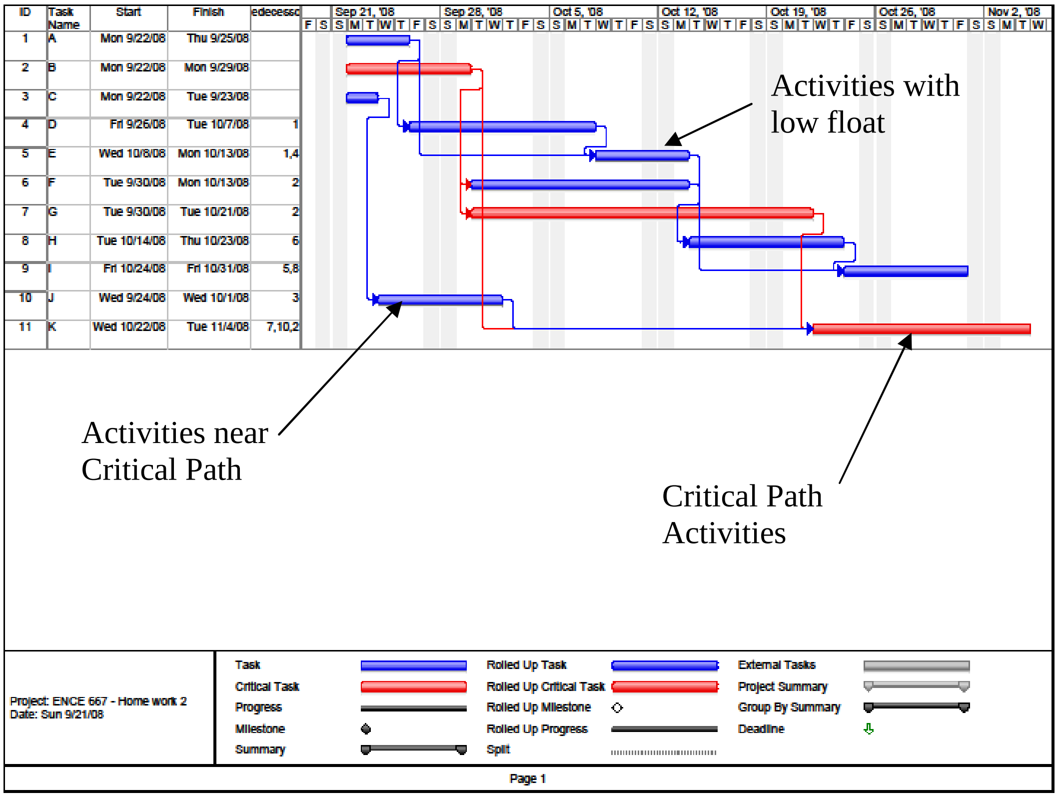

Figure 5 – Example of important activities

As shown, near critical path activities have big float but those are capable to become critical activities

3. Chapter Three - Practical ways of compensating delays

The processes involved in the construction industry are complex. For a project to be completed successfully, several different types of skills are needed. Architects, quantity surveyors, designers, contractors, sub-contractors, suppliers and engineers may use different means to convey the same information. However, all these different people must work together to get the work done successfully. Very often, these different people may work together for months or years. For projects to be completed on time and meet budgets, the different people involved in the projects require different knowledge and skills. There is a wealth of knowledge involved in a construction project. The construction industry is facing many of the same problems as the software industry. The problem is that projects often run late and over budget. This often results in failure. Construction projects are among the most complicated of human enterprises. There is a high level of skills and knowledge required to translate a client's version or list of requirements into plans and specifications and then into a real building that functions well for the people who will live or work there.

There are different ways to compensate delays. With respect to the project some or all of these methods can be used. Some projects may even require other ways as well. Followings are some of the possible methods:

3.1. Increasing working time

Figure 6 shows the regular working time in different countries. As shown in the diagram the average working time could vary between the cultures. Increasing working time could help to improve the rate of completion in projects which are directly dependent to manpower. For example if the framing of interior walls in a construction project requires to be expedited, increasing the working time from 40 to 50 can directly increase the rate of progress.

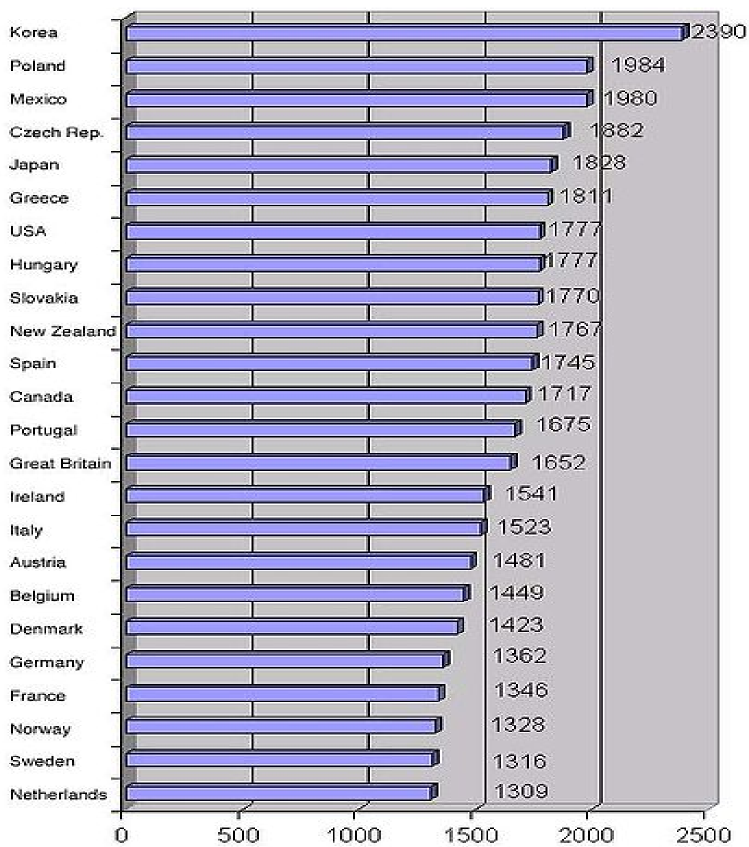

Figure 6- Yearly working time in different countries (Hours per year)[14]

[14] OECD. Differences among countries and recent trends. 2004. 28 April 2008.

3.1.1. Advantages of extra working hours

One of the major advantages of increasing working hours in a construction site is that it creates a win-win situation. In most of the times construction crews accept to work one or two additional hours and receive overtime and other benefits. Adding extra working hours in short term also reduces some hidden daily costs like startup costs, indirect costs and overhead cost. Having less safety session will have more productive hours.

3.1.2. Disadvantages of extra working hours

Increasing the working hours can reduce the productivity in long term. If working overtime is extended to long term, workers will soon become unproductive. Human's nature demands resting time in order to gain the physical and mental ability.

According to the article first published by Army Corps of Engineers the extra working hours can reduce the productivity in long term. The figure in the next page shows how extra working hours can reduce the productivity of worker and employers.

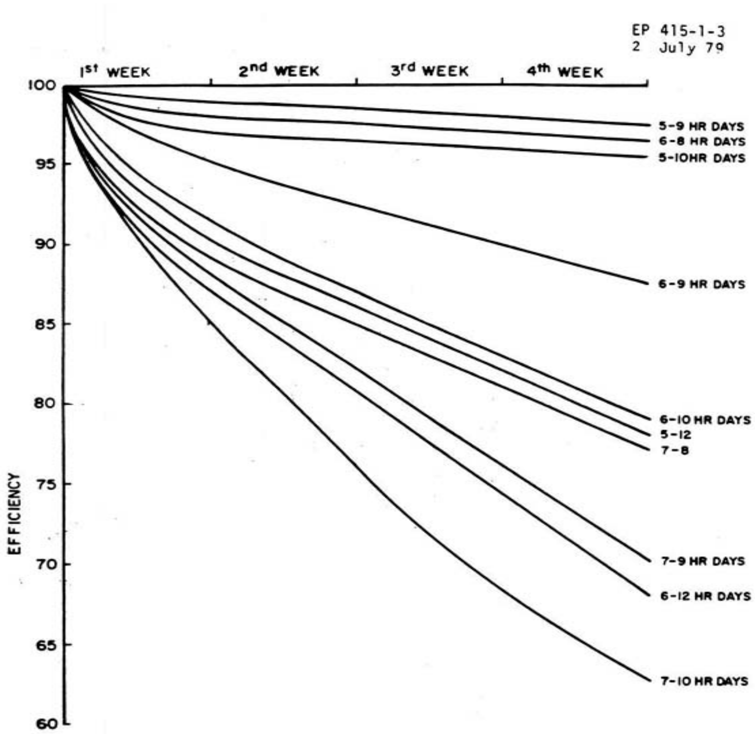

Figure 7- Effect of work schedule on efficiency (Hours)[15]

3.2. Planning and scheduling for the rest of the project

In some cases it is possible to redo the scheduling process for the rest of the project. The idea is like looking into the remaining portion of the project as a new project and plan to complete this portion in the remaining time of the original schedule.

This method requires a rapidly evaluation of the remainder of the project, developing a new schedule and taking action to work based on the new schedule. In some repetitive project like construction of pipe line this method can easily been used and a

[15] Briefings, Construction. Effect of work schedule on efficiency. December 2001. 28 April 2009 <http://www.gsblaw.com/db30/cgi-bin/pubs/Construction_Briefings_December_01.pdf>.

quick estimate would determine what the possible critical path would be and what is expected to be done.

3.2.1. Advantages of planning for the rest of the project

As explained earlier in some projects that repetitive work is being performed, the evaluation and planning for the remainder portion of the project can be done easily. This will even be more simplified in a required unit umber of completion per day. In the same example of pipe line project it can be determined to complete certain length of the pipeline per day.

3.2.2. Disadvantages of planning for the rest of the project

In complicated projects preparation of a new schedule for the rest of projects is time consuming and costly. In addition if the new schedule is developed within a considerable period of time, the new schedule will be based on data from beginning of this period which might be useless after the development of new schedule. To solve this issue the new plan should be developed for the project condition in future. In another word a short delay should be counted for the planning period of new schedule. For a project with a serious delay this may not be acceptable.

3.3. Adding more working personnel to the existing manpower

Many construction projects suffer from the lack of personnel. Adding enough manpower to help the current working people will expedite the project and is a useful way to compensate delays. Also depending on the situation this could work like a sword or a shield.

3.3.1. Advantages of adding manpower to the working personnel

In majority of construction projects lack of enough personnel is one of the important reasons that the project is not completed as expected. In those projects adding required crew will increase the rate of completion and can be an effective way in order to bring the project back to the schedule.

3.3.2. Disadvantages of adding manpower

In some cases the lack of manpower is not the main reason of the slow rate of completion. In those cases adding extra manpower to the working crew will not only leave the problem unsolved, but also may make it worse. Brooks' law may apply to those situations.

3.3.3. Brook's law [16]

Brook's law originally is one of the important agendas in software industry originated by Fred Brooks in *The Mythical Man Month* book. It can be applied in some complicated construction projects which require professional workers who have been trained over the years. Bringing inexperienced workers to such project would have a negative effect on the project which will make the delay worse.

[16] **Frederick Phillips Brooks, Jr.** (born April 19, 1931) is a software engineer and computer scientist, best-known for managing the development of OS/360, then later writing candidly about the process in his seminal book *The Mythical Man-Month*. (Wikipedia)

Brook’s law is based on two main factors:

a) The new worker will take the expert’s time to teach them how to perform their duty. Possible mistakes committed by those new comers would waste the expert’s time and delay the project more than before.

b) The new workers may generate further overhead costs which will increase the overall overhead by square of the ratio. This will waste the company’s recourses and make the delay more than before.

3.4. Learning curve effect[17]

Delay in the beginning of a project could be a result of learning curve effect. Learning curve theory is based on the assumption that repetition of the same operation results in less time or effort expended on that operation. In another way, in the beginning more time is consumed to perform a duty than is spent after repetition.

This situation can happen when a company enters to a new field of practice and bring its worker to the new industry. If the project is complex and requires experience, the learning curve may be extended to considerable time. Learning curve can be modeled with the following formula:

$$Y_x = Kx^{\log_2 b}$$

[17] Learning Curve calculator. 25 May 2007. 28 April 2009 <http://cost.jsc.nasa.gov/learn.html>.

In this formula K is the number of direct labor hours to accomplish the first activity.

"Yx" is the number of direct labor hours to accomplish the x-th activity. "x" is the activity number and "b" is learning percentage.

If the project S-Curve shows such a behavior, it is possible to be in a beginning of learning curve which will be soon on the planed schedule.

An advantage of this assumption is that no specific action needs to be taken. Things will be back to normal automatically. On the other hand wrong assumption would result more delay on the project which will not be pleasant.

3.5. Experience curve effect[18]

The experience curve effect is broader in scope than the learning curve effect encompassing far more than just labor time. It states that the more often a task is performed the lower will be the cost of doing it. The task can be the production of any good or service. Each time cumulative volume doubles, value added costs (including administration, marketing, distribution, and manufacturing) fall by a constant and predictable percentage.

In the late 1960s Bruce Henderson of the Boston Consulting Group (BCG)[19] began to emphasize the implications of the experience curve for strategy. Research by BCG in

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[18] Experience curve effects. 28 April 2009 <http://en.wikipedia.org/wiki/Experience_curve_effects#cite_note-Chase1998-1>.

[19] **Bruce D. Henderson** (1915 – 1992) was the founder of the Boston Consulting Group (BCG). Henderson founded BCG in 1963 in Boston, Massachusetts. Today BCG is among the largest and most

the 1970s observed experience curve effects for various industries that ranged from 10 to 25 percent.

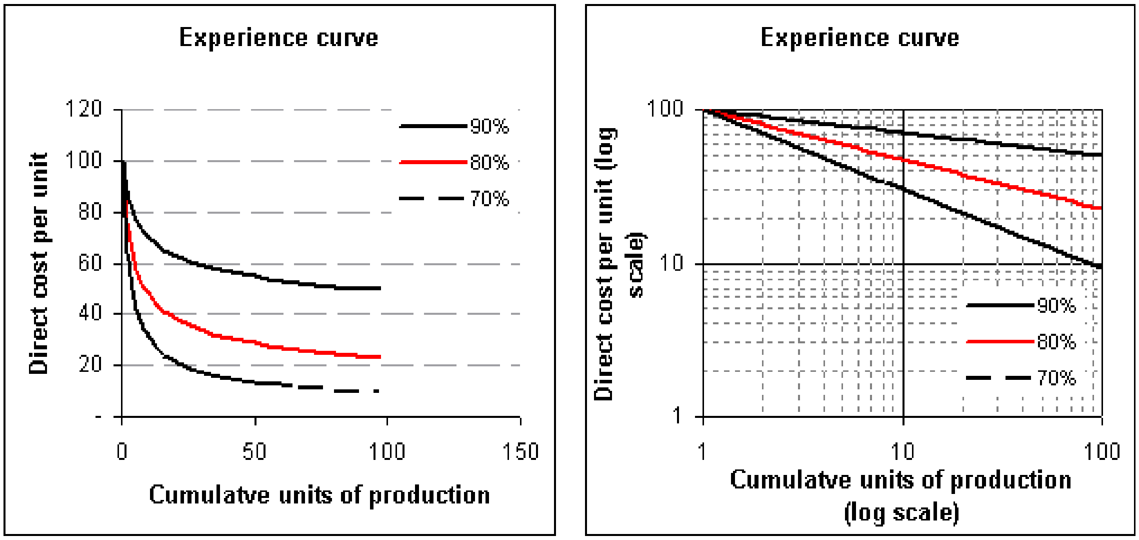

Figure 8- Experience Curve[20]

These effects are often expressed graphically. The curve is plotted with cumulative units produced on the horizontal axis and unit cost on the vertical axis. A curve that depicts a 15% cost reduction for every doubling of output is called an "85% experience curve", indicating that unit costs drop to 85% of their original level.

Mathematically the experience curve is described by a power law function sometimes referred to as Henderson's Law:

$$C_n = C_1 n^{-a}$$

profitable management consulting companies in the world. It has 66 offices in 38 countries and in 2006 had a revenue of US$ 1.8 billion. (Wikipedia)

[20] Experience curve effects. 28 April 2009 <http://en.wikipedia.org/wiki/Experience_curve_effects#cite_note-Chase1998-1>.

Where C_1 is the cost of the first unit of production, C_n is the cost of the nth unit production n is the cumulative volume of production a is the elasticity of cost with regard to output

The primary reason for why experience and learning curve effects apply, of course, is the complex processes of learning involved. As discussed earlier, learning generally begins with making successively larger finds and then successively smaller ones. The equations for these effects come from the usefulness of mathematical models for certain somewhat predictable aspects of those generally non-deterministic processes. They include:

3.5.1. Labor efficiency

In Time workers become physically faster and also smarter. They become mentally more confident and spend less time hesitating, learning, experimenting, or making mistakes. Over time they learn short-cuts and improvements. This applies to all employees and managers, not just those directly involved in production.

3.5.2. Standardization, specialization, and methods improvements

As processes, parts, and products become more standardized, efficiency tends to increase. When employees specialize in a limited set of tasks, they gain more experience with these tasks and operate at a faster rate.

3.5.3. Technology-Driven Learning

Automated production technology and information technology can introduce efficiencies as they are implemented and people learn how to use them efficiently and effectively.

3.5.4. Better use of equipment

As total production increases, manufacturing equipment will be fully exploited, lowering fully accounted unit costs. In addition, purchase of more productive equipment can be justifiable.

3.5.5. Changes in the resource mix

As a company acquires experience, it can alter its mix of inputs and thereby become more efficient.

3.5.6. Product redesign

As the manufacturers and consumers have more experience with the product, they can usually find improvements. This filters through to the manufacturing process. A good example of this is Cadillac's testing of various "bells and whistles" specialty accessories. The ones that did not break became mass produced in other General Motors products; the ones that didn't stand the test of user "beatings" were discontinued, saving the car company money. As General Motors produced more cars, they learned how to best produce products that work for the least money.

3.5.7. Value chain effects

Experience curve effects are not limited to the company. Suppliers and distributors will also ride down the learning curve, making the whole value chain more efficient.

3.5.8. Network-building and use-cost reductions

As a product enters more widespread use, the consumer uses it more efficiently because they're familiar with it. One fax machine in the world can do nothing, but if everyone has one, they build an increasingly efficient network of communications. Another example is email accounts; the more there are, the more efficient the network is, the lower everyone's cost per utility of using it.

3.5.9. Shared experience effects

Experience curve effects are reinforced when two or more products share a common activity or resource. Any efficiency learned from one product can be applied to the other products.

3.5.10. Transfer the experience to next generation

The more a method is used the better it becomes transferable to the new comers. The new generation will have shorter experience curve than the earlier generation. This is as a result of finding easier ways to become expert in a skill and pass it to the successors.[21]

3.6. Hiring supplemental subcontractors

In some cases it is possible for the General Contractor to cancel part of an unaccomplished section of a subcontractor contract and award it to another subcontractor in order to speed up the project. This can rarely happen and requires many factors to be considered.

3.6.1. Advantages of hiring additional subcontractors

The best advantage of adding new subcontractor is that it speeds up the project rapidly. To prove their productivity, the new contractors often pass the learning curve fast and enter to the productive phase sooner. Also having two or more subcontractor in a same trade will create competition which will benefit the project.

3.6.2. Disadvantages of hiring additional subcontractors

One of the major obstacles is that when the subcontract is awarded to the first subcontractor it is usually difficult to separate a portion and cancel that in order to award it to another subcontractor. Experienced subcontractors will never leave any portion of their project untouched and will show activity in every corner since the

[21] Experience curve effects. 28 April 2009 <http://en.wikipedia.org/wiki/Experience_curve_effects#cite_note-Chase1998-1>.

beginning. Another disadvantage of separating a contract is the legal consequences. The loss of credit and reputation would be counted as further disadvantages.

3.7. Extending the project duration

Extending the project duration is another way to compensate delay. Unlike all other previous methods which involve changes in field operation, this method concentrates in paper work and makes changes on contract documents.

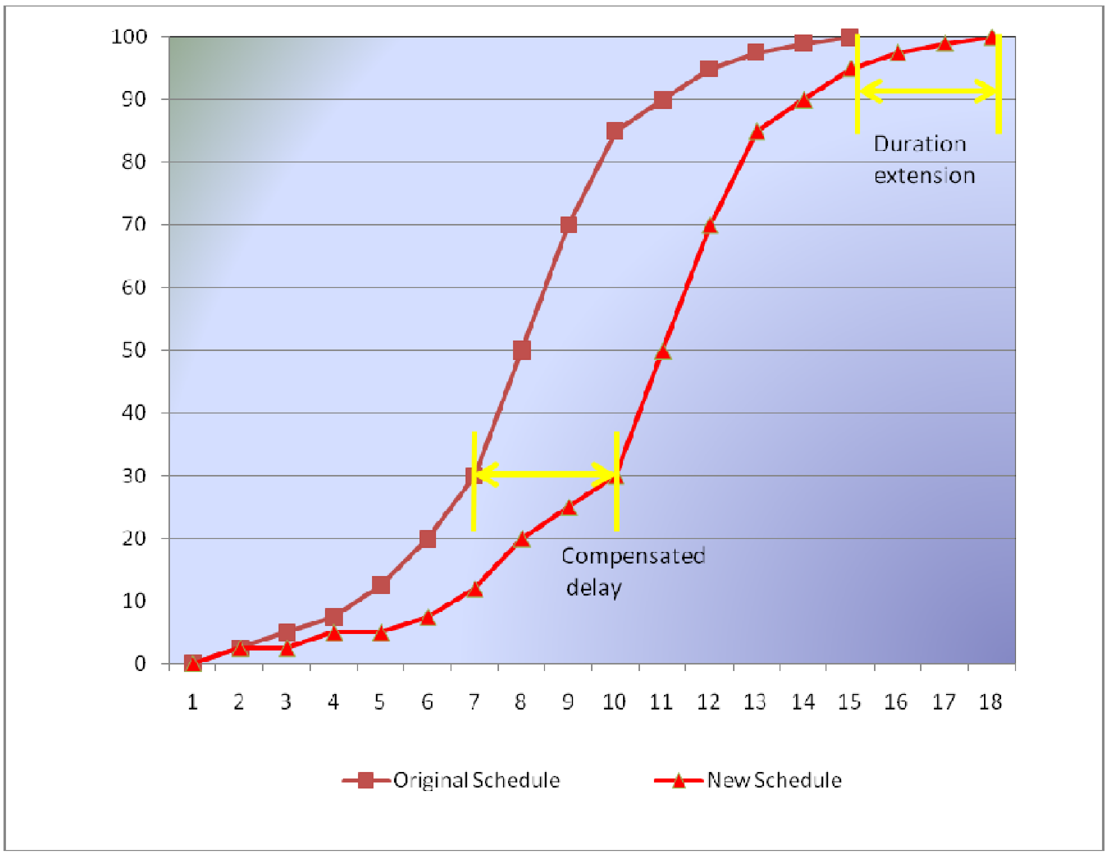

Figure 9- Effect of extending the project duration

Contractor can claim different reason to convince the owner to extend the project duration. Following are examples of the claims that the contractor can bring to the table and make changes in the project duration and planned schedule.

3.7.1. Force Majeure

Force Majeure is a common clause in contracts which essentially frees both parties from liability or obligation when an extraordinary event or circumstance beyond the control of the parties, such as a war, strike, riot, crime, or "act of God" (e.g., flooding, earthquake, volcano), prevents one or both parties from fulfilling their obligations under the contract.

The contractor can extend the duration if delays can be classified in force majeure category. Heavy rain and flooding are common reasons to claim for Force Majeure.

3.7.2. Change orders and additional works

If there is a change in the plan or specifications or if there is an extra work added to the contract, the contractor can request an extension to the project duration and consequently can lower the delay or even bring the project to the revised schedule.

3.8. Summary of practical ways to compensate delay

The following table illustrates the summary of practical compensation

Method		Advantage	Disadvantage
1	Increasing working time	Creates Win-Win Situation	Reduces productivity in long term
2	Planning and scheduling for the rest of the project	Works well for repetitive projects	Takes time in complicated projects
3	Adding more working personnel to the existing manpower	Speeds up the project rapidly	Brook's law may apply
4	Learning curve and experience curve	No action needed	It might not be a result of learning curve and causes further delay
5	Experience Curve effect	No action needed	It might not be a result of Experience curve and causes further delay
6	Hiring supplemental subcontractors	Creates competition	It may generate legal issues

Figure 10 – Summary of practical method to compensate delays

4. Chapter Four - Managerial ways of compensating delays

4.1. Lean construction

It is generally accepted that lean manufacturing had a revolutionary effect on many industries, particularly automotive assembly companies. To improve efficiency and prevent failure of construction projects, a lean construction is needed. A lean construction would involve the followings.

• Reduced defects and waste, helping to improve quality and value, etc.

• Making sure that, workers are responsible for satisfying customer needs.

• Continuing to improve processes for the entire workforce.

Lean construction much like current practice has the goal of better meeting customer needs while using less of everything. But unlike current practice, lean construction rests on production management principles, the “physics” of construction. The result is a new project delivery system that can be applied to any kind of construction but is particularly suited for complex, uncertain, and quick projects.

4.1.1. History of lean production

Lean production was developed by Toyota led by Engineer Ohno[22]. He was a smart if difficult person dedicated to eliminating waste. The term “lean” was coined by the research team working on international auto production to reflect both the waste reduction nature of the Toyota production system and to contrast it with craft and mass forms of production. Ohno shifted attention to the entire production system from the narrow focus of craft production on worker productivity and mass production on machine. He followed the work of Henry Ford and continued the development of flow based production management. But unlike Ford who had an almost unlimited demand for a standard product, Ohno wanted to build cars to customer order. Starting from efforts to reduce machine set up time and influenced by TQM, he developed a simple set of objectives for the design of the production system: Produce a car to the requirements of a specific customer, deliver it instantly, and maintain no inventories or intermediate stores.

Waste is defined by the performance criteria for the production system. Failure to meet the unique requirements of a client is waste, as is time beyond instant and inventory standing idle. A morning cup of coffee serves as an example. Instant delivery is possible but we must either have an intermediate inventory, coffee in the pot, or accept a cup of “instant” which hardly meets requirements of someone craving a low-fat double latte. Moving toward zero waste and perfection shifts the improvement focus from the activity to the delivery system. Ohno and other Japanese engineers were familiar with mass production of cars from their plant visits in the

[22] Pioneers of Lean Manufacturing. 28 April 2009 <http://www.strategosinc.com/taiichi_ohno.htm>.

United States. Where US managers saw efficiency, Ohno saw waste at every turn. He understood that the pressure to keep each machine running at maximum production led to extensive intermediate inventories he called “the waste of over production.” And he saw defects built into cars because of the pressure to keep the assembly line moving. Production at all costs meant defects were left in cars as they passed down the line. These defects disrupted down stream work and left completed cars riddled with embedded defects.

Where the US approach aimed to keep the machines running and the line moving to minimize the cost of each part and car, Ohno’s system design criteria set a multi-dimensioned standard of perfection that prevented sub-optimization and promoted continuous improvement.

Zero time delivery of a car meeting customer requirements, with nothing in inventory required tight coordination between the progress of each car down the line and the arrival of parts from supply chains. Rework due to errors could not be tolerated as it reduced throughput, the time to make a car from beginning to end, and caused unreliable workflow.

And coordinating the arrival of parts assigned to a particular car would be impossible if the movement of the car was unreliable. Engineer Ohno went so far as to require workers to stop the line on receipt of a defective part or product from upstream. (Only the plant manager could stop the line in US plants.)

Working to eliminate rework makes sense from a system perspective, but stopping the line looks very strange to people who are trying to optimize performance of a single activity. Stopping the line made sense to Ohno because he recognized that reducing the cost or increasing the speed could add waste if variability was injected into the flow of work by the "improvement." Requiring workers to stop the line decentralized decision making. He carried this further when he replaced centralized control of inventory with a simple system of cards or bins which signaled the upstream station of downstream demand. In effect, an inventory control strategy was developed which replaced central push with distributed pull. Pull was essential to reduce work in process (WIP). Lower WIP tied up less working capital and decreased the cost of design changes during manufacture as only a few pieces needed to be scrapped or altered. Large inventories are required to keep production in push systems because they are unable to cope with uncertainties in the production system. And large inventories raise the cost of change. Ohno also decentralized shop floor management by making visible production system information to everyone involved with production. "Transparency" allowed people to make decisions in support of production system objectives and reduced the need for more senior and central management.

As he came to better understand the demands of low waste production in manufacturing, he moved back into the design process and out along supply chains. In an effort to reduce the time to design and deliver a new model, the design of the production process was carefully considered along with the design of the car. Engineering components to meet design and production criteria was shifted to the suppliers. New commercial contracts were developed which gave the suppliers the incentive to continually reduce both the cost of their components and to participate in the overall improvement of the product and delivery process. Toyota was a demanding customer but it offered suppliers continuing support for improvement. Lean production continues to evolve but the basic outline is clear. Design a production system that will deliver a custom product instantly on order but maintain no intermediate inventories. The concepts include:

- Identify and deliver value to the customer value: eliminate anything that does not add value.

- Organize production as a continuous flow

- Perfect the product and create reliable flow through stopping the line, pulling inventory, and distributing information and decision making.

- Pursue perfection: Deliver on order a product meeting customer requirements with nothing in inventory.

Lean production can now be understood as a new way to design and make things differentiated from mass and craft forms of production by the objectives and techniques applied on the shop floor, in design and along supply chains. Lean production aims to optimize performance of the production system against a standard of perfection to meet unique customer requirements.[23]

[23] Ballard, Glenn. Lean Project Delivery System. 28 April 2009 <http://www.leanconstruction.org/>.

4.1.2. Lean construction compared to lean production[24]

Lean construction accepts the Ohno’s production system design criteria as a standard of perfection. But how does the Toyota system, lean production, apply in construction? The construction industry has rejected many ideas from manufacturing because of the belief that construction is different. Manufacturers make parts that go into projects but the design and construction of unique and complex projects in highly uncertain environments under great time and schedule pressure is fundamentally different from making tin cans. Lean production invites a closer look. Certainly the goal of a delivering a project meeting specific customer requirements in zero time sounds like the objective for every project, and the evidence of waste in Ohno’s terms is overwhelming. Waste in construction and manufacturing arises from the same activity-centered thinking, “Keep intense pressure for production on every activity because reducing the cost and duration of each step is the key to improvement.” Ohno knew there was a better way to design and make things. Managing construction under Lean is different from typical contemporary practice because:

- It has a clear set of objectives for the delivery process.

- It is aimed at maximizing performance for the customer at the project level.

- It designs concurrently product and process.

- It applies production control throughout the life of the project.

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[24] Construction Buisiness Owner. Lean Construction: Maximized value and Eliminate wastes. 28 April 2009 <http://www.constructionbusinessowner.com/topics/general-management/lean-construction-maximize-value-and-eliminate-waste.html>.

By contrast, the current form of production management in construction is derived from the same activity centered approach found in mass production and project management. It aims to optimize the project activity by activity assuming customer value has been identified in design. Production is managed throughout a project by first breaking the project into pieces, i.e. design and construction, then putting those pieces in a logical sequence, estimating the time and resources required to complete each activity and therefore the project. Each piece or activity is further decomposed until it is contracted out or assigned to a task leader, foreman or squad boss. Control is conceived as monitoring each contract or activity against its schedule and budget projections. These projections are rolled up to project level reports. If activities or chains along the critical path fall behind, efforts are made to reduce cost and duration of the offending activity or changing the sequence of work. If these steps do not solve the problem, it is often necessary to trade cost for schedule by working out of the best sequence to make progress. The focus on activities conceals the waste generated between continuing activities by the unpredictable release of work and the arrival of needed resources. Simply put, current forms of production and project management focus on activities and ignore flow and value considerations. Managing the combined effect of dependence and variation is a first concern in lean production.

The problem of dependence and variation can be illustrated by what happens in heavy traffic on a freeway. If every car drove at exactly the same speed then spacing between cars could be very small and the capacity of the freeway would be limited by whatever speed was set. Each car would be dependent on the one ahead to release pavement and variation would be zero. In effect, there would be no inventory of unused pavement. In reality of course, each car does use the pavement released to it from the car ahead but speeds vary. Under the pressure to get to work or home, gaps between cars close and any variation in speed demands immediate response from following cars. As the gaps close, small variations in speed propagate along and across lanes. One small hesitation can lead to a huge standing wave as traffic slows to a crawl. Recovery is difficult because it is impossible to get everyone to accelerate smoothly back up to the standard speed and interval. High speed at any one moment does not assure minimum travel time in conditions of dependence and variation. The idea that you do not get home any faster by driving as fast and as close to the car ahead is counter intuitive (at least to teenagers). Certainly the system itself does not function as well when dependence is tighter and variation greater. Managing the interaction between activities, the combined effects of dependence and variation, is essential if we are to deliver projects in the shortest time. Minimizing the combined effects of dependence and variation becomes a central issue for the planning and control system as project duration is reduced and the complexity increases. The need to improve reliability in complex and quick circumstances is obvious. New forms of planning and control are required.

Companies typically maintain elaborate cost control systems to measure this performance. These systems are the manifestations of the cause and effect theories operating in the company. At the heart of this model is the belief that the crew is essentially independent and that all costs charged to an account arise within from the effort necessary to complete the assignment by the crew.

The lean construction view is different as it views the problem in physical production terms. The crew works at variable rates using resources supplied at varying rates. Matching labor to available work is a difficult systems design problem with a limited number of "solutions." Lean works to isolate the crew from variation in supply by providing an adequate backlog (a safe distance between cars) or tries to maintain excess capacity in the crew so they can speed up or slow as conditions dictate. On occasion, people acting on intuition apply these techniques. (They drive to work on freeways.) Unfortunately neither resource nor capacity buffers reduce the variation in supply and use rates of downstream crews.

These problems are solved by long and predictable runs in the factories (and along the highways of our dreams). In these stable circumstances managers can predict the work content at each station and shift labor along the line to minimize imbalance. Such factories are mostly dreams that have little to do with construction where we only have some idea of the labor content of activities from previous projects.

People say they are helpless victims of fate when faced with managing uncertainty on projects. Their view is that uncertainty arises in other activities beyond their control. The lean approach is to assure we do not contribute to variation in work flow and to decouple when we cannot get it under control. In lean construction as in much of manufacturing, planning and control are two sides of a coin that keeps revolving throughout a project.

- **Planning:** defining criteria for success and producing strategies for achieving objectives.

• **Control:** causing events to conform to plan and triggering learning and re-planning.

Often the first question we are asked when describing a project to people unfamiliar with lean thinking is, “What kind of contract was in force?” Next come organizational and systems issues: “Was supervision by area or craft? (Union or not?) Were designers on site? Did the owner know what they wanted?” These questions are reflections of contracting or activity centered thinking.

Lean construction rests on a production management mind. We ask about the way work itself is planned and managed. We want to know the whether the planning system itself is under control, the location of inventories and excess capacity, and the extent to which the design and construction process itself supports customer value.

Lean construction embraces uncertainty in supply and uses rates as the first great opportunity and employ production planning to make the release of work to the next crew more predictable, and then we work within the crews to understand the causes of variation. Where current practice attacks point speed, lean construction attacks variation system wide.

Under lean, labor and work flow are closely matched when variation is under control and activities de-coupled through capacity or resource buffers when variation is not under control and work content unbalanced. These solutions are directed by the physics of the situation.

Where current practice assesses and attempts to control individual performance, we see the planning system as the key to reliable work flow. Construction is different from manufacturing in the way work is released to the crew. Work is released, moves down the line, in manufacturing based on the design of the factory. In construction work is released by an administrative act, planning. In this sense, construction is directives driven and so measuring and improving planning system performance is the key to improving work flow reliability. Measuring planning system performance reflects our understanding of cause and effect. This is a different mind, a new novel. Once we understand physics problems at the crew level, we see all sorts of new issues and opportunities. The first objective is to bring the flow of work and production itself under control. This effort pays immediate dividends and demands the project delivery system be changed to better support reliable work flow.

Job starts with working to understand the physics of production at the task level, and then to design the underlying systems to support high performance in Ohno's terms. The planning system is the logical first target, but other design, procurement and logistic systems must also be considered. It will be necessary to change the organization to support these redesigned systems.

Research efforts now underway explore the application of pull techniques both on site and in design. Finally, we expect new forms of commercial contract to emerge that give incentives for reliable work flow and optimization at the deliverable-to-the-client level. In this way we move from task to system to organization to contract.

Human issues come into play on implementation. Systems, teams, organizations, communication and contracts do not change the physics. Their design does limit what can happen just as physical rules place other limits. For example, the need for upstream investment to reduce downstream variation is in conflict with current practices of buying each piece for the lowest cost, or of pushing each crew to work quickly as opposed to reliably. Uncertainty in work flow places great demand on communication channels as people attempt to find some way to keep the project or their crew moving in the face of uncertainty. But flexibility defined in this way requires slack resources and injects more uncertainty into the flow of work. Where we see uncertainty as the consequence of the way we manage work, they see uncertainty as environmental and beyond their control. We operate on different theories, we tell different stories. A pattern is beginning to emerge in implementation. Managers in most companies and on most projects have an inflated view of the reliability of their planning system. This attitude changes once the decision is taken to make assignments to criteria and the results come in.[25]

4.2. Create a positive working environment

According to Gallup organization[26] employees and workers are classified in three main groups. Engaged employees, not engaged employees and actively disengaged employees.

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[25] Howell, Gregory A. WHAT IS LEAN CONSTRUCTION. 28 April 2009 <http://www.leanconstruction.org/pdf/Howell.pdf>.

[26] Gallup Organization. Feedback for Real. 28 April 2009 <http://gmj.gallup.com/content/811/Feedback-Real.aspx>.

4.2.1. Engaged employees

Engaged employees or workers who do their best at work and they work like they are working for their own business. They have high productivity and company's benefit is highly dependent on their efforts. Twenty eight percent of the overall workforces in the United States are determined to be engaged employees.

4.2.2. Not engaged employees

These are employees who only work what they are asked to do. They do not work very hard like the first group. They work as much as they are paid and do what they are asked to do. Their productivity is not like the first group but much better than the third group. Fifty four percent of the overall workforces in the United States are determined to be not engaged employees.

4.2.3. Actively disengaged employees

These are employees who not only waste their time, but also they encourage others not to perform well. They are unsatisfied in any way and always complaining from the work place. Seventeen percent of the overall workforces in the United States are determined to be actively disengaged employees.

By adding more engaged workers to the company, converting the not engaged workers to engaged workers and also actively disengaged workers to not engaged workers, the productivity rate will be increased. This will influence the project and will improve the completion rate. The change may even transfer a behind schedule project to a project which is ahead of schedule.

This is only possible by having a better and positive work place. In a disengaged work place employee turnover, stress level, absenteeism, illness, theft, mortality and morbidity rate are higher. On the other side in an engaged work place the profitability, productivity, safety, customer satisfaction and loyalty indexes are in highest possible degree.

To recognize the engagement of a work place Gallup Organization[27] has published 12 basic questions called Q12[28]. Answers to these questions would determine to what degree the employees are engaged in working place. Following are those questions that Gallup organization asks the workers and employees to determine the engagement level.

1- Do you know what is expected of you at work?

2- Do you have the materials and equipment you need to do your work right?

3- At work, do you have the opportunity to do what you do best every day?

4- In the last seven days, have you received recognition or praise for doing good work?

5- Does your supervisor, or someone at work, seem to care about you as a person?

6- Is there someone at work who encourages your development?

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[27]Organization, Gallup. Strength Base Leadership. 28 April 2009 <http://gmj.gallup.com/content/111967/Strengths-Based-Leadership.aspx>.

[28] Organization, Gallup. Feedback for Real. 28 April 2009 <http://gmj.gallup.com/content/811/Feedback-Real.aspx>.

7- At work, do your opinions seem to count?

8- Does the mission/purpose of your company make you feel your job is important?

9- Are your associates (fellow employees) committed to doing quality work?

10- Do you have a best friend at work?

11- In the last six months, has someone at work talked to you about your progress?

12- In the last year, have you had opportunities at work to learn and grow?

4.3. Building trust[29]

The construction industry has a bad reputation. Poor relationships between the client, main contractor and sub-contractors lead to problems that affect cost, quality and time, as well as damaging relationships between all parties involved.

Trust is a major factor leading to the success or failure of construction projects. Trust is the perception that another party is honest and reliable. It is about having a relationship, not just doing business. It is generally acknowledged that people build trust by working together on projects. Regarding to the temporary and short-term-based nature of construction projects, it is difficult for people to build successful relationships. When there is a trusting relationship among team members, individuals can be flexible and may respond to changes of information. This is important in

[29] Marja Naaranojaa, , and Lorna Uden. "Major problems in renovation projects in Finland ." Building and Environment Volume 42, Issue 2, (February 2007,): Pages 852-859 .

construction projects because information may be incomplete at the time of the contract and changes are inevitable as the project progresses.

4.3.1. Benefits of trust in construction

There are many benefits when there is trust in organizations, especially in construction.

- **Uncertainty of outcome is reduced**

Because the construction industry faces more uncertainty than other industries, trust is a useful tool to deal with uncertainties. As there are always changes in information, or new information being discovered that can have an impact on the way work is carried out, it is vital that team members produce information that is clear and accurate and other members can rely on. This helps to reduce uncertainty. When people have worked together for a while and have solved problems, they begin to trust each other. If problems arise, they know that they can rely on each other to handle them properly.

- **Risks are reduced when people worked well together on projects**

Where there is uncertainty, there is risk. Risks are also reduced when outcomes can be effectively ascertained. Cost is reduced when there is an understanding of risk. This means that there is a financial benefit when there is a trusting approach.

- **A more flexible approach exists.**

Because there is honesty and trust among team members, it aids problem solving in projects. Problems can be solved easier and project participants optimistically look to the problems. This will facilitate resolving the issues.

- **There is saving of time and money.**

The main benefit of having trusting relationships is that it produces profit, that is, it saves time and money in carrying out construction projects. It is important for people in construction projects to engage in trusting relationships because it can help the organizations to reduce the uncertainty, improve risk management and increase flexibility. A trusting behavior removes costs brought about by poor communications and adversarial approaches to problem. The results of these problems could end in expensive litigation.

4.3.2. How to build trust among team members in construction projects[30]

There are several ways to establish trust between parties. Followings are the most important ways.

- **Be honest in communication**

Communication is vital to building relationships in trust. It is important that people be open, willing to share important information with the rest of the team, as well as being honest, giving information that will reflect the real situation. If an individual makes a decision, it should be ensured that he/she stands by it. It is important that people give information when it is needed. Clear communication is required in construction projects to enable people to be more effective in putting across their requirements for one another in order to have better delivery. If there are unusual

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[30] Ibbotson, Alan. Building Trust Among Members of A Team. 18 July 2007. 28 April 2009 <http://www.expertbusinesssource.com/blog/1260000326/post/570012057.html>.

circumstances cropping up, it is essential to make people aware of the problems in order to minimize the impact. A successful and trusting project team has fair and free access to enable communication between all the parties, where people can communicate without fear of their messages becoming distorted. It is very important to maintain communication between the different parties and team members. Communication is essential when dealing with conflicts. Conflicts can be used to build or destroy trust. Communication provides a means of finding a solution to the problem.

- **Being reliable**

It should be ensured that the individual who makes the promises keeps them. This may be very small things, like agreeing to meet someone somewhere—it is important to turn up on time. This helps to build relationships. Construction projects need this kind of trust because in complex projects there are many specialist trades. Not everyone has the expertise to understand what is being done, so there is a need to rely on that person's experience.

- **Integrity of organization**

The role of the organization’s reputation is important. People have often said that they trust individuals more than the organizations. Organizations should have integrity, especially in construction. Construction is generally considered a small world where people often work with the same people on many different projects over many years, which is how organizations build reputations. This has an impact on whether people trust them enough to work with them on projects. It is important for companies to maintain their reputations, because they are an important asset in construction. The construction companies are mostly dealing with uneducated workers and it is important to build trust among them. Trust is a powerful tool to motivate the working class. The following comparison chart shows the trust level in different sources.

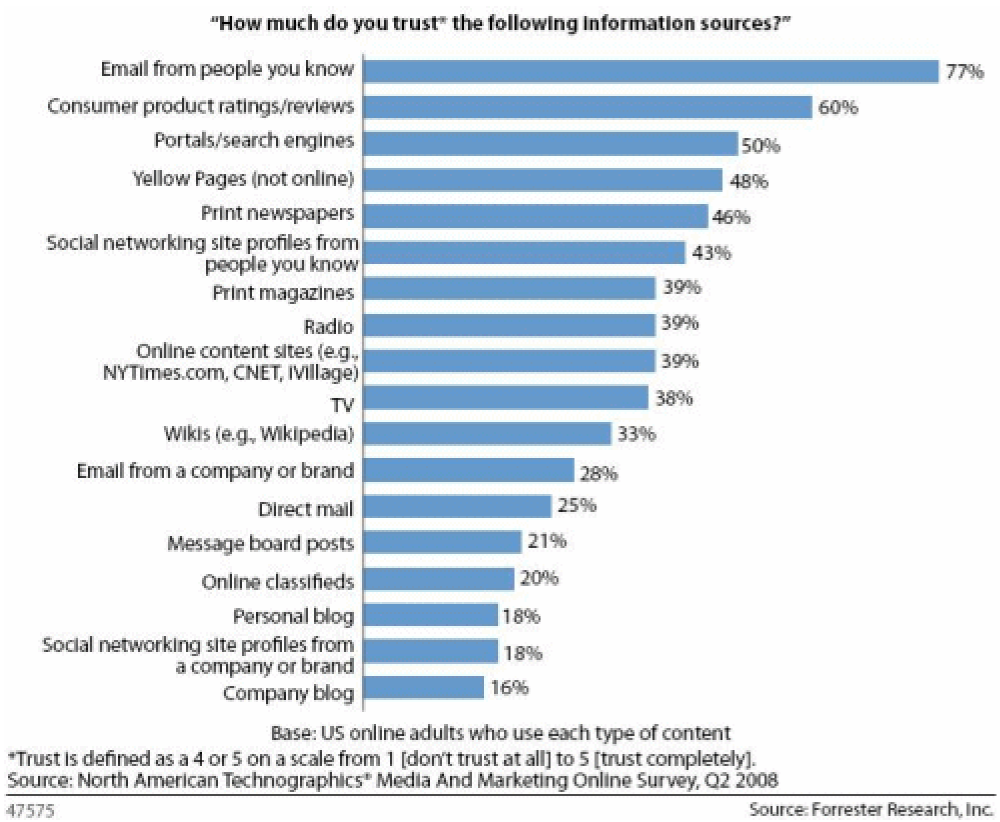

Figure 11 – Trust level comparison[31]

Study shows that people trust the company blogs the least and trust each other the most.

[31] Bernoff, Josh. People don't trust company blogs. 28 April 2009 <http://images.google.com/imgres?imgurl=http://farm4.static.flickr.com/3253/3094358118_a2be65e20e_o.jpg&imgrefurl=http://blogs.forrester.com/groundswell/2008/12/people-dont-tru.html&usg=__tHLANHCQwi4iFc8zOJN3Y8yR0PY=&h=580&w=843&sz=69&hl=en&start=31&um=1&t>.

- **Importance of experience**

People build relationships by working together. Repeated fulfillment of communications through actions and outcome create trust. There will be trust if people consistently prove that they are reliable. Having experience of working with people who are trustworthy can build trust in teams.

- **Problem solving**

It is important for project teams to solve problems together. Problem solving to mutual satisfaction is easier when project teams trust each other. Solving problems at the point of the problems is an important factor in building trust.

- **Creating shared goals**

It is vital in construction for everyone in the projects to have shared goals. This means that everyone can be seen to be fulfilling a joint task, rather than viewing their own role as separate from the rest of the project team. There should also be mutual understanding between members of the team.

- **Reciprocal behavior is important**

When someone does a good turn for another person, it is important to return the favor. This helps to build trust among team members.

- **Commitment**

Commitment is essential if the project is to succeed. Team members should be committed to the project. There are different ways that can be used to encourage commitment by members of the team. These include compliance, identification and internalization.

4.4. Knowledge management[32]

Although addressing the risk factor is a daunting task, it is important to control the risk. There must be a plan or strategy in place to deal with risks in projects. When risks are allocated to different parties, it is important to understand the implications and spell them out clearly. Risk management can be addressed by incorporating it as part of the knowledge management system.

All construction projects must incorporate change management. Change management is an orderly and transparent way of getting at the facts about changes as soon as possible. Solutions should be found such that the party who carries the risk of change may manage the risk more effectively without disadvantaging the other party. Whenever possible, change must be managed to mutual benefit. Construction changes typically refer to work processes, or methods that deviate from the original construction plan or specification. They usually result from work quality, work conditions or scope change. In order to respond to the increasing pressure from clients to deliver on time and within the budget, the construction companies have been investing in the use of information technology (IT) to support business processes and project management. The use of knowledge management can help organize the complexities involved in the design and construction process.

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[32] Levinson, Meridith. Knowledge Management Definition and Solutions. 28 April 2009 <http://www.cio.com/article/40343/Knowledge_Management_Definition_and_Solutions>.

Knowledge is now perceived by most organizations in the construction industry as a vital organizational resource and source of competitiveness. Knowledge is fast overtaking capital and labor as the key economic resource in advanced economies. These intangible assets are widely acknowledged as vital elements in improving competitiveness.

It is increasingly being acknowledged that Knowledge Management can bring about the much needed innovation and improved business performance in the construction industry. Knowledge is defined as a dynamic human process of justifying personal belief towards the truth. Information becomes knowledge when it enters the system and when it is validated (collectively or individually) as a valid, relevant and useful piece of knowledge to implement in the system. Besides the meaning of knowledge is the identification of the kind of knowledge that is to be managed.

4.4.1. IT support for knowledge management

IT is perceived by many as crucial for the successful implementation of a knowledge Management system. However, good knowledge management does not result from the implementation of information systems alone. Despite this, the role of IT as a key enabler for knowledge management remains undiminished. Information systems for knowledge management are classified into four main categories.

- **Creating knowledge**

These support the activities of highly skilled knowledge workers and professionals as they create new knowledge and try to integrate it into firms. Examples are CAD, Virtual Reality and Investment Workstations.

- **Distributing knowledge**

These include helping disseminate and coordinate the flow of information. Among these are word processing, desktop publishing, imaging and web publishing, electronic calendars and desktop databases.

- **Sharing knowledge**

These support the creation and sharing of knowledge among people working in groups. For example, if new information is generated after completion of a project, documentations and conclusions should be used for other similar projects.

- **Capturing and codifying knowledge**

These provide organizations and managers with codified knowledge that can be re-used by others in the organization. Examples are expert systems, neural nets, fuzzy logic, genetic algorithms and intelligent agents.

Although IT is important to knowledge management in construction organizations, the construction industry as a whole has been slow to recognize the benefits of IT as a major communication tool. Transferring knowledge and information in construction organizations is difficult. This is because much of the construction work is project-based, that is short term and task oriented, making it impossible to promote a culture where continuous learning is viable. Specialist knowledge is often lost from one project to the other, impeding an organization’s ability to develop knowledge and generate new ideas. IT can be used to assist the transfer of knowledge and information between project teams, enabling the development of new knowledge for innovation.

4.5. Fundamental state of leadership verses the Normal State of leadership[33]

The leadership is playing a determinant role in construction projects. Right method of leadership will influence the entire project greatly and speed up the late projects. There are two different types of leadership: Normal state and fundamental state of leadership. Changing the leadership state from Normal state to Fundamental state will not only benefit the project in short term, but also will influence the programs and portfolios.

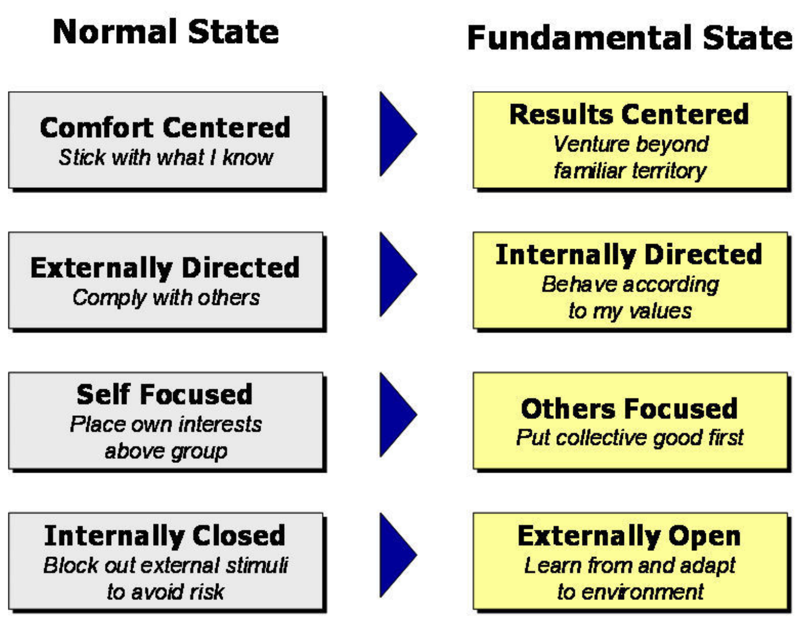

Figure 12- Shift from Normal State to Fundamental State of Leadership[34]

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[33] Robert E. Quinn, Gretchen M. Spreitzer. Entering the Fundamental Stateof Leadership: A Framework for the Positive Transformation of Self and Others. 2005. 28 April 2009 <http://webuser.bus.umich.edu/spreitze/Quinn-Entering%20the%20FSL-in%20Inspiring%20Leaders.pdf>.

[34] Decker, Bert. Peak Performance: The Fundamental State of Leadership. 28 April 2009 <http://www.bertdecker.com/experience/2005/10/peak_performanc.html>.

“In the normal state people tend to stay within their comfort zones and allow external forces to direct their behaviors and decisions. They lose moral influence and often rely on rational argument and the exercise of authority to bring about change…the result is usually unimaginative and incremental – and largely produces what already exists. To elevate the performance of others, we must elevate ourselves into the fundamental state of leadership”[35]

Fundamental state of leadership is “Result Centered”. The leader ventures beyond familiar territory to pursue ambitious new outcomes. It is “Internally Directed”. The leader behaves according to his or her values. The fundamental state of leadership is “Other Focused” meaning that leader’s interest is not governing the group’s interest. It is “Externally Open” meaning that leader is open to new ideas and ready to learn from the group.

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[35] Decker, Bert. Peak Performance: The Fundamental State of Leadership. 28 April 2009 <http://www.bertdecker.com/experience/2005/10/peak_performanc.html>.

5. Chapter Five – Crashing and Activity Overlapping

5.1. Crashing activities

Crashing is an action many of contractors take in order to compensate delays. In construction projects when a superintendent decides to ask a subcontractor or the in house personnel to work over the weekend, crashing in small scale has been formed. Regardless of the magnitude, the basics of crashing are always the same and have a single goal to achieve which is compensating the delay. The difference is that the superintendent arranges it intuitively in his or her mind, but for crashing big projects in large scales all factors must be considered. In those cases crashing is often done by sophisticated software considering project critical path and all related factors.

Crashing is spending extra money in order to expedite the completion and shorten the remaining project duration. The additional budget has to be spent only on critical path activities to shorten the duration of the entire project. Spending money on other non critical activities will only add the float of that activity without affecting the project duration which would be wasteful.

The problem become complicated when as a result of minimizing the duration of the critical activities the critical path changes and a new critical path is formed. In that case further reduction of the duration of the original critical path activities is useless. After development of new critical path, the new critical activities should be crashed. Each time a shift in critical path happens the reduction should be applied to new critical path activities.

This step by step reduction in the duration can be drawn in duration versus direct cost curve. Since reduction in project duration will increase the project direct cost, the curve usually have a negative slope.

On the other hand reducing the duration would reduce the indirect costs as well. Hence another curve is generated showing the amount of indirect costs versus different project durations. Since the indirect costs are mostly increased by time unlike the direct costs this curve will normally have a positive slope.

Adding the direct and indirect cost curves will generate the project total cost versus duration.

It is often possible to find a minimum point showing the optimum point of crashing. This minimum point represents the least expenditure on the project and the duration of that cost. Figure 10 represents this minimum point.

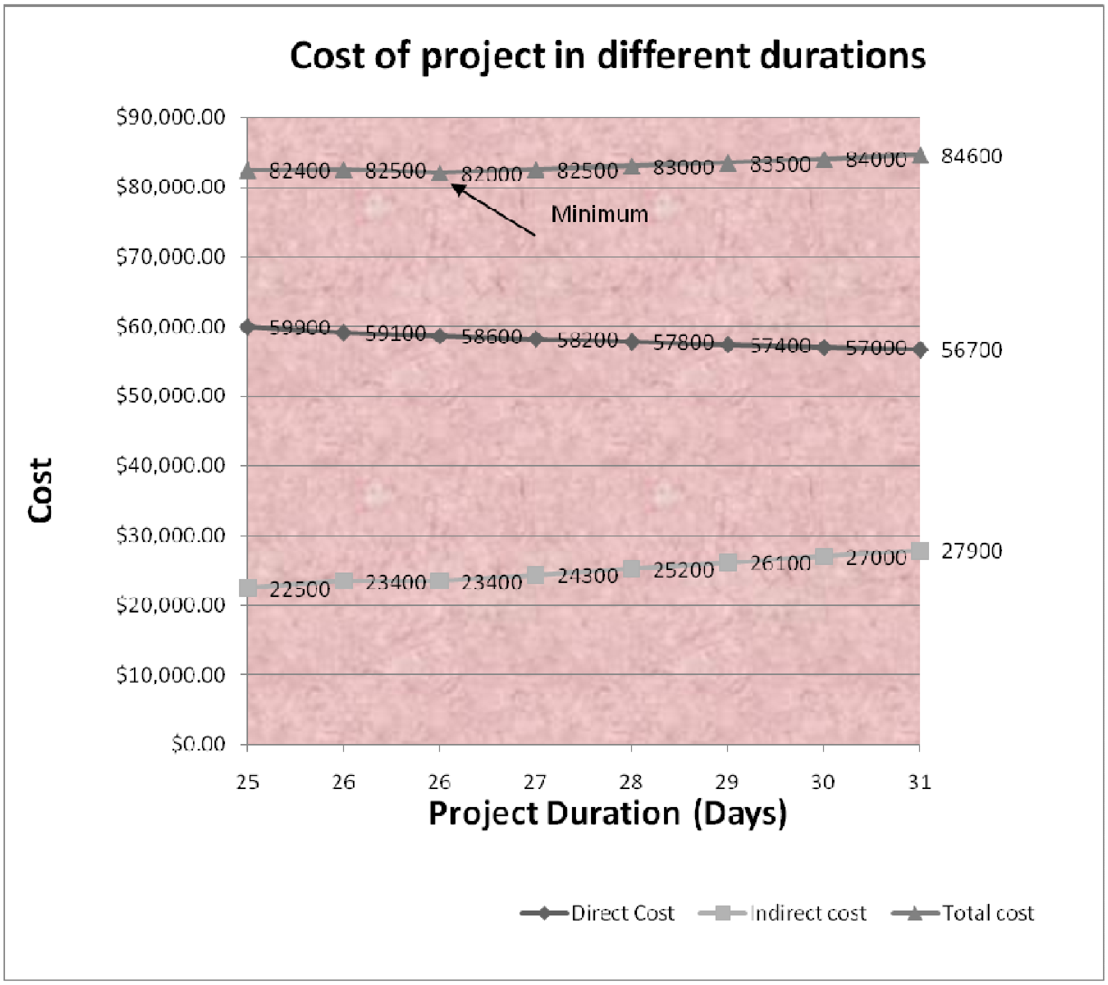

Figure 13- Example of Project Crashing

The mentioned methods are some of the most important methods that can be used to bring back the project to the schedule. In fact depending to the situations a combination of those methods will result a better effect. The project manager is the most important person who can determine which strategy works better.

5.2. Activity Overlapping or Fast Tracking

Since the early nineties, the overlapping of activities with a view to accelerating a project has been studied in the context of new product development. Smith and

Jeffrey[36] provide a review of research on product development process modeling. The introduction of the DSM has provided focus on information processing in design tasks. The DSM has been employed in studying various aspects of new product development processes. Recently, Pekas and Pultar[37] have used the Dependency Structure Matrix (DSM) in the modeling of information flow in the architecture /engineering /construction (AEC) industry. Nicoletti and Nicolo[38] have developed a linear programming model with a view to maximizing information flow in concurrent engineering projects. Roemer have presented a cost minimization model for the simultaneous crashing and overlapping of activities in a project consisting of activities in series. Yassine[39] have used dynamic programming to determine the tradeoff between uninterrupted information incorporation and waiting prior to information incorporation in new product development projects[40].

The idea is to simply overlap the remaining activities of a project. These activities are originally assumed as prodessesor or successor of each other but in fast tracking the project these are pushed to be overlapped on each other. In construction sometime with a little extra cost this could be accomplished. For example concrete gains the

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[36] Jeffrey, R. P. Smith and A. M. "Product development process modeling." (n.d.).

[37] S. T. Pektas and M. Pultar. "“Modelling detailed information flows in building design with the parameter-based design structure matrix." (n.d.).

[38] S. Nicoletti and F. Nicol`o. "“A concurrent engineering decision model Management of the project activities information flow,”." (n.d.).

[39] A. A. Yassine, R. S. Sreenivas, and J. Zhu,. "“Managing the exchange of information in product development." (n.d.).

[40] Qassim, Jos´e Eduardo Vinhaes Gerk and Raad Yahya. "Project Acceleration via Activity Crashing,." IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, VOL. 55, NO. 4, (NOVEMBER 2008).

design strenghth in 28 days. If the concrete is cured with steam the curing time can significantly been minimized. In production of precast planks this could resolve the delay issue and the manufacturing of the plank can be overlaped by instalation activities. Fast tracking of the design, procurement and building phases of a project is a good example of how overlappingcan help to take advantage of remaining time.

Vapor cured bulb-T-members await transport and final installation on Atlanta Hartsfield's fifth runway project

Figure 14 – Pre-stressed concrete beams cured by steam[41]

The above figure is an example of Prestressed concrete which has been cured by steam and is ready for istalation in shorter time.

[41] Kraft Energy. Vapor cured concrete. 28 April 2009 <http://images.google.com/imgres?imgurl=http://www.kraftenergy.com/images/introductions/WheelTRACKS-lo.jpg&imgrefurl=http://www.kraftenergy.com/intro-whycure-concrete.htm&usg=__35PTZ8Tp8osvEgfIcbHdLp2iJQk=&h=268&w=326&sz=17&hl=en&start=1&um=1&tbnid=t51JEqF>.

6. Chapter Six - Effects of Schedule Pressure on Construction Performance

Having a stressful construction project that everyone is rushing to stay on the schedule or compensate the delays is sometime resulting secondary problems.

According to the article published in “Journal of Construction Engineering and Management” acceleration of a project can be rewarding and trouble making at the same time. The consequences, however, can be troublesome if productivity and quality are sacrificed for the sake of remaining ahead of schedule or compensate the delays, such that the actual schedule benefits are often barely worth the effort. The tradeoffs and paths of schedule pressure and its causes and effects are often overlooked when schedule decisions are being made. Schedule pressure can have negative effects on construction performance.

Based on investigation performed by using survey data collected from 102 construction practitioners working in 38 construction sites in Singapore, advantages of increasing the pace of work by working under schedule pressure can be offset by losses in productivity and quality. The negative effects of schedule pressure arise mainly by working out of sequence, generating work defects, cutting corners, and losing the motivation to work. The adverse effects of schedule pressure can be minimized by scheduling construction activities realistically and planning them proactively, motivating workers, and by establishing an effective project coordination and communication mechanism. [42]

6.1. Effects of Stress in workplace

Work activities and the structure of work are instrumental in shaping one's social and personal identity. How work is structured is also a critical factor in influencing the mental health of workers. Martin Seligman's [43]study on positive work place indicates that workers want more power and control in the workplace. Contemporary work environments are still structured on the basis of domination, hierarchy and social control. Automated technology even in construction industry accentuates this control. Workers experience powerlessness and an increase in mental illness and emotional distress under pressure of mental stress. Martin Seligman's “learned helplessness” research is a sample as a model for understanding the psychopathology associated with powerlessness in the workplace. Concluding remarks concern the workplace conditions for empowering workers and raising mental health. In Seligman’s research workplace democracy and an automated technology is seen as the most viable path for worker empowerment and self-actualization.

6.2. Financial effects of decreasing the project duration

In most construction projects the contractors have to prepare themselves for financing the budget of operation until the project is completed and the received statements

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[42] Madhav Prasad Nepal, 1 Moonseo Park,2 and Bosik Son3. "Effects of Schedule Pressure on Construction Performance." J. Constr. Engrg. and Mgmt. Volume 132, Issue 2, ((February 2006)): pp. 182-188 .

[43] Seligman, Martin E. P. Learned Helplessness. 28 April 2009 <http://www.noogenesis.com/malama/discouragement/helplessness.html>.

cover the expenses. Using the project complete expenditure the Contractors can exactly know when the minimum balance is and how long this will last.

In a project which is fast tracked, the minimum balance may not only been lowered by extra costs, but also may shift in time. As a result, the contractor may need budget that is not been financed earlier. The problem becomes worse when the project become over budget.

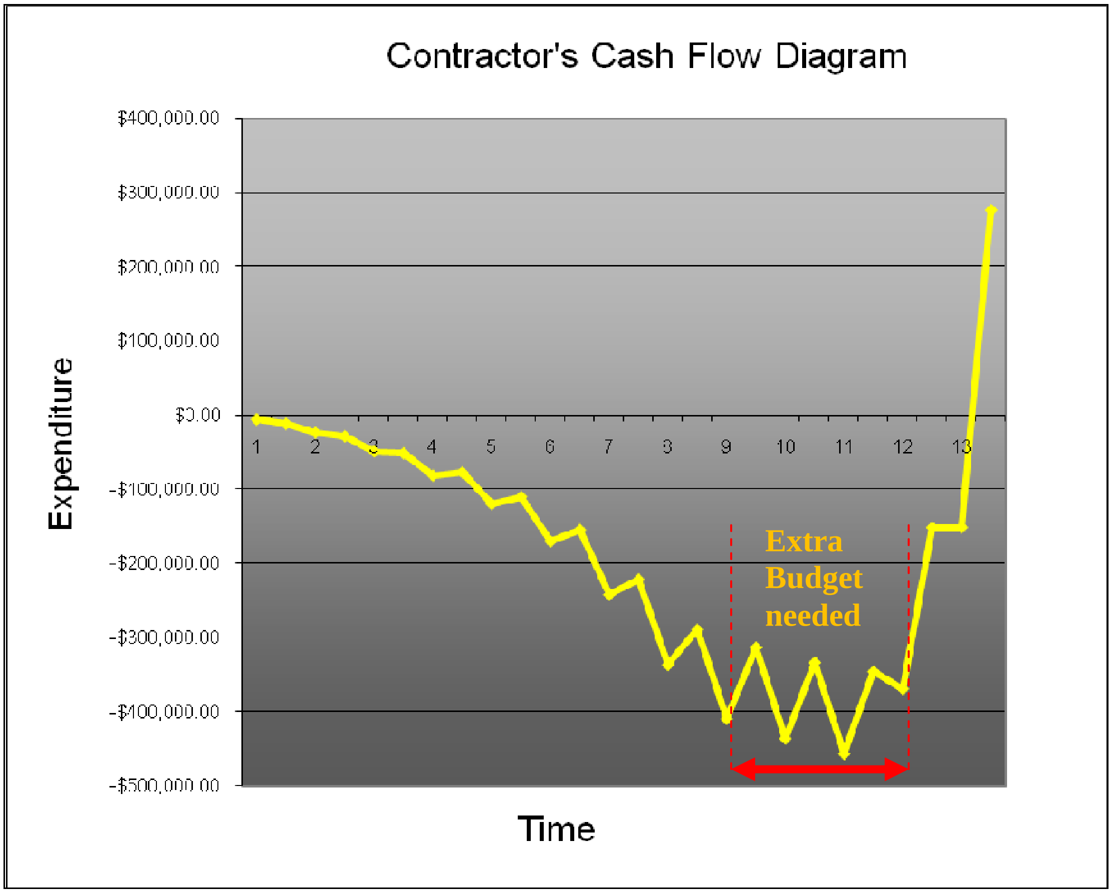

Figure 15 – Contractor's cash flow diagram

As it is shown in the above figure the maximum budget is needed in certain duration of the project life time. If for any reason the project is delayed of expedited the financing period may be postponed or expedited. This may bring additional pressure to the General Contractor and even Subcontractors.

7. Chapter seven - Conclusion

The topic of this thesis has been the evaluation of ways to recover late construction projects from a contractor’s perspective.

In chapter one Critical factors affecting the performance of construction projects in the United States, Finland and India are discussed. In Indian projects “Conflict among project participants” is identified as the main reason for failure, and “Commitment of project participants” and “Owner's competence” are known as the main reasons for success. In Finland “Lack of decision-making process”, “Lack of time for planning”, “Difficulty in updating regulations”, “User’s need”, “Lack of trust”, “Lack of risk assessment”, “Failure to learn from successful projects”, “Resistance to use of IT” and “Lack of change management” have been counted as the main failure elements.

In chapter two Earned Value, Monthly and weekly reports, study cost reports and self performing” are mentioned as tools to evaluate delays.

In chapter three Practical ways of compensating delays are introduced and a summary of them with advantages and disadvantage of each is provided at the end of the chapter. “Lean construction”, “Positive working environment”, “Employee Engagement”, “Building trust” and “Knowledge management” and “Fundamental state of Leadership” which are managerial methods have been studied in chapter four.

Crashing and Activity Overlapping or Fast tracking are studied in chapter five and Effects of Schedule Pressure on Construction Performance is discussed.

There are different ways to compensate delays in each project. The managerial ways include: “Use of lean construction”,”Create a positive working environment”, “Building trust”, “Knowledge management” and “Fundamental leadership”.

These methods can be used in all kinds of projects. They are not only related to the managing late project, but also may encompass broader range of programs in the company and can be extended beyond the life of one project. Depending on the type of construction that company is involved, the effect of these methods could vary, but all of them are effective and can expedite the projects.

The practical ways may vary for each project. Based on what was discussed, best practical ways to recover behind schedule projects are determined by the type of projects.

In general, construction projects can be divided to four main categories which are: Residential, Commercial, Infrastructures and Heavy industrial. Table 13 shows suggested methods to recover each project category.

Since each project is unique; the suggested methods can not be counted as definite answer and are only recommended methods. The ultimate decision has to be made by the Project Manager who can distinguish which method works better.

Project type	Effective method
1. Residential Building construction	1-1 Increasing working time 1-2 Adding more working personnel to the existing manpower 1-3 Hiring supplemental subcontractors 1-4 Extending the project duration
2. Commercial Building construction	2-1 Increasing working time 2-2 Hiring supplemental subcontractors 2-3 Extending the project duration
3. Infrastructures Projects such as pipe lines, channels and roads	3-1 Increasing working time 3-2 Planning and scheduling for the rest of the project 3-3 Adding more working personnel to the existing manpower 3-4 Learning or Experience curve effect 3-5 Hiring supplemental subcontractors 3-6 Extending the project duration
4. Industrial Projects	4-1 Hiring supplemental subcontractors 4-2 Extending the project duration

Figure 16 – Suggested practical ways to compensate delays in each project category

Because of working period restrictions “Increase in working time” is not recommended for industrial projects, but it works well in other types.

In Residential and Commercial projects time consuming methods like “planning and scheduling for the rest of project” may not work.

Industrial projects and Commercial projects require expert crews in the construction team and “Adding more working personnel” is not recommended for these types of projects.

“Hiring supplemental subcontractors” and “extending the project duration” are functions of project duration and subcontractors behavior and can be helpful in all types of projects.

All types of projects may experience Learning and Experience curve effect. Since no action should be taken in these projects these effects are not mentioned in the figure.

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