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Is Noncritical Progress Critical?

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WHAT IS HAPPENING TO OUR LABOR POOL?

Back in the days of cheap gas and fast cars, stories about construction labor shortages were focused on significant Projects in remote areas such as the Alaska Pipeline or the Dakotas Gasification Projects. Through the years, the construction labor shortage has spread across the country to the heartlands.

In December of 2003, the Indiana Construction Roundtable Inc., released a study warning that a future severe skilled worker shortage could lead to delays, extended costs, and a slower economic development. The study forecasts a 6,500 skilled craft worker shortage by the summer of 2004. The Projects surveyed in the study include an airport, schools, hospitals, wastewater, highways, and industrial. The study indicates severe shortages in virtually every construction craft [11].

Indiana is not alone: in Kansas, a contractor's growth is restricted due to lack of masons. The current labor force is so limited that the contractor is teaming up with a local community college to encourage the current students to learn the trades. In fact, it is common for contractors to recruit at colleges to supplement their labor force [5].

The old adage that you need to be related by blood to be an apprentice is gone. In Cleveland, labor unions are using radio stations to advertise in order to recruit new members.

Outside of the heartland, in Hawaii, the construction market is growing by a 95% increase in the number of building permits obtained in the first quarter of 2003 compared to the same quarter in 2002. What could dampen this picture? A severe labor shortage, as the area is experiencing a labor shortage in certain crafts [2].

Thoughts on the cause of the nationwide construction labor shortage vary. Questions are being asked such as does an apple not fall far from its tree or do the youth of today follow in their family's footsteps? In regards to career paths that involve the construction industry, the answer is no. Fewer children are following their fathers into the trades. In some areas of the country, the supply of skilled construction labor is simply shrinking due to attrition.

> According to labor statistics, an average of 240,000 skilled workers are needed every year to replace those who are retiring or leaving the construction industry and to allow for growth. The average age of journey-level workers is 48 years old [4].

For example, one notable area of change is the construction worker's resume. Today's construction workers are overall more educated than in the past. Most of today's workers have a high school education and often, post-secondary education on top of their trade training. In the past, the same positions consisted of individuals with limited literacy and numerical skills [1]. This demographic alone may be the reason for the decrease in workers, because with additional education, workers are able to find employment elsewhere rather than working as a trade craftsman.

Additionally, experts suggest, construction work is not respected the way it once was portrayed, thus youths are not drawn to it. Workers are leaving the construction industry due to society's social status position on manual labor. Also studies indicate that:

> Americans downgrade the very jobs where skilled workers are in short supply … Young people who don't go to college are seen as failures [7].

Although the modern construction worker is more educated, in many cases it is found that the individual is less skilled in the practices of the trade. The number of those individuals enrolling in union apprenticeship programs has steadily declined, and overall union membership is down to roughly 20% of the total workforce [7]. Workers believe they do not need as much specialized craft training to be successful because they have more academic schooling. However, the college classes are not a good substitute for shop class and hands-on skill development.

> A drop in union memberships also means a decline in workers' skills, since fewer recent hires have participated in the apprenticeship programs jointly operated by unions and contractors [7].

As a result, some construction workers do not meet the current standard for skilled workers and thus actually diminish the supply occurring in the US.

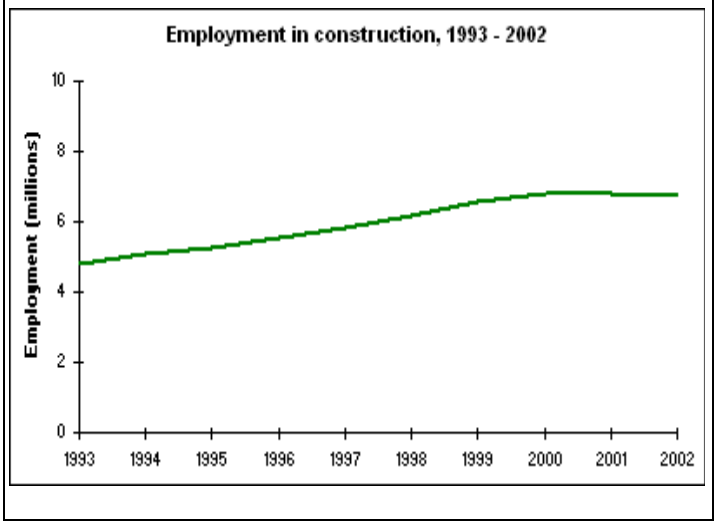

Figure 1

IT ISN'T JUST THE INDIVIDUALS—IT IS GROWTH

In addition to the number declining of skilled construction workers, the industry as a whole has seen an economic boom over the last decade. The US Department of Labor, Bureau of Labor Statistics states that the average construction employment has grown from 4,779,000 in 1993 to a high of 6,826,000 in 2001. The 2002 construction employment declined slightly to 6,732,000.

Figure 1 [6] from the Bureau of Labor Statistics records an average annual growth rate of approximately 4%.

Based on this growth rate and a decline in the ranks due to attrition, one would believe that there would be no unemployment; however, that is not the case. Nationwide there will always be unemployment due to job location, timing of Projects, and the demographics of the country. The Bureau of Labor Statistics reports a significant decline in unemployed construction workers from a high of nearly 18% in 1992 to a low of 6% in 2000. Figure 2 illustrates the significant decline in construction unemployment compared to the overall national unemployment, indicating the increased demand for construction workers.

WHAT DOES THIS MEAN TO THE BOTTOM LINE?

Success is measured on a Project by completing the work on time and on budget. The three major controlling components to all successful construction Projects are manpower, material, and management. A major key to success is having an ample supply of skilled workers.

Typically, the success of the labor component is measured via a comparison of the budget hours to the actual expended hours, and often the budget is adjusted for scope additions and deletions. Even so, rarely is there a contemporaneous or post-Project evaluation of the affect of scope variations on the labor pool (limited resources).

Further, the other "success meter," completion on time, is also not evaluated based upon the impact to limited resources. The reason for the lack of this objective analysis is that contracts tend to steer away from recognizing the potential impact caused by the limited resources.

Since the development of CPM Schedules, the focus has been on the arrow and node and not the resources. Contract time is a defined and essential component of the construction contract. As a result, today's Contract Specifications undoubtedly address equitable adjustments for time through change order and claim management clauses. The pertinent specification sections include the notification requirements, the requirement for specific types of schedule analysis, as well as how to address the impact of soil changes, weather, scope change, etc. The most important determining factor to opening the door for an equitable time extension is demonstrating that the delaying or impacting event is on the critical path of the Project.

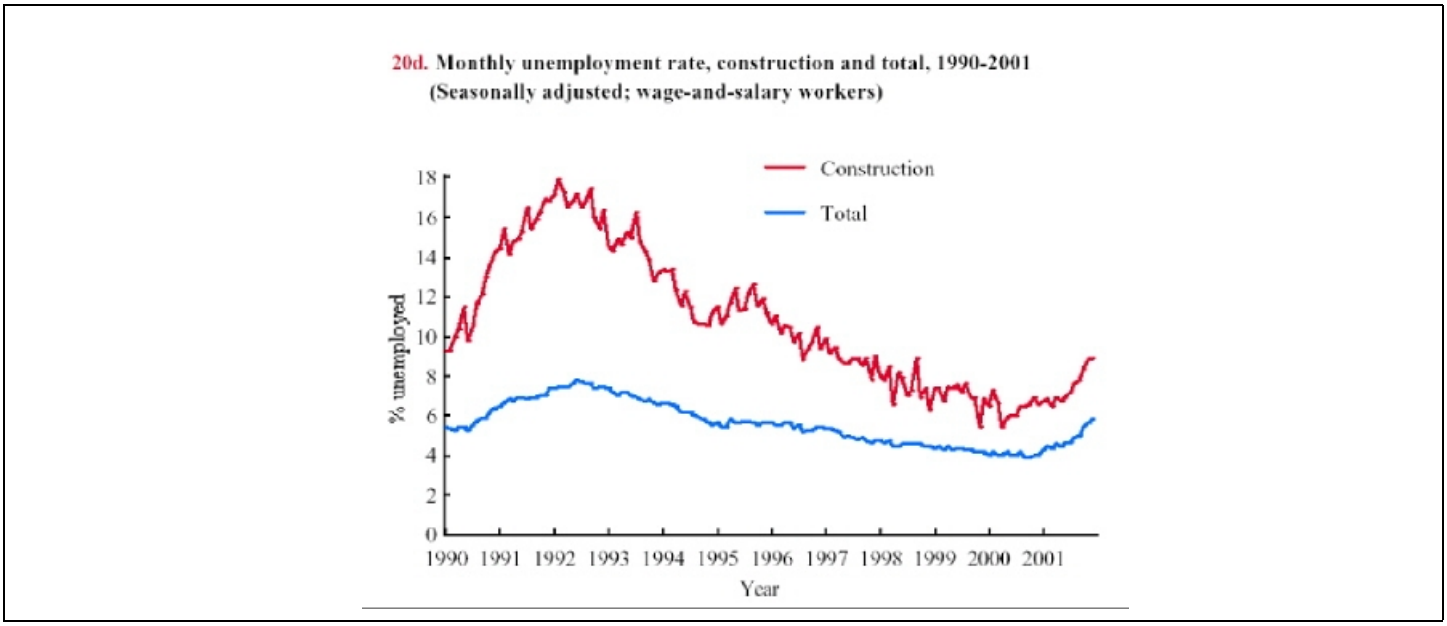

Figure 2 [6]

In fact, most Project Specifications establish the requirements and procedures for an equitable adjustment to the contract time due to conditions beyond the control of the contractor, such as change orders, differing site conditions, force majeure, or delays by third parties. A major consideration to the granting of a time extension is that the contractor is able to demonstrate the impact to the overall Project Completion Date or to an individual milestone. In other words, the Contractor must show an impact to the elements on the critical path leading to Project completion or a milestone date.

For example a contract clause taken from a General Service Administration Contract is as follows:

> The Contractor's bid daily delay rate shall be used to negotiate Government caused delays after the notice to proceed has been issued, provided that the Contractor can demonstrate *that the delay was caused solely by the Government and resulted in a delay to the critical path of the contract* as evidenced by the current and up-to-date CPM Schedule that has been approved by the Contracting Officer. Recovery of such sum shall be the Contractor's sole remedy for compensation delays. For all delays, the daily delay costs cover all costs and mark-ups covered under Section 2.03, Paragraph (a), above does not apply to delay modifications or to any portion of a contract modification that addresses delay [emphasis added] [9].

The requirements may go further to stipulate that only the elements on the critical path will be granted a time extension and relieved of liquidated damages, for example:

> Notwithstanding any other provision of the Contract Documents, *time extensions will depend upon the extent to which the Work on the Critical Path of the Construction Schedule is affected.* A Change Order granting a time extension may provide that the time for Contract Completion will be extended for only those specific elements so interfered with, disrupted, hindered or delayed and that remaining milestone completion dates will not be altered and *may further provide for equitable adjustment of Liquidated Damages* [emphasis added] [10]

Another example, the Massachusetts Highway Department specification states the following:

> No extension in the Contract Time(s) or Contract Milestone(s), and no claims by the Contractor for adjustment in the Contract Price on account of any delay in the Work or any delay or suspension of any portion thereof, shall be granted unless the Contractor adequately demonstrates to the satisfaction of the Engineer through an analysis of the current Progress Schedule that the Work or any part thereof, will be delayed or extended beyond the Contract Time(s) and/or Contract Milestones specified in the Contract Documents, or as adjusted by Change Orders due to unforeseeable events beyond the control and without the fault or negligence of the Contractor, or any of its Subcontractors or suppliers at any tier, and despite the Contractor's reasonable and diligent efforts.

The foregoing references indicate that Project Owners will recognize the need to adjust the contract time; however, that recognition is limited to the elements previously identified as being part of the critical path. Therefore, it is not sufficient to limit the definition of the critical path on the Project Schedules to identifying activity durations, and preceding and succeeding activities; the Project Schedule must identify the labor resource allocation and its limitations. This is essential in that as the Project evolves, the fluctuations of the resources are identified and to the extent that the resources exceed the upper limits (become critical) the impact can be fairly evaluated per the guidelines established in the contract specifications.

In support of the need to analyze the "limited resource," Dr. John W. Fondahl, a distinguished professor from Stanford University, in his 1990 Peurifoy Construction Research Award presentation, described a schedule activity as "Resource Critical." Dr. Fondahl's explanation was as follows:

> A critical activity in a Project can be defined as one that, if delayed, will delay Project completion. Normally, these activities have zero total float and are part of paths through the Project network composed solely of other critical activities. If they take longer to perform than their estimated duration the Project will be delayed. If they are performed at their estimated duration but start late, the Project duration will be delayed. One reason for starting late is that sufficient resources are unavailable in the resource pool. These resources will only be available when activities using them are completed and, therefore, those activities are able to release a sufficient number of the required resource units. Often those activities that must release resource units may not be critical in the sense of having zero float. However, if they fail to release the resource units needed by a critical activity, they delay that activity and, hence, the Project. Therefore, an activity having positive float can still be "resource critical," since it will delay Project completion if it fails to release resources on time. In more complex networks, there may be several activities that release resources to the resource pool on a given date and, therefore, to a critical activity that needs some of these resource units from the pool. In these cases there may not be a single specific activity in the group that must release its units and that, therefore, can be identified as being "resource critical. [3]

Dr. Fondahl explained his point by discussing a hypothetical warehouse Project. In summary, this analysis demonstrates that a significant change to the critical path goes unnoticed due to the limited resource not being considered as a component of the float calculation. The analysis illustrates that the conventional float calculations should consider resources as a constraint to the Project.

During the recent massive public works project in Boston, called the Big Dig, there weren't enough available ironworkers in

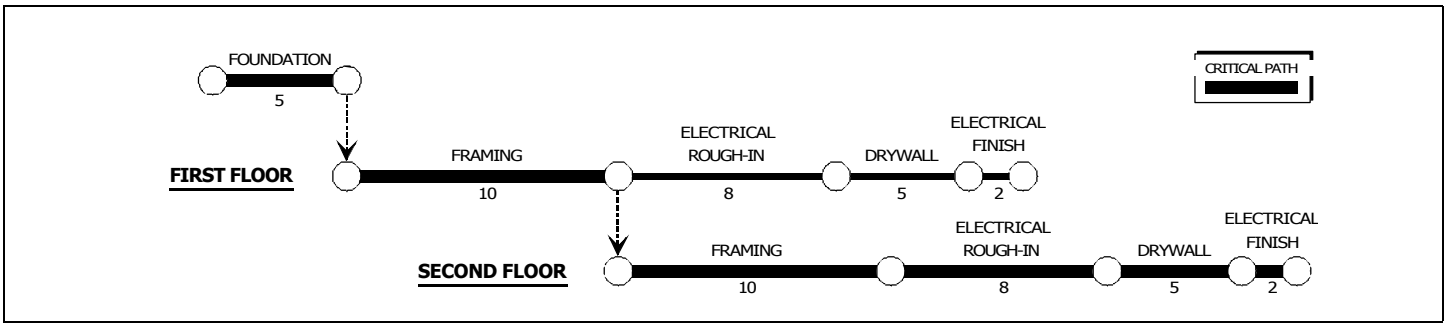

Figure 3

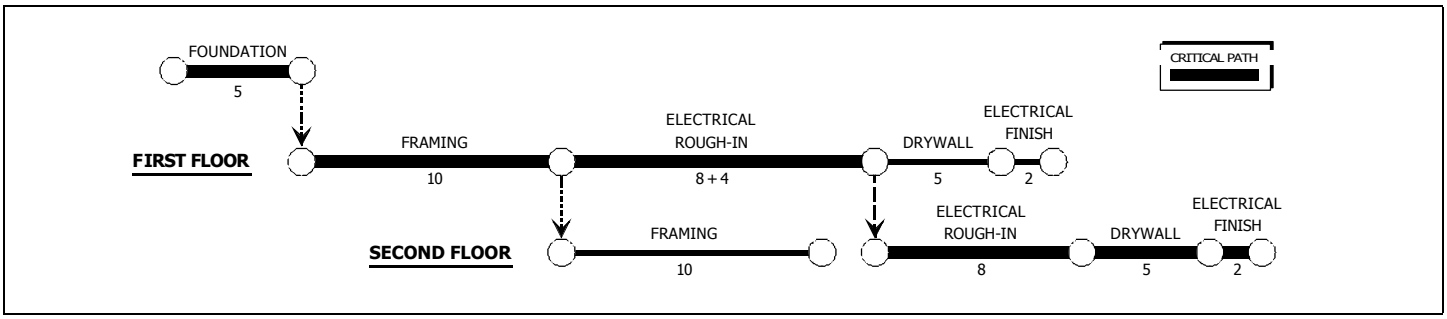

Figure 4

the area. The Big Dig is the nickname for the multibillion dollar public works Project in which the main central artery (elevated highway) passing through the center of Boston was replaced with a series of underground constructed tunnels. Considering that excavation and construction was occurring in areas where numerous buildings and utility services had been constructed over the last 300-plus years, the Project experienced a multitude of scope changes. Many of the scope additions occurred on activities that had available float, however, the added scope utilized manpower that could not be reassigned until it completed the task and thus delayed resources being assigned to the true critical path of the Project. The result: the available craft labor in the immediate Boston area was consumed. Part of the solution was to increase the circle of influence to draw labor from around the country by offering higher pay, fringes, and overtime. However, the lack of manpower could not be totally managed and resulted in extending the Schedule. Certainly, resource management became a critical component to the success of the Project.

HOW DOES IT LOOK/HOW DO WE ANALYZE?

Currently, there are numerous Projects that have construction activities that are "resource critical." Considering a far simpler Project, the "resource critical" principle can be simply illustrated by the following network example (Figure 3) of a two story framed structure with electrical services.

The critical path of the Project is:

- Foundation 5 days
- Frame 1st Floor 10 days
- Frame 2nd Floor 10 days
- Electrical Rough-in 2nd Floor 8 days
- Dry-wall/Finish 2nd Floor 5 days
- Electrical/Finish 2nd Floor 2 days
- Total Duration 40 days

First Floor Framing successor activities have 10-day floats as determined below.

- Foundation 5 day 5 days
- Frame 1st Floor 10 days
- Electrical Rough-in 1st Floor 8 days
- Drywall/Finish 1st Floor 5 days
- Electrical/Finish for 1st Floor 2 days
- Total Duration 30 days
- Total Float = 40 days – 30 days = 10 days

This is important because the electrical contractor is a small contractor with limited manpower availability, but he does intend to dedicate his only 5-man crew to the Project. Work begins, the framing of the first floor occurs as scheduled, and the framing crew moves onto the second floor. The electrical contractor started the rough-in on the first floor when the Owner decided to add a security and data system to the first floor, which adds 20 workdays of work to the electrician's first floor rough-in scope. The additional 4-day scope change occurs on the non-critical path of the Project, thus the approved Project Completion Date is not extended. In reality, due to the resource restraints, the Project is extended by 4 days because of the additional work delays of the electrician (see Figure 4).

Currently many contract change order clauses do not address "resource critical" extensions. Some contractors, faced with the dilemma of restricted manpower, add logic ties to represent manpower limitations. The manpower links require the completion of physically unrelated tasks such as electrical rough in on the completion of the 1st Floor prior to starting the rough-in on the 2nd Floor. Resource links are applicable in some cases; however, it may become very difficult to administer on complex Projects and may result in network logic distortion if not periodically verified. Further, in many cases the contractor's or Project's true manpower restraints may be higher than the original scheduled crew size. A contractor may have the resources to increase its crew or split crews. The better solution is the use of resource loaded schedules, which has been largely ignored by the construction industry. Owner, Architect, and Contractor should recognize that many of our Projects and Schedules are resource constrained and should use appropriate contract language and analysis to properly determine Project Completion Dates.

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