The Theory of Criticality in **Concurrent Delays**

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ABSTRACT

Assigning liability and quantification of compensability are the two prime objectives in forensic analysis in construction delay claims. These objectives are inextricably linked to the issue of defining 'criticality' of delays. That issue becomes a more perplexed one when it involves concurrent delays. Since the advent of using Critical Path Method (CPM) for resolving delay claims, there have been two fundamentally different approaches for defining the 'critical path'. These differences are represented by two distinct theories, namely 'Total Float Value' (or Zero Float school) and 'Longest Path' (or Lowest Value school). Accordingly, in defining the 'criticality' of the delays, a delay analyst may face an all important question whether all activities having total float less than or equal to zero are critical, or only those having the maximum negative float are critical. The former is the position of Total Float Value theory and the latter represents the Longest Path theory. Dependent on the theory relied on, the two approaches would possibly generate completely different or even opposite outcomes in the apportioning of compensation. Often, these contrasting outcomes could generate more disputes between the parties than those they try to resolve. The objective of this paper is to review the conduct of these theories in determining the 'critical effects' in forensic scheduling, particularly in the context of concurrent delays. The review is based on published academic works and case law, and has identified some problem areas in praxis, with the intention of promoting a broader dialogue for finding solutions for same.

Key Words: compensability, concurrent delays, criticality, float, longest path.

INTRODUCTION

A forensic delay analyst who uses a CPM based construction programme for apportioning compensability would have to select mainly between two primary approaches for defining the 'criticality' of the delays to completion date. This situation is best explained by the two fundamental theories, known as the 'Longest Path' (or Lowest Value school), and 'Total Float Value' (or Zero Float school). Accordingly, he would have to face an all important question: whether all activities in the CPM based construction programme having total float less than or equal to zero are critical, or only those having the maximum negative float are critical. The former is the position of Total Float Value theory and the latter represents the Longest Path theory. Dependent on the theory relied on, the two positions would possibly generate completely divergent or even opposite outcomes in the apportioning of compensation.

The delay analyst's dilemma would become more complex when he is tasked to deal with concurrent delays.

The essentially distinct characteristics of these two theories are discussed here in the context of concurrent delays, highlighting their potentially contrasting outcomes produced in delay analysis and resulting problem issues in praxis.

Types of Delays

Generally, the apportioning by responsibility can be characterised in three types of delay (Alkass et al., 1996; Wickwire et al., 1988, 2003; Baram 1994; Reams, 1989, 1990; Kraiem and Diekmann, 1987):

- "Non-excusable" delay which is caused by fault of the contractor or for which the contractor has assumed the risk, and therefore, entitled to neither an extension of time nor monetary compensation;
- "Excusable but non-compensable" delay which is typically outside the control of the parties (for example, 'acts of God'), and entitled to extension of time but no monetary compensation;
- "Excusable and Compensable" delay which is caused by the employer or for which he has assumed the risk, and therefore, the contractor is entitled to an extension of time and monetary compensation.

Arditi and Robinson (1995) and Stumpf (2000) identified the interrelationships between these types falling

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into any of three categories, namely, Independent Delays (which are single and occur in isolation) or Serial Delays (which are consecutive, non-overlapping delays) or Concurrent Delays. Unlike 'independent' or 'serial' delays, the concept of 'concurrent' delays remains the single most perplexed issue in determining the compensability. It is perhaps considered the most controversial subject in forensic delay analysis (Livengood, 2007).

Concurrent Delays

The relevance of concurrent delays in delay analysis is wholly related to one issue: compensability. When all delays are critically affecting the time for completion, a party who needs to defend a claim would find the significance of a concurrent delay as it may permit him to offset the compensability claimed by the other party (Bramble and Callahan, 2000). In other words, its use is for the contracting parties trying to cancel out the compensability of one another.

However, in the construction scheduling, the term 'concurrent delay' has numerous definitions (Zack and Federico, 2011). That makes this already complex issue furthercomplicated. It appears that much of the controversy surrounding the term 'concurrent delay' is whether the events leading to delay must be simultaneous in occurrence or merely offsetting in effect.

According to some academic and professional work, a concurrent delay can be described as a situation in which two or more delays are occurring at the same time during all or a portion of the delay periods being considered (Wickwire et al. 2003).

For others, to be considered as concurrent delays, the delays need not actually take place at the same time (Ness, 2000). Thus, 'concurrent delays' may occur (i) when there are two or more independent delays during the same period, and (ii) during any part of the project performance period, not necessarily at the same time (Bramble and Callahan, 2000; Tobin, 2007; 'SCL Protocol', 2002).

Though there appears no universally accepted definition for 'concurrent' delay', the second definition above seems corroborating with some case authorities in the UK and the US courts. For example, in the UK jurisdiction the existence of such sequential 'causes' of concurrent delay 'effects' was accepted by Judge Seymour in *The Royal Brompton Hospital*[1] when he considered an argument that two delays happening at different times were the concurrent delays. In the US, in *Raymond Construction of Africa, Ltd.*[2] the court determined that three consecutive delays were concurrent; similarly, in *Williams Enterprises, Inc*[3]. the federal court determined consecutive delays as concurrent delays.

Considering the foregoing, unless expressed otherwise in a contract, it may be safe to consider that both 'true concurrency' (related to occurrence of two or more delay events at the same time) and 'concurrent effects' (related to two or more delay events arise at different times but the effects of them are felt at the same time) should have equal status and effectiveness. The increasingly popular Delay and Disruption Protocol of the Society of Construction Law (the 'SCL Protocol') has considered this approach in its core principles (ref. item 1.4, and 'Figure 9'); for now, that seems to have offered a 'way-out' to the delay analysts to agree on a 'definition'.

However, in another front, the divide between the above two positions still stands out against such consensus. That usually happens when a CPM based programme is used for apportioning the compensability between concurrent delays. This is mainly because the delays occurring with concurrent effects of not so equal potency are dealt with differently in the delay analysis, at least by two prominent theories as to 'criticality' in forensic scheduling.

Theory of 'Criticality' in Forensic Scheduling

Peters (2003) emphasised the inextricable link with the issue of the definition of criticality in analysing concurrent delays. This is due to that the definition of 'criticality' can be set to either all activities on the Longest Path, or alternatively, all activities with a float value less than zero (Keane and Caletka, 2008). These two contemporary definitions provide the basis for the two prominent theories as to 'criticality' in forensic scheduling. The AACE International (2011) 'Recommended Practice No. 29R-03 Forensic Scheduling Analysis, which is the US counterpart of SCL Protocol, has recognised and explicitly differentiated the fundamental differences between these two theories, namely 'Longest Path' theory (which is also called 'Lowest Value School') and 'Total Float Value' theory' (which is also called 'Zero Float School'), as to defining the critical path. Acknowledgement and understanding of these differences are fundamental for determining the entitlement to and the quantum of compensability in concurrent delays.

A CPM programme's critical path is the Longest Path of logically connected activities which, when the individual time durations of each activity are added, equals the overall duration of the project. At any given time there could also be multiple critical paths parallel to this longest critical path (Wickwire et al., 2003). While this Lon-

[1] The Royal Brompton Hospital NHS Trust v Hammond And Others [2001] 76 Con L.R. 148

[2] Raymond Construction of Africa, Ltd. v United States, [1969] 411 F2.D 1227 Ct. Cl

[3] Williams Enterprises, Inc. v Strait Manufacturing & Welding, Inc., [1990] 728f. Supp.12 D.D.C.

gest Path is perfectly capable of predicting the project duration and the *project completion date* at a given time, it will not reveal the existence of all the other subordinate multiple critical paths at that time (which are also critical to the *contract completion date*). The 'critical path' is a dynamic phenomenon. As the project progresses, the Longest Path may change and a previously subordinate critical path may become the Longest Path. Thus, where two causes of delay are of different causative potency, according to the Longest Path theory the longer delay is then regarded as the effective cause and the shorter or the subordinate one as the ineffective. In other words, the minor cause is treated as if it were not causative at all (Marrin, 2002). This is because, under the Longest Path theory, if an activity has a float with respect to the Longest Path in excess of a given delay, it can absorb that delay, and therefore no time extension will be required relative to the existing *project completion date*. In other words, a residual 'float' will be created by the largest negative float (of the Longest Path) which can absorb the shorter delays in the subordinate (critical) paths; thus, the mere fact that an activity has a negative float will not determine its criticality.

However, on the other hand, if the 'criticality' is determined by Total Float Value theory all activities that have negative float (i.e. one or more unit below zero total float) relative to the existing *contract completion date* are considered 'critical' (Jentzen et al., 1994; Peters, 2003).

Considering the characteristics of both concepts 'true concurrency' (where the delay 'effects' are of equal potency) and 'concurrent effects' of sequential delays (where the delay 'effects' may be of not so equal potency), one can easily observe that the Longest Path theory is generally premised on the former concept while Total Float Value theory goes with the latter. Accordingly, depending on which of the above theories is followed, a 'critical delay' could be a delay which has caused (or which can be shown to be likely to cause) a delay to either the prevailing *contract completion date* or the (predicted) *project completion date*. These two definitions for 'criticality' obviously generate different or even opposite outcomes in the apportioning of compensability.

Determining 'Criticality' in Concurrent Delays

Once a schedule is constrained to its completion date that will alter one of the basic rules of CPM scheduling (O'Brian and Plotnick, 2005). In doing so the late finish of the last activity becomes equal to the early finish of the last activity, and accordingly, if that last activity is delayed beyond that late finish date, the calculation of the 'Total Float' will be a negative value. Thus, when a project is behind schedule, the network model may display negative float values indicating how many work days the schedule activity is behind schedule.

Now, in defining the 'criticality' of the delays, a delay analyst may face an all important question that is:

> Whether all activities having total float less than or equal to zero are critical, or only those having the maximum negative float are critical?

The answer to this question holds the essential difference between the above two theories interpreting the criticality of activity paths carrying negative float value (Perera, 2012). Importantly, that will also decide which position should be adopted in defining 'concurrent delays', whether to consider for setting-off the 'true concurrency' only or the 'concurrent effects' of sequential delays as well. Ensuring that the concurrency analysis is in harmony with the contract's definition of 'criticality' is essential because *"Virtually all forensic delay methodologies provide for extensions of contract time on the critical path only" and "therefore, critical path definition is of utmost importance"* (Livengood and Peters, 2008, p. CDR.06.14).

In order to understand further the fundamental differences between these two theories, it would be pertinent to see how they apply in a concurrent delay situation giving entitlement of the parties. For this, two scenarios are examined below with reference to a graphical presentation in Figure 1.

- **Scenario no.1**: Longest path delay (in Path 1) is caused by the employer with a compensable delay and subordinate path delay (in Path 2) is caused by a nonexcusable contractor delay.

  Outcome under 'Longest Path' theory: the contractor may consume negative float (created by longest delay of Path 1) as long as the contractor's subordinate path (Path 2) finished earlier than the employer's longest delay. He is not in a critical delay relative to the (predicted) Project Completion Date which is set by the Longest Path, and also is entitled to recovery of extended overhead expenses for the entire length of the Longest Path delay.

  Outcome under 'Total Float' theory: Concurrent effect of delays is considered and the contractor is granted extension of time for the duration of the effect of subordinate delay; employer loses right to liquidated damages (LD) and contractor has to forego extended overheads unless he can segregate costs from those caused by employer delay. The contractor, however, is entitled to both time and money (in the form of extended overheads) for the remaining non-concurrent period. In this outcome the employer does not have to compensate for extended overhead costs for the entire Longest Path delay period of employer's compensable delay.

- **Scenario no.2:** Longest path delay (in Path 1) is caused by the contractor with a non-excusable contractor delay and subordinate path delay (in Path 2) is caused by the employer with a compensable delay.

Outcome under 'Longest Path theory': the employer may consume negative float (created by longest delay of Path 1) as long as the employer's subordinate path (Path 2) finished earlier than the contractor's longest delay. He is not in a critical delay relative to the (predicted) Project Completion Date which is set by the Longest Path, and also is entitled to recovery of LD for the entire length of the Longest Path delay.

Outcome under 'Total Float theory': Concurrent effect of delays is considered and the contractor is granted extension of time for the duration of the effect of subordinate delay; employer loses right to LD and contractor has to forego extended overheads unless he can segregate costs from those caused by employer delay. The employer, however, is entitled to recover LD for the remaining non-concurrent period. In this outcome the contractor does not have to pay LD for the entire Longest Path delay period of contractor's non-excusable delay.

The foregoing illustrates that if the 'Longest Path' approach' is adopted the delays on the other subordinate paths are considered non-critical relative to the (predicted) Project Completion Date. In this instance, the effect of subordinate concurrent delay would not permit to offset the compensability of the longest delay. However, if the 'Total Float' approach is the one adopted then all the delays (in the longest and the subordinate path) are considered 'critical' relative to the (prevailing) Contract Completion Date. In this case, the subordinate delay would permit to offset the compensability of the longest delay to the net extent of the concurrency (subject to segregation of costs).

However, in the absence of clear contract terms, the legal position on which approach or theory to be followed to define 'criticality' is not clear. This is a continuous debate even in the US where CPM based forensic schedule analysis is almost mandatory in delay claims resolution and given higher prominence than in any other jurisdiction. One of the famous landmark cases among the US case authorities in this regard is *Santa Fe, Inc.*[1]. In this case, there was a LD clause in the contract and as the contractor (Santa Fe) delayed, LDs were imposed. The contractor appealed for a remission of LDs and sought extension of time. A section of the *'Santa Fe'* contract entitled 'Adjustment of Contract Completion Time' which stated as follows:

> *"Actual delays in activities which, according to the computer-produced calendar-dated schedule, do not affect the extended and predicted contract completion dates shown by the critical path in the network will not be the basis for a change to the contract completion date".*

The above provision was obvious that the 'criticality' had to be determined by the impact on the 'extended and predicted' completion date and not on the contract completion date. By virtue of this provision, the contract required to use 'Longest Path' approach to measure criticality. The contractor maintained that impact of changes on the unchanged work could not be demonstrated by the CPM rules and the government's reliance on rules was not applicable or just because *"all uncompleted work becomes negative and therefore critical, once the scheduled completion date has been reached".* He also argued "…*any work sequence or CPM path which runs past its contractually required completion date to be critical and any delays on those work sequences to be on the critical path".*

However, rejecting the contractor's argument, it was held that delays that did not affect and extend the *predicted* contract completion date should not be the basis for a change to the *contract* completion date. The contractor's arguments for negative float activities were rejected on the view that *"there is still a critical path repre-*

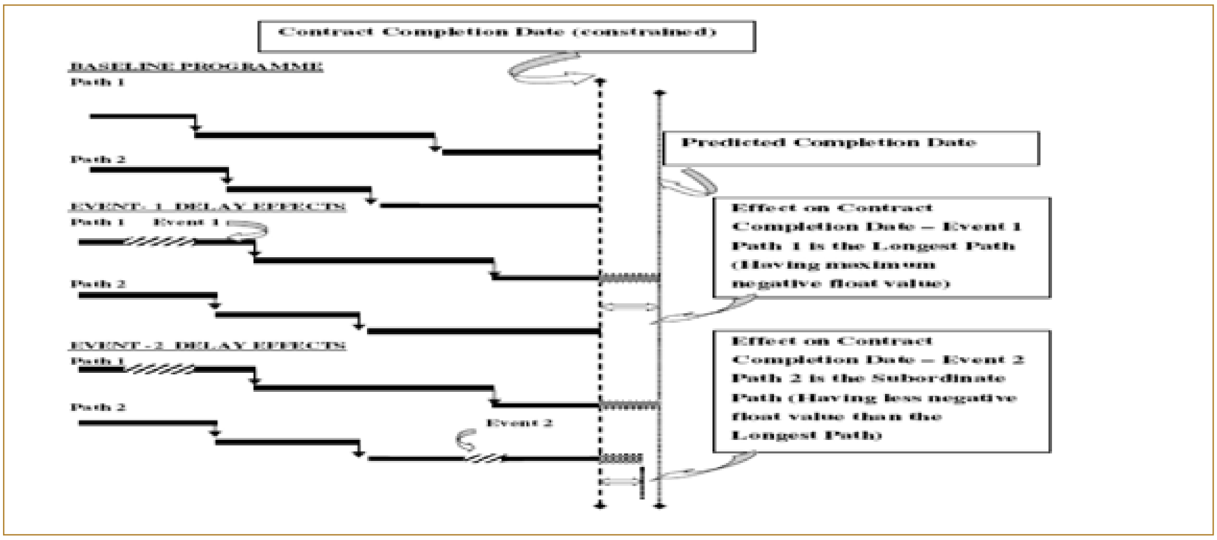

Figure 1 Graphical Illustration of Delay Effects

sented by the negative slack activities with the highest numerical designation (for example -180 days versus -50 days). The activity chain representing the highest negative slack (for example, the -180 days) represents the longest chain of activities through the project in terms of time" (Wickwire et al., 2003, p.376).

Figure 1 Graphical Illustration of Delay Effects

It could have been interesting to see how the *'Santa Fe'* would have been decided if that specific provision was not present in the contract, but the court did not make any comment on that aspect. In this context, however, there has been no suggestion from any other published work what alternative method of delay analysis can be used if the contract is silent about the 'critical path' or, more particularly, if the contract requires the 'criticality' to be measured against the contract completion date, a situation which may conflict with the Longest Path theory and tend to be more in line with the Total Float theory. For example, FIDIC 'Red Book' 1987 4th edition refers to an agreed date of 'Time for Completion' (i.e. the prevailing contract completion date) as the basis to determine extension of time or LD as the case may be. In that case, it could strongly be argued that use of the Longest Path approach would be a mismatch to the agreed intention of the parties. Thus, there seems to be an inherent problem in such current practices which use Longest Path approach disregarding the expressed terms of contract. For filling that vacuum it may require a serious future effort for developing tenable alternative analysis method(s) conducive to Total Float theory.

Notably, the SCL Protocol submits in its 'core principles' that: *"Unless there is express provision to the contrary in the contract…an EOT should only be granted to the extent that the Employer Delay is predicted to reduce to below zero the total float on the activity paths affected by the Employer Delay."* It also states *"The Protocol uses the expressions Employer Delay to Completion and contractor Delay to Completion, both of which mean delay to a contract completion date.."* [Emphasis added]. Accordingly, the SCL Protocol has taken a clear position that, in absence of an express provision in the contract which may require otherwise, treating all delays having negative floats on the subordinate paths, including the delays on the Longest Path, as 'critical' delays to the contract completion date. As the SCL Protocol defines the term 'Contract Completion Date as *"The date by which the contractor is contractually obliged to complete the works"*, there seems no ambiguity in its position. These principles have been presented in the 'Figure 9': *Employer Risk Event on path 2 while contractor in unrecoverable critical delay on path 1'* of the SCL Protocol, which is reproduced below. This 'Figure 9' has clearly illustrated that the contractor's entitlement to EOT is based on the lesser or subordinate critical delay (on path 2) to Contract Completion Date.

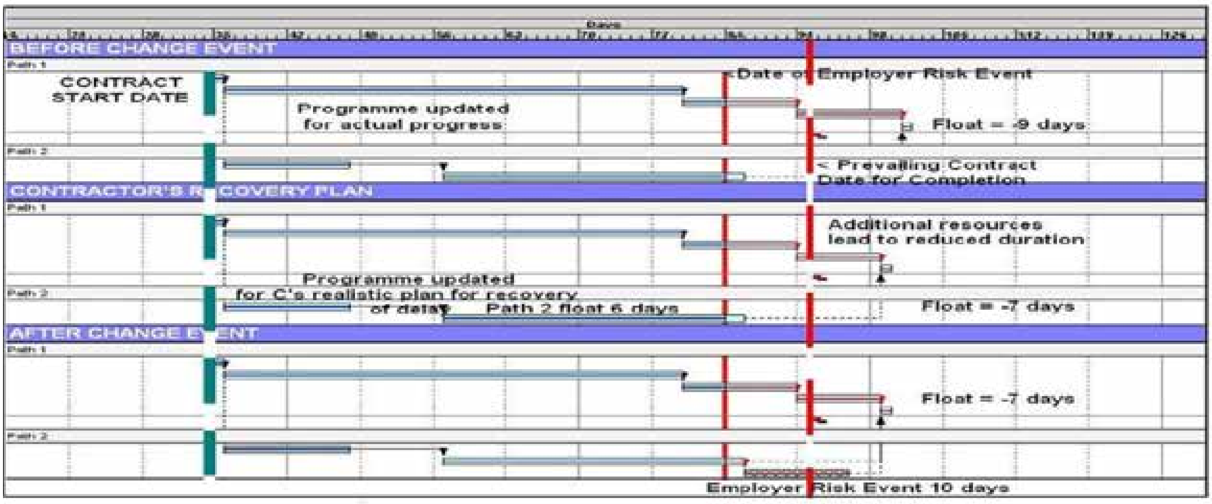

Figure 2 SCL Protocol 'Figure 9' (Source – SCL Protocol, 2002)

It appears, therefore, the SCL Protocol principle illustrated in "Figure 9" fully corroborates with the 'Total Float Value' theory. Consequently, it may be argued that it would be irrational for one to uphold SCL Protocol principles in this regard while, at the same time, adopting 'Longest Path' approach for determining 'criticality' of delays. This seems to be a significant contribution by SCL Protocol to streamline the definitions for 'concurrent delays' mentioned above with the theory of 'criticality'. Nevertheless, it would only emphasis the urgent need for developing suitable alternative delay analysis method(s) which can be used in harmony with Total Float theory, as at present there appears no such analysis technique publicly available.

CONCLUSIONS

The paper has reviewed, using published academic works and case law, the perplexities of the issues of 'concurrency' and defining 'criticality' of delays. The intrinsic links between these issues in assigning the liability and quantification of compensability in delay analysis are also explained.

The two fundamental theories for determining 'criticality' of delays are identified; here, the concept of 'true concurrency' (where the delay 'effects' are of equal potency) is essentially represented by Longest Path theory and the alternative approach to consider 'concurrent effects' of sequential delays (where the delay 'effects' may be of not so equal potency) is embodied in Total Float theory.

It has emphasised the current lack of a universal position as to the definition of 'criticality' on the issue; even in the US legal system, which has considered the forensic analysis issues more in depth than any other jurisdiction, the position as to this issue seems to be unclear.

The paper also emphasises the need, for adding certainty to the contract riskdistribution and avoiding post-contract disputes, to conspicuously address the specific approach to be adopted as to the issues of 'concurrency' and 'criticality' within the contract itself. The absence of agreement on these issues prior to arising of the delay claims in a project would possibly contribute to more disputes. Likewise, adopting such approach which could be a mismatch to what is already expressed (or reasonably implied) in a contract would also be a problem in praxis and lead to escalation of disputes.

In summary, therefore, whether the criticality is defined by the (predicted) project completion date (Longest Path theory) or the (prevailing) contract completion date (Total Float Value theory) is a matter for the terms of the contract applicable to a given project. Liability in contract will depend upon the terms of the contract and the intention of the parties (Atkinson, 2007). Thus what is in the contract will finally decide which way to go with regard to the contractor's entitlement in concurrent delays occurring after the contract completion date.

The paper has also appraised the positions taken by SCL Protocol in its 'core principles' as to the issues of 'concurrency' and 'criticality'. Accordingly, it insists the need to have a broader dialogue as to the potential paradox where the SCL Protocol principles are championed while still adopting Longest Path approach and thereby inadvertently accepting only the concept of 'true concurrency' in delay analyses. However, the paper acknowledges the current lack of delay analysis technique(s) that could be reliably used complying with Total Float theory, and emphasises the need of future research for developing appropriate alternative method(s) in order to fill that void in the repository of delay analysis methodology.

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