# Calculating and Apportioning Responsibility for Project Delays in Construction Dispute Resolution Using Modified But-For and Daily Windows Analysis Methods.

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**ABSTRACT**

Resolving construction claims has become an inevitable part of the Project Manager's job for both Contractors and Employers. The ability to win a claim is dependent on proving legal responsibility, correctly calculating, and apportioning responsibility for project delays, and the claim amount. Project delay analysis is a process of calculating and apportioning responsibility for project delays. Existing delay analysis methods are evaluated and found inadequate, and this work describes a number of improvements to address the identified shortfalls. Two accurate delay analysis methods, the Modified But-For (MBF and the Daily Windows Analysis (DWA) method, are presented to calculate and apportion responsibility for project delays using a three-dimensional concurrent delay representation that clearly shows the Employer, Contractor, and third-party delays and use of a set of fair concurrent delay rules to apportion responsibility for concurrent delays. This will help to minimize disputes in the Construction sector.

**Keywords:** *Concurrent Delays, Construction, Claims Project delays, Dispute Resolution, Delay Analysis, Daily Windows Analysis (DWA), Modified But-For (MBF) Analysis*

## 1.0 INTRODUCTION

In the past, construction delays used to be a mutually accepted condition. Today, construction delays are very problematic. Employers have tighter budgets and contractors incur real costs by staying on a job longer than planned. During and after project construction, both contractor and employer are today more likely than ever before to make formal claims for costs incurred due to project delays caused by the other party. To win a delay claim, the claiming party must establish the cause of the delay, its total impact on individual activities, and the project as a whole. Proving the effect of individual delay events can be a complicated task. It demands the use of reliable and accurate delay analysis techniques. This paper presents two methods for calculating and apportioning responsibility for project delays in construction dispute resolution – the modified but for and the daily windows analysis methods.

## 2.0 CLASSIFICATION OF DELAYS

Events that affect the project's critical path result in project delays. There are 5 categories of construction delays. Delays affecting non-critical activities which do not extend the duration of a project and warrant neither a time extension nor delay-related cost damages.

Delays where a time extension, money, or both will be paid out to the contractor, are non-excusable, excusable compensable, excusable non-compensable and concurrent delays (e.g., non-excusable and excusable compensable). These types of delays are shown in Figure 1.

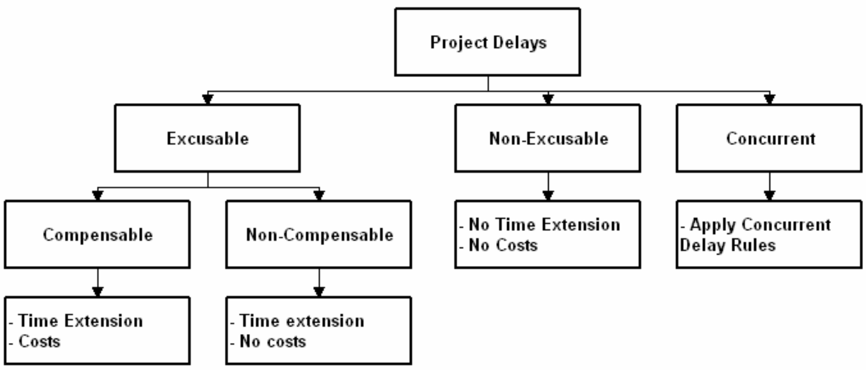


*Figure 1: Classification of Project Delays.*

In Uganda, PPDA Works Contract 2014, for example, defines employer risks arising from implementation delays in GCC Clause 11, contractor risks in GCC Clause 12, compensation events in GCC. Clause 44, liquidated damages in GCC. Clause 49, acceleration in GCC, Clause 29 and bonus in GCC. Clause 50.

A non-excusable delay is the responsibility of the contractor. Non-excusable delays are defined in most contract documents. Non-excusable delays are within the contractor's control, and are a result of the contractor's actions or inactions. The contractor cannot recover extra costs incurred, or obtain a time extension for non-excusable delays.

An excusable-compensable delay, is within the control of, or is due to the negligence of, the employer or third parties for whom the employer is contractually responsible. Excusable-Compensable delays are also defined in most contract documents. Examples include owner's failure to grant site access, defective contract documents, late arrival of employer-furnished materials or equipment, and changes in the scope of work.

Excusable-Compensable delays entitle the contractor to a time extension. In the absence of a clear allocation of delay responsibility in the contract, the contractor must establish that the cause of delay was unforeseeable, beyond its control, and without its fault or negligence to obtain any relief.

There is also another type of delay, the excusable-non-compensable delay, for which neither party is at fault. Examples include acts of God and unusually severe weather (in some contracts). Excusable-Non-Compensable delays are also defined in some contracts.

At the time of contract formation, parties are at liberty to decide what will constitute excusable-non-compensable delays and the resulting entitlement. In the absence of a contract clause allocating responsibility, courts typically decide excusable-non-compensable delay based on whether the delay situation was foreseeable at the time of bidding and was beyond the control of both the employer and the contractor. The court will grant a time extension to the contractor if the delay increased the overall project duration. The contractor is however not being granted recovery extra costs as a result of this type of delay.

The concurrent delay, occurs when two or more delay types occur during the same period, both of which, together or independently impact the critical path. Concurrent delays can also be a result of two separate delay events delaying the same activity. In both cases, if one of the two events had not occurred, the project would still have been delayed for the same amount of time, by the other event. Concurrent delays are rarely defined in construction contracts. Only a few contracts such as the Federal Acquisition Regulations of the United States of America. (FAR 52.242.14) define and provide for entitlement for concurrent delays.

If a particular delay occurs in isolation, the effect of the delay on the total project duration can be calculated with ease. This also applies to consecutive and non-overlapping delays. Problems are however encountered when delays are overlapping. Resolving concurrent delays is an active area of research and no consensus has yet been reached. In many cases, courts have refused to apportion responsibility for delays where both the employer and contractor are at fault. Despite this, courts are now more likely to apportion delay damages and award compensation based upon proportionate responsibility.

Without delay analysis techniques, courts were not able to separate the impact of delays caused by each party and generally held that each party would be responsible for the cost impact of its delay. Neither party would recover any money from the other for concurrent delays. But this was not reasonable in many cases. With delay analysis techniques, the impact of each party's actions can be identified and the relative weights of the impacted activities can be determined, leading to a more equitable assessment of damages. Where apportionment has been agreed upon, several rules have been developed to ensure equitable assessment of damages.

## 3.0 EXISTING DELAY ANALYSIS METHODS

Over the years, many different delay analysis methods have been used by the construction industry stakeholders to calculate and apportion responsibility for project delays. In principle, all the delay analysis methods attempt to achieve this, unfortunately, with different degrees of reliability and accuracy. There are several delay analysis methods available, but currently, there is no single standard or acceptable procedure in the construction industry. I have grouped existing delay analysis methods into five categories (starting with the least accurate): Bar Chart Analysis, CPM Update Review, Impacted As-Planned Analysis, But-For Analysis, and Windows Analysis.

### 3.1 Evaluating Existing Methods

Existing delay analysis methods are evaluated in this section. A set of general criteria has been developed against which each method is tested: delay identification, delay definition, point of view, treatment of concurrent delays, and delay analysis procedure. Based on the scores, existing delay analysis methods were found to have significant drawbacks. This study is intended to address these problems by improving on commonly used methods (the But-For and the traditional Windows Analysis). A brief discussion on the identified weaknesses is discussed in this subsection.

### 3.2.2 Delay Identification

Major improvements have been made in this aspect of delay analysis. The But-For Method and the Windows Analysis method can identify delays caused by different parties. Delay predecessors, successors, and resource utilization information can also be identified and documented. Some methods, however, still identify only O and C delays. There is need to extend this to cover the identification of N delays. Also, all existing methods provide no help in assessing responsibility for a delay event.

### 3.2.3 Delay Definition

Activity delays that do not affect the critical path do not result in a project delay. Some methods fail to satisfy this fundamental concept. It does not matter whether the delay event happened during the original contract time or extended contract time.

### 3.2.4 Point of View

Different results are obtained when the analyst considers the owner's point of view and then considers the contractor's point of view. This often results in disputes. The employer's and contractor's points of view need to be reconciled.

### 3.2.5 Concurrent Delays

Existing delay analysis methods cannot identify, calculate, and assign entitlement for concurrent delays. All methods except the Daily Windows Analysis, fail to account for the dynamic nature of the critical path. All methods fail to provide a consistent procedure to aggregate concurrent delays.

### 3.2.6 Delay Analysis Procedure

Using the same methods may result in different results when different procedures are used. Methods with the same names may have different delay analysis procedures. This creates disputes when analysts supposedly using the same method use different procedures (algorithms). There is a need to have a standard algorithm for a given method. The reader is encouraged to read the available literature on the first three categories will now discuss the last two in the analysis outlined below.

## 4.0 THE MODIFIED BUT-FOR METHOD

This section describes several improvements proposed to address the identified shortfalls. In the But-For Method and Windows analysis method. Starting from the most widely used method (The but-For method), the Modified But-For (MBF) method has been developed. The MBF method addresses identified shortfalls with the current But-For method. This did not solve all the problems. A second method, the Daily Windows Analysis (DWA), was developed starting with the most accurate method, the Windows Analysis method. The two new methods have been tested against the criteria developed earlier to assess delay analysis methods and a brief discussion on the implications of the proposed developments to the construction industry is presented below.

### 4.1 Data Preparation

Delay analysis requires two main sources of information: the as-planned schedule and the as-built schedule. Commercially available project management software, Microsoft Project is used to capture, store, and retrieve relevant project information. As such, current developments become practical, easy to use, and readily available on a familiar platform to the industry professional. Several modifications, including a new delay representation, are made as detailed in this section.

### 4.2 As-Planned Schedule

Developing an as-planned schedule involves four main steps: activity definition, activity sequencing, activity duration estimating, and schedule development. The as-planned schedule is checked for accuracy and errors in logic, as the contractor may intentionally incorporate errors to obtain an advantage for potential delay claims. The level of detail should be checked for its adequacy. The level of detail should be sufficient to allow the analyst to allocate and analyse major activities. The analyst should also examine the interrelationships among the activities to ensure that the most appropriate relationships are being used. The analyst should further check whether the planned production rates are realistic. In summary, the as-planned schedule should be able to provide the following information: activity name, activity ID, planned start date, activity duration, planned activity end date, predecessor activities, successor activities, relationships between activities (FS, FF, SF, SS), resources utilization, and any relevant comments.

### 4.3.1 As-built Schedule

In addition to the activities identified in the as-planned schedule, new activities (including delay events) are identified to properly represent how the project was constructed. Delay activities can take the form of any of the activity types (production, procurement, management, hammock, and dummy activities). It may be necessary to split activities to properly represent a delay event. As-planned activity information is updated to include actual activity information. The party responsible for a delay event or disruption is identified and recorded (as O, C, or N). Additional comments like the date when notice was given to the employer, correspondence about the problem, site minutes where this problem was raised may be included. The as-built schedule must be accurate, be updated periodically to reflect project progress as specified in the contract, and be supported by accurate documentation.

### 4.3.2 Activity Delay Representation

Activity delays are introduced as new project activities. The original activity is split into two or more activities depending on when the delay occurred. Delay activities are given an extra identifier for legal responsibility. In the simple example where the project required 8 days to complete. The project experienced some delays during construction, as a result, the project duration slipped from 8 to 11 days. Two delays occurred, affecting activities B and C. Activity "B" was delayed by the employer for 3 days. The delay happened right after the activity was completed (e.g., late testing/acceptance by the employer). Two new activities are used to represent this delay: new activity "B1" and activity "employer delay". The activity "employer delay" is given an extra identifier "O" indicating that the delay was caused by the employer. Figures 4.3.1 and 4.3.2 below show the As-Planned for and As-Built Schedule tasks respectively.

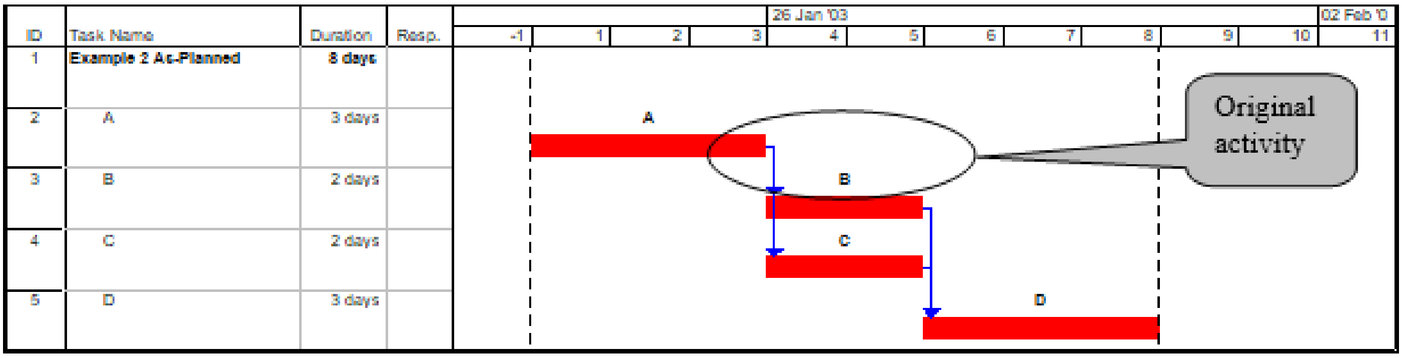


Figure 2: As-Planned Schedule.

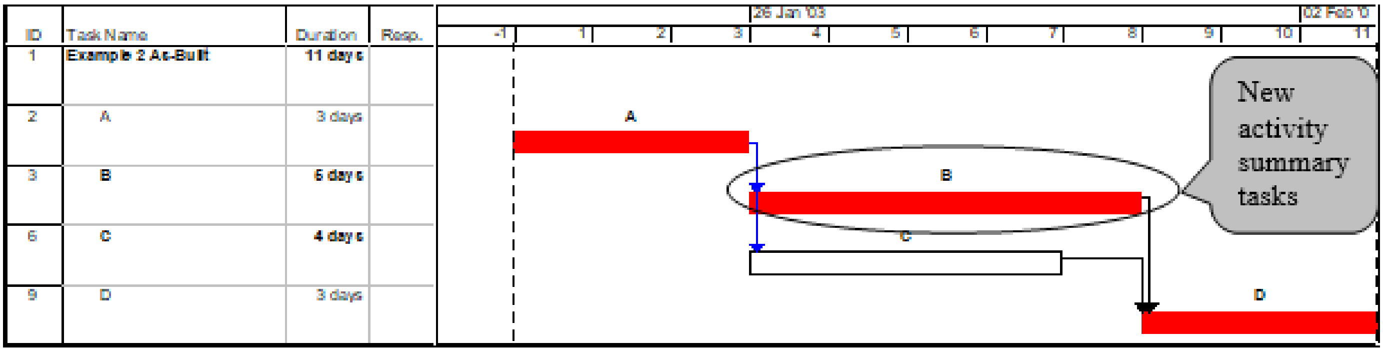


Figure 3: As-Built Schedule.

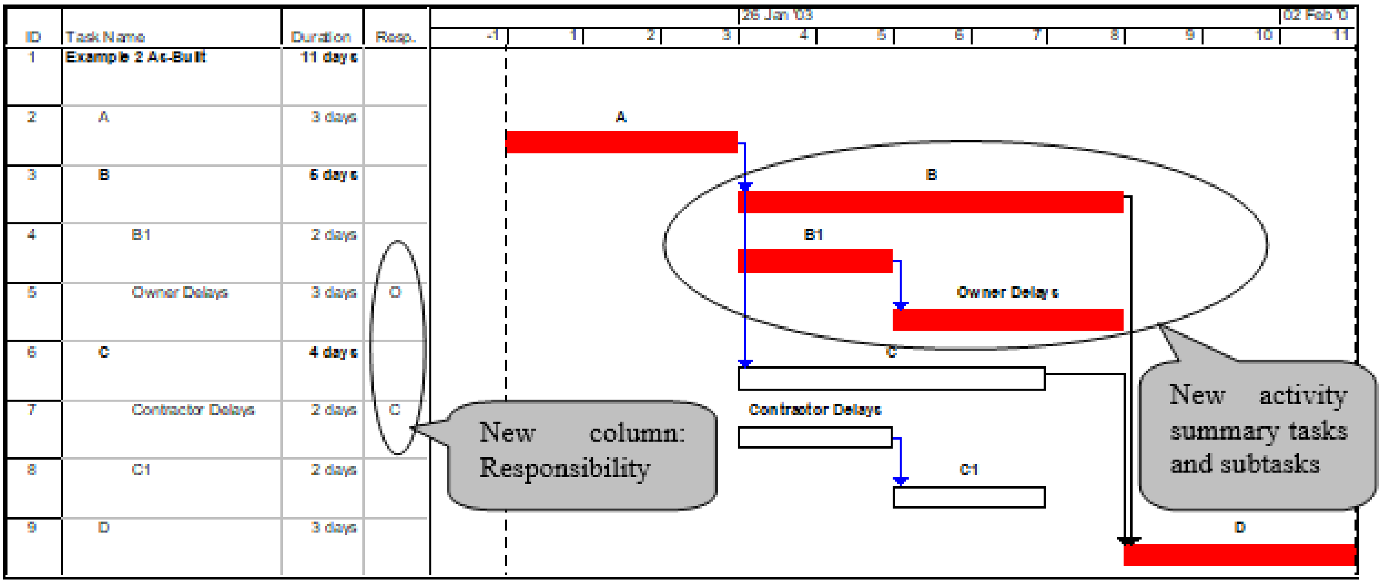


Figure 4: The Expanded As-Built Schedule including New Subtasks

Using the summary task tool, one can avoid viewing all these details and see only the summary activity. Activity C was also delayed for 2 days, but this time by the contractor. Similar modifications are made to this activity, but since the delay is caused by the contractor, the responsibility column will have C. The contractor delay occurred at the beginning of activity C, as reflected in the new representation.

### 4.4 Concurrent Delay Representation

Before explaining the details of the new delay analysis methods, it is important to describe their expected output and how it is represented. A simple project indicated a project delay of 3 days. This delay could have been caused by individual delay events of either party alone, or by a combination of them (in varying proportions). As such, the representation of project delays caused by each party alone and both parties together needs to be systematic. Starting with a simple case involving two parties, a new concurrent delay definition and presentation is developed. This is later extended to cases involving three parties.

### 4.5 Concurrent Delay Rules

Responsibility for delays caused solely by one party creates no problem. When more than one party contributes to the same delay, a systematic procedure is required to calculate and apportion project delay responsibility. The most equitable concurrent delay rules are selected as detailed in Table 4.5.1.

*Table 1: Concurrent Delay Rules Adopted in this Study*

| Delay Parties | Concurrent Delay Type | Decision Rule | | |
|---|---|---|---|---|
| | | Time Extension to Contractor | Payment to Contractor | Payment to Owner |
| 1. C delays | O'CN' | No | No | Yes |
| 2. N delays | O'C'N | Yes | No | No |
| 3. O delays | OC'N' | Yes | Yes | No |
| 1. Only O and N delays | OC'N - O'C'N | Yes | No | No |
| 2. Only C and N delays | O'CN - O'C'N | Yes | No | No |
| 3. Only O and C delays | OCN' - O'C'N | Yes | No | No |
| 4. O, C, and N delays | OCN - O'C'N | Yes | No | No |
| 5. Two O delays | O+O - O'C'N | Yes | Yes | No |
| 6. Two C delays | C+C - O'CN' | No | No | Yes |
| 7. Two N delays | N+N - O'C'N | Yes | No | No |

(a) The contractor is allowed neither a time extension nor costs for contractor-caused delays (O'CN'). The contractor is charged liquidated damages for this type of delay.

(b) The contractor is allowed a time extension and costs for employer-caused delays (OC'N').

(c) The contractor is allowed a time extension for third-party-caused delays (O'C'N).

(d) When two or more different types of delays occur together (OCN', O'CN, OC'N, or OCN), the contractor is allowed a time extension only. The contractor is not charged liquidated damages, and does not recover any costs.

(e) When two or more O delays occur together, the contractor is allowed one-time extension and can recover costs for every disruption each delay caused.

(f) When two or more C delays occur together the contractor is charged for one set of liquidated damages.

(g) When two or more N delays occur together, the contractor is allowed one-time extension and cannot recover costs, and is not charged liquidated damages.

### 4.6 The Modified But-For Method

The Modified But-For method is an improvement to the existing But-For Method. It addresses the problems identified during the evaluation of delay analysis methods as follows:

(a) It identifies legal responsibility as one of the problems associated with existing delay analysis methods.

(b) Existing But-For methods give different results when one considers the employer's point of view and the contractor's point of view. Where there is inconsistency, the Modified But-For method addresses this problem by considering both contractor's and employer's views. The employer and the contractor use the same algorithm and therefore will obtain one solution set, thus reducing the disputes.

(c) Existing But-For methods failed all three tests developed to assess the method's ability to handle concurrent delays. The Modified But-For method addresses their shortfalls and identifies:

(i) Three types of project risks (O, C, or N) and the resulting total delays (O, C, and N);

(ii) Delays caused by only one party (OC'N', O'CN', and O'C'N);

(iii) Concurrent delays involving two parties (OCN', OC'N, and O'CN); and

(iv) Concurrent delays involving three parties (OCN).

(d) The MBF method uses a pre-specified set of concurrent delay rules to calculate and apportion responsibility for project delays, a function that existing methods lack.

(e) The MBF method provides a consistent delay analysis procedure (one algorithm, one definition, one solution set), thereby removing problems associated with inconsistent algorithms used by existing But-For methods.

### 4.7 Modified But-For (MBF) Algorithm

The MBF algorithm addresses existing shortfalls of the But-For Method. It gives the same results for the same set of facts all the time; it does not matter whether it is the employer, contractor, or third party doing the analysis. This method involves identifying all the individual activity delays and then removing one combination of delays at a time, for all the possible combinations. In this case, seven delay combinations can be defined: O, C, N, O + C, O + N, C + N, and O + C + N). The total project delay is re-calculated for every delay combination removed. The method then calculates concurrent delays using standard set theorems. The method applies the pre-specified set of concurrent delay rules to calculate and apportion responsibility for project delays. The procedure can be summarised as follows:

(a) Create an as-built schedule with the delay events caused by each party to various activities identified (O, C, or N).

(b) Iterate for all delay combinations:

(i) Remove delays, one combination at a time, for all combinations (O, C, N, O + C, O + N, C, and N, and O + C + N).

(ii) Calculate the new project duration.

(iii) Calculate the new total project delay.

(c) Draw a Venn diagram representation of the total project delay with the values in each segment calculated.

(d) Apply concurrent delay rules.

(e) Prepare the conclusion and report.

The process of building up the Modified But-For (MBF) Algorithm starts by identifying all the possible delay combinations that can occur on the project. For the case involving three parties (O, C, and N), seven combinations are possible: O, C, N, O + C, O + N, C + N, and O + C + N. The method then removes one combination of delays at a time from the as-built schedule, to calculate the project duration that would have resulted but for that combination of delays. For each delay combination removed the resulting project delay is calculated as the as-built duration less the resulting project duration after the delay combination is removed.

For example, the first cycle removes all delays (O + C + N delays). This cycle calculates the impact of all the delays. As such, the as-built project duration less the calculated project duration in cycle one represents the total impact of all the delays (i.e., OUCUN). On the Venn diagram, this is equivalent to OUCUN = a + b + c - d - e - f + g. Therefore, OUCUN = a + b + c - d - e - f + g = T0 - T1. The second cycle involves removing all O delays. This is equivalent to the delays the project would have experienced but for O delays. The delay calculated will represent delays that are caused by only O, O'C'N' = a - d - f + g. Since the resulting project duration is T2, and the resulting project delay is T0 - T2, O'C'N' = a - d - f + g = T0 - T2. This process is repeated by removing all seven combinations.

At the end of the seven cycles, seven simultaneous equations are obtained. These equations are then solved to obtain the variables a, b, c, d, e, f, and g and the values in each segment can be calculated. The MBF then applies the pre-specified set of concurrent delay rules to calculate and apportion responsibility for project delays. To automate these calculations, a macro program using Visual Basic language that works with Microsoft Project software has been developed. A flow chart representing the MBF method is shown in Figure 5.

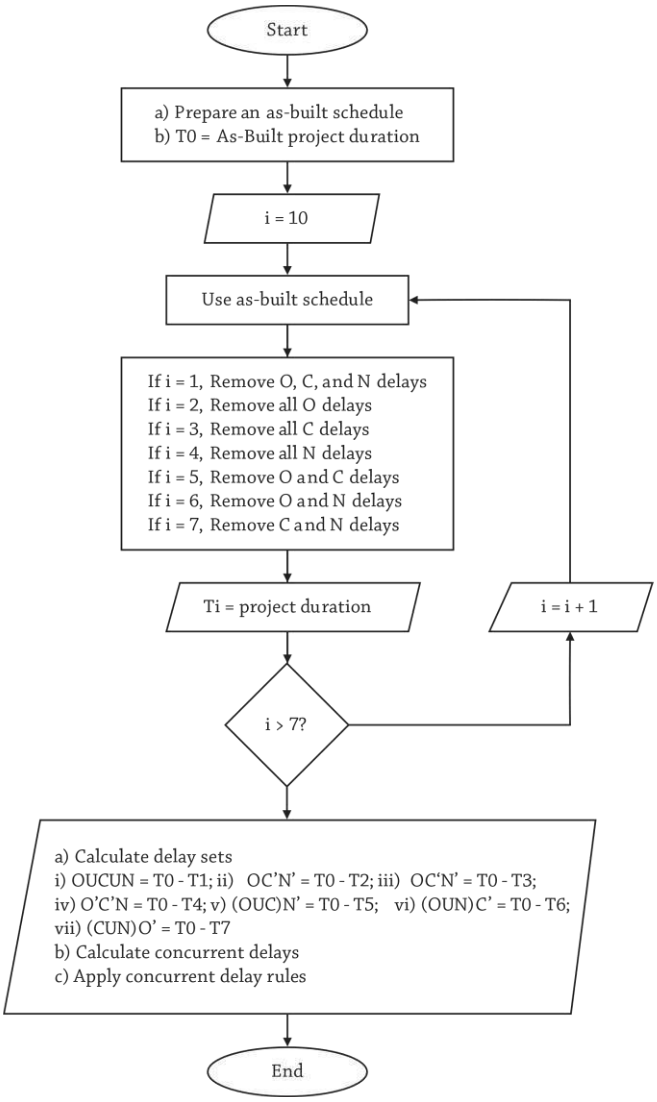


Figure 5: Proposed Algorithm for the Modified But-For Method (MBF)

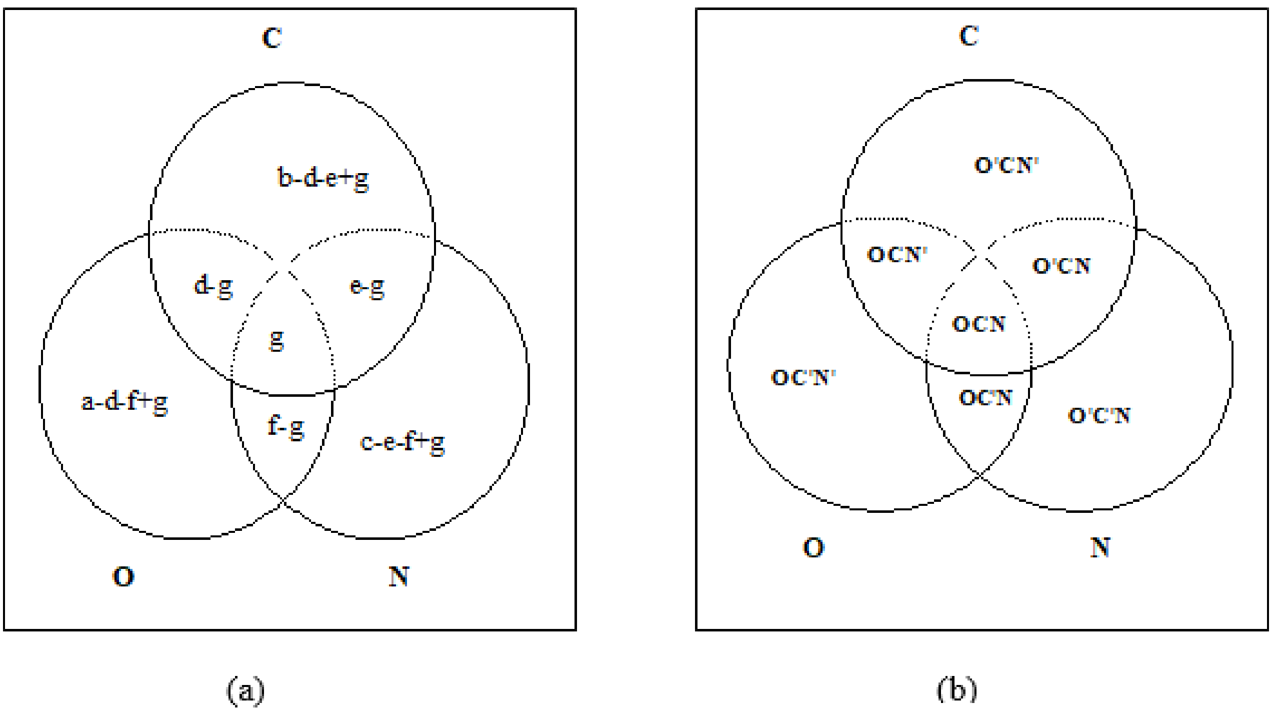


Figure 6: the Modified But-For Method (MBF) Venn diagrams indicating variables and Delay Types

## 5.0 THE DAILY WINDOWS ANALYSIS (DWA)

The DWA method proposed in this study uses a window size of one day. It addresses current weaknesses associated with the traditional Windows Analysis method by incorporating all improvements associated with the MBF method considered earlier. The analysis considers one project day at a time and starts from the as-planned schedule. By considering one day at a time the DWA method addresses problems associated with the current Windows Analysis method: window size, and start/end dates of windows and uses the Venn representation as discussed earlier. The DWA method puts delays to when they occurred and considers the dynamic nature of the critical path. This makes the DWA method superior to all existing methods (including the proposed MBF method). The DWA method is computerized to address existing computation problems. When tested against the developed criteria, both methods (MBF and DWA) scored higher than all existing methods.

### 5.1 Daily Windows Analysis (DWA) Algorithm

The DWA method starts from the as-planned schedule. For one day at a time, starting from day 1, delay events are identified and inserted in the as-planned schedule. Project delays are calculated from each update. Delays on the critical path are identified as individual delays or concurrent delays. The revised schedule is saved and is used as a starting point for the following day's analysis. This procedure is repeated until all project days are analysed. Daily delay results are added up to obtain total project delays.

The Daily Windows Analysis method can be summarised as follows:

(a) Create an as-planned schedule

(b) Identify delays caused by each party

(c) For each day, starting from day one

(i) Add delays, one combination at the time, for all combinations.

(ii) Calculate delays

(iii) (steps (i) and (ii) can be replaced by simply identifying which delays are on the critical path on the day under consideration)

(e) Apply concurrent delay rules.

(f) Sum up all the delays and prepare a conclusion.

DWA method calculations are as follows:

(a) Delays that occurred on day 1 and have a duration of one or more days are reset to a duration of one day.

(b) Delays that occurred after day 1 are identified and removed from the as-built schedule.

(c) The duration of delays that occurred before the day being analyzed is set to the actual duration if they ended on or before the analysis day; else the duration is set equal to the current day of analysis less the start date.

(d) Delays that occurred on the critical path are identified. If only one type of delay occurred during the day being analyzed, it is recorded as observed (OCN , OCN , or OCN). When more than one delays occur on the day being analyzed and each of them is on the critical path, this is recorded as a concurrent delay (OCN, OCN, OCN , OCN).

(e) Proceed to the following day.

(f) Repeat steps (a)-(e) until the last day of the project

An Algorithm for Daily Windows Analysis (DWA) is shown in Figure 5.1.1 below.

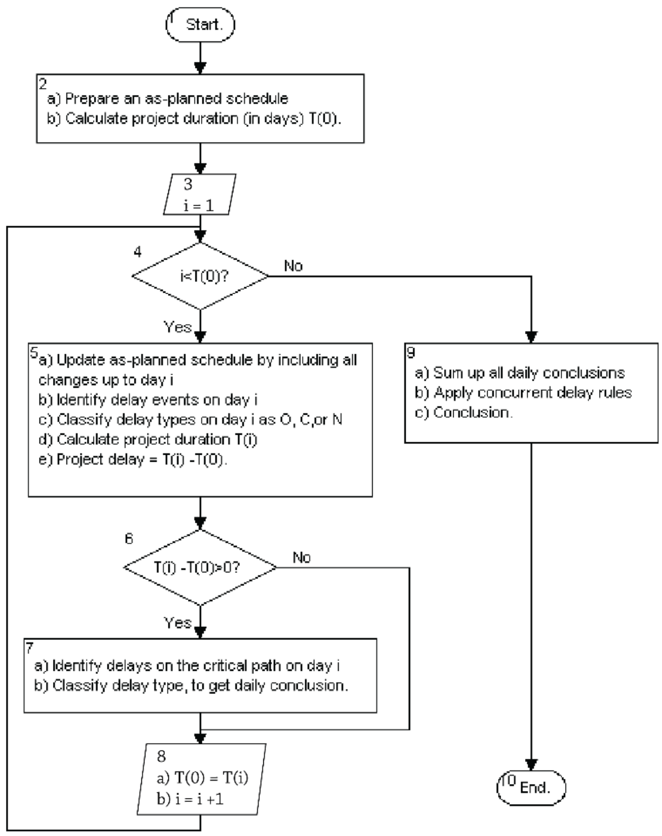


*Figure 7: Proposed Algorithm for Daily Windows Analysis (DWA).*

## 6.0 CONCLUSION

Calculating and apportioning responsibility for project delays is a major problem in the construction industry. Various methods are being used to calculate and apportion responsibility for project delays. The methods give different results for the same set of facts. This often leads to disputes on account of the inadequacy of these methods. However, two new methods: The Modified But-For Method (MBF), and the Daily Windows Analysis (DWA) have been developed and introduced to address the identified weaknesses. The new methods have been tested and they show a significant improvement as compared to existing methods (improved score from 6/14 to 14/14 for the Daily Windows Analysis). An algorithm is introduced for each of the two methods; the algorithms are incorporated into existing project management software (Ms Project) so that they are immediately available to the final users. The Daily Windows Analysis method correctly identifies project delays more accurately, uses more accurate delay definitions, considers both the employer's and contractor's points of view, uses more accurate definitions for concurrent delays, and provides a consistent delay analysis procedure. The Daily Windows Analysis method is therefore proposed as a superior benchmark for delay analysis. This study paves way for additional studies to be conducted in this area to develop a truly reliable and more accurate delay analysis method.

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