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KUMASI.

Application of Linear Scheduling to Road Works in Ghana

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MASTER OF SCIENCE CONSTRUCTION MANAGEMENT

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DECLARATION

I hereby declare that this submission is my own work towards the MSc and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text

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ABSTRACT

Project progress and monitoring reporting is an integral part of any construction endeavour and as such the road sector is no exception. For a sector that covers a field of activities varying from one project to another in terms of the scope of work, requires a system capable of adequately reporting the actual work executed on the field. The aim of this study was to develop a system of reporting and monitoring for road construction projects. This study adopted the qualitative research strategy because, the study reviewed road project documents to arrive at the reporting system developed. Moreover, the study employed semi structured interviews with persons with over ten years of experience and top officials in the road sector. It was found that the developed system is a best fit for road construction monitoring and reporting. The multiplicity of work and the associated complexity which is becoming the main feature of road projects, coupled with the fact that top level management needs to be abreast of the day to day running of major projects going on across the length and breadth of the country is an added advantage of the developed system. It is therefore recommended, further study may be done on how to automate the system and generate the diagrams as the actual works are done when quantity of works are keyed in. The system will also work better when pictures of various sections of the works are added up to stage completion, section by, and also the probability of importing from other scheduling software‟s.

Keywords: Linear Scheduling Method, Line of Balance, Scheduling, road construction

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DEDICATION

I dedicate this thesis to my boy, Nana Yaw Appiah.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The road sector covers a field of activities involving a lot of operative skill that vary from one project to another in terms of the scope of work to be done that is predictable and unpredictable ones. This presents the problem of monitoring the works as to what was envisaged to be done as per the desired intervention and what actually is done. Quantities showing volume of work items done can be very misleading for example 50 percent progress on a work item might not necessarily be half of the work done, but it can be more or less work done when you actually get on the ground, in this respect reporting accurately on progress becomes somewhat difficult and does not paint the right picture in most instances.

The act of monitoring works to be done hence becomes very essential to employers, financiers of projects and top management. It is only through this process that they get any form of idea as to progress being made on ground to actualise the project (Harmelink, et al., 1998) and also an idea about cost in respect to percentage of work completed and hitherto their financial obligations there off. It goes a step further in ascertaining duration of project, outstanding works, and more so works which are accruing because of the ongoing construction project which were not envisaged at the project planning stage. In tracking or reporting progress of work, activities are mostly presented in geometry displaying the where work is done on site at a point in time such that unauthorized access point can be visually spotted, by the use of different colours various activities can be

distinguished from the other (Gallo, et al., 2011). It is on the back drop of this that this study is fashioned.

This brings to mind the time space diagram, it is a two dimensional axis diagram with time and distance as variables, it is used in research works for establishing the relationship between time and distance, it is also used in the transportation field to visually programme vehicles and their route of operation and also it is used in plotting flights in the aviation industry (Anwar, et al., 2013).

In project management terms, the time space diagram is mostly used for linear projects as against time, for instance laying of pipes, construction of tunnels, railway lines, passing of electrical wires for transmission. As it is a time-distance diagram, it shows the position of an activity at any point in time and also the direction of the activity. Road construction is a linear projects which have interrelated activities in a sequential manner which is not of great concern but issues like distance-based (alignment-based) projects, activities are performed continuously along the length of the horizontal alignment of the project. Highways, railroads, tunnels and pipelines are examples of such projects. The Linear Scheduling Method (LSM) is a very useful and informative tool for scheduling alignment-based projects. At times an activity does not consist of a continuous work throughout a project, but defined by work that takes place at a specific location over a period. An example of such activity is the construction of a bridge or box culvert in a highway project. This type of activity is represented by a "bar", which sets aside a time period, at a specific place, for the work to be completed before any other activities are allowed to occupy that space (Arthur, 2009). This situation underpins and justified the research report here. The strength of this method of scheduling does not lie in its ability to organize a project‟s individual activities, but instead it is gained from the multitude of graphical capabilities

inherent to this method. For instance, a scheduler may choose to place a scaled plan or profile from the project‟s drawings alongside the distance scale in order to create a connection between an activity and a physical location on the proposed plan. In addition, each activity can be assigned a unique line style, type, thickness, or colour to differentiate it other activities, it also allows changes in start and end times of activities and productivity in ways that will guarantee the continuity of the activity (Yamin & Harmelink, 2001). The project manager may choose to add a resource histogram or cumulative cost curve aligned with the time scale to help visualize the project‟s status during the planning and construction phase. This research is a step

toward fulfilling this need.

1.2 Problem statement

Reporting and monitoring work in the road sector in Ghana and specifically in the department of urban roads is challenged on the back drop of work varying from what was initially planned and what is being done practically on the ground and how additional works are reported.

Projects are normally conceived by doing an inventory and prescribing various engineering solutions in the form of a line diagram, which is then converted to the bills of quantities to ascertain the proposed cost of the project and the quantities thereof. Reporting basically uses the weightings of quantities in relation to the entire works and the volume of work done in that work item. Unfortunately this method of reporting presents a problem when work volume change from where they were proposed, to another place within the same site or an increase or decrease of volumes of work and where it is going to be done

specifically within the project length. The current method of reporting also fails to show specifically the exact point within the project where the progress is at, at a given time.

1.3 Aim of the study

The aim of this study was to develop a system of reporting and monitoring where by monitoring remotely one will be able to know exact progress, change in scope of work, additional works if any on the project, without necessarily going through a series of pages and trying to connect them to save much needed time.

1.3.1 Objectives of the study

The specific objectives were to:

- Identify ways of improving the existing monitoring and reporting format at Department of Urban roads; and
- To apply linear scheduling technique in proposing a simple method of reporting progress works on Road projects.

1.4 Justification

This study will help management to track work in terms of:

- The location of the activity and also the direction of progress as well as the rate of progress.
- To be able to see additional works graphically without necessarily going through a bulky report.

1.5 Scope of the study

Given the extensive and varied nature of road projects and also the need to comprehensively address the issue of monitoring and reporting on progress of work, the study was limited to the Department of Urban roads of Ghana. It is the road agency responsible for mobility, traffic management and safety within all the metropolitan and municipalities within the country where they are present.

1.6 Study methodology

The research was exploratory in nature and case study approach was choose as most appropriate research strategy to add to existing systems and documentation and get as much information on tracking road projects with space time diagram as possible. Methodology was an inductive one where is made to reference concepts and theories identified from literature to present an approach based on the time space diagram. The case study project selected was to help test validity of the format and applicability to road project in general in Ghana. The findings from the literature and case were discussed in relation to the objectives of the study. Conclusions were related to improving the aspect of reporting and monitoring of works in the Department of Urban

Roads in Ghana.

1.7 Organization of the research

The study was arranged into five chapters. Chapter one provided background introduction of the study and explains the problem at hand; the aim and objectives with the justification of the study and organisation of the research. On chapter two presented a comprehensive literature review on linear projects are reported on and monitored. Research methodology was laid in chapter three which underlined the research method used to gather evidence

towards the attainment of the study objectives. The fourth chapter focused on discussion of key issues emanated from the reviewed literature and case study with reference to the aim and objectives and chapter five dealt with conclusion and recommendations drawn from the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses literature on various scheduling tools used in the construction industry, general view of the construction industry, identifies various and discusses the advantages and disadvantages of scheduling tools.

2.2 Overview of the built environment

2.2.1 Road construction

The built environment is coined to enhance the life of mankind in the society. It comprises of irrigation system, transportation system, buildings, electrical installations and among others, these physical developments address the infrastructure needs of the society (Khan, 2008). Although all the listed forms are equally important, transportation plays a key role in the twenty-first century. Transportation system can be further classified into air, road, rails and water transport. Notwithstanding these options it is believed that most commuters are conversant with the road transport especially in developing countries like Ghana. The history of road construction is difficult to trace however, it can be linked to the world Wars as during those times roads were constructed intentionally and un-intentionally with the aim of transporting ammunitions, food and other military installations.

2.2.2 Advantages and disadvantages of road construction

According to Mikkelson (2005) road transportation has gained popularity in developing countries since most government and international organization finance its construction.

Road transportation in noted to create avenue of infiltrating the local market of society and even the cultural values of a society and also environmental related challenges such as deforestation, soil erosion amongst others. In terms of weight it could be realized that its importance outweighs its flaws, the road sector also contributes to the development of the agriculture sector which is one of the developing industry in Ghana. Road construction in the developing countries is labour intensive thus acting as a source of employment to people, to actually contribute to the Gross Domestic Product (GDP) and also contribute to the socio-economic standing of nations Mikkelson (2005). Road construction like other projects arise as a result of needs, which require different kinds of resources in realising it ranging from human resource to financial resources. Moreover, road construction operates on the confines of time, cost and quality which have been coined to mean the main objectives or driving force of project (Khan, 2008; Choudhury,

2008), although other perspective have been gaining popularity for some time now.

2.3 Scheduling tools

Construction is very dynamic activity coupled with various degrees of risk and uncertainty. It requires intellectual reasoning, labour-intensive in order to achieve the development goals of the project. In view of that, planning is an essential pre-requisite for all construction activities. According to Lu (2003), modelling tools have been developed to assist the planning stages of complex construction activities by using key variables of the intended project. Mather (2000) asserted that, simulation models which are event based have been developed with encoded pattern of executing specific construction activities

with the aim of making work easier, simplified and faster. This model simulate the construction process which makes it possible to identify the risk prone areas.

Road construction and reconstruction of roads have gained root in both developing and developed countries. This field of construction consumes a lot of client‟s resources especially finance. This makes it imperative to accurately and adequately plan the process of its construction in order to predict what will happen at any phase of the project and make rooms for control purposes. Scheduling is required for any activity within the construction industry since it makes it easy to forecast the budget, time, resources needed at every phase of the road construction project. Harmelink & Yamin (2000) opined that, due to the complex systems for construction, complicated scheduling tools have also been developed to assist project managers in the discharge of their duties. Moreover, the conventional scheduling tools used for construction purposes are geared towards building construction rather than the road construction.

Arthur (2009) declared that, most of the scheduling tools used in the project management circle is related to linear projects. Road construction activities are repetitive in nature because the procedure is more or less the same for such works. Arthur (2009) further on asserted that, linear scheduling can be broken down into alignment and point-base project. Johnston (1981) revealed that, the United Stated Navy developed the point-base schedule. This tool was developed to help the Navy assess and adequately monitor the progress of its manufacturing units in order to document the rate of production. Such tool is the Line of Balance (LOB).

2.3.1 Vertical Production Method

Another linear scheduling tool for repetitive works was developed by O‟Brien in 1975, it is termed as the Vertical Production Method. This tool was used for vertical linear projects such as construction of high rise buildings. This method is of the manner of a flow chart but in a twist of a graph. The building level is plotted against time showing when crews are expected to complete their work from one level to the other. Moreover,

O‟Brien (1975) suggested that, activities such as excavation and other site works should be modelled using the critical path method diagram (CPM). It might be that, the limitation of the VPM is that, it is unable to graph horizontal linear projects. Arthur (2009) objected that, even though CPM has been tested and used for construction projects. It loses its essence when employed on scheduling repetitive similar projects, thereby a combination of VPM and CPM should be employed in vertical construction works for scheduling purposes.

2.3.2 Time-space diagram

Stradal in 1982 also invented the time-space diagram approach of scheduling, used for linear scheduling purposes. This is developed from the premise of point-based scheduling but has a bit of the alignment –based incorporated in its design. Similar examples of this scheduling tools are the foundation of pump projects, construction of complex apartment, high-rise buildings and even road construction projects. Arthur (2009) added that, the time-space diagram is able to show the flow of work which is easy to understand and comprehend although, it is complicated.

2.3.3 Line of Balance

Arditi (1986) worked on the Line of Balance (LOB) scheduling tool. The LOB is used for repetitive works such as road construction. Badukale and Sabihuddin (2014) described LOB as a tool which uses lines to communicate the progress of a project at any point in time. However, it usage in terms of linear projects like railway and road construction is limited. Notwithstanding that, it can also be used on non-repetitive works.

Arditi (1986) further laid out some requirement for the construction of LOB. LOB is productivity bias, requires the introduction of buffer before every activity with the exception of the earliest activity. In terms of the importance of LOB, Arditi opined that LOB is easier to construct as compared to other linear scheduling tools. LOB also makes it possible to picture the entire projects at the early stages of the life of the project. in addition, LOB is more understood buy site engineers and also help in controlling the project against budget and time. Badukale and Sabihuddin (2014) added that, the main objective of LOB is to present a balance view of repetitive projects. In addition, LOB helps project managers in allocation of resources based on order of priority. It has the ability to be updated and modified without much difficulties. It visually shows the productiveness of the labour force and the project at large. However, the learning curve of labour force is not taken into consideration when constructing the LOB. Moreover, it is unable to show the critical path of the activities as compared to the CPM.

2.3.4 Linear Schedule Method

Alignment Scheduling as per this study is referred as the Linear Schedule Method (LSM). As described earlier, it is used for linear assignment projects such as road construction projects. Johnston (1981) proposed the Linear Schedule Method for road construction projects which employs bar chart, blocks and lines in its operations. From Figure 2.1, the bar, block and lines represent some specific activities. For instance the line represent

activities such as finish shoulder and blocks. The block also represents the base and the sub-base whilst the bar activity represents the culvert works. Moreover, activity like excavation works is also represented with a different operational sign. Actually, it is difficult to comprehend the basis for the assignment of the various signs to the work activities.

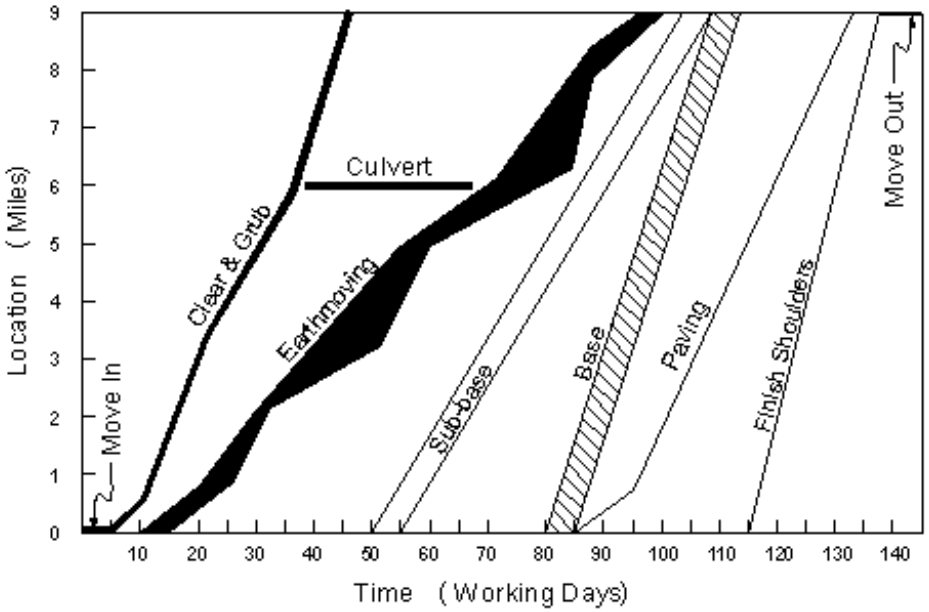

Figure 2.1Linear Schedule Method (Johnston, 1981)

According to Johnston (1981), the Linear Schedule Method has the capability of showing every buffer introduced on a project, the volume of activities undertaken in a given day is also shown on the graph because the variables for the scheduling tools are the working days against the location of those activities. Moreover, the resource needed for each activity can be traced from the model. The Linear Schedule Method (LSM) was shown to contractors to expressed their view and their experience in using it but accoding to Johnston, they indicated that we have not seen such tool before neither have they exploit it. However, it was realised that there is a gap between the bar chart tool used for

monitoring the progress an activity and the critical path method diagram. And such gap is bridged by the introduction of the LSM. The following conclusion was made by Johnston in his study:

1. LSM reveals much data on the activities to be undertaken in construction as compared to the bar chart;
2. LSM is mostly preferrably advantageous that scheduling tools like the critical path method diagram. The importance of the critical path diagram is experienced only on distinct and separate projects. Whilst the LSM is useful for repetitive activities of projects, moreover, it is better in revealing the scope of works and presents the obstacles likely to be encountered on a project and provides the scheduler the opportunity to solve such challenges. However, the two, LSM and CPM can be applied on a single project simultaneously;
3. LSM is used for scheduling projects such as road construction, paving, tunnel, pipelines, raiway construction, road maintenace, runway construction and mass transit operations;
4. LSM is a tool for reducing time spent on undertaking a specific activity which results in positivel reducing the cost of a project;
5. However, the technicalities involved in the construction of the model requires a thorough training and education on the Linear Schedule Method. And practical testing of it is also necessary; and
6. Moreover, LSM is simple, easier and accommodates the details of a project. It also improves the productivity of workforce and reduced cost. In addition, lag and lead time can be accommodated on the chart.

A comparative study of LSM and critical path method diagram was conducted Chrzanowski *et al* (1986). The study revealed that, the LSM is very simple and easy to use is the greatest advantage os using it. Notwtihstanding that, it is also imperative to use both the critical path method diagram along with the LSM because some activities requires the combination of these two scheduling tools. Chrzanowski *et al* (1986) also added to the work of Johnston (1981) by agreeing with the conclusion that, LSM provided more data to the scheduler and its user. LSM is also known as a tool for sorting out and filling the limitation gap of scheduling tools. Distinct and separate activities can be modelled using the CPM to determine the relationship and sequence of an activity. Moreover, separate scheduling tools can be used for different projects. Importantly, LSM and CPM are complimentary to each other.

Harmelink (1995) developed a model of linear scheduling with the aid of AutoCad. The objects of the study was on two areas; proving it is possible to computerise linear scheduling and demonstrating the techniques of identifying the critical path of the activities. Critical path is described as the untouchable sequence of a project and also the longest duration of a project. The critical path theme is used for the CPM scheduling technique whilst the LSM uses the controlling activity path. time and distance are drawn on the vertical and horizontal axis respectively. The time controlling path is determine by considering time from the upward and downward direction and also from the forward and backward direction of the distance plane. Based on that the relationships between the activities are then established.

Figure 2.2 describes the various parameters used for determining the controlling activity path and the parameters as such from the LSM. There are three main parameters which are the Least Time Interval which is defined as the shortest time connection to consecutive

project activities. The Coincident Duration also is the time interval between the activities identified with the Least Time Interval but also happening simultaneously. And the Distance interval also is the shortest distance connected two or more activities as far as the Least Time Interval and Coincident Duration are concerned.

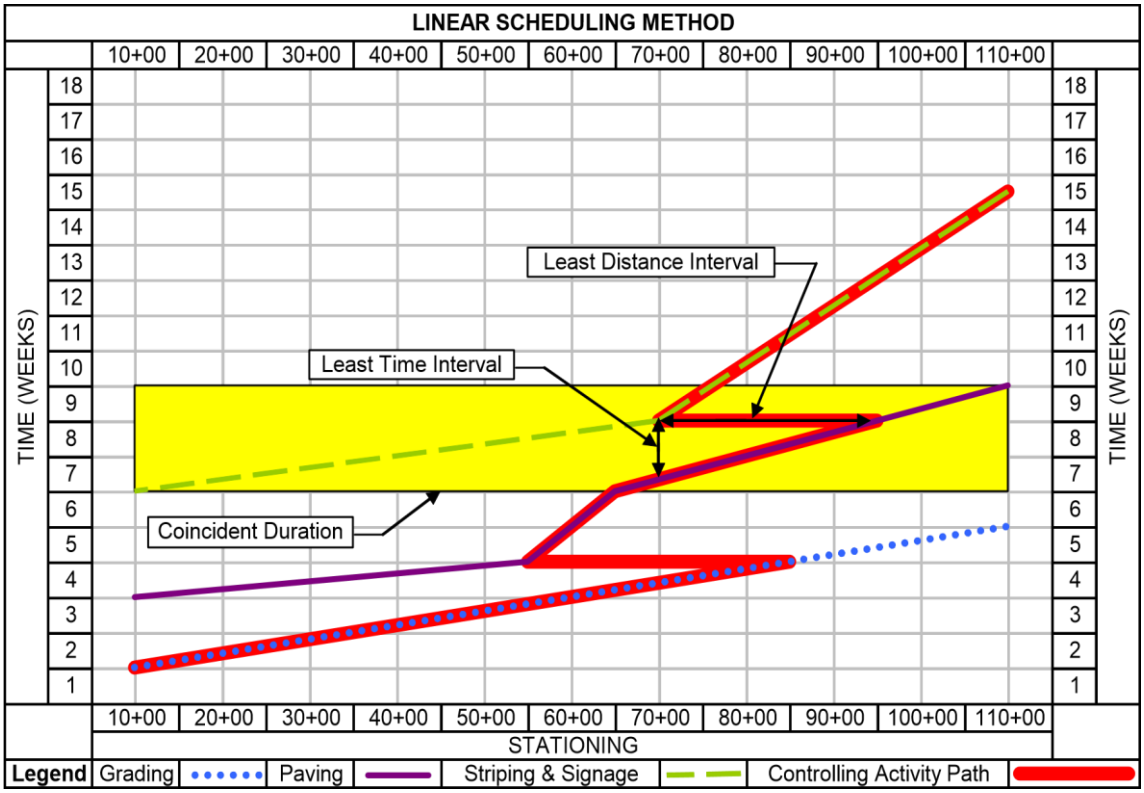

Figure 2-2 LSM depicting its parameters (Harmelink, 1995)

The illustration shown in Figure 2.2 reveals the the three parameters on the stripping and signage actitivites and paving. The portion with the yellow background shows the Coincident Duration within week 7 and week 9. Week 4 and 5 also shows a Coinicident Duration as a because of the relationships between the Least Time Interval and the Least Distance Interval and that of the paving and striping/ signage activities. The Coincident Duration between week 4 and 5 have no yellow background since such will just complicate the LSM graph.

Harmelink (1995) also presented a LSM graph depicting the lines, blocks and bar chart signages assigned to activities. In addition, Harmelink indicated that activities on LSM can be classified as partial or full based on the relationships between activites and the project duration. All activities that starts and ends with the project is called full-span whilst those which are executed within some point in time of the project life is also partial-span. However, this model does categorically provide any difference between the partial-span activities. Figure 2.3 also suggest that, activities can be further broken into continuous and intermittent. The former can be related to the full-span because the understanding gained from its definition is similar to that of the full-span as well as the intermittent activites. Harmelink further added that, in terms of reality the LSM is an important tool for determmining the analuguous path of activities which is called the controlling activity path. Also, the LSM has the capability to reveal the rate of productivity for linear activities. Managers can be able to make realistic decisions, due to the as built production rate information that the system generates to easily track progress of projects of this nature. Moreover, LSM enables users to have plan their activities visually and enhances the communication between project stakeholders because

stakeholders get a better picture of the project.

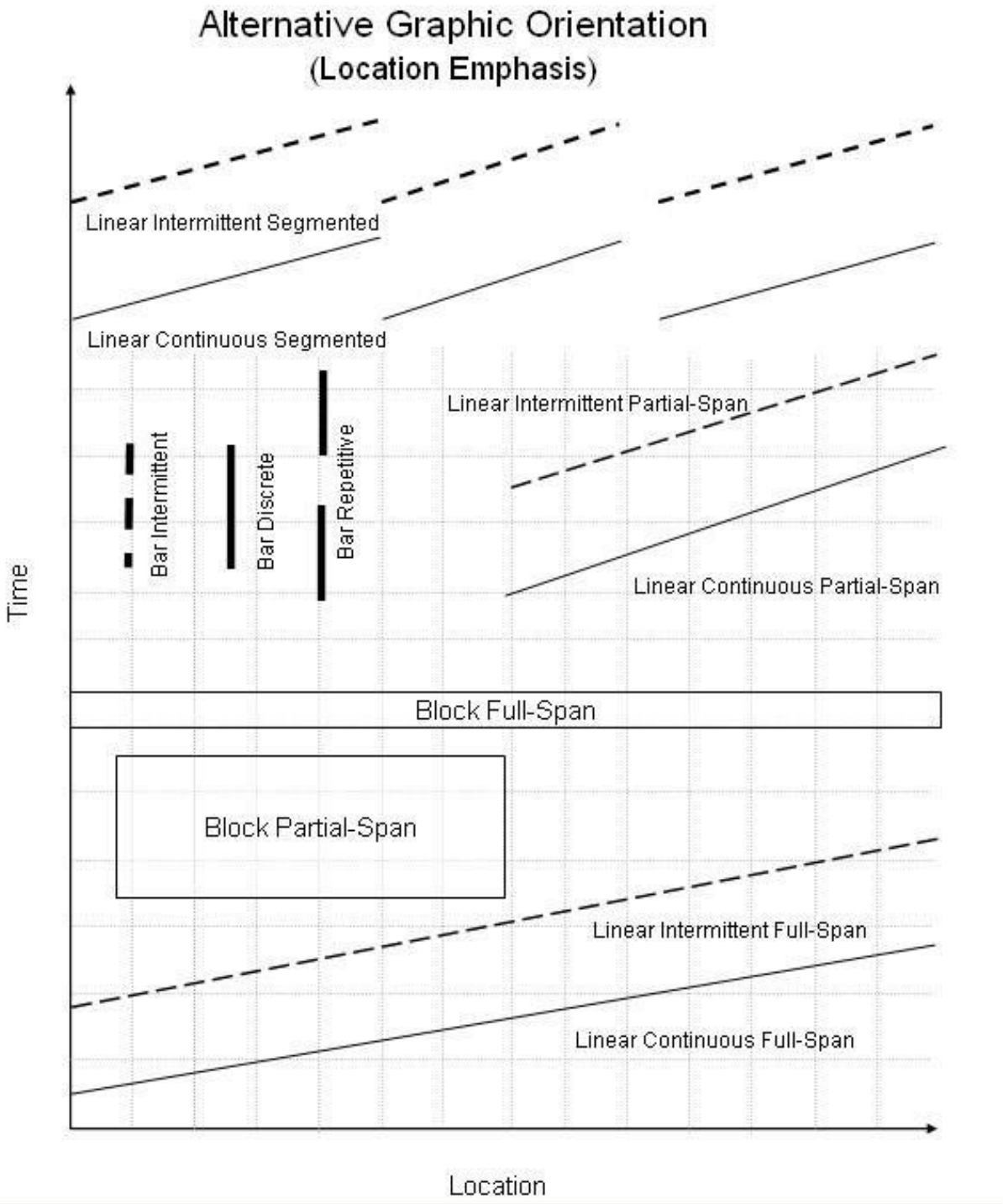

Figure 2-3Lines, blocks and bar chart presentation of LSM (Harmelink, 1995)

Arthur (2009) posited that, even though new technologies are emerging everyday it is imperative to design Scheduling software which can perform the function of commercial CPM which is recognised and patronised by schedulers. Such features should include

allocation and loading of resources as well as resource levelling. Harmelink and Rowings (1998) also reported on how to develop controlling activity path. The controlling activity path is similar to the critical path of the CPM tool. LSM permits some portion of an activity to be controlled by CPM only permits an entire activity to be crucial and untouchable.

Using the CPM, when an activity in the critical path which happens as a result of some sections of the activity, it can be broken down further into two. Such will naturally reveal the actual critical path. The CPM becomes complicated when a portion of an activity falls within the critical path because such activity is further broken down to know the actual critical path and activities as well. Development of LSM provides schedulers a robust Linear schedule tool with better functionality as powerful as the CPM.

2.3.5 Linear Construction Planning Model

El-Sayegh (1998) also designed a linear scheduling tool with the aim of determining and calculating for linear projects which can also be used for probabilistic models. Such model can be employed to generate LSM based on the input of the user. It could also be used for LSM using the Monte Carlo simulation that elaborates on the inconsistency and uncertainty of a linear project. A software package houses this probabilistic model called the Liner Construction Planning Model. This software package permits users to type in the resources needed for the schedule such as work force, sequence of activities, material costs, labour costs and the constraints on resources. This software has the ability to produce liner schedules according to activities, crew and further shows the idle and active workers as well as the idle time of workforce. It make use of the CPM functions such as independent float, total float, early and late start time and early and late finish time. However, the challenge or limitation of this software is all buffers are introduced manually.

El Sayegh (1998) added that, the software is focus on planning for an entire project which is important for project managers. Meanwhile, it is required to combine both the activities of a project in detail and the various phases of the project in order to better productivity. In addition, it was recommended that, the software needs an upgrade in its graphics and also road activities such as cut and fill should be represented on the charts and inaccessible portions of the site should also be indicated. Furthermore, the software should is able to contain cost information such as planned value of the work and also a tool that will monitor the progress of the project in the like of earned value analysis calculations. Also users of the software should be educated and trained especially civil engineering students and professionals in the construction industry. Liu (1999) outlined a technique in linear scheduling for estimating constraints resources. Liu adopted an empirical method in resource scheduling that permits the scheduler to set a criteria for making decisions of resources and its allocation. This method resolves any conflict with regard to resource allocation by using a reasonable duration for over-exploited resources. his work has an algorithm component which determines the optimum method which is influenced by least schedule period. Herbsman (1999) posited that a minimum of American states uses the Linear Schedule Method for scheduling purposes. However, it was concluded that LSM is a tool that is simple to organize and easier to use especially for construction projects which are linear and repetitive in nature such as pipeline and road construction. LSM is easily understood by top management staff as well as middle and head of work sections because it facilitates in monitoring of project performance.

Table 2.1 lists differing kinds of construction comes and therefore the planning ways and characteristics most frequently related to those comes. The authors provided 2 examples, a bridge project and a road rehabilitation project, that were each scheduled by CPM and

LSM. Findings drawn from the {2} example comes regarding the attributes of CPM and LSM square measure summarized in Table 2.2. The authors over that a lot of work required to be finished LSM to supply a similar skills as CPM, significantly within the resource management and period uncertainty for LSM.

Table 2-1Recommended Scheduling Tool for Different Types of Projects

Type of Project	Scheduling Method	Main Characteristic
Linear and continuous projects (pipelines, railroads, tunnels, highways)	LSM	• Few activities Executed along a linear path/space Hard sequence logic Work continuity crucial for effective performance
Multiunit repetitive projects (housing complex, buildings)	LOB	• Final Product a group of similar units Same activities during all projects Balance between different activities achieved to reach objective production
High-rise buildings Hard logic for some activities, soft for others Large amount of activities	LOB/VPM	• Repetitive activities Every floor considered a production unit
Refineries and other very complex projects	PERT/CPM	• Extremely large number of activities Complex design Activities discrete in nature Crucial to keep project in critical path
Simple projects (of any kind)	Bar/Gantt	• ndicates only time dimension (when to start and end activities) • Relatively few activities

(Yamin, 2001)

Table 2-2 Comparison of Critical Path Method (CPM) and Linear Scheduling

Method (LSM) along with Important Project Management Attributes

Attribute/dimension	CPM	LSM

Aid in reduction of uncertainty/risk	Although CPM schedules use fixed duration for activities, it can be easily complemented by PERT with statistical capabilities. This feature helps planners to get a better idea of time and schedule risks.	There is no formal method developed to date that could allow LSM to determine uncertainties in time completion
Aid in improving production and economical operation	With the incorporation of resource leveling/allocation techniques, CPM schedules can improve the overall completion time and costs by affection production (add or remove resources). Some limitations have been identified when scheduling continuous projects-difficult to maintain continuity in crew utilization.	Limited capabilities in improving production by changing resources. Easy to schedule continuity on linear projects, improving coordination and productivity.
Aid in achieving better understanding of objectives	In complex projects, CPM network can be very convoluted. This complexity makes them difficult to understand and communicate.	LSM is very easy to understand, and it can be used at every level of the construction project.
Accurate calculations	CPM allows the PM to calculate the time it would take to complete a project, and together with the PERT could provide statistical insights to this process. It is difficult to accurately determine and represent space restrictions (if any).	Location/time calculation is easily done. This is the greatest advantage of LSM over CPM when scheduling linear projects. This capability allows PM to accurately plan activities both in time and location
Critical path	It is the main feature of the CPM, which can be done very easily	The LSM algorithm calculated the controlling activity path (CAP) which is equivalent to the critical path, with the additional feature of location criticality.
Ease of use	Extensive computerization has made the CPM method easier to use. However, the user needs a considerable amount of training before actually being able to produce valuable information for controlling purposes.	Very intuitive and easy to understand. It can be used at all levels of the company (managers, superintendents and crew). Lack of computerization makes it difficult to use in large and complex projects.
Easy to update	The method could be difficult to update. Once several updates have been done, it becomes difficult to read. Updated schedules are usually out of date when they are finished.	Updating LSM is simple. Linear schedules can be used as as-built documents for claim purposes or for historical productivity databases.

(Yamin, 2001)

Table 2.3 below shows the various software‟s available their merits outputs and limitations there of from reviewed literature, representing inportant attributes of the various software‟s.

Table 2-3 Critique of existing programme software

SOFT WARE	MERITS	OUTPUTS	LIMITATIONS
Tilos	Has the ability to add multiple graphics to a schedule including a scaled view of the plan of the proposed project in away such that the scale is indicative of the actual project at all times Has the ability to display cost curves and histograms and resource available. It can give a view of a project in either a Gantt Chart view or a Linear Schedule view. It is very flexible and can be customised to include multiple user defined activity library and schedule views for future use Data entry is made easy by the use of project templates, which includes preprogramed schedule views customised to fit project attributes. Allows the drawing of activities similar to CAD and adjustment of the activity calculation details, location dependencies resources and cost. It permits for the user to import project information from formats like ,ascii, Ms project, Ms Excel and Asta Power point project	Has the ability to export the reports to Microsoft Excel for printing	Cannot generate written reports.
Spider Project	Capable of showing schedule in Gantt chart, resource Gantt chart, activity network and linear chart. Allows the schedule of both linear and point base projects. Has created in spreadsheet-like format.	Allows for multiple on screen views and printing options. The user can add text and scalable pictures to a diagram, line type colour of activities is also at the discretion	It only allows for line type activities It lacks the ability to customise and the ability to draw activities in CAD type interface
	Utilises the distance location, start and finish of an activity. Allows user to choose what he wants displayed on which axis		

Time Chainage	It allows production rates to be used as implant to calculate the schedule. Activity details include production rate activities relationship and location where the activities take place. Actual production and activity progress may be entered to track progress during construction. Allows for the scalable graphics like plan or project profile and some text if desired. Allows the user to utilise different activity shapes as lines blocks or parallelogram It also gives reports by displaying progress versus distance percentage complete.	Inputs of data is through the use of spread sheet.	Does not have the ability to create custom reports, print bar chart or CPM diagram. Has no ability to create a library. Does not allow to import and export project data.
Linear plus	Permits input activity data in both spread sheet and graphic fashion Permits the creation of linear, block and complex activities Permits user to import data from external source, generates templates to be used for the future works. It allows for the insertion of graphic and text into the schedule. Includes both cast and resource histograms	Has user friendly out puts and also web friendly and allows project to be viewed on the internet	Does not have the ability to output CPM diagrams and reports on the project.
Chainlink	Serves more as a linear display of a schedule. Ability to import and export and files to Primavera, Ms Project and generic comma delimited files. Ability to display various activity types such as linear and block activities. User can choose desired colour, line type and shape for each activity, picture files may be added to the diagram such as plan and profile.	Incorporates many features useful for visualising projects such as road projects and variable activity types.	Lacks the ability to include activity relationship and accompanying calculation i.e the ability to calculate the data associated with predecessor/succe ssor relationship

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter elaborates on the processes adopted for the study in order to achieve the said aim and objectives. This chapter discusses the research strategy used for the study, the approach used in soliciting for data and how the results will be presented.

3.2 Research approach

According to Kothari (2004), quantitative and qualitative are the main research approaches. Quantitative research makes meaning out of figures. Moreover, it is mostly used when the study is conducted on large population and sample size. Dawson (2007) also believes that, quantitative research is preferable for scientific research and produces concrete results through statistical analysis. Meanwhile, qualitative research on the other hand, is mostly employed on social science related research. It actually enhances in discovering and making meanings into social behaviours and construct.

This study will adopt the qualitative research strategy because, the study aim at reviewing and making meanings into existing literature. Moreover, the study want to build on existing programming tools in the road sector without using figures and variables.

3.3 Research design

According to Saunders *et al* (2009), research is classified into three main areas according to their purpose. These are exploratory, descriptive and explanatory. Exploratory research enhances researchers understanding of a concept and useful in appreciating into details a problem associated with a concept. An advantage of exploratory research is its flexibility

and adaptability to change (Kothari, 2004). Descriptive research is mostly used when the purpose of the study is to accurately, describe a concept or theory. This employs figure in making its analysis and synthesizing data. The descriptive according to Saunders *et al* (2009) is a blend of explanatory and exploratory research. The explanatory research actually discusses the likely relationships between two or more variables, which is quantitative in nature.

This study employed the use of exploratory research because the researcher wants to understand the concept of linear scheduling tools in the road sector and how to upgrade such tools to help the monitoring and tracking of road project.

3.4 Research strategy

Research strategies are used to all the three (3) research design discussed earlier that is exploratory, explanatory and the descriptive research design. Saunders *et al* (2009) listed about six (6) strategies used for research, including experiment, survey, case study, action research, grounded theory, ethnography and archival research. Experimental research is mostly used for natural science research. Survey allows researchers to collect quantitative data. Case study is used to get in-depth understanding about a particular situation and mostly work with small size of people. The action research is when the researcher himself is part of the objects being studied. Grounded research requires developing a theoretical framework as the basis of a study. Ethnography is developed from the anthropology field of study. This strategy solicit for information mostly through observation. And finally, the archival research also solicit for information using existing documents and records for the purpose of a research. The study adopted the archival strategy.

3.5 Population

According to (Saunders, Lewis, & Thornhill, 2009), population is the totality of an object or group of people with similar or same specific qualities. The population of the study comprises of five (5) scheduling tools.

3.6 Sample size and technique

A sample is a representation of a population. Four (4) out of the five (5) scheduling tools were purposively sampled for the study. These selected scheduling tools were selected because of their importance to the monitoring and tracking of road projects in Ghana. In addition, two (2) people with expertise in scheduling were also interviewed.

3.7 Data Collection

The study used desk survey in finding out the crucial information needed for the study. This was done by reviewing extant literature of linear scheduling. The sampled tools were discussed in details by comparing their uses and limitations, the theoretical principle of its operation. On the basis of this, a proposed innovative way of reporting progress was developed and presented to two (2) experts in the road sector for their views.

3.8 Data Analysis

The study discuss the identified tools relevant to the Ghanaian road sector and develop a merged version of the sampled scheduling tools.

CHAPTER FOUR

ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter discusses the proposed method of reporting on linear projects primarily in the Department of Urban Roads as in the objectives and a semi structured interviews with experienced persons in this field and their comments covering the subject matter. The proposed system of reporting primarily amalgamates the line diagram of a proposed project (scheduled work) with the concept of the time space diagram as one, which is used to form the basis for monitoring and reporting capturing as much as possible the dynamics that normally occurs in this area of work, and can show the actual progress of the project at any given time and its exact position within the limits of the project. It does this by actually diagrammatically represent completed works on a time chainage scale.

4.2 Existing systems

The current method available and in use within the Department for capturing the progress of work is primarily the use of bar charts, this however inhibits the ability of any person monitoring to be able to easily understand the import of the works without going through a series of documentation and accompanied results. The following are the setbacks.

a. When there is a change in the quantity, thus where there is increase or decrease in the volume of work of a specific activity.
b. To clearly calculate the rate of production of the works
c. To clearly indicate the progress at any specific time with respect to the works, thus the specific chainage and also when working at a specific spot such as constructing a culvert.

d. It also fails to specifically indicate which type activity are going on along a carriage way thus what is being done on the left hand side and on the right, with respect to drains kerbs and any changes thereof.

This proposal seeks to find answers to these bottle necks by suggesting ways to properly represent completed work in a diagrammatic form and making it easy for anyone monitoring either remotely or close to abreast with the projects progress.

4.3 Profile of validators

DUR 1 was the Regional director of the Department of Urban Roads Ashanti Region, He has worked with the Department since 1988 to date and a member of the Ghana institute of Engineers. Has being in the position of being reported to and also onward reporting to top management and has being at the fore front of improving the method of reporting together with management.

DUR 2 is currently the Resident Quantity surveyor at the Department of Urban Roads in charge of Ashanti region. He has also been working with the Department since 2004, a member of the Ghana institute of surveyors and also primarily generating reports of ongoing projects under his jurisdiction.

4.4 Proposed method of reporting

Figure 4.1 shows the proposed method of reporting and tracking of linear projects and further discussed under its thematic areas.

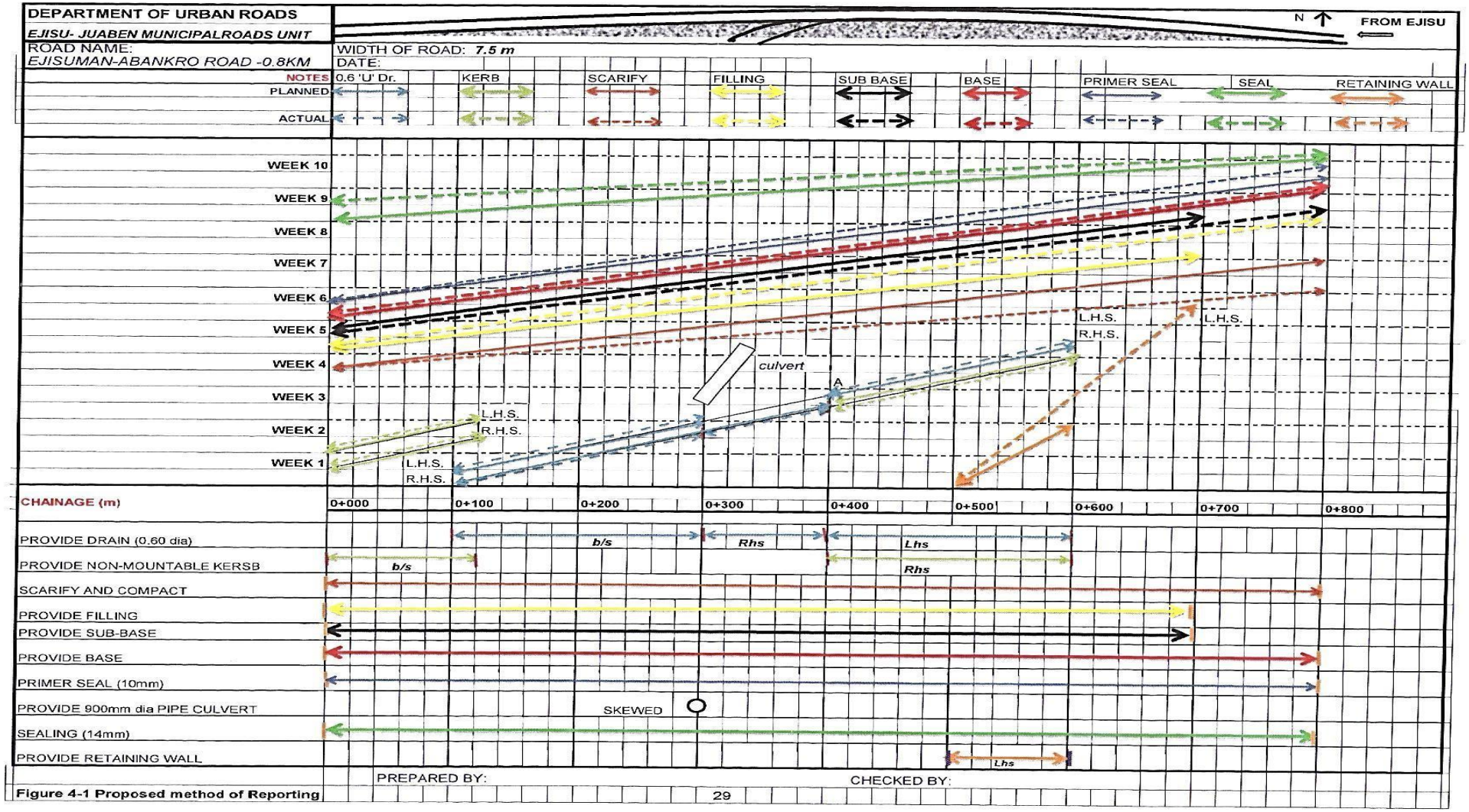

Figure 4-1 Proposed method of reporting

4.4.1 Change in quantity of work

As the name suggest, this scenario captures activities when they exceed the scheduled quantity to be done the system captures this in the time space diagram by just visually comparing proposed or the planned work to actual work done on the on the field and can be clearly seen either an increase or decrease of planned work activities in appendix 1 with activities such as *retaining wall* and the provision of *filling and subbase*

DUR1 "was highly impressed by how the proposal could do this as at just a glance even a variation other can be foreseen without digging in to the surveyors levels and quantities but wanted it developed further to include the quantities accruing to such additional work"

DUR1 "was highly impressed but wanted it developed further to include the quantities and change in design (and pictures) if any, accruing to such additional work"

4.4.2 Rate of work

This system also shows you the rate at which work is progressing, that is actual progress as against planned or scheduled progress, when work moves towards the „y" axis depicts slow progress and a movement towards the „x" axis show a faster pace of work. This is shown by in appendix 2 by work activities like *filling, Scarification* and also the *retaining wall*.

DUR1 "was absorbed by this, as time eventually runs with cost and being in management it becomes an extremely important tool in granting extension of time with or without cost it will also be a very good tool for management to take decisions especially with budgetary support and also when to terminate work and wanted further additions as

to what is causing delays being from the contractors method or from supervising engineers."

DUR2 "liked the idea and particularly as it will cut down the volumes of reports that due to volumes of work becomes a tedious work and the likelihood for management to easily review the reports and abreast with the issues at hand"

4.4.3. Working at a spot

Works that are not moving along with the project such as culvert can also be easily shown, its location and if skewed or not can be clearly seen as depicted by in appendix 3 by the skewed culvert shown at chainage 0+300.

DUR1 " liked the idea but wanted an improvement on it such that by a click of a button on it should be able to show us all the details, such as the stage of construction and to the finish to give a graphical appreciation of the works underway, and was particularly trilled by the possibility of representing traffic management and safety provision(***that is road line markings traffic light street lighting pedestrian and crush barriers*** *) with this system as a separate design from actual construction of the Road pavement."*

DUR 2 "he took a likeness to this but wanted more in the form of graphics to be added and the possibility of adding so form text in case there is a change in design such as from a pipe culvert to a box culvert and its associated details can be added."

4.4.4 Working on both sides of road

The proposed system also offers the possibility of showing activities going on both sides of the road such as drainage and kerb works and any changes which result in the actual implementation thereof as shown in appendix 4 with work activities of kerb and drainage work.

DUR1 " was particularly interested in this function of the proposed system as most variations stem from these activities, and also made the point of being able to generate as built drawing from the actual progress making it a very good tool to review the design of works and also offers the possibility for an eternal person monitoring the ability to visit the project unaided by any engineer a very good tool in the era public private partnership, and further providing means of being in-tune with the project with the addition of the pictures on progress which he sternly advocated to be part of the new system, chainage by chainage."

DUR 2 "he fancied this attribute as on a large project one can get confused as to which side a drainage is placed irrespective of the site visits as this will serve as a check in certificate preparation."

DURI and DUR2 confirmed by their responses the assertion made in the background, problem statement and literature review to the inefficient way we report and monitor linear projects and how effective the proposed system would be with the addition they proposed in the discussion. They found the possibility of reporting on linear projects in this manner as the next level of reporting in the road industry with the multiplicity of work and the associated complexity which is becoming the other of the day, coupled with the fact that

top level management needs to be abreast with the day to day running of major projects going on across the length and breadth of the country, but do not have the time and luxury to be reading lengthy reports, this proposal presents top level managers, financers, ministers (government), the ability to connect with the projects and take the desired decisions easily.

Additionally there is the need to set up to automate this system, have the ability to import pictures and data to tell the progress of work at any given time in the project life, contentious issues such as increases in thickness of filling due to bad sections of road profile, pavement thickness, cut and fill, change in design detail can easily be dealt with this proposed method and also make supervising engineers and surveyors pay more attention to details on road projects and bring equity to certification and value for money to government, stake holders and the end users at large.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The aim of this research was to find better method of monitoring and representing actual progress of projects within the Department of Urban Roads in respect of linear nature of the projects that are under taken and for that matter the road sector in Ghana as a whole. The findings are being group as recommendation to add on to current method being used The study sort to find answers to the following key objectives.

1. Identify ways of proving the existing monitoring and reporting format in the department of urban roads.
2. To apply linear scheduling technique in proposing a simple method of reporting progress works on road projects.

With the background of the above this chapter provides a detailed overview of the findings deduced from the desk study and selected interviews to answer the research question posed and achieve the objectives.

5.2 Conclusion

From the data provided and discussed in chapter 4 of this study report, the following concludes are drawn:

1. With regards to key question one, there were about four main areas which the current systems in use does not address but the proposed system does these include:

Change in quantity of work*:* the proposed system could do this by showing on the time chainage scale what was scheduled thus the planned work, and the actual work done being more or less and to what point it was done to.

Rate of work: the new proposal presents the rate of progress in respect to the scheduled rate visually as either lagging or ahead on schedule, which becomes a

very important tool for managers and engineers on the project to take decisions to improve performance, recommend variation orders, termination of and the like. ***Working at a spot:*** this new system is able to show this and show if skewed and time taken to finish it, it can also shoe installation of multiple traffic light systems like the gantry and other road furniture easily.

Working on both the sides of the road: the proposed system gives the possibility of show activities such as drain and kerbs along a road project and to what point and any changes if any.

2. In relation to key question two, the new system thus fig 4.1 was developed to fulfill the objective.

5.3 Recommendations

From the study the following areas of recommendation are made to address the problem:

- That the proposed linear method of reporting and monitoring of road projects should be adapted and used with the bar chart to give better explanations as to work progress which the weightings alone cannot give, thus the exact point within the project where the progress is at, at a given time, the rate of production, changes in design and scope and even foresee variations as the project progresses.
- The linear reporting method also make it very easy to graphically notice any changes within a project without necessarily reading a bulky report makes it a good tool for onward reporting to top management financiers and even government and in the era of public private partnership the system will allow an independent monitoring of the project unaided.

5.4 Recommendation for future research

- With this as the basis a further may be done on how to automate the system and generated the diagram as the actual works are done when quantity of works are keyed in.
- The system will also work better when pictures of various sections of the works are added up to stage completion, section by, and also the probability of importing from other scheduling software‟s

5.5 Limitation of study

The study was not without limitations, time was a very big constraint coupled with the problem that most works and literature had to be purchased. However, the researcher has no doubt that this constraint has not seriously affected the validity of the findings and conclusion of the study.

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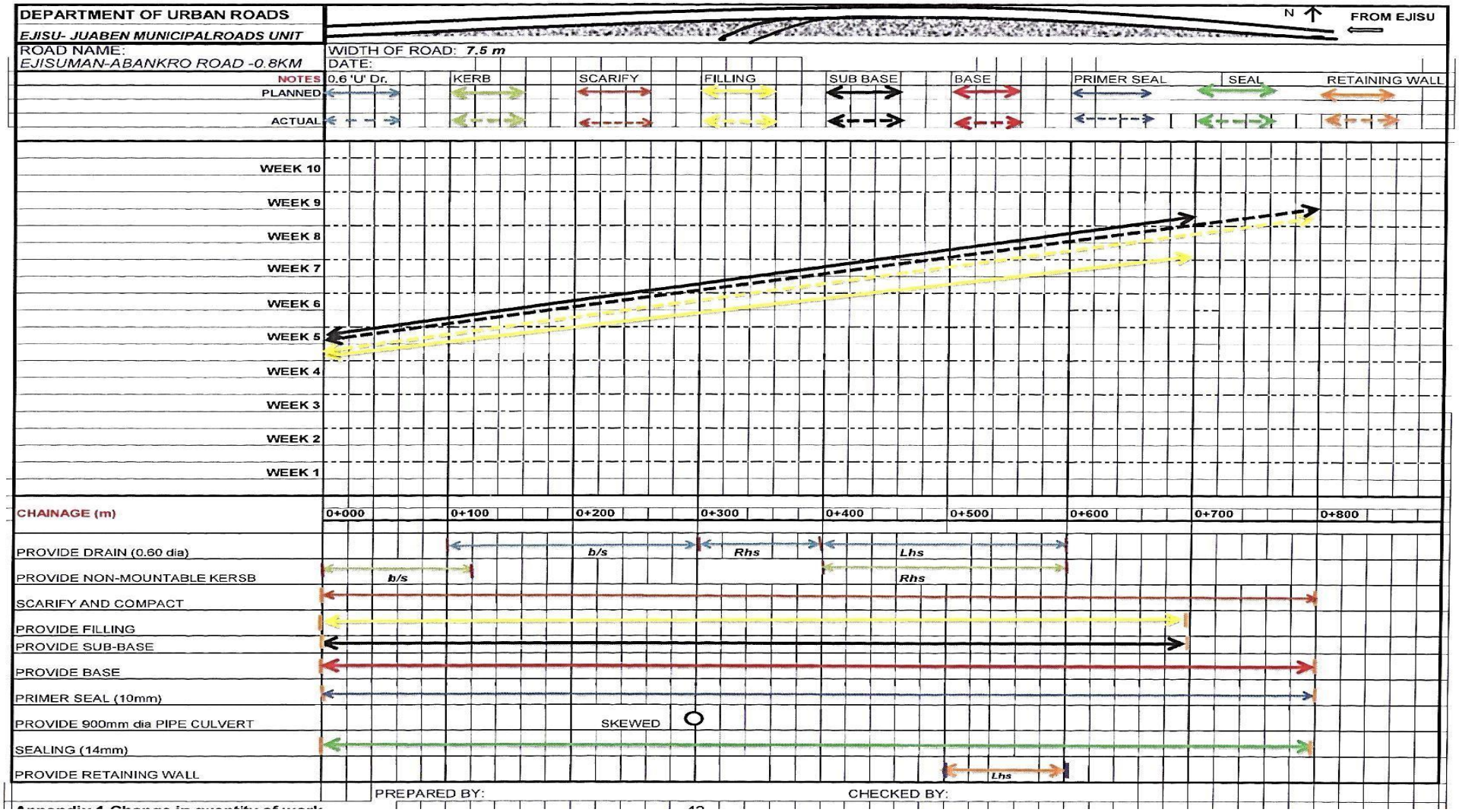
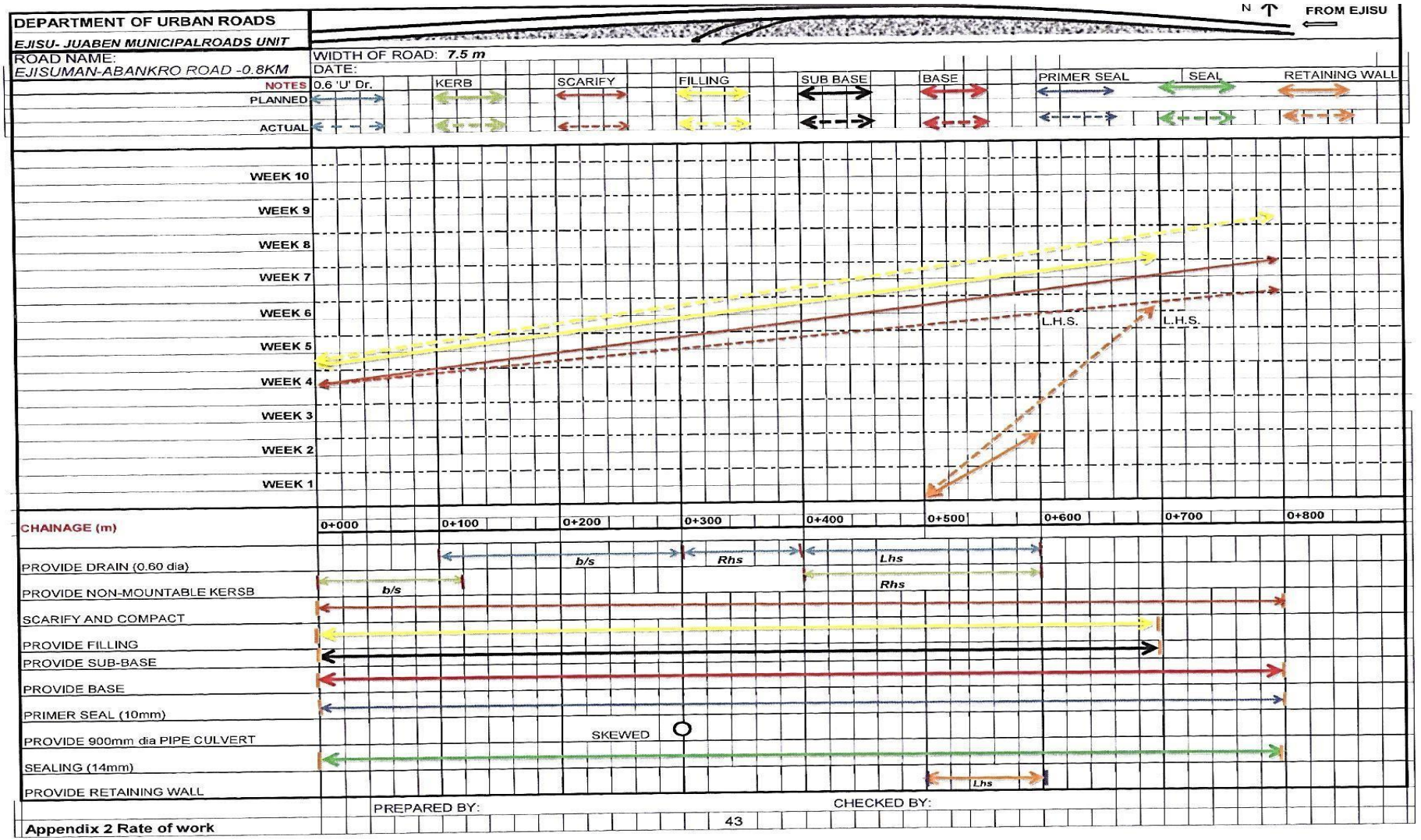
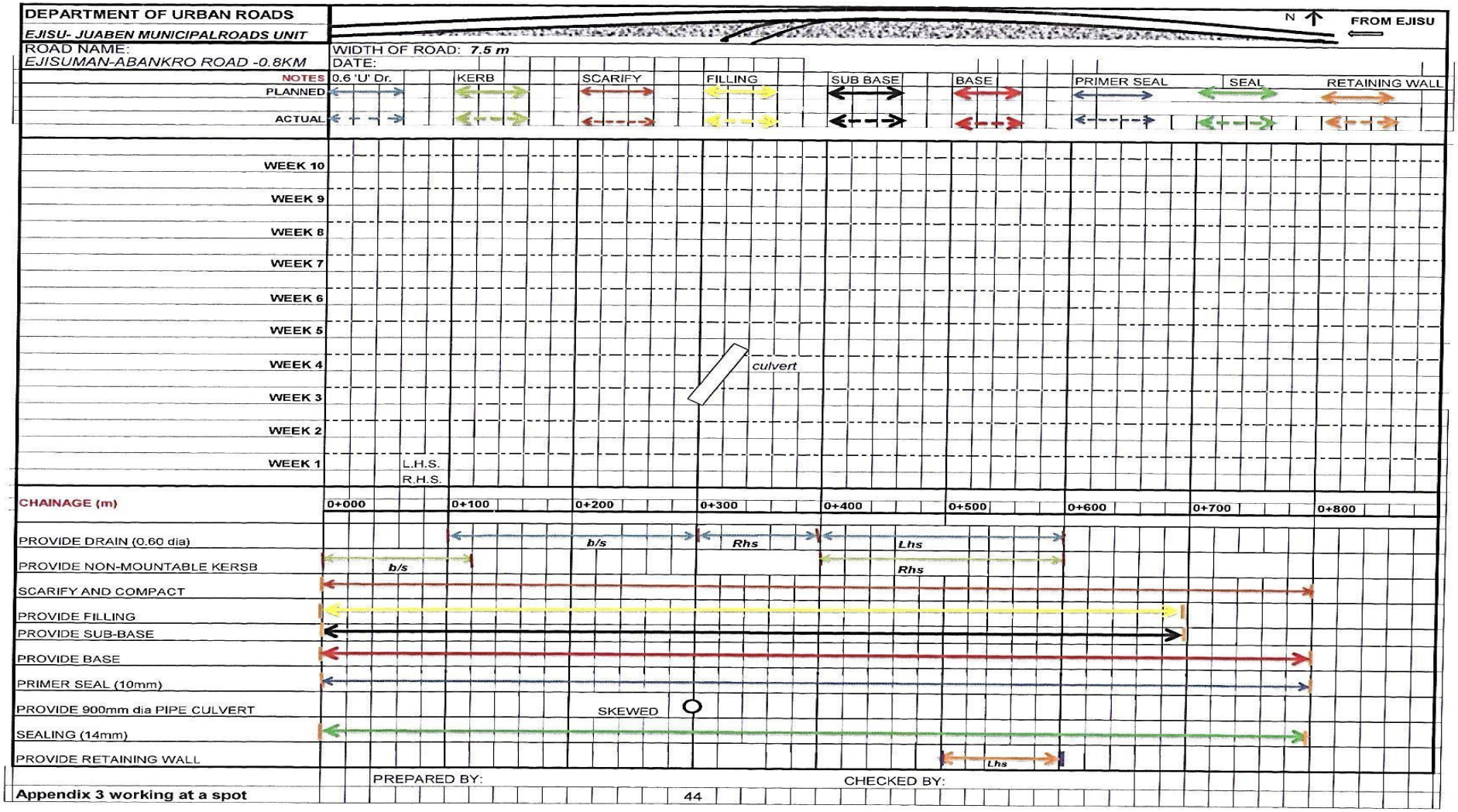
APPENDICES



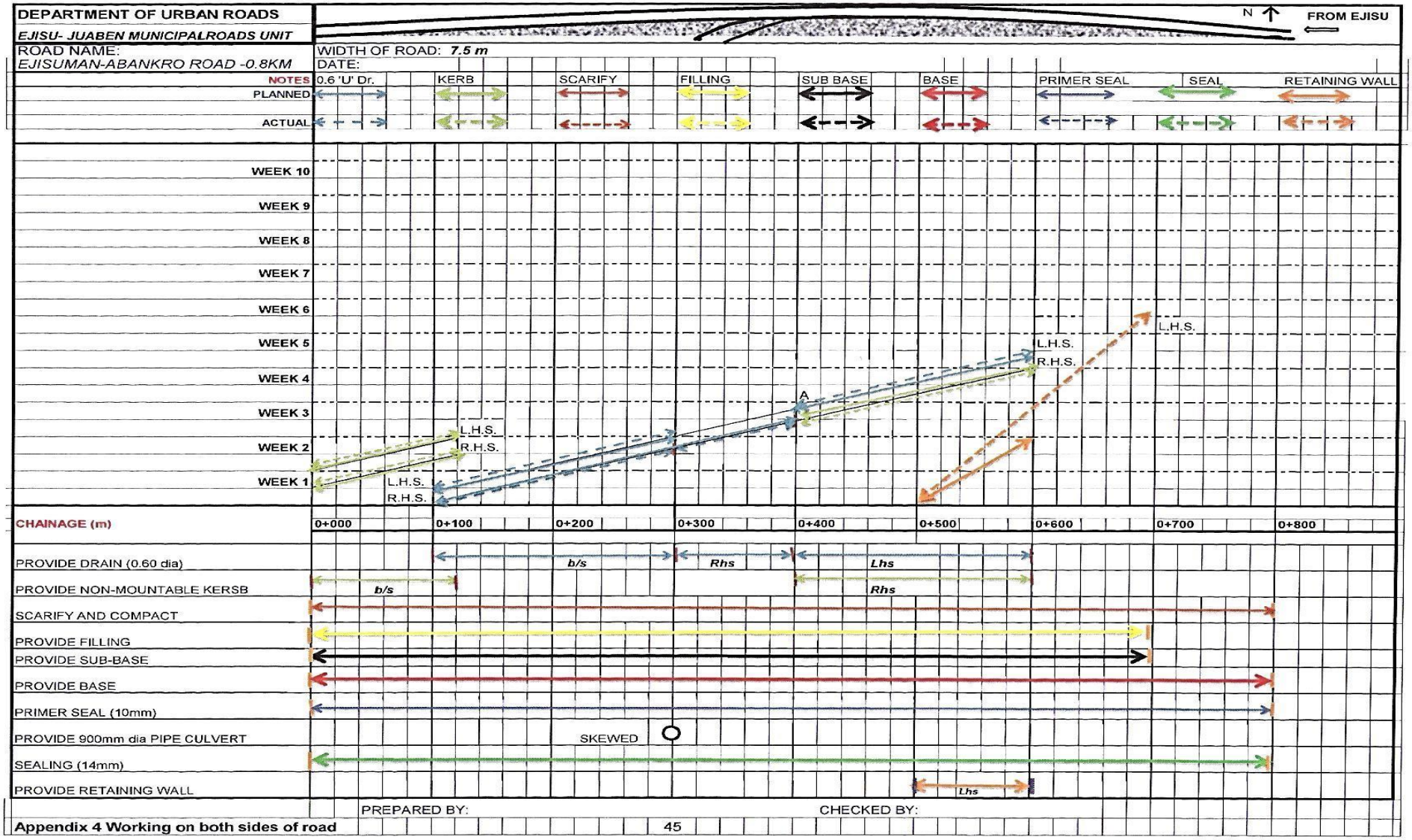
Appendix 1Change in quantity of works



Appendix 2Rate of work



Appendix 3 Working at a spot



Appendix 4 Working on both sides of road