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Incorporation of GIS in the planning of Location-based highway construction

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ABSTRACT

This research shows that a GIS may be used to apply LBP on a highway construction project on its own. For highway building projects, LBP has been used in the past but only as a supplement to other methods. Highway construction projects are now being planned and scheduled using a variety of digital technologies. A single platform for all of the data will make it easier to keep track of, comprehend, and execute plans and timetables with more precision and comprehension. It is possible to store both graphical and non-graphic highway project data in GIS. With the use of GIS, tools have been created that can calculate job quantities, plan work activities, and estimate costs depending on where the work is taking place. With the use of GIS, highway project designers have the ability to alleviate many of the issues they now encounter.

Keywords:GIS;highwayconstruction;linearscheduling;location-basedplanning

I.INTRODUCTION

Repetitive construction projects include activities that are done at several places on the project. Repetitive linear projects are ones that cover a large area and are carried out repeatedly. Examples of linear projects include motorways, tunnels, trains, and pipelines. These projects resemble assembly lines in manufacturing, except instead of moving the product along a fixed path, workers and equipment move along the length of the project as it is being built to complete the duties. As a collective, crew members are responsible for completing a certain project. An area becomes accessible for another team to do its next duty when a crew has completed its assignment there. Linear projects like highways have fewer activities than building projects, but their design is critical in order to keep the labour motivated. It is very damaging to such machinery for crews to sit idle for long periods of time. the most serious of tasks.

1.1 Thelocation-basedplanningprocess

LBP changes the emphasis of planning from activities to places. The goal is to keep tabs on the movement of workers as they move between the several places where the project is being worked on. Each site has its own set of tasks and their associated amounts.Crews working on a certain project go from site to site until the job is complete.

An area is considered "complete" after all of its duties have been fulfilled. Design flaws, risk in project delivery and total manufacturing costs may be reduced by this method.

LBP, Contrary to popular belief, CPM has not found widespread acceptance despite its aptitude for planning recurring projects (Tokdemir et al. 2006). Contrary to commercially available planning and scheduling software that implements CPM, this method is not widely available, there is no computer implementation of it. When it comes to managing large civil and infrastructure projects, Dynaroad is the best option. However, it is mostly utilized in Scandinavian nations like Finland, Sweden, and Norway, where it is not well known. Here are some of the most important aspects of location-based planning.

1.2 Thelocationbreakdownstructure(LBS)

It is a work breakdown structure like those used in activity-based project planning. It is possible to determine a roadway project's LBS by segmenting its linear geometry. In the LBS, each segment is seen as if it were a real location. It's common for LBS to be hierarchical, with various layers of organization. Higher levels have a lesser number of major places, whereas lower levels have a greater number of smaller locationsAs seen in Figure 1, It is possible to plan and finish sub-projects at the highest level without relying on one another. Only one team at a time should be allowed on the lowest level, and the expenses of each assignment should have been pre-calculated. Depending on the terrain of the site and the amount of space needed for uninterrupted job execution, the locations at each level might be the same length or different lengths.

<table>
<tr><td colspan="6">Complete highway project (100 km)</td><td>Level 1</td></tr>
<tr><td colspan="3">Highway segment awarded to contractor A (50 km)</td><td colspan="3">Highway segment awarded to contractor B (50 km)</td><td>Level 2</td></tr>
<tr><td>15 km</td><td>15 km</td><td>20 km</td><td>20 km</td><td>15 km</td><td>15 km</td><td>Level 3</td></tr>
<tr><td colspan="6">Each 100 m segment of highway with estimated quantities, construction material, and crew requirements</td><td>Level 4</td></tr>
</table>

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Figure1. Locationbreakdownstructure(LBS)atdifferentlevels

1.3 Location-basedcostestimation

In order to arrive at the final cost of an LBT, the materials and labor expenses are added together. A cumulative cost curve, often known as an S-curve, is generated by integrating the expenses with the schedule. Once an LBT is finished, the cost is tacked onto the final project cost. As a result, contractors may get their compensation only when the work at their sites is complete, and this helps prevent contractors from abandoning unfinished jobs. To ensure that all jobs are completed in all places, location-based payments like these are beneficial.

1.4 NeedforLBPforhighwayprojects

It is common to use CPM and the Program Evaluation and Review Technique (PERT) in highway project planning since they are both network-based approaches. There is a great deal of resentment among planners about these approaches (Herbsman1987; NCHRP 2000). Some of the key limitations of these approaches are the difficulty of maintaining crew continuity, the difficulty of using various crew strategies and the fact that task production rates are unavailable at any one moment throughout the project execution.

There are few more efficient ways to organize small-scale projects than using bar charts. There is a distinct benefit to being able to quickly and easily prepare and comprehend them. Because of this, they have a big drawback in terms of time and resource management: Location-based scheduling, on the other hand, Net-work based approaches take more time and effort to create, but the graphical representation of critical production information is easier to visualize. It may also aid in the detection of space and temporal conflicts between different activities. With this knowledge, it is possible to plan for long-term developments, such as highways. In addition to this, Information like lead time, synchronization, concurrency and work in progress is included in location-based scheduling charts as well as sequence and direction and interfering trades and buffers.

1.5 Currentpractice

Traditionally, the first stage in highway construction planning is to estimate the total amount of work that will be required throughout the course of the project. Design drawings created using CAD-based technologies are used to calculate quantities. Microsoft Excel spreadsheets like this one are used to store and calculate the numbers. This includes information on materials, labour, and equipment. From the design documentation, you may learn about the materials, labour, and equipment that will be utilized to complete certain jobs. The current pricing for materials, labour, and equipment are all recorded in the same spreadsheet. The size of the equipment is normally determined by its availability and the circumstances on the job site, although this is not always the case. On a regular basis, Regardless of the equipment utilized, normal production rates are used to estimate work durations. For a given unit of time, job durations and costs may be calculated. The project may be broken down into smaller segments based on physical impediments like mountains, valleys, and rivers, or depending on the number of personnel that can be allocated to many regions at once, in order to speed up completion of each part (Hassanein&Moselhi 2004). CPM or Gantt charts are created using software such as Primavera or Microsoft Project depending on the tasks that must be accomplished in each section.

1.6 BenefitsofLBP

Parts of LBP are used in highway construction planning in general. An increased reliance on the LBP technique may lead to better final plans and schedules in terms of their reliability and consistency. If you begin by breaking down the whole length of the highway into smaller sections, you can more accurately estimate how much labor is required for each section. For example As a result, it will be easier to identify and define the activities that must be carried out in each phase. Various crew combinations may be picked for different segments based on the specific qualities of each one. In order to more accurately estimate the time needed to complete a given activity, multiple production rates might be allocated to distinct segments. The use of location-based cost estimate facilitates the payment of contractors in accordance with the actual location of their work. This method of payment assures that all jobs are accomplished at each site. Complete sites may be ignored during the final assessment of long-distance projects because of this.

2. Researchobjectives

There are just a few research on the use of location-based planning and no computer implementation, unlike other systems like CPM or PERT, according to a survey of the literature. Although scholars have noted that linear projects, such as roads, are better suited to the linear scheduling approach, few studies have shown this via case studies. Studies on highway construction with a particular focus on earthwork are very rare; the vast majority are devoted exclusively to building construction. Research also reveals that different phases of building planning have looked into the GIS's capability to investigate the possibilities. Data management in the construction industry, GIS may be used for a variety of purposes, including project management, cost calculation, and timetable visualization. Prior study has not studied a GIS-based planning and scheduling tool that can be used on its own. Using GIS to execute LBP approach on highway construction is the focus of this research.

2.1Developmentofdatabase

2.1.1Graphicaldatabase

The system receives both visual and non-graphic information on highway projects. The planner uses ArcGIS to digitize each project's graphical data in the form of drawings. The proposed highway alignment and other building elements are digitally and georeferenced using topographic maps. ArcGIS can accept a variety of CAD data formats, including DWG, DXF, and DGN, directly from CAD-based programs, which is how the vast majority of graphic data is transmitted. GIS data (such as polygons and points) may be exported straight to CAD using the ArcGIS software that was utilized in this research. It is possible to save maps to images (.jpg or. If) (raster data). A geodatabase's feature classes (composed of vector data) store information on the highway's alignment and development (.gdb). Relational database management systems may be used to store and retrieve data that is geo-referenced (RDBMS).

Graphical information on the highway alignment and construction components is provided using CAD-based drawings during the project planning stage. Side drains and culverts as well as breast walls were considered in this analysis. ArcGIS received LISCAD import files for all of the project's construction drawings.

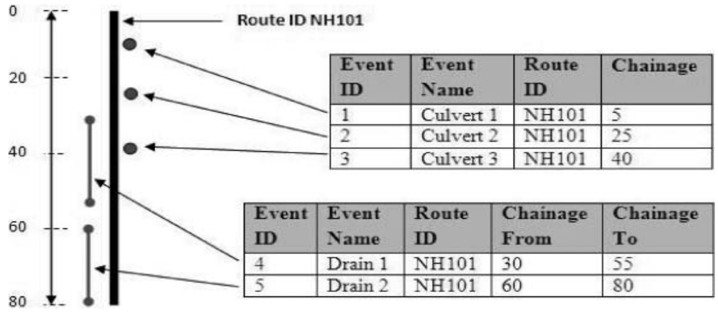

Figure2.Routeandeventfeatures(pointandline)ingraphicalandtabularformat.

Using a geodatabase, a relational database management system, georeferenced data may be retrieved and managed (RDBMS). Feature classes hold an enormous amount of visual data. feature classes are used to organize features into groups based on their nature and purpose (point, line, or polygon). With the point feature class, culverts were depicted as simple points, whereas the pavement layers, side drains, and breast walls were all represented by lines. Dynamically linked and stored in tables are the properties of all graphic aspects. When new features are added to a feature class, a feature table is immediately produced. Objects are identified in the feature table by a unique object identification number, which may be found in each row.

As a result of using ArcGIS, Once shown as a line feature, the highway alignment has now been depicted as a route feature. Any line that can be measured over its whole length is referred to as a route. Numerous highway construction parts were placed in their proper locations along the route feature as part of a series of route events. An event that occurs along a route, whether it's in the form of an individual point or a continuous line, is known as a "event." The location of a point is all that defines a point event, while the beginning and ending positions of a line event describe a line event. Route ID-NH101, for example, has zero chainage at the beginning and 80 chainage at the finish, as indicated. All three points and two lines are placed on the road NH101 in their respective locations. Culverts and drains are each represented by a point or a line event. Defining events triggers automated generation of the tables displayed in, which include route and event data.

2.1.2 Generationoflocationbreakdownstructure

Creating the LBS is as simple as taking a highway route and breaking it down into smaller route characteristics. On the highway route in ArcGIS, where the user desires to divide the highway to produce LBS sites, those points are noted. Only one hierarchy level was explored in this research because of the convenience of implementation. From the points specified by the user, a software was created to produce locations inside LBS The chain age of the highway route features is used to determine the sites' beginning and ending chain ages. There are two points highlighted in Figure 10 from which three places may be generated. Alternatively, the script may be programmed to take the beginning and ending chain ages of each site as user input and utilize that to produce new locations. An automatically created feature table, as illustrated in, contains the user-specified locations. The table includes the following columns: Identification of the starting and ending points in the chain, as well as the length of the chain and the name of the site. There are as many sites in the LBS as there are rows in the table. Building components are identified and recorded based on their sequence in relation to the highway route features, as is shown in.

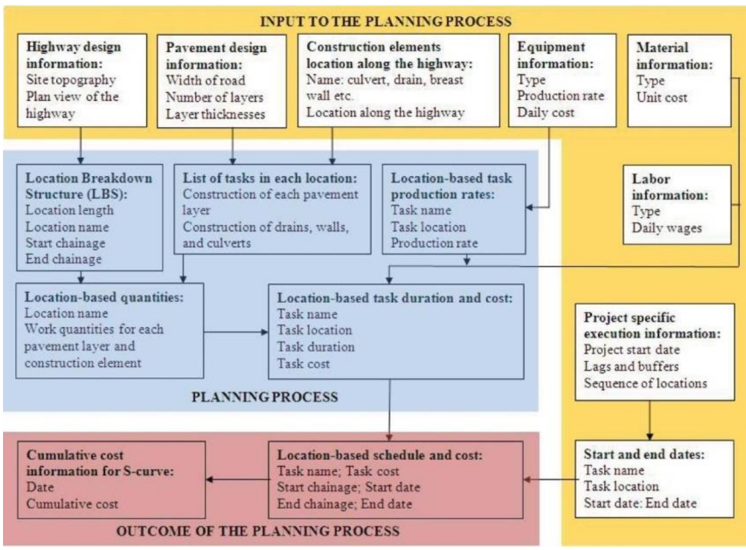

Figure3. Developedlocation-basedplanningprocessforhighwayconstructionplanning.

2.1.3 Computationoflocation-basedquantitiesanddefininglocation-basedtasks

In order to save time, another script performed the LBQ calculation automatically. In each place, it specifies a variety of building components. Considerations for the present research encompassed everything from pavement layers to drains and breast walls. LBQ is determined by measuring the length, width, and thickness of each layer of pavement in the pavement table. Instead of manually determining LBQ values for different architectural elements such as culverts, drains, and breast walls, feature tables may be used. To each LBT's LBQ, an individual task identification is given (ID). Construction of culverts, drains, breast walls, and pavement layers are some of the tasks we are examining in this investigation (sub- grade, sub-base, base, and surface). Each component of a structure has its own table, and LBQ has its own table just for it. Fields such as Location ID, Task ID, Task Name, and Quantity may all be found in the LBQ and LBT databases, among others.

Different building components at different locations may need different numbers of LBQ and LBT. There is a task table in which a highway project's duties are listed. The planner selects the tasks from the task table for the project at hand. “In the task table, each job is connected to a particular crew ID defined in the crew database. The daily cost and daily productivity of each crew ID is also given in the crew table.” It's important to remember that crew productivity is influenced by factors including crew equipment size and local environmental variables.

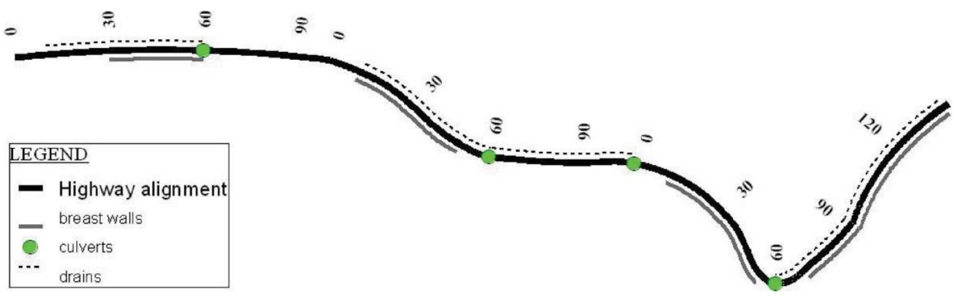

Figure4.The route of the highway and the components of construction are situated in accordance with the chain of command.

III.CONCLUSION

GIS may be used for location-based planning of highway building projects as shown in this research. GIS-formatted files were used to gather both graphical and non-graphical information needed for highway building planning. Using GIS scripts, a programmer was created to automate the LBP process by allowing for user input at each stage. Using the GIS data, the user first constructs an LBS from the road alignment. As a result of this, LBQs are calculated and LBTs established, personnel are allocated to jobs, During the next steps, task durations and costs are determined. When used in the context of a GIS, the developed tool creates tabular and visual representations of an estimated timetable and cost depending on a given location. In a graphical depiction, a location-based timetable was displayed on a date vs. chain age graph with chain age on the horizontal axis. It was decided to utilize an S-curve to show the location-based costs. A linear repeated project's execution plan is best represented using a linear timetable.

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