# SIMULATION OF RESURFACING PAVEMENT OPERATION OF HIGHWAYS UNDER LANE CLOSURE CONDITION

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**ABSTRACT**: Lane closures during paving operation on roads usually restrict the continuity of paving operations and traffic flow, causing delay in paving time and delay of traffic flow time. This paper studies the resurfacing operation of highways using computer simulation. It describes the different types of traffic control devices. It also describes the different types of paving including; semi-rigid paving and flexible paving. To achieve this objective, filed data collected during construction, was used to determine duration, productivity rate to test a development simulation model. The tool utilizes STROBOSCOPE as a simulation engine and is coded by Visual Basic 6.0.

***Keywords**: Computer Simulation, Lane Closure, Resurfacing Operation, Highway Reconstruction Project*

## 1. INTRODUCTION

Highway maintenance, especially pavement rehabilitation or resurfacing, requires lane closures. Such maintenance is associated with substantial cost, traffic disruption and safety hazards. Highway construction projects are classified as infrastructure construction projects which are characterized by long duration, large budget, and complexity. Resurfacing of highways involves different activities and is executed in different conditions which may raise uncertainties that influence production rates of construction resources. These different conditions includes unusual or complex works, equipment breakdown, unfavorable weather conditions, and unexpected site conditions. Several simulation systems have been designed specifically for construction [1, 2]. These systems use network-based Activity Cycle Diagrams to represent the essentials of a model, and employ clock advance and event generation mechanisms based on Activity Scanning or Three-Phase Activity Scanning.

Modeling utilizing simulation can be applied either in a general or special purpose simulation environment. General purpose simulation (GPS) is based on formulating a simulation model for the system under study, running the simulation and analyzing the results in order to decide whether the system is acceptable or not. In case of being unacceptable, the process is re-iterated and a new alternative system is considered. Different GPS software systems have been developed for a wide range of industries: AweSim[3] and GPSS/H [4]; for construction: Micro-CYCLONE [5] and STROBOSCOPE [1]. Special purpose simulation (SPS) is based on creation of a platform or a template for a specific domain of application [6, 7, 8, 9]. The steps for simulation, in this case, are the same as in the GPS case except for the first step (construct simulation model) since the platform has the characteristics and behavior of the system under study. Also, the modification is limited to the input parameter(s) of a pre-defined system and not to the characteristics and behavior of the system. This paper describes the activities involved in highway resurfacing operations. Then, it presents the developments made in simulation models that are dedicated for such activities.

## 2. RESURFACING HIGHWAY OPERATIONS

The first stage in highway resurfacing is converting traffic flow to opposite direction or closes some of the lanes. Traffic controls devices are used to convert the flow in the opposite direction or close some of the lanes. After control devices are laid, the old concrete platform and median are broken, waste is removed out of the site, and new concrete

is poured.Finally, the new asphalt layer is laid. The following subsections describe these activities for the different types of paving including; semi-rigid paving and flexible paving.

### 2.1 Converting Traffic Flow

In highway work zone, hundreds of people lose their lives and more are injured due to vehicle crashes. Therefore, traffic control devices should be set to convert flow in opposite direction or close some of lanes. Traffic control devices including flagger control (Figure 1-a), traffic signs (Figure 1-b), arrow panels and portable changeable message signs (Figure 1-c), channelizing devices (Figure 1-d), temporary pavement markings (Figure 1-e), lighting devices (Figure 1-f), and temporary traffic control signals (Figure 1-g). Once the control devices are set, median and platform concrete are broken using jack-hammer and the waste is removed outside the site.

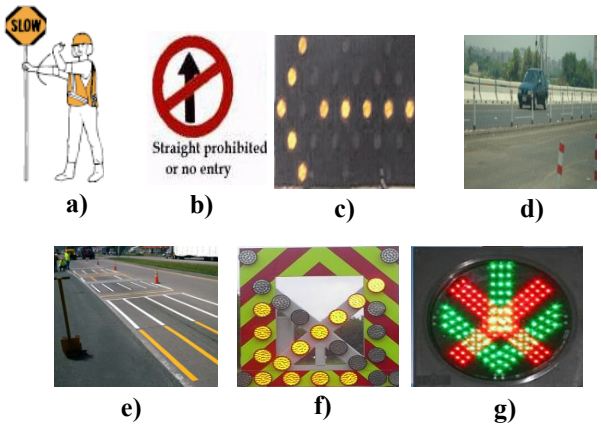


Fig. 1 Traffic Control Devices

### 2.2 Reconstruction Semi-Rigid Paving

The following activities are considered in reconstructing semi-rigid paving:

1. Breaking old concrete slab: It represents the first activity in repairing project. Jack hammers are used to break old slabs, which connect between flexible pavement and rigid pavement.
2. Removing the waste out of the field: Loaders are used to load the waste in the trucks. Then, the trucks haul to dump the waste away and return to field.
3. Dewatering: This activity is performed to ensure that work area and approach/access are free from accumulation of water and materials at all times.
4. Excavation: Soil excavation is performed to put new base layer. Jackhammer is used in this activity.
5. Removing waste from the flied: Removing the excavation waste outside work zone area.
6. Placing base layer: This layer is placed under converted slab.
7. Pouring concrete reinforced slab: This activity has three steps:
   - The formwork crew makes forms for slab with the required dimensions and the exactly shape of slab.
   - The reinforced work crew forms steel bars according to the specifications.
   - Pouring concrete using pouring crew.
8. Casting footing blocks: Footings are casted at the site.
9. Fixing footing blocks: Footing blocks are fixed for the length of median and platform edges.

### 2.3 Reconstruction Flexible Paving and Finishing

The following activities are considered in reconstruction flexible paving and finishing:

1. Removing old flexible pavement: The old flexible pavement layer is removed to get new smooth surface.
2. Compacting first layer of asphalt pavement: This layer is used to connect between base layer and surface layer.
3. Surfacing of second layer: This is the final layer of paving, which must be smoothness.
4. Repairing transverse expansion joint and contraction joint: Several types of joints exist including.
5. Finishing surface: Hot paint is applied to divide the road into lanes to guide the drivers on roads. The activity also includes fixing reflected signals on ground.
6. Installing electric work: This activity involves installation of electric signals and fixing lights columns on road.

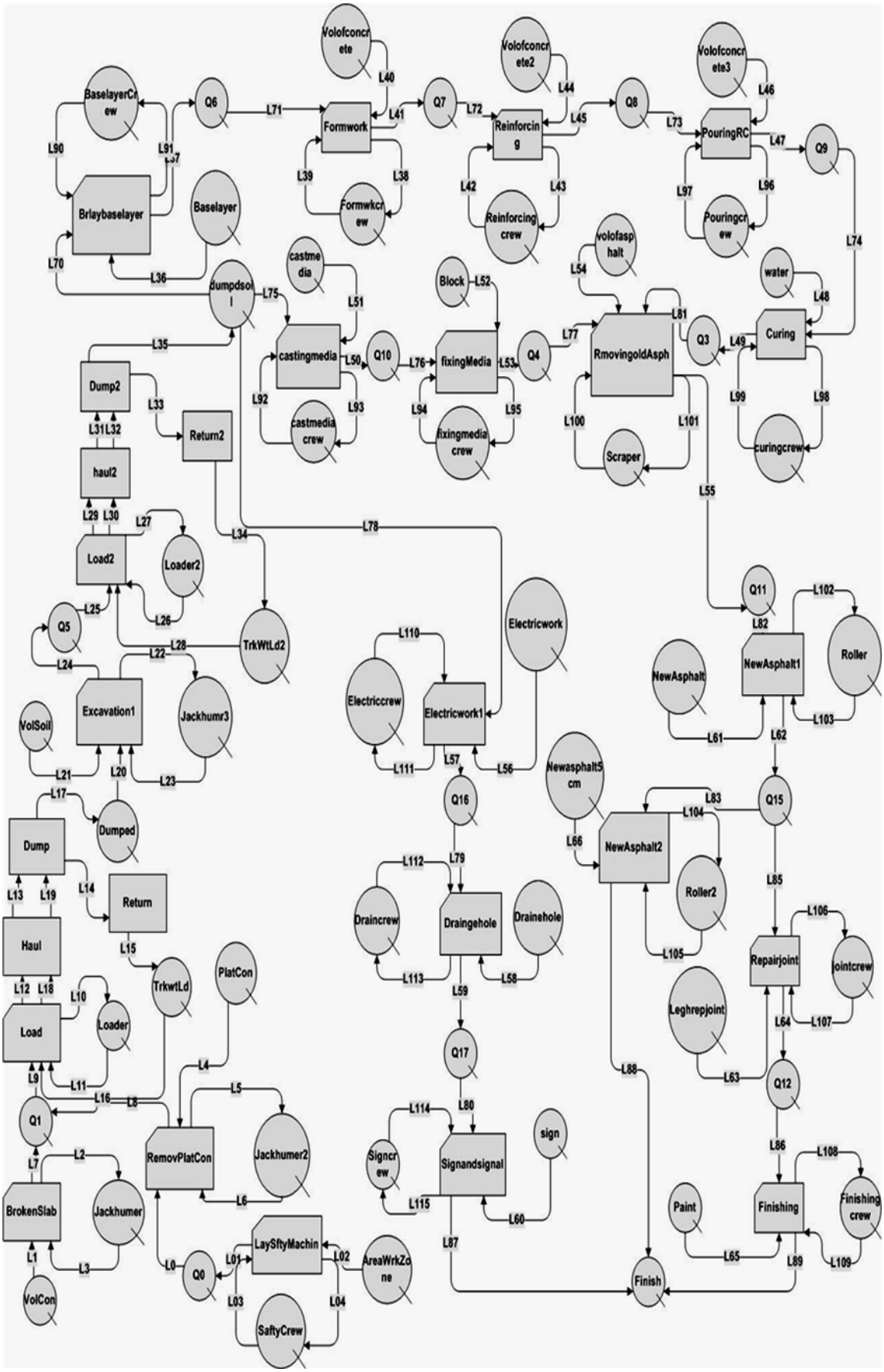


Fig. 2 General Simulation Modeling for Resurfacing Operation

7. Dewatering holes: Dewatering holes are used to drain the water that might fall on the road due to rainfall or any other reason such as break of a water pipe. Such holes are located at the lowest road level at the edges.
8. Fixing signs: The signs and signals are important items since they guide the drivers on road.

## 3. SIMULATION MODULE FOR RESURFACING OPERATION

The proposed simulation module utilizes STROBOSCOPE [1]. The simulation module is developed in Microsoft Visual Basic 6.0 to control STROBOSCOPE program. Four simulation models are built in the developed Simulation Module as listed in Table1. These simulation models are developed based on the activities involved in highways' resurfacing activities, described in Resurfacing Highway Operations. The simulation module provides the total duration time. Resurfacing highway involves fifteen processes [10]: 1) laying safety control devices, breaking concrete, 3) removing the waste materials from work zone, 4) excavating the old base layer of paving, 5) removing the waste soil of base layer outside site, 6) laying new base layer, 7) pouring new reinforced concrete slab, 8) ?constructed median, 9) Removing old paving, 10) laying new paving, 11) electric work, 12) drainage hole, 13) sign and signal, 14) repairing joint, and 15) finishing. Figure 2 represents the components of simulation model for resurfacing highway. The area of work zone Queue is initiated at the beginning of the simulation session by one dummy resource. A sample control statement is used to launch the simulation session as follow:

*SIMULATEUNTIL;*

The simulation model runs until the Dummy resource reaches the Finish Queue. The stopping of criteria occurs when there is no more Paint, Sign, and Volume of New Asphalt resource to run simulation. This termination of simulation is named "lake of resources" termination.

Table 1 Developed simulation models for resurfacing operation.

| File name | Description |
|---|---|
| 1st Stage | Converting traffic flow |
| 2nd Stage | Reconstruction semi-rigid paving |
| 3rd Stage | Reconstruction flexible paving and finishing |
| General Model | All three stages of resurfacing operation |

## 4.CONCLUSIONS

This paper proposed a simulation model that aids contractors in planning of highway resurfacing operation. The simulation module received from the user input data such as project data (task's duration, required resources, labors, material cost, and equipment rates). Then, the simulation module runs in order to calculate the duration of execution at each zone.The simulation module contains four simulation models that are developed to represent highway resurfacing operation stages. The simulation module uses STROBOSCOPE software as a simulation engine to estimate the construction duration.

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