

Night-Time Construction Issues

Donn E. Hancher, Ph.D., P.E.

Terrell-McDowell Chair Professor of Construction Engineering & Management

151B Raymond Building

University of Kentucky

Lexington, KY 40506-0281

Phone: (859) 257-4857

Fax: (859) 257-4404

hancher@engr.uky.edu

Timothy R.B. Taylor, E.I.T.

Research Assistant

151D Raymond Building

University of Kentucky

Lexington, KY 40506-0281

Phone: (859) 257-8033

Fax: (859) 257-4404

tbtayl0@pop.uky.edu

ABSTRACT

This paper summarizes the findings of the Kentucky Transportation Cabinet (KyTC) study KTC-00-16, *Night-Time Construction Issues*. The current state of night-time construction is examined through a survey of night-time construction practitioners. In order to determine the feasibility of performing a project at night the factors that affect night operations are discussed as well as a night-time project evaluation form. As lighting is a crucial element of any night project, a new form of lighting technology is briefly discussed. An idea which is slowly beginning to gain favor with transportation departments is outlined, the contractor supplied work plan. Finally, ideas for improvements in public relations as well as recommendations for overall night-time project improvement are discussed.

KEY WORDS

Night-Time Construction

Night-Time Project Selection

Contractor Work Plan

1.0 INTRODUCTION

There is an increasing demand for performing many transportation related construction and maintenance operations at night, especially in urban areas, to reduce conflicts with the traveling public. This approach can be beneficial for reducing traffic disruptions; however, there are several concerns to state highway departments and contractors which must be considered. There is a perceived loss of productivity in performing night-work which can increase the costs of the work and an increased risk for the safety of the workforce. There is also an exposure for liability for the safety of the traveling public and increased citizen complaints of noise near night-time project locations. Because of these, and several other factors, special guidelines are needed for the proper implementation of night-time construction.

2.0 SURVEY OF NIGHT-TIME CONSTRUCTION PRACTICES

In order to determine the issues, problems, and impact of night-time construction a survey was conducted among the State Departments of Transportation, selected Kentucky highway contractors, and the Kentucky Transportation Cabinet Resident Engineers. The three groups received a similar survey which focused on their opinions and past experiences with night-time construction. Of the surveys that were mailed, responses were received from 32 State Transportation Departments, 20 Kentucky highway contractors, and 23 Kentucky Resident Engineers

The survey sought to determine the issues that contributed to the decision to work at night, what problems had been encountered during night work, what effect night work has had on project schedule, cost, and safety, and how night work affected the quality and productivity of certain construction activities. Additionally the groups were asked what they felt was the biggest advantage and disadvantage of performing work at night.

Table 1 shows the top 5 responses from each group concerning the question: *Which of the following heavily contribute to your decision to work at night?*

TABLE 1 Top 5 Issues Contributing to the Decision to Work at Night

Dept. of Transportation	Highway Contractor	KyTC Resident Engineer
1. <i>High Daytime Traffic</i>	1. <i>High Daytime Traffic</i>	1. <i>High Daytime Traffic</i>
2. <i>Traffic Control</i>	2. <i>Contract Incentives</i>	2. <i>Temperature Concerns</i>
3. <i>Road User Costs</i>	3. <i>Schedule Issues</i>	3. <i>Traffic Control</i>
4. <i>Longer Work Periods</i>	4. <i>Traffic Control</i>	4. <i>Schedule Issues</i>
5. <i>Schedule Issues</i>	5. <i>Safety</i>	5. <i>Longer Work Periods</i>

As was expected, high daytime traffic levels heavily influence the decision to work at night, generating the greatest number of responses from each group. While their respective ranks may vary, *schedule issues, traffic control issues, and longer work periods* were ranked in the top 5 by each group.

Additional comments were made regarding the decision to work at night. Indiana mentioned that disasters have necessitated night work in the past. Nevada mentioned political concerns as affecting their decision. One contractor stated that for reasons unknown their production increased during the night shift. Kentucky Resident Engineers contrasted between rural and urban areas. Residents in rural districts stated that temperature concerns were their main reason for working at night, while residents in urban areas stated that daytime traffic levels were their main concern.

Table 2 shows the top 5 responses from each group concerning the question: *Which of the following problems have you encountered during night operations?*

TABLE 2 Top 5 Problems Encountered During Night Operations

Dept. of Transportation	Highway Contractor	KyTC Resident Engineer
1. <i>Quality</i>	1. <i>Quality</i>	1. <i>Safety</i>
2. <i>Lighting</i>	2. <i>Lighting</i>	2. <i>Lighting</i>
3. <i>Safety</i>	3. <i>Safety</i>	3. <i>Quality</i>
4. <i>Productivity</i>	4. <i>Equipment Maintenance</i>	4. <i>Employee Morale</i>
5. <i>Public Irritation</i>	5. <i>Productivity</i>	5. <i>Traffic Control</i>

The results do not present one clear consensus problem associated with night work; however, there are several problems common among the three surveyed groups including *safety*, *quality*, and *lighting*.

There were several noteworthy comments made regarding problems encountered during night operations. Several states reported that glare was the biggest problem associated with construction lighting. Maryland reported that downsizing lead to project staff working double shifts. North Dakota stated that “although safety is a concern, we have not experienced injuries or death attributed to night work.”

The State Departments of Transportation and the Kentucky Resident Engineers were asked for information regarding the volume, value, and location of night work in their state or district over the last 12 months. Statistical information is shown in Table 3.

TABLE 3 Average Volume, Value, and Location of Night Work (Previous 12 months)

	Departments of Transportation	KyTC Resident Engineers
<i>Ave. Number of Projects</i>	23.0	2.2
Minimum	1	0
Maximum	150	5
<i>Ave. Dollar Value (12 months)</i>	\$100,973,205	\$14,026,857
Minimum	\$2,000	\$50,000
Maximum	\$400,000,000	\$55,000,000
<i>Ave. Percent Rural</i>	20%	54%
<i>Ave. Percent Urban</i>	80%	46%

Additionally the contractors were questioned regarding the number of night-time projects they had performed. The average for the 20 contractors was 14.1 projects.

The three surveyed groups were asked to rate the effect night work had on project schedule, cost, and safety on a 1-5 scale (1-very negative, 3-no effect, 5-very positive). Table 4 shows the average values for each group.

TABLE 4 Night Work's effect on Schedule, Cost, and Safety

	Dept. of Transportation	Highway Contractors	Resident Engineers
<i>Schedule</i>	3.8	3.7	3.9
<i>Cost</i>	2.5	2.8	3.2
<i>Safety</i>	2.8	2.9	3.0

What is surprising in these results is that project safety, commonly perceived as being compromised at night and, as previously discussed, rated in the top 3 among problems associated with night-time construction, was rated as being not affected by the three groups. A possible reason for this, as provided by comments from the respondents, was that at night, workers are more aware of the dangers and thus were more conscious of safety practices.

The highway contractors were questioned regarding any special work rules that they applied to their labor force for night operations. Most contractors stressed that safety was emphasized for night operations; however, only one of the 20 contractors reported to providing advanced training for night shift employees. Nearly all contractors stated that additional reflective clothing was worn at night. Several contractors also stated that they did not perform detailed finish work at night.

The commonly held belief is that the degree that quality and productivity are affected by night work varies from operation to operation. Certain operations can be performed better at night while other operations are negatively impacted. The three surveyed groups were asked to

rate how night work affected the quality and productivity of the following activities on a 1-5 scale (1-very negative, 3-no effect, 5-very positive).

<i>Earthwork</i>	<i>Concrete Pavement</i>	<i>Rock Excavation</i>
<i>Bridge Deck Pour</i>	<i>Asphalt Pavement</i>	<i>Striping</i>
<i>Bridge Deck Overlay</i>	<i>Blasting</i>	<i>Sign Placement</i>
<i>Structural Bridge Work</i>	<i>Drainage/Utilities</i>	<i>Traffic Control Systems</i>

Table 5 shows activities whose quality or productivity or both are NOT negatively effected by night work.

TABLE 5 Operations that are NOT Negatively Effected by Night Work

Quality	Productivity	Both Q & P
<i>Bridge Deck Pour</i>	<i>Bridge Deck Pour</i>	<i>Bridge Deck Pour</i>
<i>Bridge Deck Overlay</i>	<i>Bridge Deck Overlay</i>	<i>Bridge Deck Overlay</i>
<i>Structural Bridge Work</i>	<i>Asphalt Pavement</i>	<i>Rock Excavation</i>
<i>Drainage/Utilities</i>	<i>Rock Excavation</i>	
<i>Rock Excavation</i>	<i>Traffic Control</i>	

Nearly all of the transportation departments listed the main advantage of night-time construction as the decreased impact on the traveling public through less congestion and decreased construction time. The contractors also shared this sentiment while including lower temperatures leading to better quality and more comfortable working conditions during the summer, contract incentives, longer work periods, better productivity, ease of material delivery, and reduced equipment costs. Resident engineers felt the main advantage was primarily the reduced traffic volume and less inconvenience for the traveling public but also cited ease of material delivery, decreased construction time, minimal business disruption, lower temperatures, and longer work periods.

The transportation departments were evenly split between product quality and project safety being the main disadvantage of night work. Comments were also made regarding limited work hours, employee morale concerns (both DOT and contractor personnel), public irritation,

staffing requirements, and decreases in productivity. The contractors shared the departments' sentiments regarding quality and safety as the main disadvantage. They also cited local laws governing night work, public irritation, decision making difficulty, manpower shortages, worker morale, equipment repair, and poor visibility. One contractor stated that there were no disadvantages to night work. The resident engineers also cited quality and safety as their major concern. Also mentioned was public irritation, noise, visibility problems, KyTC personnel scheduling, decision making, and lighting.

Several states provided additional comments on the subject of night-time construction. Arkansas stated that "alcohol impaired drivers are more numerous at night." Georgia has been utilizing night work for several years but does not have special specifications or requirements for night operations. Nevada stated that "success is contractor/project specific." Texas recommended only using night work when day work was not feasible.

The highway contractors also included additional comments. One comment stated that rough grading could easily be accomplished at night while final grading was nearly impossible. Another contractor predicted that most striping will eventually be done at night. Several contractors stated that the success of night work depended upon several factors including location, project type, and traffic considerations. One contractor stated that worker availability problems could be reduced by maintaining constant and uniform night operations.

The survey results both upheld and disproved some common perceptions of night-time construction. Safety, while commonly perceived as being compromised at night, was rated as not affected by the three surveyed groups despite repeatedly being cited as one of the primary disadvantages of night work. The belief that the main reason for utilizing night work was high daytime traffic levels was upheld while the commonly perceived negative impact on quality and

productivity was disputed. According to the survey the cost of night work is generally higher than similar day time construction activities. Overall the results seem to indicate that the success or failure of night work varies depending upon the type of work being performed, the experience of the contractor with performing night work, and the location of the project.

3.0 FACTORS AFFECTING NIGHT-TIME CONSTRUCTION

In order to accurately assess the potential of a project for night-time operations it is important to identify the issues and parameters that affect night work. Figure 1 shows the parameters and issues that effect night work. This chart was developed from a 1997 report by O. A. Elrahman and R. J. Perry entitled *Guidelines for Night-Time Maintenance and Construction Operations (1)*. The chart was expanded by the research project's Advisory Committee to reflect issues that are relevant in Kentucky. Following is a description of each factor.

Traffic Related Parameters

Safety: The safety of the traveling public should be a leading factor in the decision to work at night.

Congestion: The impact of the proposed construction on the traffic flow through the site.

Traffic Control: Traffic control affects both safety and congestion. Ellis and Herbsman in their 1993 report *Developing Procedures for Night Operations of Transportation*

Construction Projects describe the two main goals of traffic control as (2):

1. To "ensure the smooth, safe movement of the traveling public through the work zone."
2. To "provide safety for the workers and equipment in the work zone."

Work Time Restriction: Any operating hour restrictions that have been placed on the project through local, state, and federal agencies as well as contract restrictions.

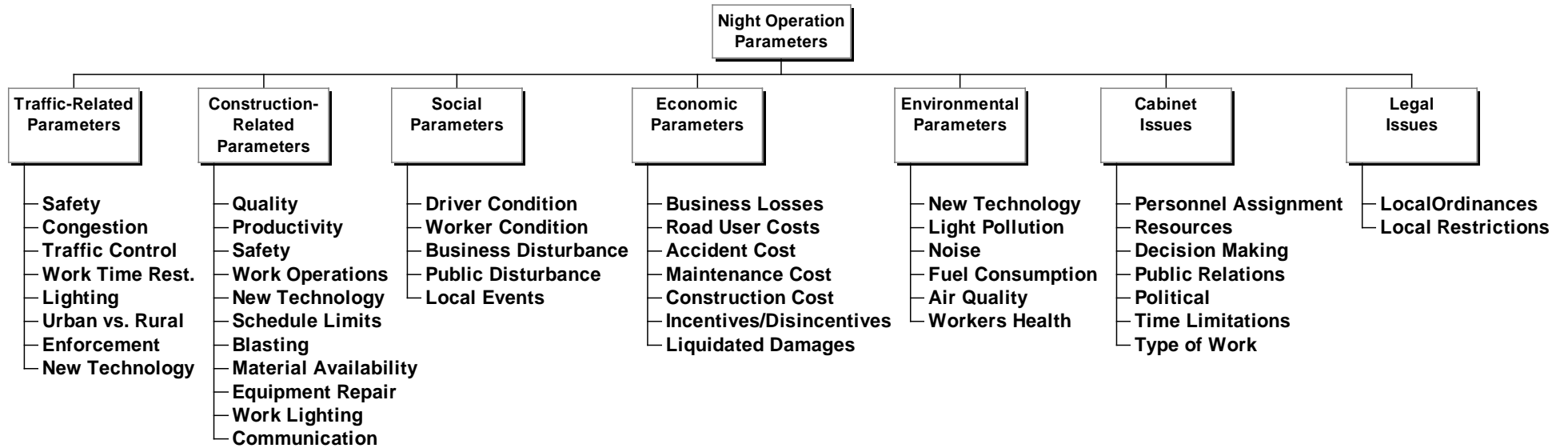


FIGURE 1 Factors Affecting Night-Time Construction

Lighting: Construction lighting must be arranged in a manner that minimizes glare to the traveling public while still adequately illuminating the job site.

Urban vs. Rural: Typically rural areas have decreased traffic volumes moving at higher speeds compared to slower moving, dense urban traffic.

Enforcement: Traffic control and construction speed limits must be enforced in order to be effective. This is generally achieved through local or state police departments.

New Technology: Signage, message boards, channeling devices, etc. that are more conducive to night-time construction.

Construction Related Parameters

Quality: The effect night work will have on the quality of the final product.

Productivity: The effect night work will have on the productivity of the contractor.

Safety: Methodologies employed for night operations may differ from identical daytime operations for safety reasons.

Work Operations: Whether night-time conditions require different procedures or methodologies than daytime operations.

New Technology: The effect improved equipment and methodologies can have on night operations.

Schedule Limits: Restrictive schedule limitations. Possibility of decreasing completion time through double shift work.

Blasting: Careful considerations should be made concerning blasting operations at night.

Material Availability: Arrangements for the delivery of materials to the job site. Also added expenses for night-time material production and delivery may be incurred.

Equipment Repair: Contingency plans for dealing with the breakdown of major pieces of equipment should be developed.

Work Lighting: Lighting can affect nearly every aspect of night work.

Communication: During night operations communication between field and office personnel is difficult at best.

Social Parameters

Driver Condition: Drivers at night are more likely to be fatigued or under the influence of drugs or alcohol.

Worker Condition: Workers are more likely to be fatigued at night. Figure 2 from Ellis and Herbsman's 1993 report *Developing Procedures for Night Operations of Transportation Construction Projects* shows factors affecting the ability of workers to cope with shift work (2).

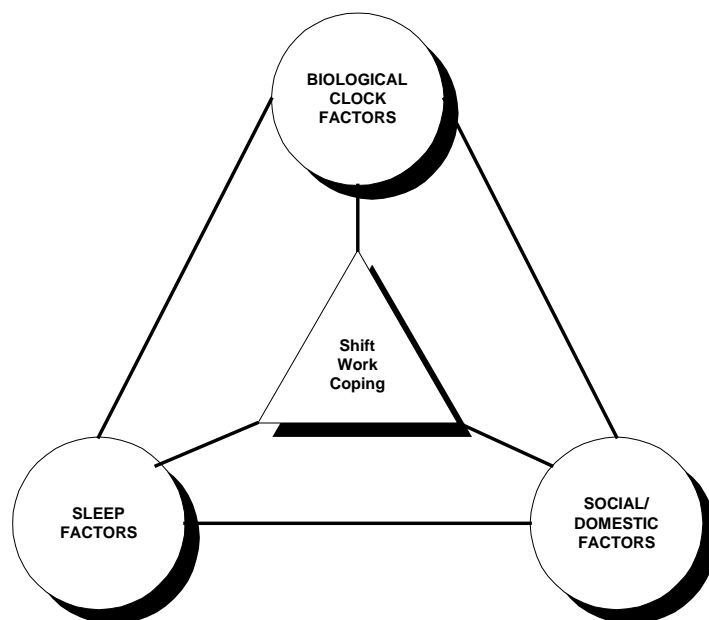


FIGURE 2: Shift Work Coping Factors (Ellis and Herbsman, 1993)

Business Disturbance: The effect (noise, traffic, dust, etc.) that night operations will have on surrounding businesses.

Public Disturbance: The effect (noise, traffic, dust, lighting, etc.) that night operations will have on the surrounding residential areas.

Local Events: The presence of local community events (church functions, sporting events, concerts, etc.). If necessary, work may have to be suspended during the function.

Economic Parameters

Business Losses: The economic impact on surrounding business (including trucking and shipping) due to inaccessibility and construction interference.

Road User Cost: The road user cost (day and night) should be calculated for the area of the project.

Accident Costs: The costs associated with motorist accidents and their impact, both financial and traffic wise, on the project and surrounding community.

Maintenance Costs: Costs associated with equipment maintenance activities to be performed

Construction Cost: The contract price of the project.

Incentives/Disincentives: Incentives for night work or early completion. Disincentives for late finish or extensive traffic delays.

Liquidated Damages: Financial losses resulting from the late completion of the project.

Environmental Parameters

New Technology: Equipment or methodologies that reduce the environmental impact of night-time construction including improved mufflers, reduced idling time, etc.

Lighting Pollution: Excessive illumination caused by over-lighting a site.

Noise: Tables 6 and 7 from a 1999 report by James Ernzen and Cliff Schexnayder entitled *Mitigation of Nighttime Construction Noise, Vibration, and Other Nuisances* give examples of common noise generators and activities (3).

TABLE 6 Common Noise Generators

Noise Generator	Percent Identifying Activity as Cause of Problems*
Back-up Alarms	41%
Slamming Tailgates	27%
Hoe Rams	24%
Milling/Grinding Machines	16%
Earthmoving Equipment	14%
Crushers	6%

TABLE 7 Activities That Cause Nighttime Noise Problems

Activity Type	Percent Identifying Activity as Cause of Problems*
Pavement Breaking	27%
Paving/Resurfacing	25%
Pile Driving	24%
Bridge Deck Removal	24%
Rehab	20%
Patching	12%
Earthmoving	2%
Crushing	2%

* As rated by the 50 State DOTs

Fuel Consumption: Generally at night less fuel is burned through idling cars in congestive situations.

Air Quality: Pollution from automotive exhaust emissions could be lessened by reducing congestive situations.

Worker's Health: Health issues arising from the inhalation of automotive exhaust fumes.

Cabinet Issues

Personnel Assignment: Selecting the personnel to work at night based upon employee satisfaction, family disruptions, supervisory problems, etc.

Resources: The ability of the Cabinet to staff and operate both day and night operations.

Decision Making: The ability of on site field personnel to make decisions regarding the project.

Public Relations: Activities undertaken to inform the public about the nature of the work, why it is being performed at night, what delays are expected, and the availability of alternate routes.

Political: Political reasons behind operational decisions.

Time Limitations: Employee work hour limitations.

Type of Work: Activities which the state has deemed unacceptable for night work or activities in which the state encourages night work.

Legal Issues

Local Ordinances: Legal policies or rules established by the local government regarding the performance of construction work at night.

Local Restrictions: Restrictions imposed by non-governmental organizations such unions, materials suppliers, etc.

4.0 NIGHT-TIME PROJECT SELECTION

In an attempt to quantify the evaluation of a specific project for night-time construction a *Project Evaluation Form* has been developed. This form's questions are divided among categories that address Traffic Issues, Economic Issues, Social Issues, Construction Issues, and Other Issues of a project. The questions quantify the effect night work will have on a project through the use of a 1-5 scale (1-Very Negative, 3-No Effect, 5-Very Positive). After completing the form the evaluator will then weight the categories according to their relative importance on the particular project.

It is important to note that this form *does not* “make” the decision regarding whether to work at night. The form, if nothing else, forces the construction planner to consider the issues that will affect performing the project at night.

The following is a worked example of a fictitious project. Its function is to illustrate the use of the proposed Night-Time Project Evaluation Form. It does not reflect an actual project.

**KyTC
Night-Time Construction
Project Evaluation Form**

Project: Route 123 Project No.: 1 District: 7

Form Completed By: Joe Engineer

Position/Title: Chief Engineer Date: 5/31/00

Traffic Issues

Based upon a recent traffic analysis, what is the current *level of service* of the site during the day?

A B C D (E) F _____
0 1 2 3 4 5 4

Based upon a recent traffic analysis, what would be the estimated *level of service* after a daytime lane closure?

A B (C) D E F _____
0 1 2 3 4 5 2

Based upon a recent traffic analysis, what is the current *level of service* of the site during night-time?

F E D C B (A) _____
0 1 2 3 4 5 5

Based upon a recent traffic analysis, what would be the estimated *level of service* after a night-time lane closure?

F E D (C) B A _____
0 1 2 3 4 5 3

Traffic Issues Average: 3.5

Economic Issues

How will local businesses be impacted by day-work?

Low Impact 1	2	Moderate Impact 3	(4)	High Impact 5	<u>4</u>
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How will local businesses be impacted by night-work?

High Impact 1	2	Moderate Impact 3	4	Low Impact (5)	<u>5</u>
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What is the estimated daytime road user cost of the construction site?

Low 1	(2)	Medium 3	4	High 5	<u>2</u>
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Economic Issues Average: 3.7

Social Issues

What is the location (radius) of residential development (including churches, hospitals, etc.) in relation to the job site?

< ¼ mile (1)	¼ - ½ mile 2	½ - 1 mile 3	1-2 miles 4	> 2 miles 5	<u>1</u>
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How will this development be affected by the following during night operations:

Lighting

Very Negative 1	2	Moderate 3	(4)	Low 5	<u>4</u>
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Noise

Very Negative (1)	2	Moderate 3	4	Low 5	<u>1</u>
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Vibration

Very Negative 1	(2)	Moderate 3	4	Low 5	<u>2</u>
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Traffic

Very Negative 1	2	Moderate (3)	4	Low 5	<u>3</u>
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Social Issues Average: 2.7

Construction Issues

How would performing this project at night affect:

<i>Quality</i>					
Very Negative		No Effect		Very Positive	
1	2	(3)	4	5	<u>3</u>
<i>Schedule</i>					
Very Negative		No Effect		Very Positive	
1	2	3	(4)	5	<u>4</u>
<i>Cost</i>					
Very Negative		No Effect		Very Positive	
1	(2)	3	4	5	<u>2</u>
<i>Safety</i>					
Very Negative		No Effect		Very Positive	
1	(2)	3	4	5	<u>2</u>

Construction Issues Average: 2.75

Other Issues

Are there any other operations, conditions, or special events that could affect the feasibility of night operations?

Very Negative		No Effect		Very Positive	
1	2	3	4	5	
Description					
Barrier Wall Placement					<u>5</u>
Local Football Stadium (High School)					<u>2</u>
					<u> </u>
					<u> </u>

Other Issues Average: 3.5

Issues	Weight*	Rating	Weighted Rating
Traffic Issues	20%	3.5	0.7
Economic Issues	20%	3.7	0.74
Social Issues	20%	2.2	0.44
Construction Issues	25%	2.75	0.69
Other Issues	15%	3.5	0.525
100%			

ΣTotal Weighted Rating: 3.10

Scale

4-5 Definite Candidate for Night-Time Construction

3-4 (Good Candidate for Night-Time Construction)

2-3 Marginal Candidate for Night-Time Construction

1-2 Poor Candidate for Night-Time Construction

*The standard weight for each category should be 20% unless the evaluator deems other weights more appropriate.

Based upon the outcome of this evaluation the project would be a good candidate for night-time operations. However, the rating of 3.1 is just about the cut-off for a marginal candidate so the evaluator would have to carefully consider the decision to work at night.

5.0 NEW LIGHTING TECHNOLOGY

As lighting affects nearly every aspect of night work the types of lighting permitted for night operations should be considered carefully. While traditional lighting may be adequate for operations that take place away from the traveling public, special considerations should be made for activities that take place on or near the roadway. The key concern in this area is the reduction of glare to both workers and on-coming traffic.

A new lighting technology now available for highway contractors that greatly reduces the harmful effects of glare while providing ample site illumination is the Airstar Balloon Light

manufactured by Airstar, Inc. The light uses an outer balloon to diffuse glare from the light source. Several Kentucky highway contractors have begun using this new technology however, at this time there has been no notable research into the use of balloon lighting.

6.0: CONTRACTOR SUPPLIED WORK PLAN

The Night-Time Construction Work Plan is a method to ensure that all special considerations that must be made to successfully implement night-time construction have been undertaken. The plan, if nothing else, will require the contractor to think about these special considerations concerning night-time construction. The concept is that the contractor would develop a plan for night-time construction activities and submit the plan to the state at the pre-construction meeting. Night work should not begin until the plan has been approved and implemented. The outline presented below is based on current night-time construction research, specifications from state transportation departments, and input from KyTC and contractor personnel (4, 5, 6). The plan can include, but is not limited to, the following elements:

Lighting Plan

- Layout of light towers
- Description of lighting equipment
- Electrical power source details
- Other relevant information

Traffic Control Plan

- Layout of road and lane closures
- Ramp control details
- Channeling and guiding devices
- Location and text of variable message boards

Special Safety Considerations

- Equipment warning devices
- Personnel protective clothing
- Overhead power lines

Emergency and Contingency Plan

- Contingency plan(s) for anticipated emergencies
- Local emergency contacts
- Local utility contacts
- Motorist accidents and breakdowns

Other Elements

- Abatement of construction noise and vibrations
- Materials/Supply/Equipment Availability

7.0 PUBLIC AWARENESS ACTIVITIES

One key factor that can help alleviate certain problems associated with night-time construction is a well-organized public relations campaign. Keeping the public informed about the time, location, duration, and type of work serves two purposes. First, it lets the public know why the work is being performed at night. If the public understands why night work was selected they will be more accepting of the associated problems. Second, informing the public regarding the location of the work will provide motorists the opportunity to select alternate routes, thus reducing congestion near the site. It will also prepare them for delays if alternate routes or times are not feasible.

There are several mediums that are currently being used by state transportation departments to dispense information regarding highway operations including (4):

- | | |
|----------------------------------|---------------------------------------|
| • <i>Project/Highway Signage</i> | • <i>Highway Advisory Radio (HAR)</i> |
| • <i>Local Newspapers</i> | • <i>Local Television</i> |
| • <i>Local Radio</i> | • <i>Internet Website</i> |
| • <i>Telephone Hotlines</i> | • <i>Public Listserves</i> |

In order to maximize the number of people reached it is recommended that a combination of media outlets be utilized. Regardless of the outlet, information should be “as concise and current as feasibly possible to maintain the credibility of the medium” (4).

Based upon current literature and KyTC and contractor personnel inputs, there are several areas in which current public relations practices could be improved including:

- Provide a listserv for the public that sends traffic and construction information everyday around 6:00AM (before morning commute) and 4:00PM (before evening commute). When the user registers for the service he/she can select from a list of

roads and then only receive information regarding those roads. The mailing can detail planned construction activities (including land closures), estimated delays, and possible alternative routes. Information would be provided for day and night operations.

- Work with the contractor to ensure that when a lane is closed, work is being performed. If work is not on-going the lane should be open during non-construction hours. This reduces the public's perception that lanes are being closed without concern for traffic delays.
- Ensure that all information distributed through various media outlets is accurate. This maintains the credibility of the outlet, otherwise the public will ignore broadcasted information. It is also essential that information updates are timely. For example, if the state's web page is to be updated at noon everyday adopt appropriate measures to ensure its prompt and accurate update.
- Contact local emergency agencies (police, fire, medical) in advance of construction and invite them to the pre-construction meeting. This allows the agencies to adjust their emergency routes accordingly. This information should also be supplied to local trucking/shipping companies, churches, schools, and other special events that could be impacted by night operations.
- During the planning phase of construction local government officials and business leaders should be invited to attend planning meetings. This will allow the planners insight into the local situation in order to determine how to minimize the impact of operations on the surrounding community.

- Message signs should be placed in the planned construction area in advance of construction operations to warn commuters about future operations.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Night-time construction of transportation facilities will become more prevalent in the future. As states begin to shift highway rehabilitation activities towards the evening hours care must be taken to ensure the safety of the workforce and motorists and the quality of the final product. If properly implemented, night-time construction can greatly decrease the duration of road work projects, while providing a safe environment for both workers and the traveling public.

Based upon current literature, the practices and policies of state transportation departments, and the advice and input of the research advisory committee, the following recommendations are offered in regards to improving night-time construction.

1. A detailed night-time work plan should be required of the general contractor before night operations begin.
2. Lane closures on highway construction projects should be limited to a maximum of 3 miles with at least a 5 mile buffer in-between consecutive closures to reduce the public's inconvenience and negative perceptions.
3. The use of police officers for enforcement of construction zone speed limits should be a contract pay item. Research and experience have shown that the use of law enforcement is the most effective means of reducing vehicle speeds through construction zones. The officers should also be clearly instructed of the reduced speed limits and when and where double fines may be issued.
4. Special signs should be erected in night-time construction work zones regarding *double fine* areas for traffic violations. The signs should have flashing lights mounted

on top with the message “*Double Fines in Effect When Flashing.*” Double fines should only be issued when the lights are active.

5. The use of speed measuring/warning devices should be encouraged at the beginning of the construction zone for highway construction projects. The device should display and/or warn motorists when they exceed the posted construction speed limit.
6. To reduce travel speeds through night-time construction work areas, temporary thermal plastic speed bumps should be installed.
7. The general contractor on night-time construction projects should be required to have a full-time traffic control monitor to ensure that all traffic control devices are in good working order and are properly maintained.
8. The contractor and resident engineer should be vigilant for material deliverers that have exceeded their allowed daily drive time. Those found in violation of daily time limits should be reprimanded and ordered off the job.
9. The “chain of command” for night-time construction projects should be well organized and made clear to all supervisory personnel at the beginning of the project. A list of when, how, and whom to contact for key decisions should be readily available.
10. The *Night-Time Project Evaluation Form* should be used during the initial planning phases to estimate the feasibility of performing all or part of the project at night.
11. A night-time construction training program for state (required) and contractor (optional) personnel should be implemented. For emphasis this program should be held at night.

- 12.** The use of balloon lighting for night-time construction projects should be further investigated.
- 13.** All permanent and/or temporary roadway lighting to be constructed for a project should be erected as soon as possible to aid in illumination during the night-time construction process.
- 14.** In order to decrease construction time on critical highway projects, contractors should be offered an incentive for 24 hour work schedules.

References

- (1) Elrahman, O. A., R. J. Perry. *Guidelines for Night-Time Maintenance and Construction Operations*. "Road and Transportation Research" September 1998, Vol. 7 No. 3.
- (2) Ellis, Ralph D., Zohar J. Herbsman. *Developing Procedures for Night Operations of Transportation Construction Projects*. Raleigh, NC. 1993.
- (3) Schexnayder, Cliff J., Ernzen, James. *Mitigation of Nighttime Construction Noise, Vibration, and Other Nuisances*. Washington D. C. 1999.
- (4) Last Resource, The. *A Procedure for Assessing and Planning Night-Time Highway Construction and Maintenance, 2nd Draft*. July 1999.
- (5) Last Resource, The. *Guidelines for Design and Operation of Nighttime Traffic Control for Highway Maintenance and Construction, 2nd Draft*. April 1999.
- (6) Construction specifications from the following transportation departments were reviewed
 - California*
 - Connecticut*
 - Kentucky*
 - Michigan*
 - Minnesota*
 - New York*
 - North Carolina*
 - Pennsylvania*