

# **AN ANALYSIS OF HUMAN FACTORS IN NIGHTTIME WORK ZONES**

**Final Report**

**November 26, 2001**

**Submitted by:**

José Holguín-Veras  
Robert Baker  
Angel Medina  
David Sackey

**City College of New York**



**NJDOT Research Project Manager:**

**Raj Chawla**

**In cooperation with**

**New Jersey**

**Department of Transportation**

**Division of Research and Technology**

**and**

**U.S. Department of Transportation**

**Federal Highway Administration**

## **DISCLAIMER STATEMENT**

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the New Jersey Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

## TECHNICAL REPORT STANDARD

1. Report No. FHWA/NJ-2001-025	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle <b>ANALYSIS OF HUMAN FACTORS IN NIGHTTIME WORK ZONES</b>		5. Report Date 49777-07-02	
7. Authors Jose Holguin-Veras, Robert Baker, Angel Medina and David Sackey		8. Performing Organization Code	
9. Performing Organization Name and Address City College of New York Y- Building, Room 220 New York, New York 10031		10. Work Unit No.	
12. Sponsoring Agency Name and Address New Jersey Department of Transportation P. O. Box 600 Trenton, New Jersey 08625		11. Contract or Grant No. 49777-07-02	
		13. Type of Report and Period covered. Final 10/00 – 09/01	
15. Supplementary Notes: Federal Highway Administration, U.S. Dept. of Transportation, Washington D.C		14. Sponsoring Agency Code	
		16. Abstract This paper presents the results of a research project aimed at providing insights into the human factors associated with nighttime work zones on the New Jersey Department of Transportation construction and maintenance projects. It examines the impacts that nighttime construction activity has upon the workers, from their perspective. These impacts were assessed through field surveys and interviews that included: highway engineers, construction workers, field supervisors, and contractors. The research methodology is briefly discussed. Field data from these interviews are analyzed for human factors such as sleep deprivation, eating habits, commuting difficulties and social/domestic issues. This research found evidence of long working hours, social and family disruption, long commutes and sleep deprivation. Most of the workers interviewed agreed that nighttime work has: (a) a negative impact on their body rhythms; and (b) a negative reaction impact on their social and family life. They were also agreements with their statements that their families react negatively to them due to working at night.	
17. Key Words		18. Distribution Statement	
19. Security Classification of this report Unclassified	20. Security Classification (of this page) Unclassified	21. No. of Pages	22. Price

## **ACKNOWLEDGEMENTS**

This research is the result of the initiative taken by representatives of the construction industry of the State of New Jersey, gathered at New Jersey Quality Initiative Council, and the New Jersey Department of Transportation, to take a closer look at the human factors of nighttime construction projects. The concerns of the private industry and NJDOT about the welfare of the nighttime construction workers, and their willingness to conduct research on this topic, are to be acknowledged and appreciated. The project team also wants to express their gratitude to Labor International for their invaluable assistance to the research team.

This research project was funded by a grant from the New Jersey Department of Transportation (NJDOT) and the USDOT, Federal Highway Administration through the Region 2, the University Transportation Research Center to the City College of New York. This support is both acknowledged and appreciated.

## TABLE OF CONTENTS

EXECUTIVE SUMMARY .....	1
INTRODUCTION .....	2
OBJECTIVES AND SCOPE.....	4
LITERATURE REVIEW .....	5
NIGHTTIME WORK AND CIRCADIAN RHYTHMS.....	5
NIGHTTIME WORK AND SLEEP.....	5
NIGHTTIME WORK AND STRESS .....	6
NIGHTTIME WORK AND SOCIAL/DOMESTIC ISSUES .....	6
NIGHTTIME WORK AND SAFETY .....	7
RESEARCH METHODOLOGY.....	8
ADVISORY GROUP .....	8
FIELD DATA COLLECTION INSTRUMENT .....	9
Basic questions:.....	9
Physiological, psychological and medical effects of night work:.....	10
Effects of night work on family and social life: .....	10
Ergonomic aspects of problems of night work organization and staffing: .....	10
FOCUS GROUP .....	11
DESCRIPTION OF THE NIGHTTIME CONSTRUCTION PROJECTS VISITED.....	12
PROJECT 1: RURAL MILLING AND RESURFACING PROJECT.....	13
PROJECT 2: SUBURBAN BRIDGE REHABILITATION PROJECT .....	13
PROJECT 3: FIBER OPTIC PROJECT.....	13
PROJECT 4: SUBURBAN RESURFACING PROJECT .....	14
SITE PHOTOGRAPHS .....	14
SURVEY RESULTS .....	14
DEMOGRAPHIC PATTERN OF WORKERS INTERVIEWED.....	15
GENDER .....	15
MARITAL STATUS .....	15
AGE DISTRIBUTION .....	16
TYPICAL RESPONSES .....	17
SUMMARY OF FIELD INTERVIEWS .....	18
CONCLUSIONS.....	26
SUGGESTIONS .....	29
DEFINITION OF A NIGHT-TIME CONSTRUCTION RESEARCH PROGRAM.....	29
FOUR DAY WORK WEEK .....	32
PAY DIFFERENTIAL .....	33
ITEMIZATION OF TRAFFIC ENFORCEMENT COSTS .....	33
TEMPORARY ACCOMMODATIONS .....	34
MOTIVATION .....	34
APPENDIX A: Site Photographs.....	36
APPENDIX B: Summary Of Transcripts- Rural Interstate Milling And Resurfacing Project.....	40
APPENDIX C: Summary of Transcripts- Bridge Rehabilitation Project.....	44
APPENDIX D: Summary of Transcripts - Fiber Optic Cable Construction Project.....	47
APPENDIX E: Summary of Transcripts: Urban Milling and Resurfacing Project.....	60
REFERENCES .....	63

## LIST OF TABLES AND FIGURES

Figure 1: Methodology Framework .....	8
Table 1: Breakdown of Workers by Category .....	15
Figure 2: Distribution of Workers by Marital Status .....	16
Table 2: Typical responses from a cross-section of workers .....	18
Figure 4: Number of Working Hours per Day.....	21
Figure 5: Total Commute Time for Workers .....	22
Figure 6: Hours of sleep.....	23
Figure 8: Work Preferences .....	25
Figure 9: Combination of Work, Commute and Sleep time .....	26
Plate 1: Typical Working Area- Bridge Rehabilitation Project .....	37
Plate 2: Typical Working Area- Fiber Optics Project.....	37
Plate 3: Lighting in Working Area- Fiber Optics Project .....	38
Plate 4: Equipment Maintenance Staging Area-Milling and Paving Project.....	38
Plate 5: Typical Staging Area- Milling and Paving Project.....	39

## **EXECUTIVE SUMMARY**

This report presents the results of a research project aimed at providing insights into the human factors associated with nighttime work zones on the New Jersey Department of Transportation construction and maintenance projects. It examines the impacts that nighttime construction activity has upon the workers and seeks to define work standards to mitigate these factors. These impacts are assessed through field surveys, focus group and interviews that included: highway engineers, construction workers (laborers), field supervisors, and contractors.

Thirty construction workers on four highway construction projects, along with a focus group of union laborers were interviewed for their opinions and comments, to questions on human factors related to work on nighttime work zones in the fall of 2000. The interviews were conducted during construction staging and on the construction site.

Field data from interviews were analyzed for human factors such as sleep deprivation, eating habits, commuting difficulties and social/domestic issues. The research found evidence of long working hours, social and family disruption, long commutes and sleep deprivation. The workers interviewed agreed unanimously that nighttime work has: (a) a negative impact on their body rhythms; and (b) a negative reaction impact on their social and family life. They were almost unanimous in their statements that their families react negatively to them working at night.

A majority of the workers generally preferred daytime work. However, a few liked working at night because they were able to adjust their schedule accordingly and also because working during the nighttime resulted in extra money.

The vehicle speeds of the traffic through the work zone and safety were also a major concern to all the workers. Nighttime construction has many advantages and efforts to address or mitigate its impact on the nighttime worker are very important.

## INTRODUCTION

The last half of the 20th Century and the beginning of the 21st has witnessed an unparalleled increase in urban congestion. In spite of the advances made in Intelligent Transportation Systems, real traffic control and transportation planning, congestion is still on the rise, the mobility goals set by planners, and communities are still to be reached.

Traffic congestion is one of the major causes of productivity losses in the United States. In recent estimates of urban congestion, it is found that 18 urbanized areas experience area-wide congestion conditions on their urban freeway system <sup>(1)</sup>. According to a 1990 Federal Highway Administration study, the total cost of congestion for 50 urban areas was estimated to be \$43.1 billion. This represented a 10 percent increase (\$39.2 billion) in the economic impact of the congestion since 1989 <sup>(2)</sup>.

Other studies <sup>(3,4)</sup> have estimated that by 2005, congestion could rise to 8 billion vehicle-hours and \$88 billion in wasted time and fuel. It is safe to conclude that the continuous growth of congestion will represent a serious threat to the productivity and competitiveness of the nation's economy, to the environment, and the quality of life. Another perspective on congestion is provided by the Urban Mobility Study <sup>(5)</sup>. These statistics indicate that the period of peak congestion has increased from one hour in 1970, to three hours in 2001. In other words, the length of the "peak hour" is actually three hours. The increases in annual delays per person have also jumped, during the period 1982-1999, to 26 hours/person (very large areas), 21 hours/person (medium size areas) and 8 hours/person (small areas) <sup>(5)</sup>.

Congestion has two major components: recurring congestion, which is caused by the high volume of traffic, and non-recurring or incident congestion, which is caused by traffic accidents and other incidents such as construction projects. Incident congestion cost is estimated to be 1.3 billion vehicle-hours of delay and \$10 billion in wasted time and fuel <sup>(6)</sup>. For large metropolitan areas such as New York, incident congestion is estimated to cost more than \$1.2 billion per

year or about \$100 per person per year <sup>(6)</sup>. The total cost of congestion for the 50 urban areas studied in <sup>(2)</sup> increased by 10 percent between 1989 and 1990, to \$43.2 billion from \$39.2 billion.

In a context of increasing congestion, daytime highway rehabilitation and maintenance operations are bound to cause significant traffic disruption. For that reason, Departments of Transportation and municipalities have increased the frequency of nighttime construction work to reduce the congestion impacts of highway projects. This explains why nighttime construction has recently increased, and why it is almost certain to continue increasing. However, work zone safety is a major issue. A recent study reports that of the 41,471 fatalities in motor vehicles crashes in 1998, about 2% occurred in work zone areas, with 29% of the fatalities in work zone crashes involving large trucks. Significantly, 42% of all fatal work zone crashes occurred during nighttime work, in spite of the reduction in the volume of traffic <sup>(7)</sup>.

On the positive side, nighttime construction operations have significant advantages: minimal impact to the traveling public, less congestion, less environmental pollution, minimal traffic disruptions, longer working periods, ease of material delivery through lower truck cycle times, and lower working temperatures during hot summer months. However, nighttime construction activities do have a negative impact on the workers. Sleep deprivation, exhaustion, difficulties in balancing the conflicting pressures of family life and nighttime work are some of the factors that have been documented in the literature. The above indicates that there is a trade-off between the collective benefits of nighttime work and the negative effects experienced by the workers. It is therefore imperative to gain a solid understanding of the human factors associated with nighttime construction work to properly determine the most appropriate solution. This knowledge may also lead to the development of work-zone standards and regulations that mitigate the negative impacts upon the workers. This project was initiated through the New Jersey construction industry and the New Jersey Department of Transportation (NJDOT). The purpose of this was to collect pertinent information, so that these agencies

would gain a better understanding of the human factors in nighttime construction zones. Given the exploratory nature of this research, the project team, in consultation with NJDOT, decided to gather the necessary data using direct interviews with the workers, which were treated as confidential information. This paper reports the findings of this research.

## **OBJECTIVES AND SCOPE**

The main objective of this study was to determine the significant human factors associated with nighttime construction work. Human factors such as fatigue, inadequate sleep, safety, effect on the workers' life and their families, as they relate to social and domestic life. This knowledge would provide supporting information for the definition of work-zone standards.

The scope of this research focused on the study of human factors associated with nighttime work at New Jersey construction and maintenance sites. Other important factors, such as construction quality and performance were not part of the focus of this investigation.

The project had significant constraints, the most notable one being the unavailability of sufficient financial resources, which limited the amount of data that was collected for the study. As part of this project, the researchers visited four construction projects. At each site, interviews with the workers were conducted. This paper provides a summary of the findings reached, after the collected data were analyzed. The findings of this report provides documentary evidence about human factors in nighttime construction zones, as well as supporting information to policy makers interested in mitigating human factors in nighttime construction zones.

This paper is comprised of four sections, in addition to the introduction. The first section, *Literature Review*, provides a brief summary of key findings reported in the published research on the subject. The next section, *Research Approach*, presents an overview of the main features of the methodology used. The third section, the *Survey Results*, discusses the survey conducted. Finally, the *Conclusions* summarizes the main findings of this investigation.

## **LITERATURE REVIEW**

This section outlines relevant literature review on nighttime human factors. To facilitate reading of the material, the review has been organized by topic.

### **Nighttime work and circadian rhythms**

One of the main physiological parameters of the human system is the circadian rhythms, and this is because they are responsible for the control of the regular cycles of activation and deactivation of the human body. This influences human factors such as sleep, stress and activities of this nature, whenever the human body undertakes night work.

Circadian rhythms are defined as the systems in the human body that controls the periodic physiological processes. This process governs many biological parameters in the human body, such as temperature, pulse, and blood pressure. Important findings have been made between circadian rhythms and human performance <sup>(8)</sup>. Circadian rhythms are also responsible for the physiological and psychological settings for the regular cycle of sleep and wakefulness. These rhythms are normally in a state of maximum activation by day and minimum activation by night. Thus, a person working at night is active at a time when the human system is normally in a period of de-activation. This exerts considerable stress on the body. Additionally, the natural course of the circadian rhythms is further interrupted when the worker has to make the adjustment from night-time work during the work-week to a day – night system during the weekends. This results in a complete re-adjustment of the human system at the beginning of each new workweek, and this causes the human body to undergo a great amount of stress <sup>(9)</sup>.

### **Nighttime work and sleep**

One of the important human factors that have an adverse impact on the nighttime construction worker is sleep deprivation. Sleep during the day is often difficult because of the effects of light, noise and heat. This deficiency in sleep also leads to physical disorders, nervous problems and changes in mental and motor skills <sup>(10)</sup>. Other sleep related problems include insomnia,

hunger, digestive disorders, and the loss of alertness and reduced reaction times <sup>(8)</sup>. It is estimated that about twenty percent of night shift workers in the United States suffer from sleep related problems <sup>(11)</sup>. It is also estimated that the day sleep of night shift workers is normally one to four hours shorter than normal night sleep <sup>(12)</sup>.

### **Nighttime work and stress**

A decrease in the quantity and quality of sleep leads to two main types of stress. The first one is stress that arises out of having to sleep during a period of activation of the human system and the second is stress relating to having to stay awake during a period of deactivation of the human body. This often results in overall low performance of the nighttime worker <sup>(13)</sup>.

### **Nighttime work and social/domestic issues**

The adverse impact of nighttime construction on the construction worker is one area that has not been studied extensively; it is an area that can create serious consequences for the nighttime worker if it is not properly addressed. It has a considerable influence on the marital and parental responsibilities of the nighttime worker, as well as his ability to meet his community obligations <sup>(9)</sup>. Nighttime work affects the following aspects of social and domestic life of the nighttime worker:

- Organization of the day-to-day domestic life.
- Inability to spend quality time with spouse and children
- Inability to meet with friends and attend social gatherings
- Difficulties in exercising parental responsibilities

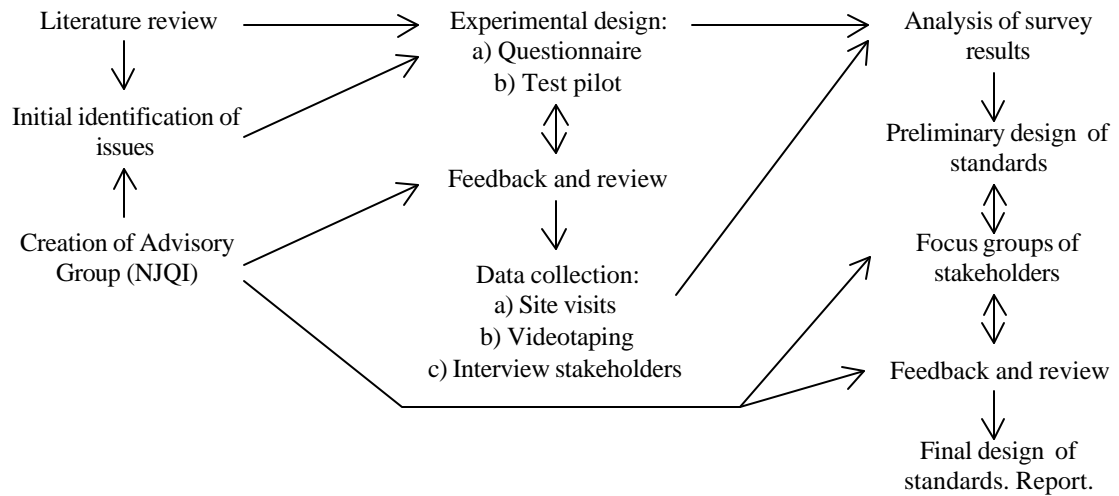
If the nighttime worker is unable to cope and to properly manage these factors, consequences such as broken homes, severed marriages and even children becoming rebellious and delinquent, are possible scenarios that can result. The overall effects of these factors, significantly diminishes the quality of life of the workers <sup>(9)</sup>.

### **Nighttime work and safety**

Safety is one of the more important concerns often expressed by the nighttime construction worker. This concern is supported by the fact that there is , inadequate lighting during the night, thus resulting in poor visibility. This consequently leads to a negative impact on the quality of work. Over speeding, due to reduced traffic volumes at night, worker fatigue and sometimes substance abuse, in an effort to stay awake, are other concerns of the night-time worker <sup>(14)</sup>.

## RESEARCH METHODOLOGY

The research method that the team used in this study is depicted in Figure 1.



**Figure 1: Methodology Framework**

The project was conducted in close collaboration with industry representatives and NJDOT. This enabled the project team to benefit from the experience, while gaining intuitive perspectives from the agencies involved in the study. The project was generally comprised of the following main tasks: (a) Creation of the Advisory Group; (b) Development of field data collection instrument; (c) Field surveys and data collection (i.e., focus group, field visits and interviews); and (d) Analysis and evaluation of data. This section discusses the approach and methodology adopted by the research team and provides brief descriptions of the different tasks outlined above.

### Advisory Group

The first task of the study was the creation of an Advisory Group, and this was comprised of representatives of the construction industry and NJDOT. The Advisory Group was drawn, for the most part, from the New Jersey Quality Initiative Council Sub-committee on Technology Deployment. The Sub-

committee advises the NJDOT on the deployment of new technologies and the development of specifications and construction practices for capital improvement projects. The main responsibility of the Advisory Group was to provide guidance to the research team and to ensure that the research approach was consistent with the project objectives.

The Advisory Group provided meaningful insights and information about the various facets of this important problem. This included: (a) a precise definition of the main focus of the project; (b) a preliminary assessment and identification of the human factors to be studied; (c) listing of potential projects to be visited; and (d) listing of contact persons that could provide advice and input to the project.

### **Field Data Collection Instrument**

Based on the input provided by the Advisory Group and the literature review, the project team designed a set of questions aimed at gathering information about the human factors associated with nighttime work. As indicated above, project constraints prevented the study from investigating other important elements such as project quality and other related concerns. Based on the input provided by the stakeholders through the Advisory Group, the most critical human factors were identified. This was accompanied with the identification and categorization of the work methods that were most relevant to the purposes of the study. A list of questions was then developed by the project team to guide the data collection, and the interviews were tape recorded, with the consent of the workers. The project team guaranteed the confidentiality of the responses. The set of questions focused on four major areas, and they are listed below:

#### *Basic questions:*

1. At what time does your work shift start?
2. How many hours per day do you work on average?
3. Do you work overtime?

4. Do you have another job?
5. How many days do you work per week?
6. Do you like to work during the night?
7. Why do you work at night? Is it because of the money? Because it is more convenient? Or because you have no choice?
8. How do you get to work?
9. Are you in a permanent night schedule or in a rotation shift?

*Physiological, psychological and medical effects of night work:*

1. What do you feel on your first night of rotation? Do you feel more active or less?
2. It was observed that if shift rotation is long, the rate of absenteeism is also higher. Do you know why?
3. Do you think that female workers are absent more frequently than males?
4. Do you get enough sleep during daytime?
5. How does day sleep affects your body rhythm? Do you feel active after day sleep?
6. How does it affect your health, (e.g., digestive system, blood pressure, headache)?

*Effects of night work on family and social life:*

1. If you have the alternative to work either at day or night, what would be your choice and why?
2. What kind of additional financial benefits do you get if you work at night?
3. Do you like shift rotation?
4. How does night work affect your social and family life?
5. Is your family reluctant towards you working at night?
6. Is night shift more convenient for you?

*Ergonomic aspects of problems of night work organization and staffing:*

1. Generally it is observed that night work productivity is lower than daytime. Do you think this is due to over fatigue or less pressure on worker to produce?

2. Are you satisfied with the safety arrangements in your work zone? (It is observed that most of the accidents occurred to the workers are within the work zone caused by the operations of machinery and equipment)
3. Do you have any medical facilities/capabilities at your work site?
4. From the safety point of view, do you prefer partial closure or complete lane closure during night construction (because of speeding motorists at late night)?
5. How are emergencies handled? If you have a serious technical or mechanical problem, can you communicate with your supervisor immediately? Or is the work stopped until the next night?
6. Do you have any problems to get supplies of material or machinery on time during night construction?
7. If you face some kind of mechanical problem, do you arrange to get it fixed on site and continue operations?
8. Do you face any transportation problems to reach your site?
9. Do you have adequate lighting at work sites? Does lighting affect the quality?
10. How does weather affects the productivity?
11. Did you ever face problems dealing with community because of noise?

Once the set of questions was defined, the project team proceeded to interview the workers. This data collection process took place during: (a) a focus group meeting; and (b) field visits. These are described next.

### **Focus group**

A focus group meeting was organized to precede the fieldwork. The objective of this meeting was to obtain direct input from union leaders and workers about human factors, and to finalize the list of questions. It was organized in collaboration with NJDOT and Labor International. The participants of the focus group included the research team, representatives of NJDOT, three Union representatives from Labor International and thirteen <sup>(13)</sup> laborers. The meeting provided a useful platform for the workers to discuss their concerns on issues relating to nighttime construction operations. The key issues and suggestions raised during the focus group were discussed next:

Both workers and union leaders had concerns about high-speed of motorists during the night, and indicated that police enforcement of traffic ordinance is a key priority. They strongly supported the idea of including police enforcement expenses as a cost item in the budgets of nighttime construction projects. This, in their opinion, would ensure that the State police have the resources to do a better job of enforcement. The main concerns identified by the focus group are listed below:

- Need for more work space at job sites in order to facilitate proper machinery and equipment movement
- Prefer daytime work if possible
- Inadequate and poor quality sleep
- Inadequate lighting
- High-speed of motorists during the night
- Long working hours (12 – 14 hours)
- Inadequate time spent with kids and families
- Inadequate financial benefits from nighttime work

### **DESCRIPTION OF THE NIGHTTIME CONSTRUCTION PROJECTS VISITED**

In order to gather as wide a spectrum of job conditions as permitted by the project resources, the project team and NJDOT decided to study four different work sites. In all, thirty workers were interviewed. The research team visited the selected project sites during the night to interview the workers, who were not identified by name; this was done to protect their confidentiality. The site selection and coordination of the visits were conducted by the NJDOT. Various categories of construction personnel were interviewed for the analysis. They included Project Engineers, Project Supervisors, Operating Engineers, Technicians, Mechanics, Equipment Operators, Truck Drivers and Laborers. The key findings are discussed in the next section.

Below are brief descriptions of the type of projects where the interview took place.

### **Project 1: Rural Milling and Resurfacing Project**

This rural Interstate project consisted of several miles of milling and hot mixed asphalt paving works. It is a divided highway with a total of six (6) travel lanes, 50 feet wide median and 12 feet wide shoulders. The AADT of the route is approximately 83,000 vehicles with more than 10 percent heavy trucks. Through traffic was retained in one lane. The duration of the milling and paving for this project was approximately four months.

The work site consisted of a milling machine and haul trucks in an advanced area and a paving machine with the crew and asphalt trucks approximately 1000 feet behind the milling operations. Two work areas of the construction project were under lighting. Several workers were working ahead of the milling machine and behind the Paving machine. The researchers visited this site twice.

### **Project 2: Suburban Bridge Rehabilitation Project**

This project consisted of removing and replacing several concrete bridge decks. The bridge was located on a divided four lane suburban highway consisting of a 3 feet wide concrete median barrier and vertical curbing in the immediate area of the construction. The AADT of the route was approximately 75,000 vehicles with some heavy trucks. The traffic was maintained in one lane. The bridge deck site was well lit by high lighting. The duration of this project is approximately six months.

### **Project 3: Fiber Optic Project**

This project consisted of laying fiber optic cable in a deep trench along a suburban highway. The highway consists of concrete median barrier with a width of 3 feet and a shoulder width of 12feet. The AADT of the route is approximately 85,000 vehicles with more than 10% heavy trucks. The traffic was maintained in two lanes. The researchers visited this site twice.

The complete project was about 11 miles along the highway. The duration of this project was approximately eight months.

#### **Project 4: Suburban Resurfacing Project**

This project consisted of maintenance resurfacing on sections of an urban principal arterial. It had six travel lanes, a median width of 12 feet and 12 feet wide shoulders. The AADT of the route is approximately 64,000 vehicles with more than 10% heavy trucks. The traffic was maintained in two lanes. The duration of this project is approximately three months.

The research team visited the selected project sites during the night to interview the workers, who were not identified by name; this was done to protect their confidentiality. The site selection and coordination of the visits were conducted by the NJDOT. Various categories of construction personnel were interviewed for the analysis. They included Project Engineers, Project Supervisors, Operating Engineers, Technicians, Mechanics, Equipment Operators, Truck Drivers and Laborers. The key findings are discussed in the next section.

#### **SITE PHOTOGRAPHS**

Photographs of the project sites visited, showing typical work stages and lighting can be found in Appendix A.

#### **SURVEY RESULTS**

Thirty (30) workers were interviewed for this study. The sample contained a broad spectrum of job types as indicated in Table 1: project engineers, construction technicians, safety officers, inspectors, operating engineer, mechanics, equipment operator, truck drivers and laborers.

The interviews were conducted using portable tape recorders, note pads, and a digital camera to document the overall site conditions at night. As indicated, the set of questions shown previously was used as a guide during the interviews. Primarily, these interviews took the form of informal conversations

with the workers. The recordings were subsequently played back and transcribed to facilitate the analyses.

Table 1: Breakdown of Workers by Category

NO.	DESCRIPTION	NOS.
1	Project/Field Engineer	3
2	Construction Technician	3
3	Safety Officer	1
4	Inspector	3
5	Operating Engineer	5
6	Mechanic	2
7	Equipment Operator	3
8	Truck Driver	2
9	Laborer	8

### **Demographic Pattern of Workers Interviewed**

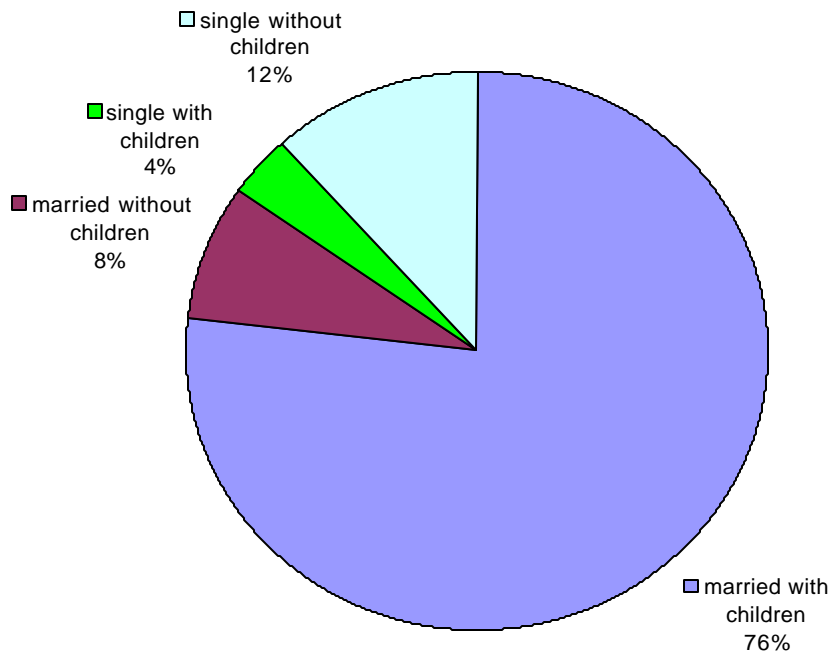
The demographic pattern of the various categories of workers interviewed for the study is discussed in the following section.

#### **Gender**

Out of the 30 workers interviewed for the study, only one was a female. Thus, the proportion of male respondents was approximately 97% compared to the female proportion of 3%.

#### **Marital status**

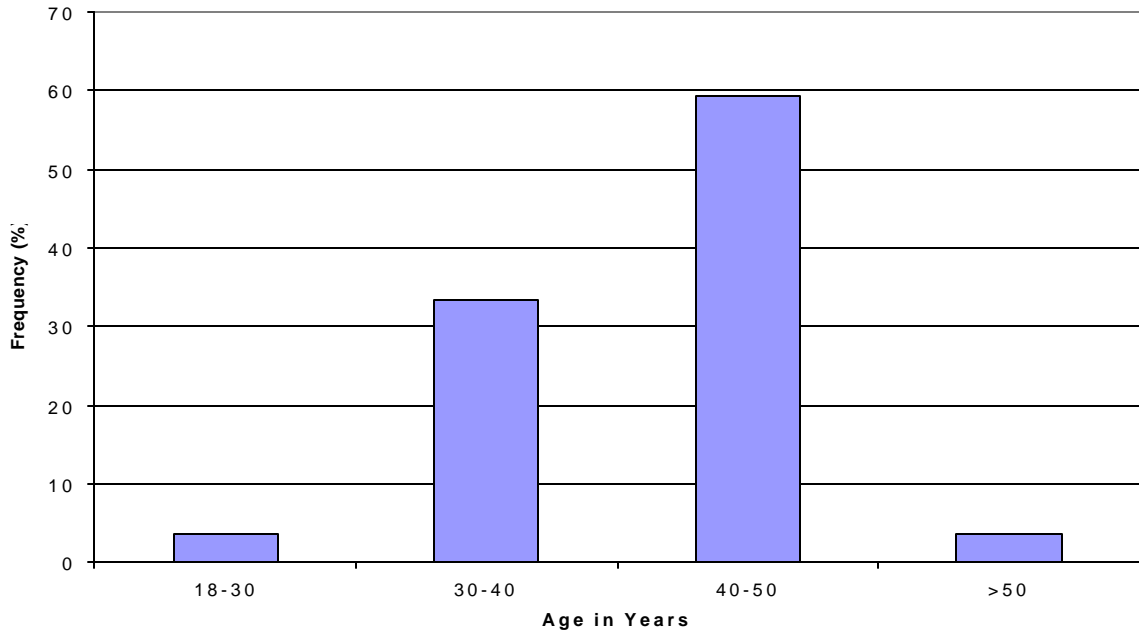
The distribution of workers interviewed for the study by their marital status is shown in Figure 2. A total of 76% were married with children. The proportion of workers who were married without children was 8%, while the proportion of workers who were single with and without children were 4% and 8% respectively.



**Figure 2: Distribution of Workers by Marital Status**

**Age Distribution**

The age distribution of the workers interviewed for the study is shown in Figure 3. 59% of the population were between the ages of 40 to 50. Thirty three percent were between the ages of 30 to 40. Those in the age category of 18 to 30 years and those greater than 55 years were approximately equal, being 4% of the population.



**Figure 5: Age Distribution of Workers**

The following section provides a summary of the analyses conducted. In addition, it provides a set of typical responses from a subset of the sample of how workers perceive nighttime work.

### **TYPICAL RESPONSES**

Table 2 shows the responses from typical workers. These observations were selected because they collectively provide a window into the life of a cross section of nighttime workers. As the responses indicate, there was total agreement among workers about the effects of nighttime work. It was concurred that nighttime work: (a) has a negative effect on the worker’s family life; (b) led to sleep deprivation; and (c) produced significant stress on their lives. A significant number of the workers agreed that Mondays and Fridays were the worst days of the week; Mondays because of the changes in the sleep patterns and Fridays because of sleep deprivation (exhausted).

A summary of the transcripts of all the interviews for the various projects, including the rural milling and resurfacing project, bridge rehabilitation project, fiber optic project and the urban milling and resurfacing projects, can be found in Appendices B, C, D and E respectively.

**Table 2: Typical responses from a cross-section of workers**

<p><b>Project Engineer</b>            On nightwork for seven weeks            Works from 7:00 PM to 5:30 AM            Married no children            Has no social life            1 hour commute each way            Worse day is Monday            Sleeps three to five hours a day            Has no regular eating hour            Still trying to adjust to night work</p>	<p><b>Mechanic/Welder</b>            On nightwork for seven weeks            Works from 6:00 PM to 6:00 AM            Married with children            Has no social life            1:45 minutes commute each way            Worse days: Mondays and Fridays            Inadequate sleep: 5 hours of sleep            Eats a lot less            Not really used to working at night</p>	<p><b>Laborer</b>            On nightwork for four months            Works from 7:00 PM to 6:30 AM            Married with children            Sees family only on weekends            Commutes 30 minutes each way            Worse days: Mondays and Fridays            No sleep problem, sleeps 6 hours            Irregular eating routine            Has not adjusted to work at night</p>
<p><b>Equipment Operator/Driver</b>            On nightwork for six months            Works from 7:00 PM to 8:00 AM            Has a family with four children            Has no social life            Has one hour commute each way            Worse days: Mondays and Fridays            Biggest problem: inadequate sleep            Irregular eating routines            Difficulties adjusting to nightwork</p>	<p><b>Operating Engineer</b>            On nightwork for six months            Works from 6:00 PM to 8:00 AM            Single has no children            Has no social life            Has one hour commute each way            Worse days: Mondays and Fridays            Sleep deprived, four hours of sleep            Irregular eating routines            Difficulties adjusting to nightwork</p>	<p><b>Project Supervisor</b>            On nightwork for six months            Works from 5:00 PM to 9:00 AM            Married, has no young children            Has no quality time with family            Commutes 15 minutes each way            Worse days: Mondays and Fridays            Sleeps only four hours a day            Not able to eat regularly            Would not work at night</p>
<p><b>Laborer</b>            On nightwork for three months            Works from 8:00 PM to 6:00 AM            Single with no children            Has no problems with social life            Commutes forty-five minutes each way            Best day: Friday            Has no problems sleeping            Has no eating problems            Likes nightwork (keeps him out of trouble)</p>	<p><b>Truck Driver</b>            N.A            Works from 7:00 PM to 6:30 AM            Married with children            Has no social life problems            Commutes half hour each way (Did not respond)            Sleeps four and half hours a day            Irregular eating habits            Likes to work at night</p>	<p><b>Construction Technician</b>            On nightwork for six months            Works from 7:00 PM to 5:30 AM            Single Father            Has no social life            Commutes fifteen minutes each way (Did not respond)            Has problems sleeping (Did not respond)            Does not like to work at night</p>

### Summary of field interviews

A summary of the concerns and opinions of the workers is discussed in this section. The first part of the section presents an overall summary of the key responses. The second part of the section discusses the quantitative analyses of the data collected in the project.

The information gathered in this investigation reveals, that generally workers do not like night work. This is due largely to the fact that, (a) It upsets their personal lives; (b) It forces them to alternate their sleep patterns as well as their eating routines, (c) It disrupts their personal business routines, and interrupts attendance of their children's school functions and activities, and (d) It gave them less time to spend with their families. This was a common theme throughout all of the interviews. The long working hours also adds a great deal of stress. Workers living farthest away from the job sites had the greatest concern regarding their commuting times.

The mechanics and operators noted additional stress from extra preparation and maintenance of equipment. They sometimes had to rely on trucks' headlights to get enough light to do maintenance work. The truck drivers were generally dissatisfied. They felt tired and overworked. Many drivers drove trucks in the daytime and nighttime with very little sleep. A few of them noted that they slept in their trucks while they waited for work to resume. They also complained about excessive vehicular speeds within the work zones. They noted that a police presence would help slow down traffic and help them feel safer. They also expressed concerns about lighting differential about work areas and non-work areas.

The NJDOT field engineers noted a concern for the challenging conditions of quality control and inspection of work on night-time project work zones . They indicated that, in spite of their best efforts, it is very difficult to ensure that quality control and inspection at nighttime projects has the same quality as during daytime. They also expressed concern about vehicular speeds at the work zones. This concern was however mitigated by the presence of the Police.

All engineers, both from the construction companies and NJDOT, indicated that often they have to go to the office during the day and this increases the amount of working hours and imposes additional stress on them. They also complained about moving from lit areas to unlit areas of the site as it makes

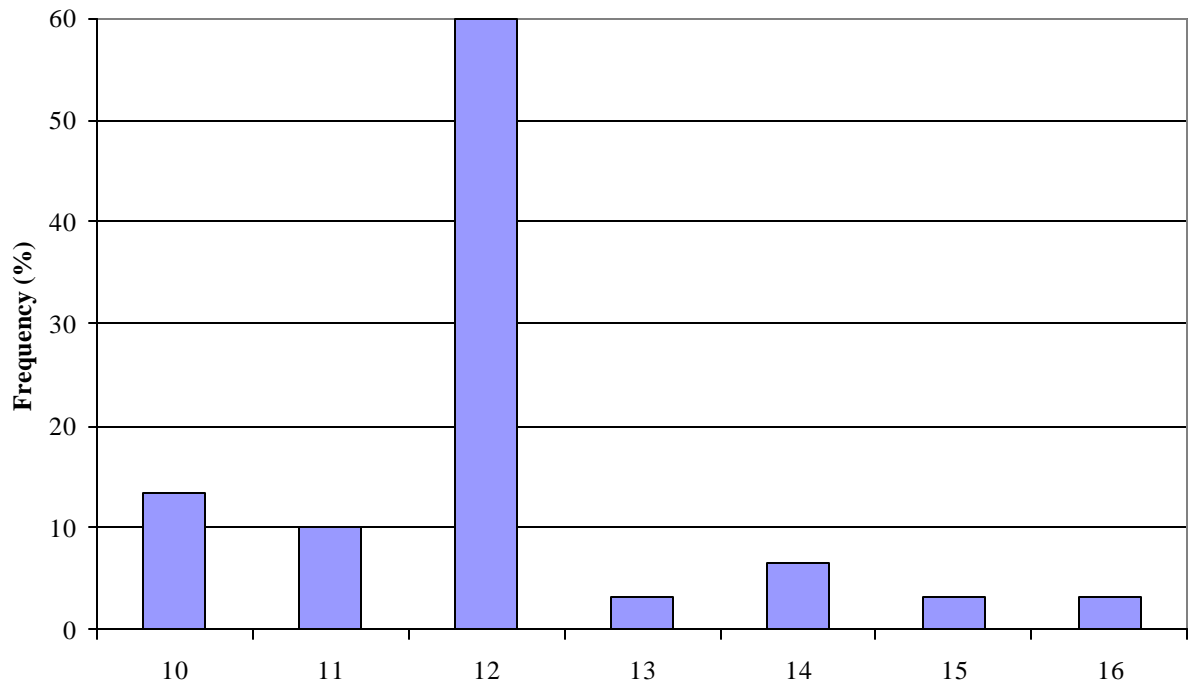
them uncomfortable. The contractors' representatives noted additional stress arising out of work scheduling, lane closure restrictions, starting and ending times being too restrictive. The contractors' representatives also indicated that the period of maximum stress is during the opening of the lanes to the traveling public; there is a monetary penalty for not opening the lane on time.

Interestingly enough, a few workers said that they prefer working at night, because it suited their personal schedules and the cooler evening temperatures makes them feel more comfortable. A young man indicated that working at night "kept him out of trouble," and that this was good for him.

The following paragraphs discuss the quantitative analyses done by the project team using the small data set collected in the survey. The summarized opinions of the workers from the transcripts were tabulated statistically into a data set containing the matrix of workers, job classifications and opinions. This matrix was statistically analyzed to determine the most significant opinions and concerns of the workers.

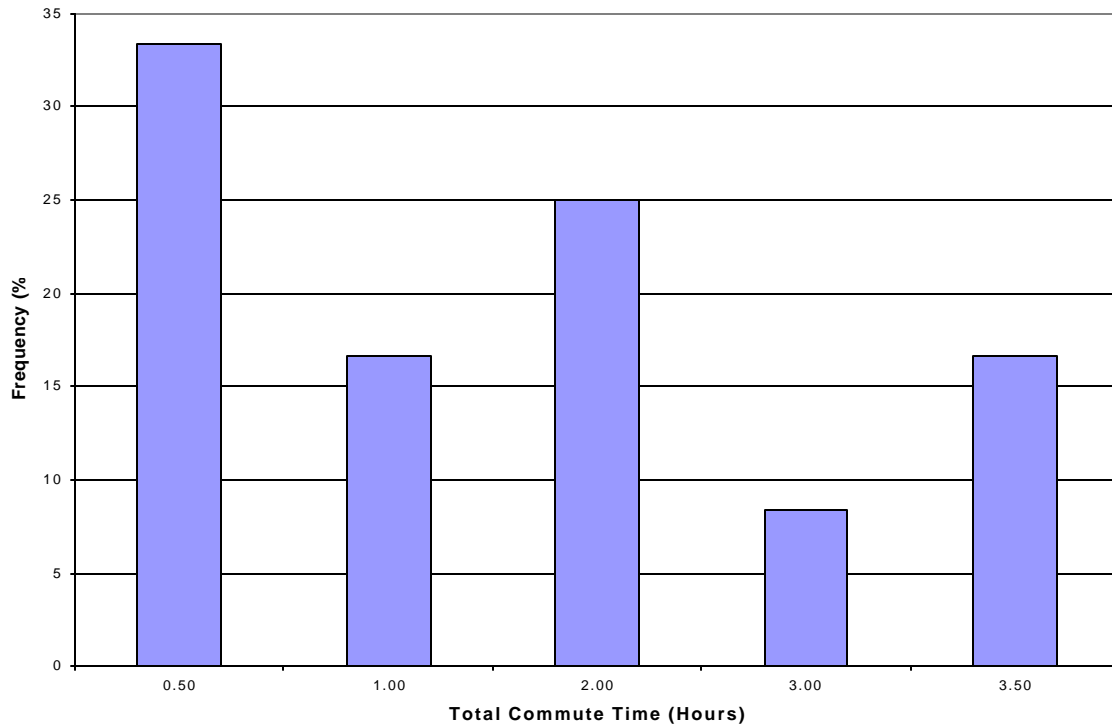
The distribution of the workers by marital status is as follows: 76% were married and have children, 8% were married without children; 4% were single with children and 12% were single without children. Those married with children expressed serious concerns about the adverse impact of nighttime work on their family life. They received persistent negative reactions from their spouses and children about them working during the nighttime. They noted that night work is a real threat to their married life and that they would never work at night if they had a choice. Those who were single and had no children seemed to be indifferent about working at night.

One of the most striking findings of this research pertains to the number of hours the workers spend each day working at night. As shown in Figure 4, the number of hours worked per day by the workers ranged from 10 to 16 hours. As shown, more than 77% of the workers work more 12 hours and more per day, including 17% that work 13 hours or more per day. The workers expressed concern about the stress that is imposed on them by these long working hours.



**Figure 4: Number of Working Hours per Day**

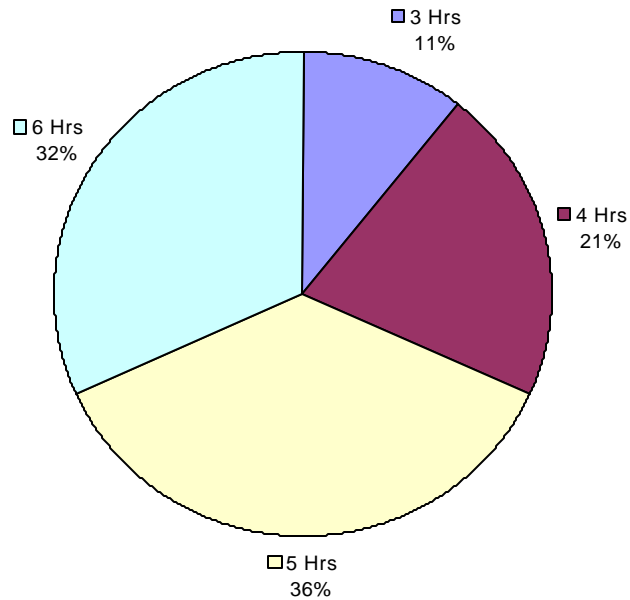
The long work hours described above are made worse by the commute time between their homes and the work sites. The data collected from five workers indicated that: 17% of the workers have a total commute of more than 3.5 hours; 8% commute three hours; 25% commute two hours; while 50% commute for less than an hour. The long commutes add a significant amount of time to the day as well as take away time that might have been spend with the family or other social activities. The long commute contributes to the total stress of the worker. Figure 5 shows the total commute time for the workers surveyed.



**Figure 5: Total Commute Time for Workers**

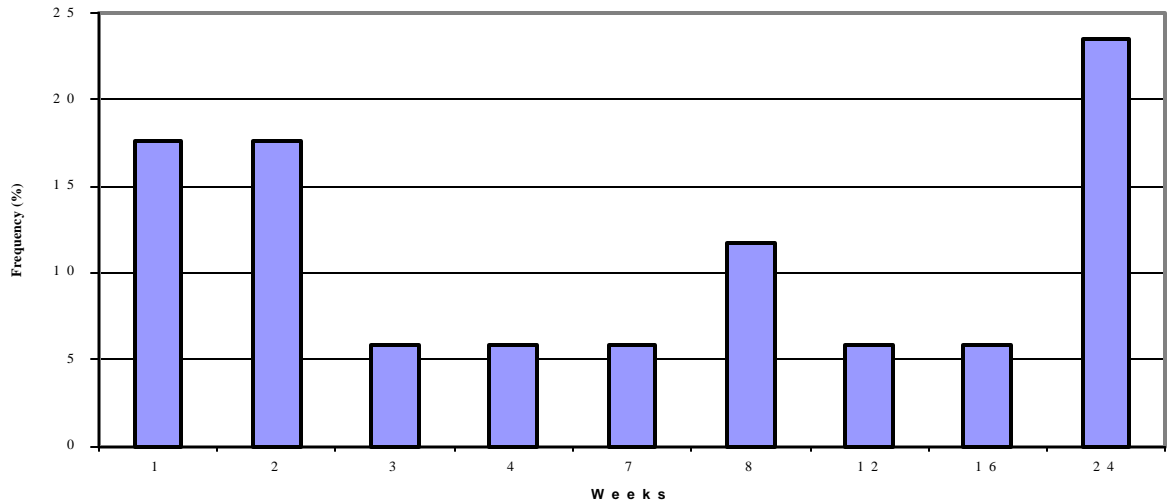
Because of the combined effect of long working hours, commute time, stress and family obligations, the workers experienced a significant reduction of the number of hours they sleep. Figure 6 shows the distribution of the number of hours of sleep captured in the survey. The average hours of sleep for the various categories of the workers range from a minimum of three hours to a maximum of six hours. As shown, 32% sleep four hours or less, 36% sleep five hours and 32% sleep six hours a day. **None of the workers had a normal sleep of eight hours.** These figures are significantly higher than the statistics from the literature for night shift workers that indicate that 20% of them suffer sleep related problems, sleeping one to four hours shorter than normal <sup>(4)</sup>. **This research indicates that the nighttime construction workers sleep between two to five hours less than the normal eight hours.** The workers attributed this to the difficulty in sleeping during the daytime because this the period during which, in normal conditions, the human body is in a state of activation.

Others also attributed it to noise and disruptive activities in their neighborhoods during the day.



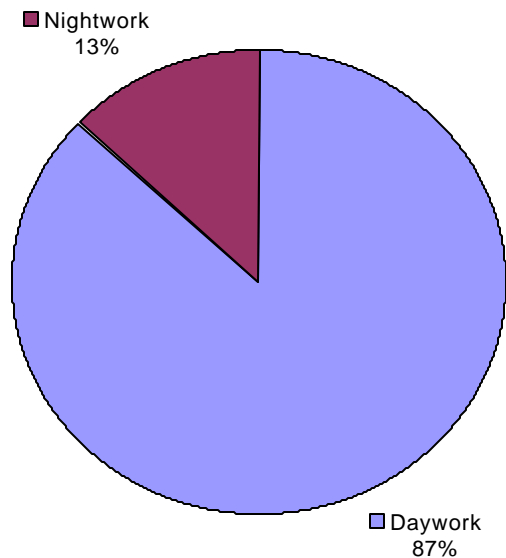
**Figure 6: Hours of sleep**

The average duration spent on the projects by the workers is shown in Figure 7. Although about 50% of the workers interviewed had spent over 10 weeks working at night, they complained that they have not been able to adjust completely to night work. They noted that it is very difficult for them to adjust completely to working at night. They attributed this difficulty to the switch to normal day night schedules on weekends.



**Figure 7: Time spent working during nighttime**

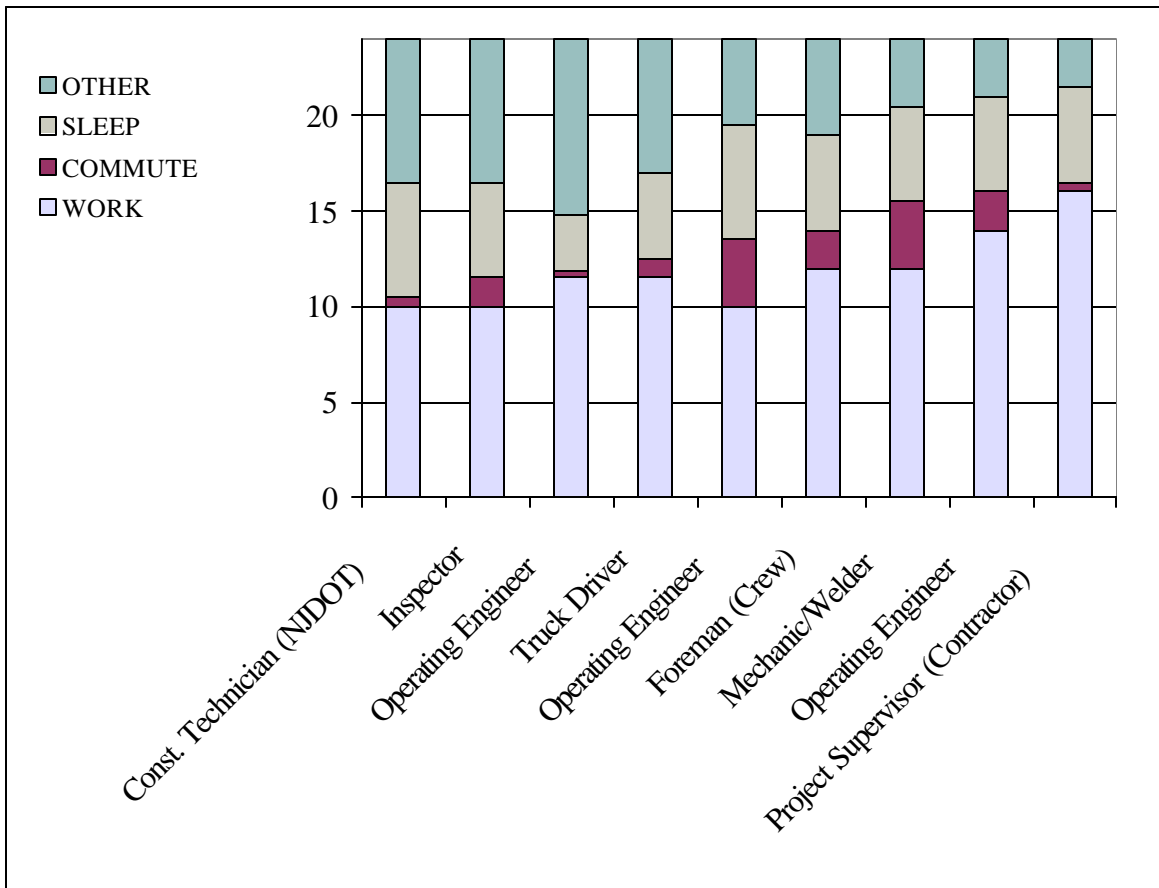
The data indicate that the overwhelming majority of workers (87%) prefer to work during daytime, while 13% prefer night work as shown in Figure 8. The four workers that like nighttime work indicated they like it because doing nighttime work: (a) enable them to get extra money (one); (b) gives them free daytime (one); (c) “keep him out of trouble” (one); one of the workers did not volunteer a reason. Three of the four workers who liked night work were middle aged/married and did not have young children.



**Figure 8: Work Preferences**

All workers on one project complained about excessive speed of the traffic. They noted that a police presence would slow traffic and help them feel safer. Although the researchers did not measure the speed of the traffic, in their opinion, the speed did appear excessive. As indicated previously, the focus group noted the same concern about excessive traffic speeds when police were not present. In general terms, there is consensus among the workers that nighttime work has: (a) a negative impact on their body rhythms; and (b) a negative impact on their social and family life.

The average time spent by the various categories of workers on commute, actual work and sleep is shown in figure 9. From the figure, the average commute time as a percentage of a full day is 6.25% compared to the average sleep time of 17.0% and a work time of 50%. If average commute time could be reduced, it could lead to an increase in the average sleep time and will contribute to an increase in productivity.



**Figure 9: Combination of Work, Commute and Sleep time**

## CONCLUSIONS

This report presents the results of a field study that assessed human factors at nighttime construction zones in the State of New Jersey. Although only a small sample of thirty observations could be gathered, the research team is confident it provides a snapshot of the situation at nighttime construction projects. The small sample is comprised of observations of nine different job types, ranging from project engineers to truck drivers.

The findings of the study confirmed the findings of the literature search that night shift workers suffer from sleep deprivation and related problems, and confirmed that the day sleep of nighttime construction workers is two to five

hours shorter than normal night sleep. Furthermore, the study confirms that night works adversely effect circadian rhythms and social/domestic life, as noted in the literature. Some of the major findings that were identified in the study include the following:

- The workers interviewed agreed almost unanimously that nighttime work has: (a) a negative impact on their body rhythms; and (b) a negative reaction impact on their social and family life.
- The workers interviewed for the study did not have adequate sleep. Average sleep hours range from three hours minimum to a maximum of six hours: 32% sleep four hours or less, 36% sleep five hours and 32% sleep six hours a day. None of the workers interviewed indicated to have slept the normal amount of eight hours. This was attributed to their inability to sleep during the daytime.
- All of the workers experienced long working hours: approximately 23% of the workers work 11 hours or less, while 77% of them work 12 hours or more.
- The above is compounded by the long commutes to the worksite. Half the workers that provided data about commute time, indicated that they drive two hours or more (total) every day to work.
- The workers with families are very concerned about their inability to have quality time with spouses and children.
- Only 17% of those interviewed said they receive extra financial benefits from working at night. They were willing to forfeit this benefit to be able to work during daytime.
- Over 90% of the workers noted that their worst days were Fridays and Mondays. They attributed this to the fact that they had to switch to a normal day-night schedule on Saturdays and Sundays and back to the night schedule on Mondays. Fridays are very difficult days because of sleep deprivation (exhausted).

- Almost all of the workers said that working at night disrupted their eating routines, and this resulted in inadequate nutrition.
- The vehicle speeds of the traffic through the work zone and the perception that more “drunk drivers” were on the highway on Friday nights, were primary concerns of workers and managers. On three projects, these concerns were mitigated by the presence of the police. On the fourth project, without the police presence, traffic speeds appeared excessive and the workers were concerned about safety.
- The vast majority of construction workers prefer daytime work to nighttime (87%). There is a relatively small group of workers that prefer to work at night (about 13%), and this was usually for personal reasons.

Both construction company managers and NJDOT engineers share the concerns discussed above. The construction company managers, in addition, have to deal with the stresses associated with limited lane closures, obtaining replacement equipment and parts during nighttime work, keeping additional supplies and parts, in the event of an equipment breakdown, and additional time required for planning nighttime work.

The resident engineers and inspectors noted that properly reviewing and inspecting work at night is an extremely challenging task, even though lighting specifications had been met. They also share the workers’ concerns about traffic speeds. A common complain from the engineers both from private companies and NJDOT is that, frequently, they have to work during the day doing administrative tasks, and also during the night managing or supervising the nighttime work.

In all, it is clear that this is a very complex problem that involves complex tradeoffs between the societal benefits of doing nighttime work (e.g., less impact to the traveling public, less environmental impacts) and the impacts on the workers’ human factors (e.g., sleep deprivation, family disruption, eating

disorders). As typical in such problems, there is no “best” solution. Instead, one must rely on determining the *preferred* solution, which is one that is based on the preference structure of the decision makers. To this effect, assessing human factors at nighttime construction zones provides documentary evidence to support such a decision process.

Rather than providing a set of answers, this paper has highlighted the seriousness of a problem that is affecting the workers at nighttime construction projects. Although the amount of data that was collected was relatively small, the results indicate that sleep deprivation, long commutes, stress, eating disorders, family and social problems, are frequent among construction workers. Addressing these problems, in a way that takes into account the perspectives from the different stakeholders, is a major challenge of which this piece of research is nothing more than the first step.

The initial interviews do not present strong evidence to make recommendation to NJDOT for work specification changes. Additional interviews should be performed to develop a statistically significant sample and analyze the worker’s comments. This research should be continued to obtain sufficient data to be able to develop stronger conclusions and recommendations.

## **SUGGESTIONS**

This section presents a discussion of the suggestions from the research team for changes to the nighttime work zone activities. Some of the suggestions are aimed at laying the foundation for a program of nighttime construction research, which the research team deems necessary to develop a full understanding of the multiple facets of this complex topic. Other suggestions are intended to ameliorate the negative impact of nighttime work on the workers’ human factors.

### **Definition of a Night-time Construction Research Program**

Nighttime construction and maintenance work is a multi-faceted problem that involves complex tradeoffs taking place among the multiple dimensions of the

work. In this context, it is important to fully understand the nature of these tradeoffs, so that proper decisions could be taken. Assessing these tradeoffs requires further research, in addition to the study of human factors in nighttime work zones (the subject of this project), on the areas of: (a) economic impacts; (b) impact to others; (c) safety; (d) technology solutions to increase safety; and (e) construction quality and productivity (in nighttime work).

Since the focus of this project was on the human factors, practically no work was done on the other important dimensions of this important activity. The suggestions given in this section represent only a partial view of an undoubtedly complex activity. As indicated above, fully capturing the key tradeoffs would require a multi-stage research program that studies in depth:

- ***Economic impacts:*** Nighttime work significantly reduces the amount of traffic disruption produced by roadwork. Although this is the generally accepted point of view, very little research has been done to: (a) quantify these savings; and (b) determine under what range of traffic conditions, nighttime is economically the best option. This project would undertake the assessment of users' travel time savings under the practical range of conditions. Among other things, this would enable NJDOT and the other decision makers to be able to quantify travel time savings produced by nighttime work, so that the funding of nighttime work is commensurate with its economic importance.
- ***Impacts to others:*** Nighttime work produces externalities that affect a wide range of stakeholders, e.g., noise disruption to homeowners. This part of the investigation would document, and assess to the extent possible, the impact of nighttime work upon home-owners and other parties that may be affected by construction operations during the night. This information would complement the state of knowledge of nighttime construction work.
- ***Safety:*** As highlighted in this research, safety is one of the nighttime construction worker's primary concerns. As of now, no attempts have been made yet to quantify safety of nighttime work in New Jersey conditions. This

research would analyze the safety record of nighttime work projects, attempt to develop safety indicators, and compare them to the ones for daytime work. This would enable: (a) to track over time the safety record of nighttime work so that timely corrective actions could be taken, if needed; and, (b) to get a full understanding of the safety implications of nighttime work.

- **Technological solutions to increase safety:** This research project would be aimed at identifying, evaluating and proposing the use of technological solutions that may have the potential to increase safety in nighttime construction zones. Although not being able to deliver the full benefits of police presence, there are technologies that may contribute to reduce traffic speeds and increase safety. Among them, automatic speed meters that display the speed of vehicles, and automatic cameras to take pictures of license plates of speeding vehicles.
- **Construction quality and productivity:** Representatives of the construction industry, contacted as part of this research project, provided anecdotal evidence of the challenge of doing nighttime work. In their opinion, achieving the same level of quality as in daytime work is a challenging task because of the inherent difficulties of nighttime work. This research would try to quantify both the quality and the productivity of nighttime work, so that proper actions can be taken, if deemed appropriate. Other aspects to be studied include the economics of supplying materials to nighttime construction zones.
- **24 hours and 24x7 operations:** One idea that deserves further consideration is the implementation of 24 hours and 24 hours-seven days a week operations (24x7) combined with full road closure. Among other things, these modalities may have the potential of significantly reducing the burden on both the workers and the traveling public, as well as increasing construction productivity. This project would conduct an assessment of advantages and disadvantages, and would define guidelines on when to implement such modalities.

- One idea that deserves further consideration is the implementation of 24 hours and 24 hours-seven days a week operations (24x7) combined with full road closure. Among other things, these modalities may have the potential of significantly reducing the burden on both the workers and the traveling public, as well as increasing construction productivity. This project would conduct and assessment of advantages and disadvantages, and would define guidelines on when to implement such modalities.

The research team recommends that further research on the areas discussed above to identify alternatives to minimize the impacts of nighttime construction zone. A systematic research program in this important area would gradually create a body of knowledge upon which to develop nighttime construction zone standards.

In general terms, the suggestions shown below are the result of the observations made by the research team during the study of human factors in nighttime construction zones. Although human factors are an extremely important subject, producing balanced and sound recommendations on how to improve nighttime work requires a comprehensive research program that studies all the different facets of this important activity. Since the latter could not be done, because of the project's constraints, the research team advises the stakeholders that the suggestions made are the result of a preliminary study of a very complex problem. More research is needed to develop the full picture of the overall impacts of nighttime work.

### **Four Day Work Week**

As demonstrated in this research, lack of sleep, and the resulting exhaustion, is a major problem among construction workers. It is clear that something should be done to reduce the amount of hours construction workers spend at nighttime projects. In other industries, e.g., 24x7 supermarkets, this has been accomplished by having multiple shifts. However, the unique conditions in nighttime construction projects, in which dividing a 12 hours work time in two

shifts of six hours each may translate into significant downtime and inefficiencies, seem to suggest that reducing the work week may be a better vehicle to accomplish the same objectives. A shorter work week may translate into workers that are more rested and that experience less disruption on their social and family lives. However, it is important to keep in mind that a shorter work week may have a negative effect on the workers, if adequate pay differentials are not implemented. This is because, in the absence of pay differentials, workers may have to look for additional work to compensate for the lost income. This issue is discussed next.

### **Pay Differential**

The research team believes that nighttime workers should be compensated for the important work they do. In economic terms, nighttime work reduces the traffic disruptions caused by construction work. The economic value of the congestion saved by nighttime work is considerable. A small portion of these savings should be transferred, in the form of a pay differential, to the people that make it possible. Pay differentials, though not reducing the negative impacts upon the workers, would be a significant morale booster that would translate into a more able and responsive worker.

The research team believes that a pay differential, combined with a shorter workweek would have significantly ameliorated the negative impacts of nighttime work on human factors. This is because these two suggestions combined would translate into the workers having additional time to rest and stay with their families. Otherwise, a four-day work week without pay differential would undoubtedly result in workers looking for additional work (somewhere else) to compensate for the lost income produced by the shorter work week.

### **Itemization of Traffic Enforcement Costs**

The issue of safety at nighttime construction zones is of primary importance to workers. The workers concerns can be significantly ameliorated by appropriate

police presence. However, since police presence at nighttime construction zones involves additional costs, it seems appropriate to include a line item in the project costs for traffic enforcement. Among other things, the itemization of traffic enforcement costs would: (a) ensure adequate resources for traffic enforcement; (b) mitigate workers concerns; and (c) avoid overwhelming police departments' resources with the additional strain of patrolling nighttime construction zones.

### **Temporary Accommodations**

As demonstrated in this research, the combination of long working hours, long commutes times, changes in the body rhythms, and stress lead inexorably to sleep deprivation. This is particularly acute in those cases in which the commute time is significant, i.e., more than two hours. In order to mitigate this factor, the research team suggests that accommodations be provided for workers in nearby hotels. Among other things, reducing the commute time may increase the productivity of the worker.

More research is needed to assess the cost-effectiveness of “technological solutions” that, though not providing the full benefits of police presence, may contribute to reduce traffic speeds and therefore increase traffic safety.

Examples of such technologies are: (a) automatic speed sensors that display the speeds of individual vehicles; and, (b) “red light cameras,” or variation of, that could used or modified to take photos of license plates of speeding vehicles.

### **Motivation**

The importance of motivation cannot be stressed enough. Good managers that, almost invariably, are also good motivators understand this. Although this research was not set to investigate the role of the manager-worker relationship on the satisfaction of workers involved in nighttime projects, the conversations with workers seemed to reveal that workers that feel “abandoned” and “not cared for” by project supervisors are more likely to feel negatively affected by

nighttime work. On the other hand, workers that feel “part of a team” seemed to have a much better attitude toward nighttime work. This seems to suggest that managers should try to provide adequate motivation and working conditions, and ensure that the nighttime workload is equitable spread among all involved.

In all, this research project has taken a preliminary look at very complex nighttime work zone activities that have ramifications deep into both the human factor of workers and the economics of construction projects. The suggestions put forward here, based mostly on the study of human factors, may contribute to minimize the negative impact of nighttime work upon workers. However, as indicated in various sections of this document, a broader research program is needed. In this context, rather than providing a set of definite answers, this project—because of its inherent limitations—has defined a broad set of questions to be addressed by future research. Only then, the New Jersey Department of Transportation, the construction industry, and the academic community would be able to fully understand the overall impacts and implications of nighttime work; and to define a meaningful set of work standards.

## **APPENDIX A: SITE PHOTOGRAPHS**



**Plate 1: Typical Working Area- Bridge Rehabilitation Project**



**Plate 2: Typical Working Area- Fiber Optics Project**



**Plate 3: Lighting in Working Area- Fiber Optics Project**



**Plate 4: Equipment Maintenance Staging Area-Milling and Paving Project**



**Plate 5: Typical Staging Area- Milling and Paving Project**

**APPENDIX B: Summary Of Transcripts- Rural Interstate Milling  
And Resurfacing Project**

### **Operating Engineer**

- The engineer noted that he has worked on this location for three (3) weeks and on another site for 3 ½ months.
- He does not like the shift rotation (double shift) at night. It is hard to get use to night work after working days.
- He is married and has a family.
- Night work is horrible; it destroys his family life. When he comes home, they are going to school and when they are coming home, he is going to work.
- Working at night causes the stress level to go up.
- He gets a 15% shift deferential in pay for working at night
- He works from 6 PM to 6 AM, or 8 PM to 8 AM (12 hrs), He works more hours during the night than during the day.
- He sleeps about 3 hrs. It is had for him to go to sleep when the sun is up.
- He prefers to work during the day.
- On the weekend, he sleeps while everyone else is awake.
- If equipment breaks down, we fix it here.
- The job does not stop, we continue working and let the management deal with problems.
- Management is accessible for problems.

### **Operator (multipurpose)**

- He works with a jackhammer, runs the water truck for the machine and other activities.
- He is married and has a family.
- He commented that when he works at night, it seems that his life is work, and sleep: Nothing else.

- He prefers to work during the day, but has no choice.
- He sleeps about 4 hrs.

### **Pavement Foreman**

- He has worked for the company for thirteen years.
- He is married and has family.
- He likes the job, but prefers day assignments. Night shift affects his family.
- He prefers to work during the day because it is safer, can see a lot more and can do a better job.
- He does not get extra pay for working at night.
- He drives 1½ hour to the site each way.
- He does not sleep very well. His has not adjusted to the night schedule.
- He gets 4 to 5 hours sleep a day.
- Laborers' seldom take time off. Operators do not have sick or leave days. If they do not show up, they are not paid.
- Working in the center lane is very scary. Generally, we close the right or left lane for NJDOT job. The only time that we have work on the center lane with moving traffic on the right and left lanes was for the Turnpike.
- There is state troopers assigned to the job, but I never see the trooper enforcing the speed limit or giving them tickets.
- There is a safety meeting every month.
- There were problems or issues with the light specification and the safety inspection.
- We have a mechanics on site in case equipment breakdown. We may have problems getting parts.

- For emergencies, several members of the crew are certified for CPR and other emergencies. Road mechanic has a cellular phone and before he starts any job, the Company gives him a list of emergency numbers to call.

**APPENDIX C: SUMMARY OF TRANSCRIPTS- BRIDGE  
REHABILITATION PROJECT**

### **Field Engineer (NJDOT)**

- Prefers to have rotating shift so that laborers will rest and to reduce potential incidents.
- Points out the issues of supervising multiple contracts and the need to work at night and do paper work during the day.
- There is state troopers assigned to the job, but when they enforce the speed limit violation goes down. When enforcement stop speed violations goes up again.
- Laborers do not use protection for the dust. Supervisor explains that they refuse to use it. This is a very dangerous health situation.

### **Technician (NJDOT)**

- Has family with kids.
- Prefers to work during the day because it is more normal.
- He likes his job, but prefers to work during the day. Night shift affects his family. His wife made him get a dog as a condition to work at night.
- He does not get extra pay for working at night. A NJDOT employee.
- Not sure, what is going on with lighting/safety inspections. NJDOT has people assigned to do inspection.
- Normally the guys do not wear the respirators and two years ago, I was told you needed to wear it. This was the case at this site.
- There are mechanics on site or on call in case equipment breakdown. It takes longer to repair if mechanic is on call. There are spare equipment on site in case of breakdown

## **Laborers/Jackhammer**

- This person enjoys working at night; his wife also works at night.

## **Project Engineer**

- Complained about the inflexibility and lack of cooperation from NJDOT. He feels that the work should be a team approach. He made recommendations about changing specific tasks that will benefit both NJDOT and the contractor, but DOT will not consider the option because it is not on the contract. He provided an example where he suggested that cones should be used at highway entrance rather than the tall barrier because the car that is trying to enter the highway has difficulty seeing the approaching vehicle. After few accidents, the proposed change was implemented. There was not need for those accidents to happen before making the changes.
- He noted that the contract is a tool to make sure that the work is done correctly, but it should be flexible. The contract does not take into account actual issues that happen when you are performing the work.

**APPENDIX D: SUMMARY OF TRANSCRIPTS - FIBER OPTIC CABLE  
CONSTRUCTION PROJECT**

### **Equipment Operator/Driver**

- Works night shift for past 6 months
- Works from 7 PM to 8 AM
- Family with four children
- Worst days are Monday and Friday. Mondays are difficult to get adjusted to shift work. Saturday and Sunday, he switches to regular hours to be with the family.
- His biggest problem is not enough sleep. The sleep deprivation catches up with him on the weekends

### **Operating Engineer**

- Working night shift for the past 6 months on this project
- Work hours 6 PM to 8 AM
- He has one hour commute to work each way.
- He is single; has no social life.
- He is sleep deprived; about 4 hours. Not adjusted to night work. Worst days are Monday and Friday.
- He takes a half hour for a meal break.
- He has difficulties adjusting to night shift work.

### **Equipment/Backhoe Operator**

- Working night shift for the past 2 months on this project
- Work Hours from 7:30 PM to 5:00 AM
- He has a 45 minute commute to work each way
- No meal breaks
- He has not problem sleeping during the day

- Married, his family consists of teen-age children.
- He noted additional stress because his equipment moved from lit areas to non lit areas.
- He has “adjusted” to night shift work.

### **Contractor’s Project Supervisor**

- Working night shift for the past 6 months on this project
- Work hours form 5 PM to 9 AM.
- He is married, has no young children at home. He would not work the night shift. He has no quality time with his family.
- He has a 15-minute commute each way.
- He has no problems with sleeping - sleeps about 4 hours each day. He sleeps all day on Saturday.
- He conducts weekly safety meeting for the workers.
- He made a comment that production scheduling and deadlines produce additional stress on the night shift.
- Also, he commented that supervisory staff is need at the job site for longer hours than the workers to prepare paper work and project coordination on the night shift. He felt additional nighttime stress due to lane restrictions and work scheduling.

### **Director of safety for the company**

- Work from 8 PM to 5 AM (9 hrs), but people are here before that. This is the time that they are on the road, when the lane is closed.
- Worked yesterday from 6 PM to 5:45 AM (11 hrs, but most of the time I work during the day.

- In this particular job, there is a day shift and a night shift, and laborers are rotated, usually for 6 weeks.
- We did a lot of study and found that for many people it is hard for them to work at night because they can not get proper sleep; we do not want them coming on the job when they are already tired. They lose their awareness, they lose their sense of alertness, and that is not wanted .
- The company gives them incentive for working at night base on safety. Some guys get \$300, depending on how safe you work. There is a 15% more pay an hour than the regular shift.
- We only try to enforce the lunch break, but there are times when they work through the lunch break and they are paid for it.
- There is less productivity in the evening because you are concerned about the traffic situation, the lighting system has to be adequate, and also the barricade. It is definitely better during the day.
- The problem is traffic. It is harder working at night because of the traffic
- This is private work and the safety requirements of the DOT, I feel, is a 100% better.
- State Troopers were available.

### **Foreman in charge of the crew**

- Works for this company for 16 years.
- Married with children.
- Likes to work daytime, but the company hasn't got many nighttime jobs except this one.
- Mostly, I work during the day.
- Travel time to the job site is one hour each way.

- Works from 6 PM to 6 AM (12 hrs).
- Supervises an 8 member crew.
- Takes about 10-15 minutes break and if you do not want to take lunch you are paid.
- Has no problems sleeping - sleeps about 4 to 5 hrs daily, except Saturday the whole day.
- In the first couple of weeks, it affects you a little bit;, but you get adjusted.
- Feel a little bit more tired in the morning and a little bit fatigue during the summertime.
- Every night we a State Trooper is assigned to help control speeding vehicles.
- He is satisfied with the lighting and state inspector checks of specification.

### **NJDOT Construction Technician**

- Works night shift for the past 6 months on this project.
- Works hours from 7 PM to 5:30 AM.
- He is a single father; sets aside specific time for “supper” for everyone to eat together; and quality time. No social life.
- He has a 15- minute commute each way.
- He has problem sleeping - neighborhood noises, etc. Sleeps all day Saturday and Sunday to catch up.
- He made the same comment as the supervisor above: that work scheduling and deadlines produce additional stress on the night shift.
- In addition, he commented that as an inspector, he is on the job site for longer hours than the workers in order to prepare paper work and project coordination for the night shift. He must also work with NJDOT supervisors that work during the day.

### **Truck Driver (Independent-Owner/Operator)**

- He does not work every night; he rents out the truck during the day.
- He works both at night and during the day: 3 nights per week, very irregular schedule.
- He has a family; but no family life.
- Friday and Saturday nights are the most stressful, and this is due to drunk drivers and speeding traffic.
- He has adjusted to night shift work.

### **Machine Operator**

- Working night shift for the past 2 months on this project
- Family life is stressful.
- He has a one hour commute each way
- Works from 8 PM to 8 AM (12 hrs).
- He commented that on Monday, it is difficult to readjust to the work schedule.
- He gets extra pay for working the night shift

### **Laborer**

- Loves to work on the night shift because it “keeps him out of trouble.”

### **Truck driver**

- Works for the company for 27 years.
- Has family with kids.
- Works from 7p to 6:30a (11 ½ hrs).
- Drives to work; ½ hr each way.

- Enjoy working at night because it gives him the time to do his personal business during the day; takes his car for inspection, insurance, goes to the Doctor, etc.
- Sleeps for about 4 ½ hours.
- Works 5 days per week.
- He claims that some of the laborers work double shifts and sometimes they get very tired

### **Operating Engineer**

- Works on this site since September (for two weeks).
- He is single and has no social life.
- Drives to the site; one hr each way.
- Works from 6 PM to 8 AM (14 hrs).
- Sleeps between 3-5 hours per day.
- Not adjusted to night shift work.
- Worse days are Mondays and Fridays.
- Has half hour for lunch. It seems that most people have no regular eating hour.

### **Operating Engineer**

- Worked on this site since July (months), but started the night shift days ago.
- Has work in construction for about 15 years, 11 with this company.
- He has a wife and children. His wife complains and wants to know when his night shift will end. It is very hard because he does not see his family that much.
- It is not always easy to sleep during the day; that is one of the most difficult things, sleep patterns; you need more sleep when you work at night.

- He hates working at night because it is twice as hard to do everything. Decreased visibility, supplementary lighting, it is very difficult; and one has to use all of his senses. The only good thing is there is that there is less traffic on the highway.
- Mondays are terrible, and there are many extra hours besides the stress; it is not an easy thing.
- Only sleeps three hours and need three days to recover from the weekend.
- Drives to the site; 10 minutes each way.
- Works form 7 PM to 6:30 AM (11 1/2hrs).
- I am working all the time. Usually until the end of the day, with no lunch break.
- The most pressure (stress) that I feel on this job is the time limit that we have for getting off the highway. If we are late, it ruins traffic up tremendously. I do not think there is anyone in our crew that does not feel the stress during the time when the lanes must be opened.
- More experienced people are put in the night shift because it is harder.

### **Laborer**

- Works for this company for 11 years.
- Works on the night shift since June (4 months)
- Married with children.
- Worse part of the job is that he can only see his family on the weekends.
- He would like to work during the daytime, because of the work hours.
- The additional pay that he obtains does not compensate for the time missed with his family.
- Concerned over speeding motorists during work.. Nobody seem to respect speed limits.

- Concerned over inadequate lighting. During the daytime, one has a better vision; the nighttime is a different story. The safety issue suffers.
- He gets enough sleep, but during the weekend, the hours become confusing. You sleep during the day and when it is night, you feel like staying awake.
- Productivity is the same for day and night.
- We get coffee breaks and sometimes we get a chance to take lunch breaks; Most of the time we try to skip the lunch breaks.

### **Laborer**

- Married with children
- Working at night is horrible. It messes up your whole body, you do not go to the bathroom right, you do not act towards your wife and children right. You turn into a completely different person.
- Work during the day and work overtime at night. The actual hours are from 3 PM to 11 PM with additional (over time) hours up to 6:00 AM (15 hrs).
- Receive additional payment for overtime, so it supplements the pay.
- Like to work at night because of the extra money. I needed to do that for extra money to support the family; so I stay up all night, overtime and during the daytime.
- No breaks; you've got to be there the whole time.

### **Laborer**

- Works at the site for the last month.
- Spouse doesn't like me working at night, worries about me constantly.
- I am a daytime person, and I do not really care for night work, it is harder to concentrate, and I sometimes feel disoriented. I need to get up at least a couple of hours early to become alert and motivated.

- Usually get about 6 hours sleep and when I wake up, I am still tired.
- Receive additional payment for night shift difference; it is a small amount for work at night.
- Work from 7:30 PM to 6:00 AM (11½ hrs), but arrive to the site early for preparation.
- In term of safety, the company is good with that, I feel safe with how they set us up. We don't go out unless it's pretty safe.
- Get ½-hour break for lunch.
- There are two women working at laborers in this company, one work at night and another on day.
- There is plenty of State Police Troopers out here.

### **Laborer**

- First week at this site; switching from day shift to night.
- He never had a night job in his life, except this summer.
- Has no problems sleeping, but feels sleep deprived. He sleeps about 6 ½ hrs.
- Having problems adjusting to night work, especially with his bathroom schedule. He tries to keep his diet the same; Tends to have a sandwich in the middle of the night.
- Start working at 7 PM and it takes an hour to get there. He goes to the yard before going to the site. He arrives home about 7 AM.
- Works from 7 PM to 6:00 AM (11 hrs).
- There is no lunch break and he eats while working. (They may not get paid for the lunch break and therefore he continues working during this time.) He said that "I prefer to do that; I don't want to stop to sit down, as you start to get tired".

**Laborer**

- First week at this site; switching from day shift to night.
- Has a wife and child. Child does not like the fact that his father has to go to work at night.
- Having no problems adjusting to night shift, but he likes it because of the extra money.
- Has no problems sleeping; He sleeps about 6 ½ hrs.
- He is eating less.
- Works from 7:30 to 5:00 AM (9 ½ hrs) or about 60 hours per week.
- There is no lunch break and he eats while working, even though he gets paid for the lunch break.

**Laborer**

- Worked in construction for 8-9 years.
- Has been on this site for 4 months.
- Has a family.
- Not adjusted to the night work.
- Sleeps for about 6 hours, and does not really have many sleeping problems.
- Works from 7p to 6:30a (11 ½ hrs).
- He would rather be working during the day. Not satisfied with the pay for night work ;does not think that it makes much sense.
- Takes a small break for lunch, and has a sandwich or coffee.
- Drives to work; half hour each way.

**Laborer**

- He has worked in construction for about 15 years and 3 months with this company.
- He is single with no children.
- He has no problems sleeping.
- This is the first night job he has had, and he has no problem adjusting to it.
- He loves to work at night, as it keeps him out of trouble (young laborer - 26 yr old).
- The worse day is when it rains, like today, because if a trench is open and it rains, this cause problems.
- Drives to the site; 45 minutes each way.
- Gets a 15 minute lunch break.
- In case of rain or any other problem that delays work, the pay is reduced ( even for a short time; 2 hrs). There are special regulations for being paid if the job is closed due to rain, or due to other problems. See union contract.
- The best day is Friday because the weekend and I go out.

### **Mechanic/Welder**

- Has work on construction for 27 years and with this company for 7 weeks.
- Has family with children. My wife has a hard time keeping them all by herself.
- At home, my wife is stressed out, therefore I am stressed out too.
- I do not see nearly half the people I normally see and talk with.
- Drive to the site about 1 hr and 45 minute each way. Sometimes I have to take many naps on the way.
- Start working at 6 PM and go home at 6 AM. Approximately 12 hrs per day.
- On the weekend I have to be re-adjusted, I do not get enough sleep. You switch to day shift.

- Sleep for about 5 hrs, I eat a lot less, I don't get enough sleep
- Not adjusted to night shift work. Prefer to work during the day. I still got to work during the day even if I will get less pay.
- No problem sleeping because I am so tired; I do not have a problem.
- Never really get used to work at night.
- Worse days are Monday and Friday. On I am ready to get a day off to have some sleep.
- Take short break for coffee or sandwich.

**APPENDIX E: SUMMARY OF TRANSCRIPTS: URBAN MILLING  
AND RESURFACING PROJECT**

## **Inspector**

- Works in this site since September (2 weeks).
- Has family with children. The only time he spends with them is at dinner before going to the job.
- Has baby sitter problems since he is not there.
- Eats less.
- Sleeps between 3 and 5 hours. Still trying to get adjusted to night work.
- No adjusted to night shift work.
- Drives to the site about 45 to 50 minutes each way.
- Starts working on the road at 8 PM and open the lane back at 6 AM. Works on average about 60 to 70 hrs. per week.
- A lot of stress is because he is tired and traffic.
- There are state troopers on the site.
- Worse day is Friday, suggested that Friday should be off. To reduce stress, he should not work four (4) nights in a row. At present, they are working 6 nights.
- Has ½ hour for lunch. It seems that most people have no regular eating hour.

## **Project Engineer (NJDOT)**

- Works in this site since September (7 weeks).
- Married with no kids.
- Sleep between 3 and 5 hours per day. Still trying to get adjusted to night work
- Driving to the office is 2 ½ miles from home, so that help since I stop at the office early in the morning on his way home and on the afternoon on his way to the job site.

- Worse day is Monday.
- Working at night the only thing you get is production; but you miss the quality of work.
- Have many responsibilities at the construction site and at the office. Find him-self making stupid mistakes. It feels as you have two jobs: a day job and a night job.
- Has ½ hour for lunch. It seems that most people have no regular eating hour.

### **Operating Engineer**

- Operate the milling machine
- No chance to see the family, except a couple of hours.
- Have some minor problems with family due to the night shift, but wife understand.
- Have no problems going to sleep and sleep between 5 to 6 hours.
- It takes about one hour and 45 minutes (1 3/4 hrs) to get to the site each way.
- Works from 45 hours to 70 hours per week.
- Monday is the worse day during the week. Body has to shift back to night work. The problem is that he stays up all day Monday and then he has to stay up the whole night. The worse problem is driving back on Monday. You are tired and sleeping. You are going from a day schedule back to night again.
- If they work 6 days per week, this will increase the family level of stress. The only free day will be Sunday and he will be sleeping the whole day.
- Prefers to work 5 days rather than 6 days and work less time.
- Prefers to work day
- There is a 15% pay increase for working at night.
- Takes coffee break and work during lunch break.

## REFERENCES

1. US Department of Transportation, "Our Nation's Highways: Selected Facts and Figures", US Department of Transportation, Federal Highway Administration, Office of Information Management, 1995.
2. Federal Highway Administration, "Estimates of Urban Roadway Congestion – 1990", Office of Traffic Management and Intelligent Vehicle Highway Systems, FHWA, Washington, D.C., March 1993.
3. Lindley, J. A., "Urban Freeway Congestion Problems and Solutions: An Update", ITE Journal, December 1989.
4. Lindley, J. A. (1987 b), " Urban Freeway Congestion: Quantification of the problem and Effectiveness of Potential Solutions", ITE journal, January 1987.
5. Texas Transportation Institute's Urban Mobility Study (TTI, 2001)
6. Cambridge Systematics, "Incident Management", Alexandria Virginia, Trucking Research Institute, October 1990.
7. 1998 Work Zone Crashes Fact Sheet, American Traffic Safety Services Association, Fredericksburg VA. December 15, 1999.
8. Carpentier, J., Cazamian, P. " Night work: Its effect on the health and welfare of the worker." International Labor Office. ISBN 92-2-101676-5, Geneva (1977)
9. Ellis, R. D., Zohar, J. Herbsman, Kumar Ashish, Pritesh N. Chheda "Developing Night Operations in Florida, Final Report". Florida Department of Transportation. April 1992.
10. Fynn, Peter. "The Effects of Shift Work on the Lives of Employees." Monthly Labor Review pp. 31-35 October 1981
11. Biological Clock and Shift Work Scheduling." Report by Sub-Committee on Investigations and Oversight."

12. Vidacek, S., Kalherna, L., Folkand, S. "Productivity on a Weekly Rotating Shift System: Circadian Adjustment and Sleep Deprivation Effects" Vol 29, No. 12 Ergonomics. December 1986
13. Tilley, A. J., Wilkinson, R.T. "The Sleep and Performance of Shift Workers" Human Factors. 1982.
14. Ossama, A.E., Perry, R.J. " Nighttime Construction Operations" Special Report No. 116, Engineering Research and Development Bureau , New York State Department of Transportation. December 1994

