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AN ANALYSIS OF HUMAN FACTORS IN NIGHTTIME WORK ZONES

FHWA/NJ 2001-025 November 2001

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 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.

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.
As part of this project, the researchers visited four construction projects. At each site, interviews with the workers were conducted. This Tech Brief provides a summary of the findings reached, after the collected data were analyzed. The findings of this report provide 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.

The full 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* summarize the findings of this investigation. This Tech Brief presents the conclusions of the study.

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 work adversely effects circadian rhythms and social/domestic life, as noted in the literature. Some of the major findings that came out of 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.
- 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.

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 and assessment of advantages and disadvantages, and would define guidelines on when to implement such modalities.

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.

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.