Influence of Nighttime Operations on Construction Cost and Productivity

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There has been a shift in emphasis from building new facilities to rehabilitation of highways in the United States. However, with traffic levels approaching or exceeding highway capacities, any maintenance work on highways disrupts traffic, often resulting in severe congestion, delays, and accidents. As a result, various highway agencies are shifting toward nighttime construction and maintenance when traffic densities are relatively low. The decision to work at night, however, involves a number of complex issues. Some factors involved in such decision making were identified in a research study conducted for the Florida Department of Transportation. The effects of nighttime construction on construction cost and productivity are evaluated in this paper. Comparisons are made for daytime and nighttime highway projects in Florida. Unit cost comparisons do not suggest any trend in the cost differential of individual items; however total program cost is found to be less for work at night as compared with work during the day. The results do not confirm any significant difference between the productivity values for daytime and nighttime projects.

Recently many states have changed the focus of their operations from constructing new highways and roads to maintaining the existing ones. This shift creates many problems. One such problem arises from daytime lane closures, which result in heavy congestion on roads already loaded to capacity. This problem is not limited to roads in urban areas but also includes some rural highways that are often as crowded during certain times of the year as urban areas. According to one state highway agency official, it has become difficult to distinguish morning rush hour from evening rush hour, and congestion lasts for 12 to 13 hr a day (*1*). This creates a situation in which the normal, ordinary solution of lane closure becomes unrealistic or impossible during peak times. Daytime lane closures are also hazardous, costly, and inconvenient for the traveling public. As a result, more construction and rehabilitation work is being performed during hours when traffic flow is minimal. For this reason, many highway agencies have started working at night.

In addition to several obvious advantages of nighttime work, such as cooler temperatures for equipment and material, less traffic problems, and delays, there are certain disadvantages. Many complex issues, including safety, costs, productivity, lighting conditions, manpower availability, and administrative decisions, are associated with nighttime work.

Recent literature on highway construction confirms this trend toward nighttime work and addresses the problems associated with it. However, the number of references dealing directly with nighttime operations, as a whole, is limited. Only a few studies provide a comprehensive approach and valuable information toward night-shift construction. The manufacturing industry has dealt with night-shift operations for many years and has had numerous research studies conducted. Because of the distinctly different nature of the two industries, only a few of those studies are applicable to the construction industry. Those that apply are in the area of human factors. Several published reports in the transportation area have provided information on issues relating to the planning, safety, and traffic control aspects of nighttime maintenance and construction work and their advantages and disadvantages. Price (*2*) addressed the overall nighttime paving operation with respect to lighting, personnel, and communication. He also included comparisons of quality, cost, and safety in his research. Shepard and Cottrell (*3*) conducted a study in which information was compiled on current practices in nighttime highway construction and maintenance operations. This information was used to develop guidelines for determining when work should be done at night and what traffic control devices should be used. The major areas covered in their nighttime construction feasibility study were scheduling of lane and road closures, work-zone costs, safety, public relations and user costs, and traffic control. Hinze and Carlisle (*4*) further evaluated the important factors in nighttime construction. They have focused their research on rehabilitation and maintenance activities on major metropolitan highways. Qualitative and quantitative factors related to nighttime construction were detailed in their study, along with a discussion of advantages and disadvantages.

The Florida Department of Transportation (FDOT) has determined that nighttime work is one major solution to the problem of traffic congestion associated with highway maintenance. Researchers at the University of Florida recently attempted to study all the parameters involved in a night operation (5). The objective was to provide assistance to FDOT in developing a more structured decision-making system concerning when to make a project a nighttime operation. Most of the information obtained for the study from a literature survey and other sources is based on opinions and is not quantitative. Although these opinions are based on substantial experience and are important, more accurate and quantified data are needed. The researchers, in addition to identifying these parameters and evaluating their effects, also quantified the effects on construction cost and productivity. The information presented in this paper is based on that research effort.

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OVERVIEW OF FACTORS AFFECTING NIGHT OPERATIONS

From the literature survey, analysis of several case studies, and meetings with experts in Florida and other states, a number of factors have been identified that affect the decision of shift times for highway construction. These factors play important roles in determining whether to work at night. These factors are divided into five categories on the basis of their characteristics:

- Construction-related factors:
  - –Cost,
  - –Productivity,
  - –Quality, and
  - –Noise;
- Traffic-related factors:
  - –Congestion,
  - –Safety, and
  - –Traffic control;
- Human factors:
  - –Sleep,
  - –Circadian rhythms, and
  - –Social and domestic issues;
- Miscellaneous factors:
  - –Public relations,
  - –Information,
  - –Supervision,
  - –Communication,
  - –Material supply, and
  - –Equipment repair; and
- Work-zone lighting.

Some of these factors have qualitative and some quantitative attributes. For instance, cost and productivity are quantitative factors; quality, noise, safety, and congestion are both qualitative and quantitative; and human factors and other factors are qualitative. Analysis of construction-related factors revealed that cost, quality, and productivity had some project-by-project variations caused by various factors. Construction cost and productivity are discussed in detail in this paper. The number of noise complaints is higher for nighttime work for projects in urban areas, and those projects take longer to finish. Although human factors are usually given some consideration, they are not constitute a major decision-making criterion. Traffic-related factors are considered to be the most important. Congestion is often found to be the one single factor resulting in the decision to use a night shift on many projects. Safety is a major concern during nighttime work because accidents tend to be more severe, even though the rate is relatively low. To enhance safety, appropriate traffic control is emphasized. Slower speeds, lane closures, detours, use of flashing arrow boards, use of appropriate warning devices, layouts, sufficient lighting, and use of police patrol cars are found to be some of the more effective measures for better traffic control. In addition, public relations and information are found to be important elements in nighttime construction. Not only do announcements reduce the congestion and accident rate, but the public has a positive attitude toward the delays and noise. Supervision and communication are difficult for nighttime work because most offices are only open during the day. Similarly, supply and repair also create some problems because parts and materials are not easily available at night. Although most of these factors have some effect on nighttime work, work-zone lighting has a considerable influence. It not only affects quality and productivity, but also influences traffic control, safety, and human factors.

Cost, productivity, and quality are the basic project attributes and are affected by the way work is performed. There have been various opinions with regard to variations in these factors as a result of a change in the work shift. According to some, construction costs and total project costs are normally expected to be higher for nighttime construction than for daytime construction. The reasons are attributed to overtime pay, shift differential, lighting, higher bids, and the like. However, user and public costs may follow a reverse trend. Similarly, nighttime work may have negative effects on quality and productivity.

CONSTRUCTION COST COMPONENTS

Similar to most decision-making processes, selection of a night shift over a day shift or vice versa is influenced by economics. The literature review indicated a lack of cost information for an effective comparison between daytime and nighttime construction. In highway construction, the attributable costs can be categorized into four types of costs (a) construction or owner costs, (b) user costs, (c) accident costs, and (d) maintenance costs. Construction costs are usually the estimated project costs, whereas user costs are incurred by traveling motorists as a result of ongoing construction. Accident costs are difficult to obtain and quantify. Pavement maintenance costs refer to postconstruction costs, which depend on quality control during the work. In absence of sufficient data, this discussion is confined to construction and user costs.

Construction or Owner Costs

Construction or owner costs are essentially the costs borne by the state highway agency as a result of the construction of a facility. This includes the costs of the contract (labor, material, equipment, and contractor) and agency costs (planning, evaluating, and monitoring). Construction costs can vary from shift to shift. Additional construction costs that can be attributed to nighttime work include lighting, additional traffic control, inspection, labor premiums, overtime pay, and increased material costs.

Material costs may be higher during a night shift because batch plants may charge higher rates. According to a study in Denver on two similar overlay projects, the price for hot bituminous pavement (patching) (haul and asphalt) per ton was found to be 23 percent higher than that of the day project. The price for emulsified asphalt (CSS-1H) per gallon was 42 percent higher (*2*). A cost comparison done by a resident engineer of FDOT indicates a 2 to 3 percent increase in material costs for asphalt roadway work during the night (*5*).

Labor and inspection costs are additional cost items for night construction. Shift premiums accounted for an increase of 18 percent in direct labor costs, and overtime costs for agency personnel required an additional 16 percent (*4*). One

Florida contractor agreed to pay $0.50 per hr extra for all personnel involved in nighttime operations (*5*).

Lighting is a significant factor in the differential cost between daytime and nighttime construction. Because the cost of artificial lighting is unique to nighttime work, it may be regarded as a project-specific cost. For nighttime construction, there is an added cost for traffic control because of the need for additional signs in a low-visibility environment. Additional signs for night-shift work may include changeable message signs, arrow boards, warning signs, and channelizing devices. An analysis of paving projects in Colorado mentions that the cost of flagging per hour was 71 percent higher for the I-70 nighttime paving project (*2*).

User Costs

The cost incurred by traveling motorists due to on-going construction and maintenance work on the roadway is classified as user costs. This category mainly includes vehicle operating costs, personal costs, and accident costs. Operating costs and time value are determined using tables to obtain unit user costs. Nighttime construction greatly reduces user costs related to vehicle delays. In an attempt to measure a reduction in user costs on a nighttime project in Colorado, Price found that the cost was reduced from $119,110 for daytime work to $10,100 for nighttime work (*2*). The total savings to public in the same study for one project was estimated to be more than $1 million. However, accident costs are difficult to estimate.

In the following section an attempt has been made to compare construction cost differentials for daytime and nighttime projects in Florida. For cost evaluation, two comparisons are made: (a) variations in individual item unit costs and (b) variations in total program costs for daytime and nighttime projects.

EVALUATION OF FDOT NIGHTTIME CONSTRUCTION COSTS

Research Methodology

Most highway projects are unique and usually consist of different sets of work items, which makes it difficult to compare the construction costs of nighttime and daytime jobs by directly comparing daytime and nighttime projects. To overcome this problem, a set of typical work items has been selected for this study. These work items were chosen on the basis of (a) their presence in typical day- and night-shift highway projects, (b) their significant contribution to project costs, and (c) their large quantities. A list of these work items follows:

- Removal of existing pavement (110–4),
- Regular excavation (120–1),
- Bituminous material—prime coat (300–1–1),
- Bituminous material—tack coat (300–1–3),
- Milling of existing asphalt pavement—2-in. average depth (327–70–5),
- Class I concrete—miscellaneous (400–1–15),
- Type S asphalt concrete—including bitumen (5331–2), and
- Asphalt concrete friction course—including bitumen (5337–1–2).

Rates for these work items were obtained for all projects conducted by FDOT in 1990. The statistics of these rates for work items performed during daytime are presented in Table 1. Similarly, statistics of rates for eight selected work items for nighttime jobs were also obtained. Standard deviations for nighttime unit prices were found to be extremely high. These high deviations may be attributed to the small sample of nighttime projects considered for the study and other project-specific conditions. It was speculated that unit price of an item was influenced by its quantity and its share in the total project cost. A correlation analysis performed between quantity and unit prices of items also indicated a certain trend. Bid prices for items having large quantities were relatively lower than those having small quantities. To overcome this effect, weighted unit prices were used for nighttime projects instead of the actual mean of unit prices. The weighted unit prices were obtained by dividing actual item costs for nighttime projects by their respective quantities. The actual mean of unit prices was used for daytime projects because of the large sample size.

To determine the variation in means, an item-by-item comparison of rates was performed; results are presented in Table 1. Columns 5 and 8 present the means for nighttime and daytime jobs, respectively. The differences in the means are provided in Column 9, where negative numbers indicate lower nighttime costs. The differences between daytime and nighttime unit prices were found to be negative for nearly all the items.

To quantify the difference of nighttime and daytime unit prices and to demonstrate the effect on the total program costs, further evaluation was conducted. Results of the comparison are presented in Table 2. Column 3 gives the total quantities of items for selected nighttime projects. Column 5 shows the actual nighttime costs for respective items, and Column 7 shows the projected costs if the projects were done during the daytime. Columns 8 and 9 indicate the savings in cost and percentage of daytime costs as a result of eight selected items. Except concrete, all items have a lower nighttime cost; the average percent saving in cost is found to be 36.1 percent.

Results

An analysis of the information presented in Tables 1 and 2 reveals that the variations in unit costs for the eight selected items are very high. Standard deviation in most of the cases is nearly 100 percent of the mean, which shows that unit costs are highly project oriented and depend more on project-related conditions than on type of shift.

The comparison of the two unit prices in Column 9 of Table 1 shows that seven of the eight items have a greater daytime mean unit cost and that the miscellaneous concrete has a greater nighttime mean unit cost. This shows a certain trend in the unit costs. Unit prices are generally lower for nighttime work than for daytime work. The higher concrete unit price may be attributed to the work-item characteristics. It may involve activities that are more expensive to do at night.

TABLE 1 Summary of Rates for Selected Work Items for FDOT Projects in 1990

Pay Item Number (1)	Name of Item (2)	Unit (3)	Daytime Projects: No. of Projects (4)	Daytime Projects: Mean ($/unit) (5)	Daytime Projects: Std. Dev. ($/unit) (6)	Nighttime Projects: No. of Projects (7)	Nighttime Projects: Weighted Mean ($/unit) (8)	Diff. ($/unit) (9)
110-4	Rem exist. pavement	sq.m	104	12.58	13.14	21	8.92	-3.66
120-1	Regular excavation	cu.m	151	9.68	10.08	19	3.90	-5.78
300-1-1	Bit mat'l-prime coat	L	55	0.61	0.45	11	0.33	-0.28
300-1-3	Bit mat'l-tack coat	L	190	0.36	0.36	25	0.22	-0.14
327-70-5	Milling exist. asphalt pavement	sq.m	23	0.81	0.31	18	0.71	-0.1
400-1-15	Class I conc.-misc.	cu.m	70	455.4	306.4	17	514.3	58.9
5331-2	Type S asph. conc.	Mg	188	50.58	37.64	22	29.96	-20.62
5337-1-2	Asph. conc. friction	sq.m	102	1.51	0.98	24	1.31	-0.2

NOTE : 1 square yard = 0.836 sq.m 1 cubic yard = 0.765 cu.m
1 gallon = 3.785 litres (L) 1 ton = 0.907 Megagrams (Mg)

From the comparison of the total costs of eight items for selected projects in Table 2, nighttime costs are observed to be less than the corresponding daytime costs. On all selected FDOT nighttime projects for the eight typical highway pavement construction items, the difference in night and day costs is negative. Percentage difference for projects ranges from -12.09 percent to -59.73 percent, with an average of -36.1 percent, which indicates that nighttime costs are generally lower than daytime costs for FDOT projects.

However, it may argued that a comparison of eight items is inadequate to conclude a definite lower nighttime project cost, and the large quantities of these items and their contribution to program cost also cannot be ignored. Although the contribution of these item costs to the total contract cost varies, the trend gives an indication of the probable lower nighttime cost.

EVALUATION OF FDOT NIGHT CONSTRUCTION PRODUCTIVITY

Factors Relating to Productivity

The unique aspects of night construction can have both negative and positive effect on productivity. Productivity during

TABLE 2 Comparison of Nighttime (Actual) Versus Daytime (Average) Construction Costs for Selected Pay Items for All FDOT Nighttime Projects

Pay Item (1)	Unit (2)	Total Quantity (unit) (3)	Actual Nighttime Costs: Weighted Price ($/Unit) (4)	Actual Nighttime Costs: Cost ($) (5)	Projected Daytime Cost: Mean Price ($/Unit) (6)	Projected Daytime Cost: Cost ($) (7)	Difference of Night and Day Costs ($) (8)	Percentage Difference of Day Cost (%) (9)
Rem existing pavement	sq.m.	24,648.20	8.92	219,745.0	12.58	310,074.34	-90,329.3	-29.13
Regular excavation	cu.m.	194,544.86	3.90	759,092.4	9.69	1,885,139.63	-1,126,047.3	-59.73
Bit. material-prime coat	L	57,846.30	0.33	19,247.0	0.61	35,286.25	-16,039.3	-45.45
Bit. material-tack coat	L	1,706,199.13	0.22	377,451.3	0.36	614,231.69	-236,780.4	-38.55
Milling existing asphalt pavement	sq.m.	1,128,398.75	0.71	803,537.4	0.81	914,003.0	-110,465.6	-12.09
Class I concrete misc.	cu.m.	172.51	514.3	88,733.0	455.4	78,565.61	10,167.4	12.94
Type S asphalt concrete	mg	316,465.25	29.96	9,483,435.0	50.58	16,006,813.0	-6,523,378.0	-40.75
Asphalt concrete friction	sq.m.	2,636,828.75	1.31	3,465,001.7	1.51	3,981,611.5	-516,609.7	-12.97
Total						23,825,726.0	-8,609,482	-36.1

a night shift is affected by several factors, including traffic volume, type of work, material delivery, lighting, supervision, communication, and workers' morale. Traffic volume has a negative impact on productivity. Artificial lighting required for construction operations at night varies with the type of job and has the potential to affect the output of the construction crew. In addition to lighting, certain human factors also govern the productivity of crew members at night. During typical daytime construction operations in Florida, two peak traffic loads actually reduce a work day to a 5½-hr work shift. At night, the work shift and actual daily working hours are extended (*5*). The availability and supply of materials and spare parts for equipment also affect productivity at night. Different agencies have different experiences with productivity. Although the hourly production rate at night for the same duration may not be higher than that during the daytime, the effective total productivity may be high as a result of total road closure and less interference. Sometimes as much as 50 percent of the project duration can be saved. In Florida, however, it was found that because of setup and takedown time, productivity is 28 to 30 percent less than normal (*6*). In this study, the productivity of two construction operations on different projects in Florida were compared and analyzed.

Research Methodology

To test the daytime and nighttime productivity rates of typical construction operations for highway facilities, relevant information was obtained from various sources. Daytime production rates were collected from another study done by the University of Florida for FDOT (*7*). The information includes (a) number of observations, (b) mean, (c) standard deviation, and (d) high and low production rates for each operation, which are categorized by type of project, local conditions, and traffic conditions. A summary of this data is presented in Table 3.

Nighttime production data were obtained for a construction project from the daily reports of FDOT. The project was in progress on I-95 in St. Johns County, Florida, at the time of the study. A summary of the information is presented in Table 4. Data were collected for two work items: plant-mixed surface and milling of existing pavement. Columns 3 and 4 in Table 4 provide mean and standard deviations of production rates for respective work items as observed during the night project.

To compare the two production rates for nighttime and daytime construction, hypothesis tests were performed. For

TABLE 3 Summary of Production Rates for FDOT Construction Projects

Category (1)	Number of Samples (2)	Mean (3)	Standard Deviation (4)	High (5)	Low (6)
a) Plant Mixed Surfaces: Structural Course (Mg/day)					
Project Type					
Reconstruction	147	755.5	483.4	2139.6	5.4
Construction	27	565	579.6	2596.7	103.4
Intersection	15	110.6	100.6	322.9	9.1
Bridge	9	161.4	63.5	248.5	76.2
Local Conditions					
Rural	111	775.5	558.7	2596.7	5.4
Urban	72	395.4	351.0	1485.6	15.4
Limited	15	988.6	142.4	1131.0	527.8
Traffic Conditions					
Light	20	1078.4	690.2	2139.6	107.9
Medium	81	745.5	509.7	2596.7	12.7
Heavy	97	488.8	386.4	12.7	5.4
Total Combined	198	653.0	512.4	2596.7	5.4
b) Milling Existing Pavement (sq.m/day)					
Project Type					
Reconstruction	94	10,325	6,211	26,775	371.2
Construction	1	1,901	0	1,901	1,901
Intersection	0	0	0	0	0
Bridge	0	0	0	0	0
Local Conditions					
Rural	48	12,415	6,778	26,775	371.2
Urban	32	7,513	4,052	17,166	1,965
Limited	15	9,074	5,655	22,089	3,204
Traffic Conditions					
Light	14	16,976	6,821	26,775	4,588
Medium	32	10,147	6,420	24,558	371.2
Heavy	49	8,369	4,330	22,089	1,901
Total Combined	95	10,236	6,237	26,775	371.2

TABLE 4 Summary of Production Rates for FDOT Nighttime Construction Projects

Project Number (1)	Number of Samples (2)	Mean (3)	Standard Deviation (4)	High (5)	Low (6)
a) Plant Mixed Surface: Structural Course (Mg/day)					
78080-3420	14	862.3	316.1	1,295.3	291.0
78080-3421	32	1,007.1	296.6	1,453.6	296.7
78080-3422	29	991.8	383.6	1,697.2	178.3
78080-3424	20	946.4	344.1	1,492.0	295.6
Total Combined	95	968.3	343.4	1,697.2	178.3
b) Milling Existing Pavement (sq.m/day)					
78080-3420	7	9,402	4,667.2	14,078.2	2,312.4
78080-3421	10	6,169.2	887.7	7,590.8	4,458.4
78080-3424	12	6,902.4	2,472.2	11,590.3	3486.1
Total Combined	29	7,252.9	3,103.1	14,078.2	2,312.4

nighttime productivity values, the combined results of all the projects in Table 4 are used. Because all night-shift projects considered are on I-95, for daytime productivity values only, limited access facility observations from Table 3 are used. The two rates are compared with the guidelines provided by FDOT for activity duration. These guidelines are the result of analysis of actual production rates achieved on FDOT projects. The guidelines for the two items are as follows:

- Milling of existing pavement: 5,016 m^2 (6,000 yd^2) per day;
- Plant-mixed surface: 453 Mg (500 tons) per day for average jobs (less than 50,000 tons) and up to 1,088 Mg (1,200 tons per day) for large jobs (more than 50,000 tons).

Results

Statistical analysis of the available data was done by performing *t*-tests on independent samples. Although for plant-mixed surface the mean production rate for nighttime projects [968.3 Mg/day (1,067.6 tons/day)] appears to be less than that for daytime limited access projects [988.6 Mg/day (1,090 tons/day)], the test does not confirm a difference between the production rate of plant-mixed surface for daytime and nighttime jobs at a 95 percent significance level. However, if compared with the total combined production rate [653 Mg/day (720 tons/day)] in Table 3, the nighttime production rate is considerably higher. From the guidelines for estimating production rates, daily production of plant-mixed surface is given as 453 Mg/day (500 tons/day) to 1,088 Mg/day (1,200 tons/day) for average and large quantity jobs, respectively. Because all the projects considered for analysis are large quantity jobs on Interstates, the range given is in agreement with the obtained daytime and nighttime production rates of 988.6 Mg/day (1,090 tons/day) and 968.3 Mg/day (1,068 tons/day), respectively.

For milling of existing pavement, the test does not confirm a difference between day and nighttime production rates, although the mean daytime rate is higher than the mean nighttime rate. However, because of the small sample size and high variation for daytime jobs, no definite conclusion may be drawn at a 95 percent significance level. However, both the obtained daytime production of 9,074 m^2/day (10,854 yd^2/day) and nighttime production of 7,253 m^2/day (8,675.7 yd^2/day) are higher than the rate of 5,016 m^2/day (6,000 yd^2/day) suggested in the guidelines.

Analysis and subsequent study indicate that nighttime work does not significantly affect productivity. Project-by-project variations are attributable to several factors, including (a) longer working hours, (b) less traffic interference, (c) total road closure, (d) inadequate lighting, (e) workers' morale, and (f) equipment breakdown and repair. However, productivity does not appear to be a major deciding criterion in the determination of whether to perform work at night.

SUMMARY AND CONCLUSIONS

Unit costs of items are found to be highly dependent on project-specific conditions and not type of shift. Because variations in the nighttime unit prices were high, and there was a significant correlation observed between quantities and unit prices, weighted unit prices were used for comparison.

From the comparison, nighttime weighted means were found to be less for all the items except miscellaneous concrete, which may be attributed to work-item characteristics. To obtain an idea of variation in project costs, total cost comparisons were made for eight items in eight selected projects. Nighttime costs were found to be less than daytime project

costs, which is contrary to popular belief. From these findings it can be suggested that nighttime construction costs are less than daytime construction costs for FDOT projects. However, more nighttime data may help to derive conclusions with greater confidence. On the other hand, if user costs and cost savings to the public are also considered in total project cost, nighttime construction may be even more economical.

According to Price (*2*) the average per item costs were 40 percent higher and total costs were 159 percent higher. From the study discussed here, it was concluded that the cost differential is not significant. The reason for such a change may be that as nighttime work becomes more common and routine, and as the contractor becomes more familiar with various aspects of nighttime construction, the risk factor for new work decreases. As a result, bid prices for nighttime work go down and item unit costs do not vary with shift time.

Similarly, for the productivity of the two items, the *t*-tests failed to confirm any significant difference between daytime and nighttime productivity. Here it may be noted that daily output, which affects the total project duration, is different from hourly productivity. Various project-related factors, such as (a) longer working hours, (b) less traffic interference, (c) total road closure, (d) adequate lighting conditions, (e) higher workers' morale, and (f) reduced equipment breakdown, repair, and the like, may lead to higher daily output on a nighttime project, consequently reducing the total project duration. However, as far as hourly item productivity is concerned no appreciable difference was found between nighttime and daytime operations.

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