SHRP 2 Renewal Project R03

Fatigue Risk Management Guide for Rapid Renewal Highway Construction Projects

PREPUBLICATION DRAFT • NOT EDITED

SHRP 2
STRATEGIC HIGHWAY RESEARCH PROGRAM
Accelerating solutions for highway safety, renewal, reliability, and capacity

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

ACKNOWLEDGMENT
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Project No. R03

Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments

Fatigue Risk Management Guide for Rapid Renewal Highway Construction Projects

Prepared for
The Second Strategic Highway Research Program
Transportation Research Board
of
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January 2013

ACKNOWLEDGMENT OF SPONSORSHIP

This work was sponsored by Federal Highway Administration and it was conducted in the Second Strategic Highway Research Program, which is administered by the Transportation Research Board of the National Academies.

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LIST OF ACRONYMS

DOT ..... Department of Transportation
SHRP 2 ..... Second Strategic Highway Research Program
SMS ..... Safety Management System
FRMS ..... Fatigue Risk Management System
PLA ..... Project Labor Agreement
REM ..... Rapid Eye Movement

ACKNOWLEDGEMENTS

This work was sponsored by the Federal Highway Administration. It was conducted in the second Strategic Highway Research Program (SHRP 2), which is administered by the Transportation Research Board of the National Academies. This project was managed by Jerry DiMaggio, Mark Bush, and James Bryant, Program Officers for SHRP 2.

The research reported on herein was performed by Battelle, supported by EBL Consulting, Washington State University, The Minor Group, and Anderson Consulting. Thomas Sanquist, Battelle, was the Principal Investigator. The other authors of this report are Elizabeth Jackson, John L. Campbell, and Marvin McCallum, Battelle; E.B. Lee, EBL Consulting; and Hans Van Dongen and Peter McCauley, Washington State University. The authors acknowledge the contributions to this research from Glenna Redmond-Wolf, Jean Busto, and Diane Williams, Battelle; Melinda Jackson, Washington State University; and Hollis Minor, The Minor Group, and Stuart Anderson, Anderson Consulting.

CHAPTER 1 INTRODUCTION

BACKGROUND

As America's highway infrastructure continues to age and congestion becomes an increasing concern, roadways must be renewed quickly, with minimal disruption to the community. Performing the complex, dynamic and fast paced work of street, road and highway rapid renewal construction is dangerous work. On any construction site, the risk of potential injury or death is higher than for most other occupational groups. Construction workers are three times more likely than average to have an injury that requires time away from work. For those working extended shifts, night and evening shifts, and weekly overtime, the possibility of occupational injury is greater yet.

Rapid renewal practices include conducting work during off-peak hours, continuous weekend construction, extended night-time operations, and conducting work in zones adjacent to traffic. While these strategies improve schedule performance, the associated conditions increase worker fatigue and stress, resulting in reduced levels of workforce safety and construction productivity. Shift workers are particularly prone to fatigue-related injuries if they work night shift, extended shifts (10 or more hours), or longer than 40-hour work weeks. Rapid renewal highway construction will increase over the next 10 year period, engaging 25,000 – 29,000 workers and managers in this work with increased risk for fatigue.

A variety of common construction scheduling approaches increase the risk for fatigue, including:

- Extended workday – 8+ hours
- 48 – 55 hour workweeks
- Double shifts
- Change shift to night work in middle of week
- Night work
- Long-term night shifts
- Weekend work
- Extended weekend work – 33 hours to 55 hour closures
- Operations in close proximity to traffic

It is clear that the steps necessary to prevent and manage fatigue vary from one workplace to the next, depending on the nature of the work, environmental conditions and individual factors. That is, no single measure or intervention is likely to solve the problem. Therefore, the best way to minimize worker fatigue in operational settings is to follow an integrated risk management approach. A combination of work schedule management, training and education, schedule risk assessment, healthy sleep, and fatigue countermeasures has been proven in other industries to lead to a fundamental change in culture and philosophy regarding fatigue, both at the worker and management level.

The Second Strategic Highway Research Program (SHPR 2) Project developed fatigue risk management strategies and tools designed for all levels of rapid renewal highway construction

organization, including employees, field supervision and project management personnel, to understand, manage and reduce workforce fatigue risks to worker safety and construction productivity. This work was carried out in the SHRP2 R03 project, entitled *Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments*, and a separate technical report has been produced describing the methods and findings of that work.

MAIN STRATEGIES IDENTIFIED FOR SUCCESSFUL FATIGUE MANAGEMENT

- Build awareness of risk factors and motivation to mitigate, directed at the industry sector level, within state Departments of Transportation (DOTs), and with individual contractors
- Assess risk factors for specific project operations that address a broad range of scenarios for worker scheduling
- Train workers and managers to ensure an understanding of the nature of sleep loss, circadian rhythm, fatigue and related performance impacts, as well as key elements of both preventive and operational approaches to reducing fatigue
- Establish methods of monitoring and assessing risk factors and countermeasures to determine what is working well
- Provide fatigue-proofing strategies for specific operations to reduce the likelihood that a fatigue-related error will cause an accident or injury

This guide includes specific sections that will allow users to develop and implement fatigue risk management. The guide consists of four sections, as follows:

1. **Organizational Practices Guidance –** selected organizational practices that influence the adoption and successful implementation of fatigue risk management, including:
    - Assessing the corporate approach to fatigue risk management
    - Building fatigue management into the operation
    - Dispelling erroneous beliefs about fatigue
    - Analyzing fatigue risk trajectories
    - Assessing specific schedule risks
    - Formalizing the risk assessment process
    - Implementing fatigue countermeasures
    - Reporting, investigation and evaluation

2. **Technical Reference Materials –** an archival set of materials for more detailed reference by end user organizations and individuals, consisting of the following:
    - *Sleep Basics* **–** reference material concerning the biological mechanisms underlying sleep and fatigue.
    - *Individual Countermeasures* – these fall into two main groups: those applied in the field and focused on alleviating the effects of fatigue, and those applied proactively, either as part of a regular sleep maintenance plan or whenever unusually fatiguing schedules are anticipated.
    - *Organizational Countermeasures* – fatigue-proofing practices (reducing the likelihood that a fatigue-related error will cause an accident or injury) applied at the organizational

level consisting of strategies and techniques that include elements of scheduling, fatigue training, and tools for identifying and evaluating fatigue-related performance impacts.

3. **Fatigue Training Material –** comprehensive training about fatigue for the rapid renewal environment that addresses the specific risk factors and operational constraints of the work domain to assist in the implementation of comprehensive fatigue risk management guidelines. It consists of a core module of fundamental material for fatigue training for workers, managers and DOT employees, as well as an enhanced module for superintendents and safety managers providing more detail on prior sleep/wake modeling of rapid renewal schedules.

4. **Work Scheduling Aids and Guidance –** a set of guides that can be used for rapid renewal project planning and fatigue risk assessment and mitigation across a range of scenario types and workforce segments.

Users of this guide should consult the specific sections on an as-needed basis, depending on the state of fatigue management within their organization.

Further detail on content presented in this guide can be found in the companion technical report for the R03 project.

CHAPTER 2 ORGANIZATIONAL PRACTICES GUIDANCE

In this section we describe adaptations of organizational practices for fatigue risk management that are more appropriate for an industry with considerable operational diversity, such as highway construction, with a focus on *monitoring and mitigation*. The approaches described in this section are meant to be flexible and adaptive, so that they can apply to a broad range of organizational size and complexity.

Figure 2-1 illustrates the elements of organizational practice to address and implement fatigue risk management in highway construction firms (i.e., contractors). These practices would also be applicable to state employees if they are not already covered by work hour limitations in labor agreements. The upper part of the figure lists general *processes* for fatigue risk management, and the bottom part of the figure lists specific *implementation* means to institutionalize those processes. The following sections discuss each of these process and implementation steps.

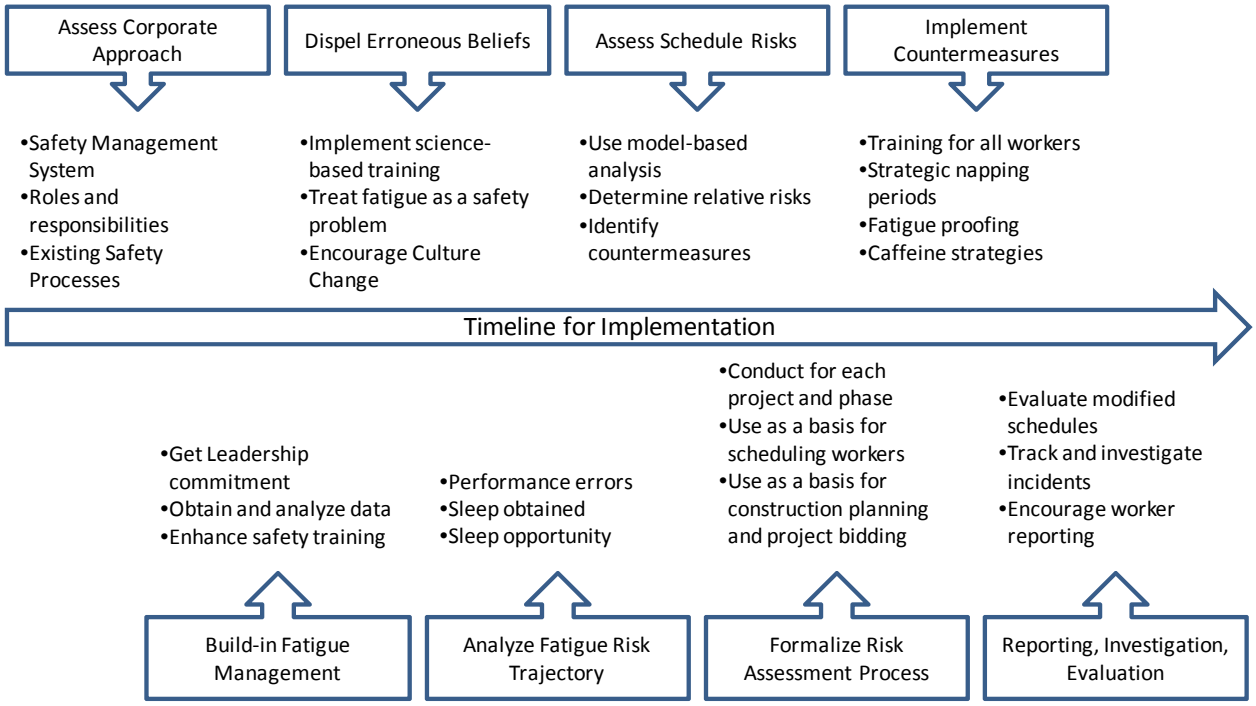


Figure 2-1. Organizational practices for implementing fatigue risk management in highway construction firms.

ASSESS CORPORATE APPROACH

The first process step in addressing fatigue risk management in highway construction is identifying the current corporate approach. The most fundamental question is whether an approach to fatigue management *exists*. Most of the time fatigue issues, if they are addressed at all, revolve around proper hydration and physical rest breaks in extremely hot weather, leaving fatigue from sleep loss and circadian rhythm misalignment (night work) unaddressed.

An enabling process for fatigue risk management is a corporate Safety Management System (SMS). It is likely that national-level construction firms have such systems in place, whereas smaller and regionalized firms may have more informal approaches. In either case, it is important to assess the extent to which fatigue risk management is or is not addressed. If an SMS exists, it can be reviewed for any mention of fatigue risks and mitigations, and for appropriate places in which management processes might be inserted to address the problem. Existing safety processes that may be adapted and extended to the worker fatigue problem include incident investigation and reporting and worker input procedures.

While safety tends to be viewed as a shared responsibility between management and staff in organizations, there are certain roles and responsibilities in construction firms that will likely have a closer connection with worker fatigue than others. These staff roles would most likely be superintendents, construction engineering planners and labor crew supervisors. Planners have a key role in establishing specific construction tasks to be carried out, and this interacts with *when* they would be carried out, e.g., the potential need for closures and night work. Superintendents tend to be aware of the pace and intensity of work and the likely productivity and safety impacts on workers. Crew supervisors would have a similar and more immediate understanding of fatigue issues on specific crew members.

BUILD-IN FATIGUE MANAGEMENT

Assessment of the basic corporate approach to safety should lead to a concrete implementation step of building fatigue management into the overall process. The initial requirement for this step is management concurrence—as in virtually all corporate initiatives, leadership commitment is essential, not only for approving whatever resources may be necessary (and this may be a relatively small amount of personnel time in most cases), but also for reinforcing messages and business practices. Changes in scheduling need to be considered in terms of impact on overall performance, so fatigue mitigation is an appropriate issue for executive consideration.

Specific methods for incorporating fatigue management in the corporate safety approach include obtaining and analyzing data, and enhancing safety training. In terms of data, information that reflects on the extent to which fatigue may be a problem is important. This may be as simple as repeated verbal reports from personnel concerning scheduling issues, or more detailed data reflecting productivity or safety incidents on different shifts. There will be wide variation across organizations in the nature of the data, and how they are obtained and analyzed, depending on the size and complexity of the contracting firm.

Safety training is one of the first lines of defense in fatigue management. While there are different models for training, such as new employee orientation and safety training, project-specific training, and daily crew briefings, each of these provides an opportunity to incorporate information about fatigue management. Chapter 4 of this report contains an extensive compilation of training materials appropriate for both workers and management which can be adapted to specific organizational approaches.

DISPEL ERRONEOUS BELIEFS

There are a number of inaccurate attitudes and beliefs held by a considerable percentage of workers, and a lower percentage of management, concerning fatigue and how to deal with it. These beliefs tend to transform into “myths” over time, influencing how people think and communicate about fatigue, regardless of accuracy. Some of these inaccurate beliefs include:

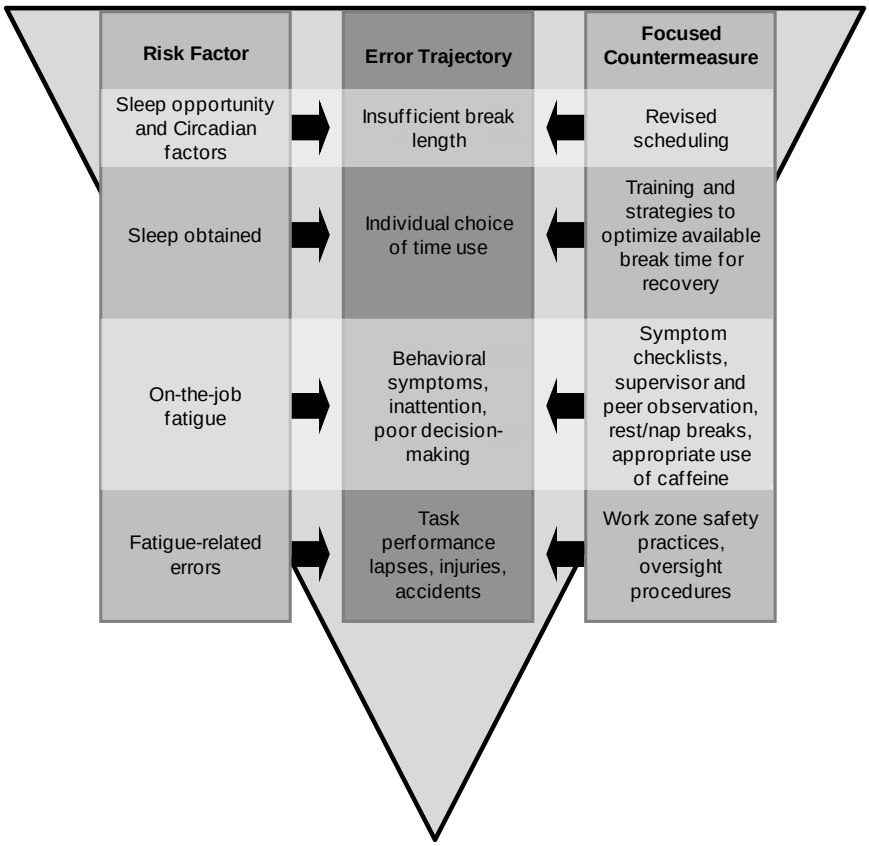
- Fatigue is something to muscle through
- Fatigue management is a personal responsibility
- Fatigue is inevitable
- Napping is not okay in the work place
- Everyone has enough time off for recovery

To the extent that beliefs such as these prevail and are perpetuated as myths through various elements of the workforce, fatigue will not be treated seriously. Thus, an important continuing process is to gradually dispel these beliefs and alter the cultural view of fatigue.

Science-based training can form the basis for addressing erroneous beliefs, through use of such material as provided in Chapters 3 and 4. Training can help to shift the conception of fatigue from that of “inevitable annoyance” to that of “safety problem,” and establish a basis for cultural change to seriously address it through fatigue risk management.

ANALYZE FATIGUE RISK TRAJECTORY

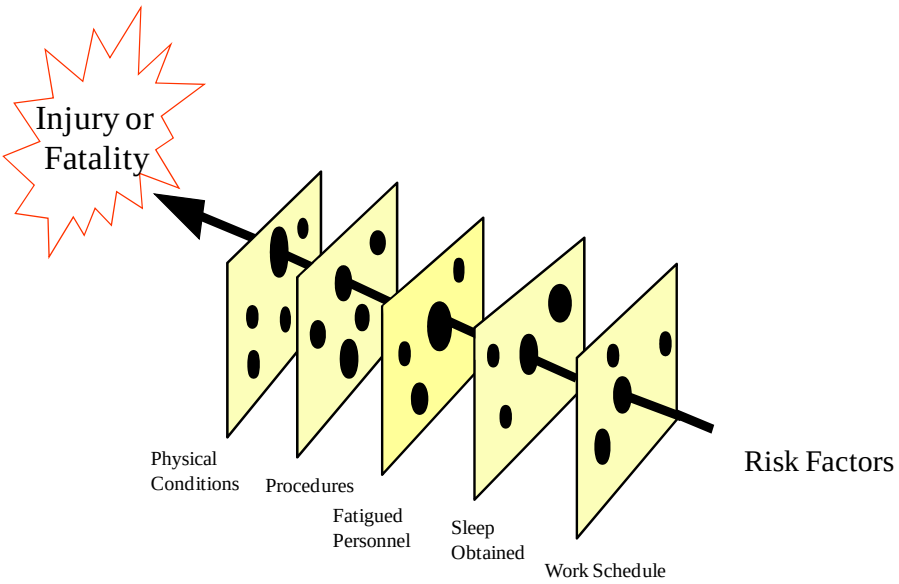
Implementing a process to dispel erroneous beliefs can be facilitated by using an analytic framework to clearly link safety issues in highway construction jobs with fatigue as a causal factor. The fatigue risk trajectory (Figure 2-2), provides a means for understanding the pathways to safety problems that can be used by safety managers for initial job/task and schedule analysis. The basic trajectory involves opportunities for sleep provided by work schedules, sleep obtained, on-the-job fatigue, and fatigue-related errors. Behavioral outcomes and countermeasures are associated with these risk factors that can be used as a basis for intervention.



Adapted from Dawson & McCulloch, 2005

Figure 2-2. Fatigue risk trajectory.

An illustration of how the fatigue risk trajectory can be used to analyze potential error-prone situations is shown in Figure 2-3. Errors occur when "holes" in the defensive layers align and prevailing circumstances enhance their likelihood. An example would be a maintenance-of-traffic worker scheduled on successive 12-hour night shifts, and getting less than 5 hours of sleep during each off period. That individual is fatigued cumulatively throughout the week, and may fail to implement traffic routing procedures correctly. Due to schedule pressures or unavailability of personnel to verify the placement of traffic routing diversions or conditions such as poor visibility or rain, this is not noticed and the result is vehicle incursion into the work zone with resulting injuries. Similar problems could occur with setting up construction equipment or rigging, putting multiple personnel at risk. Critical in this perspective on error causation is that multiple problems line up to cause an incident or accident, and fatigue is often one of those problems and therefore a risk factor to be managed and mitigated (Van Dongen & Hursh, 2010).



Adapted from Reason, 1990

Figure 2-3. Fatigue risk trajectory and multiple levels of defense.

ASSESS SCHEDULE RISKS

A systematic approach to risk assessment can utilize knowledge of how fatigue occurs over the course of work periods for staff on various schedules. This can be facilitated with a computer-based model, although for most construction firms some heuristics based on model outputs contained in the Work Scheduling Guidance (Chapter 5) will likely be sufficient. Models can be used to determine likely fatigue levels for workers, based on the schedules they are assigned to, and how long they have been on those schedules. This information can be used to evaluate the recovery opportunities provided by existing and planned worker scheduling. Construction planning for specific skills and crafts across the 24 hour period in different phases of projects will influence worker scheduling. Planners should evaluate the impact of construction scheduling requirements in terms of worker fatigue impacts, and try to ensure that work schedules dictated by construction requirements do not adversely affect individuals or groups of workers. The models can also show when commuting is likely to be a safety issue, such as the night shift, where driving home occurs at the peak fatigue level.

Fatigue profiles such as this are also useful for evaluating napping opportunities—where they might occur in the work shift, and the impact on fatigue levels. For example, if there is a desire to reduce peak fatigue prior to driving home after a night shift, fatigue profiles can be used to show the increase of fatigue throughout the night, and provide comparative profiles with and without naps. Similarly, use of earlier work stop times on shorter night shifts can be compared with later start times to show daily peak levels, and also accumulation throughout the week.

Finally, it is important to address the work hours of designers and managers, especially as they work night shifts following day shifts, or participate in long closures followed by a full week of day shift work.

FORMALIZE RISK ASSESSMENT PROCESS

Implementation of the risk assessment process should eventually be undertaken as a regular activity, starting with analysis of contract opportunities, and continuing through the bid, construction planning and execution of each project phase. Since rapid renewal projects often involve alteration of construction activities due to emergent circumstances, any schedule revisions should be reviewed as well. For example, scheduling of crew involves interaction between construction engineering and crew superintendents, and to the extent that superintendents see certain work crew affected by, say, too much night work, they should negotiate the execution of various construction tasks so that crews are provided with recovery opportunities. This may involve work breaks, naps at the work site during night shifts, re-scheduling certain tasks for day work if possible, increasing staffing, and generally providing relief from constant night work.

Fatigue risk assessment can also be used as a formal process for construction planning, as well as for determining schedule and fatigue impacts of projects in the bid evaluation stage. For example, if a request-for-proposal contains incentives for completion and/or a specific number of closures permitted, modeling could be used to determine the work schedules required, availability of crew for such schedules, and potentially whether the project warrants bidding. If schedule modeling were to show night work at a level that management considers unsustainable, alternative approaches might be proposed.

IMPLEMENT COUNTERMEASURES

Countermeasures for fatigue are an important component of an overall organizational approach. The primary countermeasure is education and awareness for all personnel, including management, to dispel the myths and erroneous beliefs about fatigue, and to instill an understanding of the biological basis of fatigue and the things that can be done about it.

A few key countermeasures have been found to be effective in a variety of industrial environments, including defensive napping prior to night work and napping at appropriate times during the work period (such as the lunch break), caffeine during periods of high fatigue or to reduce sleep inertia (the fatigued feeling upon waking) after mid-shift naps, rest breaks from the work flow, and using scheduling to try to accommodate individuals who have varying susceptibility to fatigue.

One potential approach to a work break is to consume a caffeinated beverage just before a 30 minute nap, and at the end of the nap the caffeine will be starting to take effect. If the caffeinated beverage is cold rather than hot, this may facilitate rapid consumption if time for the nap is limited. This approach will have the dual impact of reducing sleep inertia and reducing fatigue for the following several-hour period.

We suggest implementing countermeasures as a relatively continuous process, rather than a discrete implementation step. This is because conditions in rapid renewal projects are dynamic, and the specific approaches to implementation may vary with the schedule and season. For example, night work might be scheduled for a somewhat earlier start in the summer months, leading to a work stop time that allows workers to get home and into bed before it is completely

light outside. It has been reported that this facilitates getting to sleep faster and sleeping somewhat longer, and this is supported by circadian physiology.

Fatigue countermeasures involve not only mitigating fatigue through rest breaks, better sleep opportunities, etc., but also addressing the fact that fatiguing schedules cannot be entirely eliminated. Night work is a fact of life in rapid renewal highway construction. In addition to addressing fatigue reducing countermeasures, there are *fatigue-proofing* strategies for adding layers of defense against error. These include:

- Increased supervisory oversight
- Use of written procedures and checklists
- Self and peer-monitoring during critical periods
- Reducing monotonous or highly complex tasks during periods of high fatigue
- Extra personnel for critical/dangerous tasks
- Nap timing for best impact
- Interaction with peers to evaluate fatigue levels
- Self-selected rest breaks
- Transportation assistance following extended shifts
- Training for workers and managers in how to recognize fatigue

By continually evaluating schedules and conditions of work, safety managers can adapt both fatigue mitigating and fatigue proofing countermeasures to prevailing conditions.

REPORTING, INVESTIGATION, EVALUATION

The role of fatigue in construction safety problems is probably under-represented due to lack of reporting and investigation. A proactive management approach to fatigue should encourage workers to report problems, whether it is related to scheduling, specific tasks, or even other workers.

In order to better understand specific project fatigue problems, safety incidents should be investigated with the fatigue factor in mind, including whether night work was involved and individuals worked many successive night shifts without a break, whether a weekend closure was involved, and whether the individual workers were experiencing sleep restriction or sleep problems.

Commuting accidents, although technically not occurring during duty hours, can sometimes be related to fatigue from night work, and are especially likely during rush traffic in the morning.

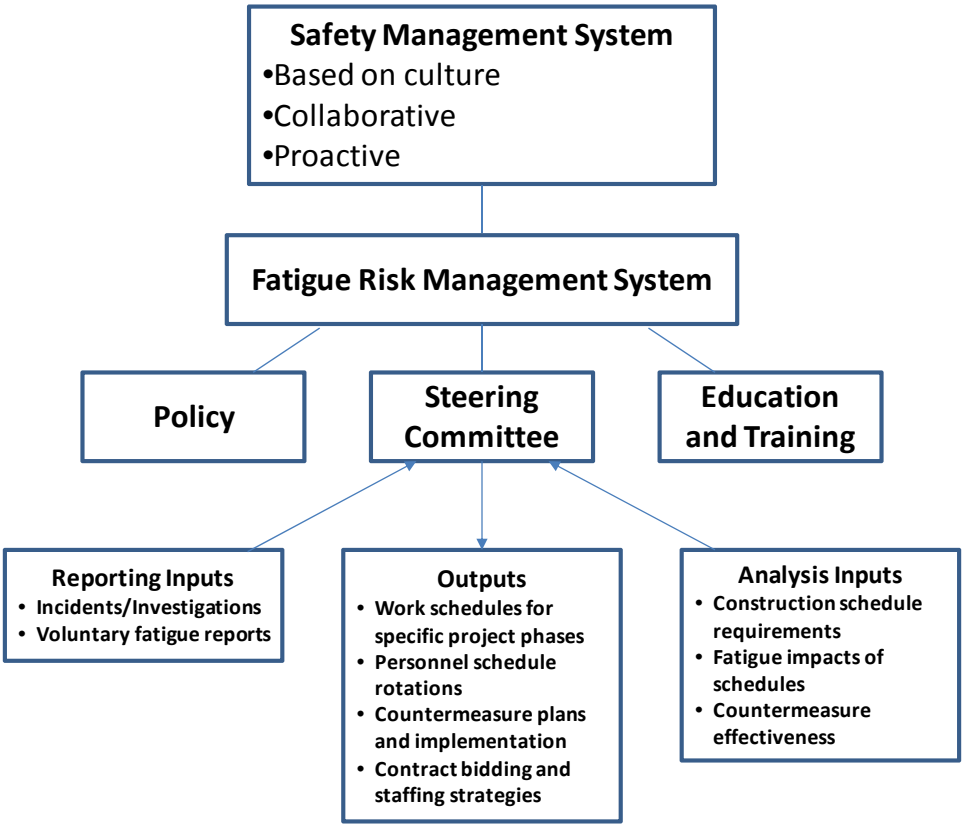
Information collected can be useful in modifying work schedules. A primary issue in implementing this step relates to the availability of data—what are the current procedures, if any, to document and investigate incidents and accidents? This will vary considerably across organizations based on their size and complexity. Trade and government organizations may play a role in providing standards and tools for structured data collection efforts.

The role of sleep disorders in contributing to workplace fatigue should not be ignored. Sleep disorders are associated with excessive daytime sleepiness and increased prevalence of motor

vehicle accidents and occupational injuries. The majority of shift workers have a sleep disorder, and some sleep disorders can be caused by shift work. Common sleep disorders include insomnia, restless leg syndrome and obstructive sleep apnea. Obstructive sleep apnea is particularly prevalent among men between the ages of 30 and 60, a risk that increases if they are overweight. Evaluation and treatment of sleep disorders has benefited the trucking industry.

SUMMARY OF ORGANIZATIONAL PRACTICES

Integration of the organizational practices described in this section is captured by the diagram shown in Figure 2-4. An overarching safety management system can be anything from informal processes conducted by an individual part-time safety officer in a small firm, to a more formalized structure with procedural mechanisms and formal reporting documentation and channels in larger organizations. The fundamental outputs of the organizational practices are the same: a deliberate and rational method for addressing and mitigating the impacts of fatigue on operational personnel.



Adapted from Gander et al., 2011

Figure 2-4. Integrated elements of Fatigue Risk Management System (FRMS).

CHAPTER 3 TECHNICAL REFERENCE MATERIAL

SLEEP BASICS[1]

How to Use This Section

The information here is organized as a set of individual topics that can be read sequentially or separately, depending on reader need. You will get the best understanding of how alertness and fatigue result from sleep and brain physiology if you read the sections sequentially, and then use the individual sections as reference material if you have questions later.

You can also copy or adapt the contents in each of these topics when developing educational materials to increase an understanding of the basics of sleep and alertness management for personnel in your organization.

Introduction

Everyone knows how it feels to get too little sleep. Many people refer to this feeling as "fatigue" or "sleepiness"—you are less alert, sometimes exhausted, tend to crave sleep, and may even nod off. The information in this section of the handbook talks about the basis for alertness, that is, getting adequate sleep. We also talk about the opposite situation— not getting adequate sleep, some of the reasons why this happens, and how it affects your level of fatigue and alertness.

Sleep is based on brain physiology and humans have specific requirements for getting adequate sleep. It is easier to sleep at certain times of our 24-hour day than others because of brain mechanisms that have evolved over millions of years. The basic information in this section will help you to understand why it is necessary to get adequate sleep, why we sometimes don't, when you might start feeling fatigued and how it affects you on the job, and what you can do to make sure you get adequate sleep.

Overview of Sleep Basics Topics

The following topics are discussed in the remainder of this section:

- Circadian Rhythms
- Sleep Cycles
- Fatigue, Alertness, and Sleep Loss
- Causes of Sleep Loss
- Getting Adequate Sleep – How to Do It

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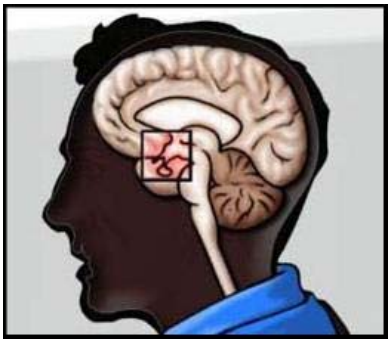
[1] The material in the section "Sleep Basics" was originally published in the Commercial Transportation Operator Fatigue Management Reference, US Department of Transportation Research and Special Programs Administration (McCallum, Sanquist, et al., 2003; *hfcc.dot.gov/ofm/docs/fmr07-03.doc*).

Circadian Rhythms

The term “circadian rhythm” refers to the daily fluctuations in physiological and psychological functions controlled by the brain’s biological clock. “Circadian” is a term from the Latin roots *circa* meaning “about” and *dies* meaning “day.” The normal human sleep-wake cycle is based largely on the circadian rhythm, as well as alertness throughout the day. The brain mechanism that controls the circadian rhythm is located in the suprachiasmatic nucleus of the hypothalamus (Figure 3-1).

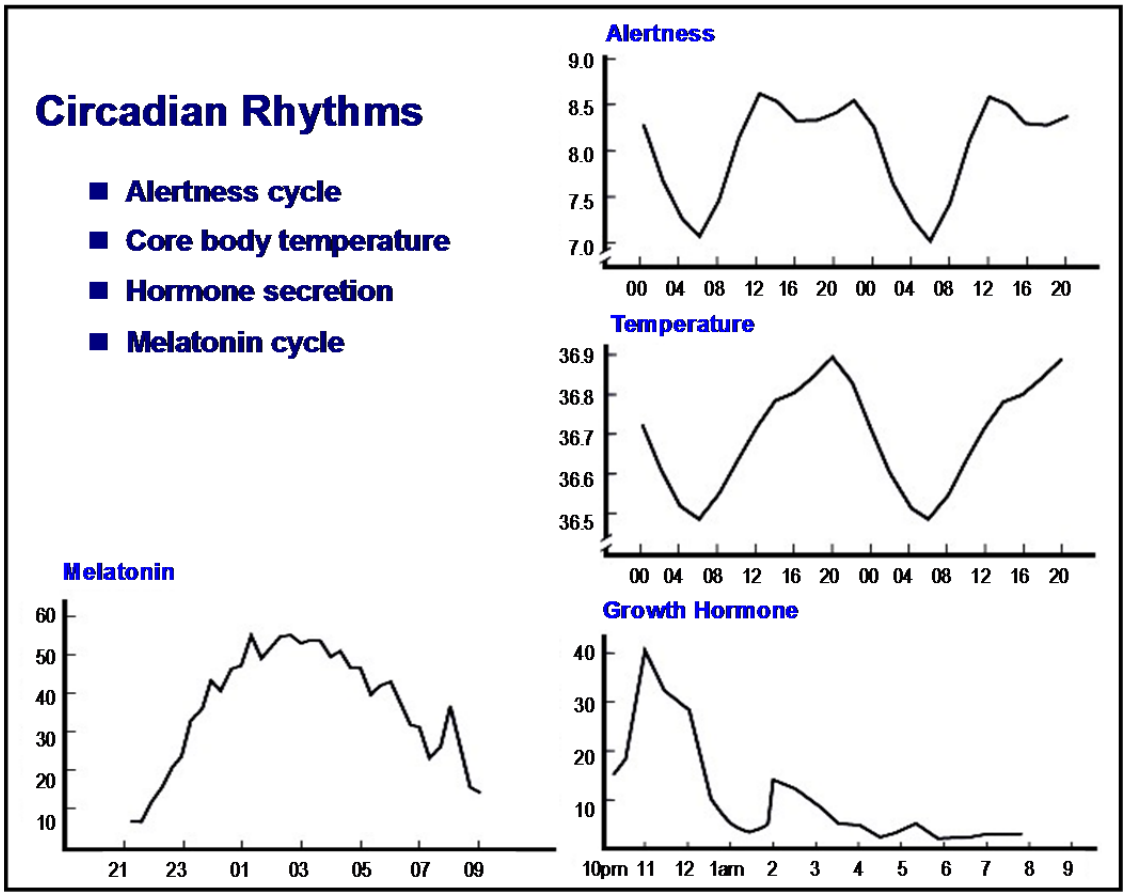
The brain’s biological clock serves as a pacemaker for numerous daily cycles, including sleeping and waking, hormone secretion, digestion, body temperature regulation, performance capabilities, and mood. The biological clock programs humans to operate on a 24-hour clock so that we are sleepy at night, and awake during the day; also, during daily waking, the circadian rhythm leads to predictable changes in alertness, such as the tendency to feel sleepy at some point during the afternoon (this is sometimes referred to as the “post-lunch dip,” although the alertness drop has little to do with whether you have eaten). Figure 3-2 illustrates the circadian rhythm in several physiological and psychological functions; it is noteworthy that when alertness is lowest, i.e., between 2400 and 0500 hours, melatonin levels are the highest—this is because secretion of melatonin by the brain leads to sleep onset. An individual’s circadian rhythm is sensitive to external time cues, such as the level of sunlight and patterns of activity in the environment.

Circadian rhythms are important to alertness management because they represent what the body was *designed* to do—sleep at night and be awake during the day. Work schedules that require people to be awake at night and asleep during the day are challenging primarily because of the circadian rhythm. The biological clock can adjust to different schedules or time changes, but this takes a certain amount of time, depending on how extreme the change is. Jet lag, for example, is a situation where the individual’s rhythm is different from that of the local environment. After a few days in the new time zone people adapt. It is much more difficult, however, for people to adapt to work schedules that are opposed to their circadian rhythm because the normal pattern of light and dark, and daily activities are the same—they do not change as they do with a time zone shift. Shift workers often switch from one activity-rest pattern to another, as on weekends, and their circadian rhythm becomes chronically misaligned with local time.



From McCallum, Sanquist, et al., 2003

Figure 3-1. Location of the brain’s biological clock that controls circadian rhythms.



Adapted from multiple sources in Kryger, Roth, & Dement (Eds.), 2000

Figure 3-2. Circadian rhythms for different physiological and psychological functions.

When the circadian rhythm is not completely adapted to a person's work-rest schedule, their on-the-job alertness is affected. This is because they are working when the brain is programmed to sleep, and they may not be getting adequate sleep during their off-work periods because of brain programming for wakefulness. This creates a chronic problem of sleep loss and low sleep quality, which further affects job performance and alertness.

Circadian Rhythms – Key Points

- The daily cycle of sleeping and waking is controlled by a biological clock in the brain.
- Circadian rhythms affect alertness during the day.
- The biological clock is sensitive to external time cues such as light and social activity.
- Humans are programmed to sleep at night and be active during the day.
- Shift work opposes the circadian rhythm, leading to problems of sleep loss and low alertness.
- The circadian rhythm can be changed but it is difficult in the presence of strong time cues.

Sleep Cycles

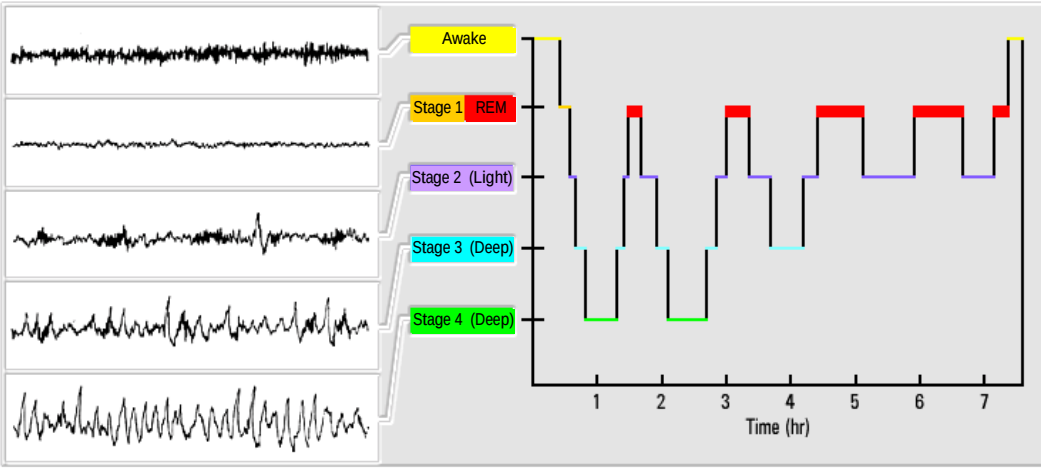
Sleep is a basic physiological need. Most people need about 8 hours of sleep per night, although some may need as little as six hours, while others may need 10 hours. On an individual basis, the amount of sleep a person requires is that amount necessary to achieve full alertness and effortless functioning during the waking hours, even when sitting quietly and being bored. When a person feels that they have to keep moving in order to stay alert, that is a strong sign of too little sleep.

Sleep is a physiological process that can be monitored by brain electrical activity. As a person relaxes from their waking state, brain electrical activity slows progressively, until the deepest level of sleep (Stage 4) occurs. Figure 3-3 illustrates the various stages of sleep, which progress through a cycle that repeats throughout the night.

As a person drifts off to sleep, they enter Stage 1. This is followed by a slowing of the heart rate and relaxing of muscle tension as Stage 2 is entered. In Stages 3 and 4, slow wave brain activity is associated with very deep and restorative levels of sleep. During these stages it is particularly difficult to wake the person. Rapid Eye Movement (REM) sleep occurs throughout the cycle and shows a brain activity pattern similar to Stage 1 or waking; this sleep stage is associated with dreaming.

Classification of Sleep

- **Awake**
- **Sleep**
  - **REM**
  - **Light**
  - **Deep**



Adapted from Carskadon, & Rechtschaffen, 2000

Figure 3-3. Brain electrical activity (on left) illustrates the stages of sleep (on right), which progress in a cyclic fashion through the sleep period.

When people take a nap during the work day for about an hour or more, they are likely to fall into the deeper stages of sleep (Stages 3 and 4) and when they awaken from such deeper sleep, they are likely to experience “sleep inertia,” which is grogginess that can last up to 15 or 20 minutes. To gain the benefits of a nap during the work day, and to avoid such sleep inertia, it is suggested

you take a nap for about 45 minutes or less, as this decreases the risk of falling into the deeper sleep stages and having the inertia upon awakening.

With respect to a person's principal sleep for a 24-hour period, it is important that the entire cyclic process of sleep be completed in order to receive the restful effects of a sleep period. Anything that interferes with sleep, such as noise disruptions, medication, alcohol, or simply insufficient duration, will change the physiological structure of the sleep cycles and impair alertness the next day.

Sleep is affected by aging. Although older people need as much sleep as younger people, they sleep less soundly and experience more awakenings during the night and shifts from one sleep stage to another. Medical conditions common in older folks make sleep disruptions more likely. A prime result of sleep disruptions is increased daytime sleepiness and more napping during the day—which paradoxically can affect the quantity and quality of night time sleep.

People also differ from one another in their preferred activity and sleep times. “Larks” tend to be “morning people,” arising early and getting to sleep early. “Owls” tend to stay up later at night and arise later in the morning. Owls tend to perform better on afternoon and evening shifts. People usually fall somewhere on a scale between being a total lark or total owl.

Sleep Cycles – Key Points

- Sleep is a basic physiological need.
- Sleep is a complex process consisting of multiple stages, some “deeper” and more restful than others.
- Rapid Eye Movement (REM) sleep occurs throughout the night and often involves dreaming.
- Upon awakening, people experience temporary grogginess called “sleep inertia” which usually disappears in 15 minutes.
- Anything that interferes with the duration or cyclic structure of sleep will reduce alertness the next day.
- Aging is associated with increased sleep disruptions leading to daytime sleepiness.
- People differ in their preference for early or late schedules (larks vs. owls).

Fatigue, Alertness, and Sleep Loss

When people do not get adequate sleep, they experience fatigue and loss of alertness during the time they are awake. This affects their ability to perform safely on the job. Sleep loss of even 1 or 2 hours can significantly degrade alertness and performance, with greater effects for increasing amounts of sleep loss.

If a person loses sleep over successive days, this can lead to an accumulated *sleep debt*. For example, if someone who needs 8 hours of sleep only gets 5 hours a night over 4 nights (i.e., over four 24-hour days), they would accumulate a sleep debt of 12 hours. This can result in a

cumulative effect on alertness and performance over that period of time. Frequently, we tend to gain some recovery sleep over our “weekends” or our 2 days off from work. Recuperation from sleep debt, however, requires getting more sleep for at least several nights. The effects of large sleep debts, say not sleeping for 2 days, can still be detected in performance levels after a week of sleeping normally for 7 to 8 hours per night.

Chronic sleep loss can contribute to health consequences, including obesity, diabetes, and high blood pressure. Even young people who experience sleep debt over a week show increased likelihood of infection and stress effects. Shift workers commonly experience sleep loss and are more prone to gastrointestinal disorders, as well as aggravations of cardiovascular disease and diabetes.

If there is enough reduction in sleep, people will reach a level of critically reduced alertness in which sleep spontaneously intrudes into wakefulness. These uncontrolled sleep episodes (microsleeps) can occur even when a person is standing up or operating equipment. It is important to recognize the signs and symptoms of fatigue, and to ensure that workers are getting sufficient rest to maintain alertness on the job.

Signs and Symptoms of Fatigue

- Forgetful
- Poor decision making
- Slowed reaction time
- Reduced attention
- Poor communication
- Fixated
- Apathetic
- Lethargic
- Bad mood
- Nodding off
- Itchy eyes
- Need to sit

Causes of Sleep Loss

One of the main causes of sleep loss is *shift work*, i.e., working during hours outside the normal daylight routine. Figures 3-4A and 3-4B show the typical pattern of day work, and night rest. This pattern is altered, or sometimes reversed for shift workers, and can lead to difficulties sleeping. The primary reason for sleep loss in shift workers is that they are trying to sleep at times when the brain’s biological clock mechanism signals that they should be awake. As a consequence, shift workers may find it more difficult to go to sleep, or to sleep as long as they wish.

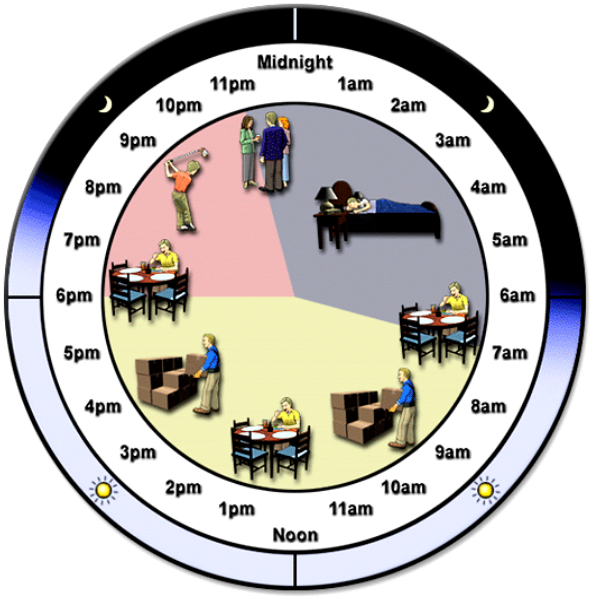
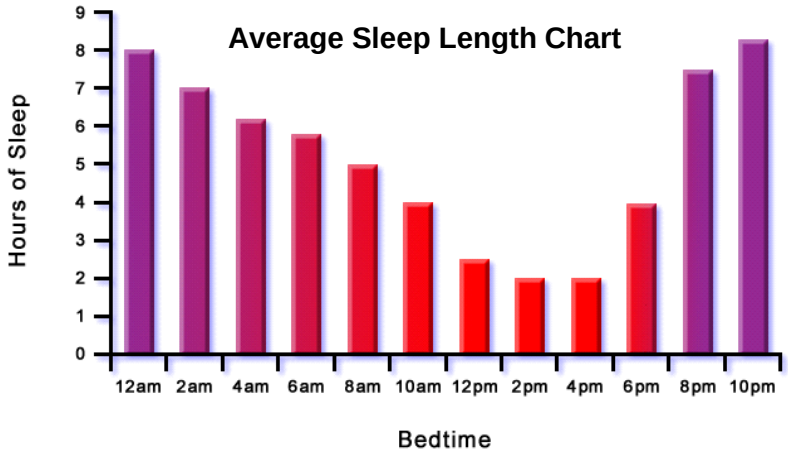


Figure 3-4A. The normal daily routine for sleep and work.



Adapted from Åkerstedt, 1995

Figure 3-4B. Sleeping at times not favored by the brain's biological clock results in less sleep.

Social and family demands can contribute to the sleep loss problems experienced by shift workers, because they may choose to spend more time in these activities at the expense of trying to rest. Many people who work afternoon or night shifts revert to a normal daytime schedule on the weekends or days off, in order to synchronize with the world-at-large. This can lead to a constant state of "circadian desynchronization" in which the body and the daily clock are in conflict.

A number of substances can interfere with sleep, including caffeine, alcohol, and over-the-counter drugs such as decongestants. The effects of caffeine typically last for about 4 to 5 hours, but may last up to 10 hours in especially sensitive individuals, so a cup of coffee after dinner may well interfere with getting to sleep. Similarly, alcohol may initially relax a person and assist in getting

to sleep, but as it is metabolized there will be a "rebound" alerting effect, causing a person to awaken more easily. Alcohol also interferes with REM sleep. Nasal decongestants interfere with sleep because they contain pseudoephedrine, which is a stimulant.

Other activities that may interfere with sleep include eating and exercise. Food consumption stimulates gastrointestinal reactions which may result in discomfort and sleep problems. Exercise on a regular basis is good for promoting sound sleep, but should not be done within an hour or two of bedtime, because it has an alerting function and can shift the biological clock forward.

Specific sleep disorders also result in sleep loss. Among the most common of these are medical conditions such as congestive heart failure and arthritis that lead to the symptom of *insomnia*, i.e., difficulty in getting to sleep or staying asleep. The condition, *sleep apnea*, affects as many as 5 out of every 100 people and is a breathing disorder involving periodic interruptions of breathing during sleep. Key signs that a person has sleep apnea are reports from others that the person snores loudly and irregularly when sleeping. Medical specialists can be consulted to determine if a specific condition exists that is interfering with sleep, and proper medical interventions can help to alleviate the problem.

Causes of Sleep Loss – Key Points

- Shift work causes conflicts between the brain's biological clock and when a person works and sleeps.
- Daytime sleep periods result in less sleep because of the influence of the biological clock, and family/social demands.
- Caffeine, alcohol, and over-the-counter decongestants interfere with sleep.
- Food or exercise too close to a sleep period can result in sleep loss.
- Specific sleep disorders such as insomnia or sleep apnea cause sleep loss.

Getting Adequate Sleep – How to Do It

The demanding world we live in makes getting adequate sleep challenging. But knowledge of some basic information and approaches can help people make the most of their rest periods to obtain sufficient sleep so they will be alert on the job.

There are four basic areas to consider for ensuring that a person gets adequate sleep:

1. The personal sleep cycle
2. Sleep environment
3. Relaxation
4. Things to avoid

Understanding the individual sleep cycle is crucial for taking the steps to ensure sufficient restorative sleep. People can determine their optimum sleep amount by recording their sleep start and stop times on their third consecutive day off when they are not using an alarm clock to wake up. This is most likely to occur when taking a vacation.

The amount of sleep needed should be enough to feel refreshed and healthy the next day but not more—this will usually be between 7.5 and 8.5 hours. Based on the amount of sleep needed, people should establish a habitual time for going to sleep and waking up, and maintain this schedule whether or not it is a workday. Additionally, daily exercise helps to promote sounder sleep.

The sleep environment should be quiet and dark, using room darkening shades if necessary. Earplugs can be helpful if there is noise. The temperature of the sleeping room should be around 65 degrees F, and the bed should be used only for sleeping—not for activities such as reading or television watching.

Relaxation can promote falling asleep. The most basic technique is to wait until feeling sleepy to go to bed. If they are not tired, they should do something quiet and relaxing like reading or watching television in dim light until they feel sleepy. Once in bed, if they cannot sleep, they should get out of bed and do some quiet activity until they feel sleepy.

Getting good sleep depends on knowing what to avoid prior to sleeping. Especially important to avoid is caffeine—this should be avoided within about 5 or 6 hours of going to sleep, since the effects can last that long. It is also important to avoid drinking alcohol within 3 hours of bedtime, since alcohol fragments sleep and makes it less restorative. Cutting down or eliminating nicotine is important for promoting good sleep. People should also try to avoid thinking about the day's problems—possibly by writing "to do" lists for the next day to get things off their minds. Drinking fewer fluids before going to sleep will reduce awakenings to use the bathroom. Finally, nap during the day only if they have no trouble going to sleep at night.

Getting Enough Sleep – How to Do It: Key Points

- Make bedtime and waking a routine schedule to get the amount of sleep you know you need.
- Ensure the environment is dark and quiet, and not too warm.
- Relax prior to bedtime; don't toss and turn—get out of bed and do something quiet until you are sleepy.
- Avoid caffeine and alcohol prior to bedtime, eliminate nicotine, drink fewer fluids to reduce use of bathroom, and avoid thinking about problems.
- Nap during the day only if you find that it does not interfere with going to sleep.

FATIGUE COUNTERMEASURES

This section of the Guide identifies and discusses promising techniques for fatigue management and mitigation in highway renewal projects. While there are clear beneficial effects of many of the countermeasures to be discussed, there is no "magic bullet" for fatigue prevention and mitigation—it is important to take an eclectic approach, and to use measures that have been shown to work and that are adaptable to the circumstances at hand. The detailed technical basis for the countermeasures described in this guide can be found in the R03 technical report.

Table 3-1. Fatigue countermeasures classified by type and judged level of effectiveness and implementation complexity.

Impact	Countermeasure Type	
	Preventive	**Operational**
Generally Effective	• Adequate Sleep • Defensive Napping • Good Sleep Environment • Limiting Overtime and/or Work Schedule Modification	• Caffeine • Napping • Anchor Sleep • Rest Breaks
	• Fatigue Education	
Less Effective	• Diet	• Temperature and Ventilation • Self and Peer Monitoring
	• Exercise	
Limited Evidence or Implementation Complexities	• Hypnotics or Stimulants • Model-Based Schedule Optimization • Fatigue Risk Management System	• Worker Status Monitoring and Alerting Technologies • Bright Light or Melatonin for Circadian Shifting

1. Adequate Sleep

Preventing fatigue by ensuring adequate sleep opportunities, proper sleep-period timing, and appropriate accommodations.

Type of Countermeasure: *Preventive*

The most effective countermeasure for fatigue is to do as much as possible to prevent it from occurring in the first place. As the material in the literature review suggests, the primary culprit for feeling fatigued is *sleep loss*. So, whatever can be done to obtain regular sleep and to prevent sleep loss should be high on the list of countermeasures. The principal advantage of getting enough sleep is that it will reduce on-the-job fatigue, thereby reducing the need for other countermeasures.

People tend to need, on average, 7.5 – 8 hours of sleep in order to preclude feeling fatigued. The first general strategy for minimizing sleep loss is to establish a **routine approach to obtaining sleep**, that allows enough time to **obtain sufficient sleep**, takes time of day (**circadian rhythm**) into account, and ensures an appropriate **sleep environment.** Ideally, this would mean going to bed at the same time every night and waking up at the same time every day, allowing for at least eight hours of time in bed. Recognizing that regular sleep times are often not congruent with everyday life, it is important to point out that day-to-day variations in sleep timing and duration can be overcome by sleeping in on days off and by supplementing sleep time with napping, provided that total sleep time is not curtailed in the long run.[2]

The sleep environment should be quiet, dark, and of comfortable temperature. Shift workers often change shift schedules from one week to the next, or more frequently. This can lead to sleep loss because the brain is not adapted to sleeping at a different time of day. The best approach for reducing sleep loss associated with a new shift schedule is to start the new shift with no sleep debt—as a rule of thumb, this means getting at least two nights of unrestricted sleep prior to beginning a new schedule. If making a *radical* schedule shift, such as between days and nights, it will also be important to obtain some *compensatory* sleep prior to the new shift start (see discussion of defensive napping). For example, if the schedule starts at midnight Sunday, it would be desirable to get two full nights of sleep on Friday and Saturday, sleep as long as possible on Sunday morning, and try to nap for a couple hours before the start of the midnight shift on Sunday. Napping prior to extended periods of wakefulness will reduce fatigue and improve alertness.

A third general approach to minimizing sleep loss is to match sleep and work schedules to individual physiology. Morning people (i.e., a “lark”), perform best on work schedules with morning starts, but even for young people earlier than 0700 is difficult. As an example, a study of construction workers on a typical three shift system found that the day shift workers got the least sleep, due to the 0600 start time (Powell & Copping, 2010). Night people (i.e., an “owl”), perform best on work schedules that start in the afternoon or evening. In either case, it is important that individual physiology be coupled with a sufficient main sleep period.

[2] This is not recommended in individuals diagnosed with insomnia, where sleep regularity is one of the pillars of sleep hygiene and typically considered essential for treatment.

Countermeasures to Minimize Sleep Loss:

- Obtain sufficient sleep
- Have a regular routine for sleep
- Ensure the sleep environment is appropriate
- Start new shift schedules with minimal sleep debt
- Obtain *compensatory* sleep before new schedule
- Match regular work schedule to personal physiology: “lark” or “owl”

The limitations associated with this countermeasure tend to involve factors that often are beyond the control of the individual, such as work shift start times, rotation of schedule, and location factors that might influence sleep, such as jet lag or the sleep environment. Additionally, some individuals tend to sacrifice adequate sleep for purposes of social or family activity; however, these factors involve individual choice and can be balanced as required.

Effectiveness

It is generally agreed in the fatigue research literature that adequate sleep is *the* most effective countermeasure to fatigue and performance decrements. The effects of adequate sleep last throughout the work period unless the work period is so long that it requires wake extension and thus causes sleep deprivation (although circadian rhythms will increase fatigue at night regardless).

Highway Construction Environment Implementation

Implementing the preventive countermeasure of adequate sleep involves a combination of worker knowledge and work schedule management to provide sufficient opportunity for sleep. As such, linkage to other countermeasures such as worker education and schedule management on the part of the construction contractor are important elements in getting adequate sleep.

2. Defensive Napping

Defensive napping as a fatigue countermeasure involves sleeping for a brief period prior to the work shift.

Type of Countermeasure: *Preventive*

Taking a nap can help to reduce fatigue and increase alertness on the job, or at other times. Naps can be effective as a short-term countermeasure to fatigue, or to compensate for periods when a worker will need to remain awake for a long time, such as when changing shifts.

Some general situations where napping would be appropriate are:

- Less than 6 hours for the main sleep period.
- Awake for 30 minutes or longer two or more times.
- Feeling as if continually drifting in and out of sleep.
- Feeling much more tired than usual upon awakening from the regular sleep period.

Taking a nap should be timed to obtain the maximum benefit. This will vary depending on circumstances, but in general the following guidelines are applicable:

- Napping for longer periods (2+ hours) prior to the start of a night shift can prevent fatigue for extended periods (e.g., through a night shift) and can be very beneficial Napping for short periods (less than 30 minutes) may result in subjective alertness), but little is known about how long this effect provides actual benefits.
- Individuals who are day-oriented and not sleep deprived, avoid napping during the hours of 1800 and 2200, approximately, when alertness is usually high (the so-called wake maintenance zone).
- Schedule a nap during the mid-afternoon (1300 – 1500 hours) when alertness is low.
- Allow 15 – 30 minutes after a nap to become fully alert. The deeper the sleep the longer the period needed to become fully alert.

Effectiveness

Napping as a defensive measure reduces fatigue in the work period approximately in proportion to the duration of the nap. Further, the timing of the nap in relation to the work period is important, such that a nap closer to the work period is generally more effective.

Highway Construction Environment Implementation

As with the preventive measure of Adequate Sleep, defensive napping is a matter of individual worker knowledge, and the opportunity to act on that knowledge *in advance of experiencing fatigue*. The latter aspect is related to work schedule management, notification of shift change, and providing sufficient advance notice to allow workers to use the time available to them to adjust through napping. In practice, the construction companies we interviewed attempt to give at least a day off prior to switching from day to night shift.

3. Good Sleeping Environment

A good sleeping environment sets the stage for restorative sleep.

Type of Countermeasure: *Preventive*

Although most people can get used to almost any sleep environment, especially when they are exhausted, certain characteristics of where an individual sleeps can enhance or compromise how restorative a rest period is.

To ensure that sleep is restorative, sleeping environments must be quiet, dark, and comfortable.

To ensure a quiet environment, the individual should remove any noise sources, especially those that are unpredictable (e.g., pets in the bedroom). Use of earplugs to reduce traffic noise or other external sounds helps many people, as well as the use of a constant low-level noise source such as a fan.

The amount of light in a sleeping area can be reduced by using black-out shades, heavy dark fabric for curtains, or "hurricane shutters" over windows. Some people also use eyeshades in areas where there is substantial light leakage.

Comfort in the sleeping environment is related to the quality of the bed, and the temperature. The bed and pillows should be of appropriate firmness for personal comfort, and the temperature not too warm or too cold by personal preference.

Two additional environmental recommendations include: orienting the clock face away so as not to worry about the time especially when having difficulty falling asleep, and using the sleeping area only for sleeping—not other arousing activities such as work or watching TV and videos.

Effectiveness

The principal advantage to using this countermeasure is that an individual can adapt their sleep environment to meet individual needs, and have a continuing positive effect on sleep quality.

Highway Construction Environment Implementation

The importance of sleep environment characteristics is primarily an educational issue. The fact that sleep hygiene principles are routinely suggested to individuals seeking sleep medicine consultation indicates the need for continuing education of workforces that may be subject to sleep disruptions. This can also include information to assist with family routine modification in order to facilitate sleep for the affected individual.

4. Limiting Overtime and/or Work Schedule Modification

Type of Countermeasure: *Preventive*

Evidence suggests that longer duration shifts and/or overtime are associated with increased incidence of error and safety-related incidents (Åkerstedt et al., 2002). The principal choices in limiting overtime or modifying the work schedule involve how long the shift will run, what time it will start, and which workers to assign.

Effectiveness

Limiting work hours and work schedule modifications are associated with increased worker satisfaction and reduced incidence of errors on the job, by providing more time for sleep.

Highway Construction Environment Implementation

Implementation of this countermeasure in the rapid renewal highway construction environment involves a number of considerations. First, there appear to be only two basic shift ranges in the projects we evaluated: day work (approximately 0700 – 1700) and night work (approximately 1900 – 0500). These schedules seem to be a blend of traditional work hours during the day, and the need to accommodate late afternoon rush hour traffic in the evening and be done by early morning. Thus, there are fairly rigid parameters associated with start and stop times that do not easily accommodate change.

Work scheduling during "regular" shifts, either day or night, appear to currently operate on the basis of project labor agreements (PLAs) for union states, and common practice in non-union states. In either case, the usual approach to scheduling involves either 8 or 10 hour shifts, with a maximum of a 55 hour week. The usual minimum time off between consecutive work periods is 1.5 days.

The aspect of rapid renewal construction work that can most benefit from limitation of work hours or schedule modification is the practice of continuous weekend closures. These closures tend to run from 2300 Friday evening to 0500 Monday morning, and are associated with considerable sleep disruption among managers, and possibly laborers. Current practice on accelerated projects is to continue using the same workforce for another week of standard day or night work schedules following a weekend closure. Workers show high levels of fatigue following this type of closure and resumption of a standard schedule. A simple modification to this practice is to provide workers Monday off following a weekend closure, or at least to implement a later start time. The trade-off involves less work accomplished on that Monday, but this may still be a beneficial trade-off for the lower productivity expected of fatigued workers.

5. Fatigue Education

Type of Countermeasure: *Preventive/Operational*

An understanding of the fundamental nature of sleep loss, circadian rhythm, fatigue, performance impacts and amelioration strategies is a key element of both preventive and operational approaches to reducing fatigue. Education is a basic element of current approaches to fatigue risk management systems, and can help to overcome widely held misconceptions about the nature of the problem and ways to deal with it.

Key points to address in educational programs include:

- In the long run, there is no substitute for sleep.
- Fatigue is based on physiological mechanisms and cannot be overcome by motivation or willpower.
- Self-assessment is unreliable, and potentially biased by work circumstances.
- Individuals vary in sleep need and responses to sleep loss, and it is difficult to predict on a case-by-case basis.
- There is no “one-size-fits-all” solution.
- There are ways to prevent and mitigate fatigue, but they must be properly employed.
- Fatigue has safety, well-being and economic consequences.

Effectiveness

Although training is sometimes considered a weak response to structural organizational problems such as fatigue, it is a necessary first step in gaining commitment at the individual and corporate level to address the problem. Simply having an educational program is no guarantee of results, and some studies suggest that knowledge decays rapidly, while others indicate that higher levels of corporate commitment and engagement lead to longer lasting impressions.

Highway Construction Environment Implementation

While important as a fundamental component in fatigue management, translation of existing scientific knowledge into usable programs for employers and workers is not straightforward. Educational programs could be imported and adapted from transportation industries such as commercial aviation. Comprehensive and contextualized training about fatigue for the rapid renewal environment will need to address the specific risk factors and operational constraints of the work domain. These include long shifts, occasional double shifts, rapid switch to night work from day work, and continuous weekend closure effects upon sleep opportunity.

6. Napping

Type of Countermeasure: *Operational*

Using napping as an operational fatigue countermeasure involves sleeping for brief periods during the work shift.

It is important to consider the following:

- Where to take the nap?
- When to take the nap?
- How long to nap?

In general the following guidelines specific to workplace napping are applicable:

- Taking 10-12 minute "power naps" almost anytime as needed and appropriate, can help refresh an individual for a short period of time.
- Be aware of the potential effects of sleep inertia following the nap, and counteract with caffeine if necessary.
- Napping used as part of a continuous, non-split shift duty period, and not used to extend the duty period.

Effectiveness

Naps of 20 – 30 minutes during appropriate periods of a work shift have been shown to improve performance and subjective alertness during the subsequent work period. Studies of extended shifts (16 hours) have included naps of up to 2 hours duration, although this has entailed more sleep inertia and potential interference with recovery sleep during the off work period.

Highway Construction Environment Implementation

Implementing on-shift napping in a highway construction environment may be a considerable challenge. Field studies suggest that some workers *do* take naps during their lunch breaks or other times when it is appropriate, and they tend to use their personal vehicles as the location for napping. Due to the safety critical nature of construction, workers must be very cautious about where and when they take breaks, particularly if they are asleep for a brief period. Personal vehicles as a location for napping are probably relatively safe, although ultimately it would be desirable to optimize the conditions under which naps are taken, in order to avoid excessive noise, vibration, overheated vehicles from sun exposure, and potential contact with construction equipment.

7. Caffeine

Alertness can be increased by consuming caffeine in the form of coffee, tea, soft drinks, chocolate, or caffeine gum; or by taking non-prescription caffeine tablets.

Type of Countermeasure: *Operational*

Caffeine is one of the most commonly used fatigue countermeasures, usually obtained through a cup of coffee. Other popular drinks and foods contain a lot of caffeine, including cola drinks, chocolate, and tea. Numerous medications also contain caffeine, as do "alertness aids" such as No-Doz and Vivarin. Caffeine is widely available and taking a brief break to take caffeine can have the additional advantage of breaking up a tiring work routine.

Caffeine affects the nervous system within 15 – 20 minutes, depending on mode of ingestion. The effects include a more rapid heartbeat and increased alertness, and they last for about 4 to 5 hours, but may last up to 10 hours in especially sensitive individuals.

It is important to use caffeine only as a short-term way to boost alertness; regular use can lead to tolerance and various undesirable side effects, including insomnia and disrupted sleep if taken too close to bedtime.

Here are some situations where using caffeine makes sense:

- In the middle of a night shift (especially on the first and second day of the work week when circadian disruption tends to be most pronounced and alertness most compromised)
- Mid-afternoon when the post-lunch alertness dip is greater because the individual did not get enough sleep.
- Prior to an early morning commute following a night shift, but not within 4 hours of going to sleep if the individual is sensitive to sleep disruption from caffeine.
- Prior to a brief nap of 15 or 20 minutes, to reduce the effects of sleep inertia from the nap. Caffeine effects will become active as the nap is ending.

It is always best to try and reduce fatigue through obtaining enough sleep, but when this doesn't happen and boosting alertness for a period of several hours is needed, using caffeine makes sense.

Caffeine will affect sleep and should not be consumed 4 – 5 hours prior to sleep, unless the individual is not sensitive to caffeine disruption of sleep. Caffeine in the body will make falling asleep more difficult, reduce sleep length, and disrupt the quality of sleep.

Our brains gradually build up a tolerance to repeated consumption of high levels of caffeine (e.g., 5+ cups of coffee per day). A frequent coffee drinker needs a higher dose of caffeine to obtain the same "boost" effect of the more casual coffee drinker. Caffeine should be consumed sparingly, to "save the boost effect" for when it is really needed. That is, plan to use caffeine in the middle of the afternoon dip (1330 – 1530 hours) or if working through the night, use it after midnight during the circadian low point.

Effectiveness

The alertness enhancing effects of caffeine have been well documented, and performance is increased on various measures when caffeine is used, particularly if people are sleep-deprived. There are, however, considerable individual differences in the effectiveness of caffeine. The duration of the effects are sufficient to counteract moderate levels of fatigue, when taken in time

periods when fatigue will be a problem. Further, some putative sources of “energy” such as high sugar colas and energy drinks, are lower in caffeine per fluid volume than coffee, and tend not to have the same alerting effects as drinks with higher amounts of caffeine.

Highway Construction Environment Implementation

This countermeasure appears to be well-implemented on an individualized and informal basis in highway construction environments. Workers report either bringing their own caffeinated beverages to the job site, or being able to obtain caffeinated beverages near the work site. Contractors may also consider providing coffee or other caffeinated beverages at a central location to the work site, for example, in the work site office, or at the location where gathering for “stretch and flex” safety meetings are held.

8. Anchor Sleep

Type of Countermeasure: *Operational*

Anchor sleep (or "split sleep") refers to a regular sleep period of at least four hours duration, obtained at the same time each day. The anchor sleep period is supplemented by an additional sleep period taken when the schedule allows.

Some work schedules do not allow a full eight hours of sleep at the same time period every day. In order to effectively cope with schedules like these, workers should arrange to get at least four hours of sleep at the same time every day; additional sleep can be obtained as the schedule permits.

Anchor sleep periods have the advantage of stabilizing the circadian rhythm to a 24-hour period, so that workers will not constantly feel "out of sync." The anchor sleep period should be timed so that circadian rhythm high and low points correspond to work and sleep periods.

Anchor sleep is not a substitute for getting a full eight hours during any 24-hour period. Instead, it is a coping mechanism meant to keep an individual's circadian rhythm synchronized to his/her daily schedule, by allowing sleep for a period of time when sleep is possible. It is important to supplement anchor sleep with supplemental naps that are sufficient to provide the complete sleep allotment needed on a daily basis. This countermeasure is helpful as it anchors the sleep cycle.

Research data indicate that it is important to have the anchor sleep period occur at a constant time every day. It is important to try and time the main or supplemental sleep episodes so that they do not coincide with circadian "forbidden zones" (wake maintenance zones) where initiation of sleep would be difficult—typically these times are approximately 0800-1200 (when not sleep deprived) and particularly 1800-2200.

Meals should be taken at the times that workers normally eat. When taking supplemental sleep, it is important that it not be too close to the anchor sleep period, or interference will occur. Caffeine consumption should be moderated during the use of anchor sleep as well, since the effects of caffeine last for about 5 hours, and may interfere with either the anchor sleep period or the supplemental sleep in individuals sensitive to this effect.

Anchor sleep should be used as a coping mechanism for situations where a worker cannot get a full eight hours of sleep, but not as a routine. While split sleep periods may provide a sufficient amount on a short-term basis, getting a sleep allotment in a single episode is preferred.

Effectiveness

Laboratory studies of anchor sleep and split sleep periods indicate that performance tends to be maintained at levels equivalent to getting a consolidated sleep period. It is not known if performance stability is maintained over weeks to months on such schedules.

Highway Construction Environment Implementation

Use of anchor or split-sleep schedules would seem most appropriate for highway construction workers who are working on continuous closure operations, particularly management personnel who are not covered by a specific labor agreement for daily work hours. An example would be a manager who wishes to be present at the start of a closure on Friday evening, and work as much as possible through the following Monday morning. An anchor sleep strategy for this individual

would be to nap in the mid-to-late afternoon on Friday in preparation for staying up all night starting late Friday night. He/she could then return home to sleep early Saturday morning, and probably get about 4 hours of sleep prior to waking. He could return to the work site for several hours, then take another long supplemental sleep in the mid-to-late afternoon. This process would be repeated until the end of the closure on Monday morning.

9. Exercise

Type of Countermeasure: *Preventive/Operational*

Physical exercise has the principal benefit of improving overall cardiovascular health and muscle tone. Additionally, regular exercise improves sleep—individuals fall asleep quicker and sleep more soundly depending on the timing and the type of exercise. Exercise also enhances feelings of alertness for a short period.

Physical exercise can also be used to reduce the feeling of fatigue resulting from not getting enough sleep. Research indicates that brief periods of exercise can reduce feelings of sleepiness, although job performance does not improve. In rested individuals, a morning exercise break may improve alertness and driving performance for a brief period afterwards.

The health benefits of regular physical exercise are clearly established, and individuals should consider initiating a regular program of exercise or maintaining what they are already doing. If they work irregular hours or in situations that limit what they can do (e.g., no ready access to a gym, or darkness), planning ahead and the use of alternative activities such as walking can be used to maintain a healthy activity level.

Regular exercise will contribute to feelings of increased energy, by helping develop stamina and improving sleep. It should be a regular part of a healthy lifestyle.

While exercise will promote health and improve an individual's sleep, it does not permit them to cut back on primary sleep. Exercise can reduce immediate feelings of fatigue resulting from schedule changes and sleep deprivation, but that feeling only lasts for about 30 minutes. The effects of exercise on job performance are complex, and tend to wear off quickly, possibly even making performance worse in the afternoon. So, while an individual may feel better after exercising during a sleepy period on the job, they are still fatigued and should be aware that performance is likely to be compromised.

Do not exercise too close to bedtime, because increases in body temperature and alertness may make it difficult to go to sleep.

Effectiveness

Exercise as a fatigue countermeasure should be used primarily to develop cardiovascular health and to promote healthy sleep. As such, exercise is a complementary countermeasure and can facilitate the primary goal of getting adequate sleep. Exercise can be used as a very short-term countermeasure for brief enhancement of alertness, but the effects may not transfer to actual performance and will not last throughout the work period.

Highway Construction Environment Implementation

Implementation of this countermeasure in the highway construction environment as a preventive countermeasure may be promoted through the regular use of morning safety meetings and "stretch and flex" exercises that are part of this routine. It is common practice with some contractors to hold these crew-mustering meetings prior to initiation of work, to discuss recent safety concerns, and to promote physical warm-up. These meetings could also be used as a platform for promoting regular exercise in the off-work hours to enhance health, restorative sleep, and general alertness. It should be borne in mind, however, that well-intentioned advice to get up early to exercise is counterproductive for fatigue management if arising early curtails the sleep period.

10. Diet

Varying meal content in order to increase alertness or promote sleep.

Type of Countermeasure: *Preventive*

The physical activity associated with eating can itself induce an alerting effect; however current research evidence suggests that specific food content has little, if any, impact on level of alertness or feelings of sleepiness.

An attempt to extend an individual's endurance or promote sleep by altering the content of meals is unlikely to succeed. It is better to focus on consuming a nutritionally healthy and balanced diet at the appropriate times of day.

Getting a balanced, nutritious diet at appropriate times is often difficult for shift workers. Schedules often limit eating to what is available when time and work permit.

Individuals can avoid this situation with appropriate planning. Packing meals prior to leaving home, taking breaks where supermarkets are located, and take-out meals from (non-fast-food) restaurants are some steps that can be taken to make sure the right foods are available when needed.

Whenever possible, individuals should try to eat meals at times that correspond to their normal meal times—this will help maintain a regular sleep-wake cycle, since meals are a time cue that influences circadian rhythms. Conversely, the gastrointestinal system will process food best when it is eaten at the right times of day. One of the primary complaints of shift workers is gastrointestinal discomfort caused by being forced to eat at night when the body is not optimally prepared to handle the food intake.

Consuming large meals prior to sleep can disrupt the subsequent sleep period and also result in gastrointestinal discomfort.

Effectiveness

Eating properly is a key element of overall general health, which can contribute to quality and quantity of sleep. Eating or drinking specific foods or beverages (other than caffeine) for alertness enhancement is unlikely to work.

Highway Construction Environment Implementation

Good dietary habits and meal content could be part of an overall fatigue, health and wellness training program for highway construction workers. There are no specific recommendations for dietary content for workers in this domain.

11. Rest Breaks

Rest breaks from the performance of a work task can reduce the effects of sleep loss for a short time.

Type of Countermeasure: *Operational*

Research studies have demonstrated that people who are sleep deprived or work on continuous but monotonous tasks during the night show degradations in their performance. However, if they take breaks, sometimes as short at 7 minutes, the degraded performance is reduced and they also feel subjectively better. The effects of the rest breaks last only for 15 – 25 minutes, but this can be very important during critical tasks that are safety sensitive.

The break does not have to involve napping, but instead simply a change in activity, such as stopping whatever task the worker is currently engaged in, walking around, stretching, talking to others, etc. The breaks may have more impact on fatigue later in the work cycle.

An additional benefit of rest breaks is that it temporarily removes workers from the work site, and thus from potential risks.

Effectiveness

Rest breaks can provide temporary (15 – 25 min) relief from performance declines and subjective fatigue due to sleep loss. They are a short-term measure, and not a substitute for adequate sleep.

Highway Construction Environment Implementation

Most highway construction jobs have some degree of self-paced structure, which would allow workers to take breaks when needed. There are certain multi-person, time-intensive tasks, such as pavement finishing, that would not be conducive to individual decisions to take a break, but with team support rest periods could be agreed upon.

Rest periods for “work to completion” kinds of tasks should be considered by construction superintendents, and planned for on the basis of when fatigue is likely to be a problem, such as toward the middle or end of a night shift or closure period, or to break up a monotonous or physically demanding task.

12. Temperature and Ventilation

Changing airflow and temperature in the surrounding environment to increase alertness.

Type of Countermeasure: *Operational*

Altering the airflow and temperature in the surrounding environment is fairly easy for most workers, through control of air conditioning or increasing fresh air by opening a window.

It is important to ensure that the air quality in the immediate operational environment is good, since fatigue is one of the symptoms often associated with impurities in the air. The fatigue that results from impurities can be a physiological reaction to reduced oxygen, and is an indication that the environment should be changed. For highway construction workers, air impurities might result from improperly ventilated exhaust systems or fumes from construction material such as asphalt.

Temperature tends to affect alertness indirectly, by changing the overall comfort level. If an individual is inclined to feel sleepy anyway, a warm environment may increase those feelings. However, the opposite is not true—there is little benefit to opening a window or lowering the temperature if an individual is already fatigued.

While there may be a brief effect of lowering the surrounding temperature or increasing airflow, research data suggest that the impact is very short, and not likely to increase alertness for longer than a few moments. So, if an individual is feeling sleepy, it is best to use another countermeasure.

Effectiveness

Changing temperature and/or ventilation may yield a momentary enhancement of alertness, but it is not an enduring effect and should not be considered a practical countermeasure.

Highway Construction Environment Implementation

Given the only momentary effects of changing temperature or ventilation, use of this countermeasure in the construction environment should be limited to supplementing short-term other countermeasures, such as rest breaks or exercise.

13. Self and Peer Monitoring

Use of observational data to assess levels of fatigue in self or co-workers.

Type of Countermeasure: *Operational*

Performance impairment does not necessarily indicate fatigue, and self-report of fatigue does not necessarily indicate performance impairment, but the likelihood of either is increased in the presence of the other. For these reasons, it is important that workers pay attention to their own subjective state, as well as monitoring the quality of their work.

There are various rules of thumb that workers can use to self-monitor, including knowledge of their prior sleep-wake patterns, overt symptoms such as yawning, drooping eyelids, "catching" themselves falling into microsleeps, and feelings such as "fighting sleep"—items also featured in one of the most frequently used fatigue rating scales.

People are aware of their fatigue as it is developing and influencing their performance, including safety incidents, and that this awareness is strongly correlated with physiological measures of fatigue such as brain wave measurements. The self-awareness of fatigue state needs to be linked to knowledge of proper actions (such as taking a break), so that people will not try to fight fatigue with relatively ineffective countermeasures. However, it is also known that fatigue impairs judgment and self-regulation, and so self-observation and report should not be relied upon exclusively.

Fatigue involves subjective feelings of tiredness, behavioral patterns of taking shortcuts and omissions, and a physiological basis. Observation of worker behavior by peers or supervisors relies on the observer's ability to distinguish specific behavioral characteristics indicative of impairment. A variety of symptom checklists have been employed by researchers, primarily as adjuncts to primary methods such as physiological or self-report measures. The checklists include facial markers such as eye closure, loss of facial muscle tone, etc. as a basis for determining likely state of alertness. The behaviors may occur without necessarily indicating an underlying state of fatigue, or the state of fatigue may be momentary. Fatigue may also be present without the overt symptoms, or with the overt symptoms occurring only occasionally and, therefore, be difficult to observe. The successful use of observational approaches depends on the ability of the observer to distinguish "normal" behaviors from those clearly indicative of impairment and to be able to do so on a near-continuous basis as fatigue is a dynamically changing state. This makes peer/supervisor observation an unreliable method for detecting fatigue. That said, workers should be encouraged to alert others when observing potentially fatigue-related behaviors, as the likelihood that fatigue is actually present is high when the symptoms are readily noticeable.

Effectiveness

Research indicates that individuals can reliably self-assess their own momentary state of fatigue, and less so in others. The overall effectiveness of this approach depends on knowledge and ability to act on the assessment of fatigue. This becomes a matter of implementation.

Highway Construction Environment Implementation

Interviews with construction superintendents suggest that they have certain rules of thumb for determining when their crews are fatigued, including erratic performance, facial characteristics, irritability and knowledge of their prior schedule. Superintendents also state that they are aware of

which individuals are more likely to be able to work certain hours and schedules, and their propensity to fatigue. They construct schedules and assignments, to the extent they are able, on the basis of that knowledge.

These findings suggest that supervisory monitoring is already taking place, albeit on an informal basis. There may be a role for approaches to “fatigue-proofing” highway construction environments through a combination of training on fatigue effects, how to recognize them, and more clearly establishing criteria for recognizing fatigue on the job and what to do about it. Examples from other work environments include using more humor and joking around on the night shift to see how people respond, and those showing unusually low response or irritability (compared to their usual personalities) would be watched or backed up more closely in safety critical tasks.

14. Hypnotics or Stimulants

Type of Countermeasure: *Preventive*

The use of synthetic or natural drugs to promote sleep when schedule changes interfere with falling asleep, or the use of synthetic or natural drugs to reduce the effects of sleep loss and enhance alertness under conditions of fatigue.

Hypnotics

If a worker has a sudden change of schedule that interferes with their ability to go to sleep, there are drugs and herbal substances that can be used to promote sleep. Hypnotic drugs such as Ambien are part of a class of drugs that are useful for inducing sleep. These drugs reduce the amount of time required to fall asleep, improve ability to stay asleep, and can maintain sleep for 7 to 8 hours.

Herbal remedies such as Valerian root, chamomile, kava, and lavender are promoted as sleep aids, but the evidence for their effectiveness is much less clear.

Sedatives and hypnotics have the advantage of being applicable to a number of situations that might interfere with sleep, such as shift changes, jet lag, or stress-related short-term insomnia. The drugs can help to alleviate these short-term problems and be discontinued to preclude the risk of dependency.

Depending on the specific type of drug class, there are changes in the nature of an individual's sleep although the significance of these changes is unknown.

It is possible to develop a dependence on hypnotics if used for a long period of time, and there is often a "rebound insomnia" in which sleep is slightly worse for 1 or 2 nights after discontinuing the drug even if used for only short periods of time.

If the drug is a particularly long-acting one, or if the individual has high sensitivity, there may be a "hangover" effect the next day where the individual may feel sluggish, or show sleep inertia. Sleep inertia or actual inability to wake up while on hypnotics largely precludes their use during operations.

Hypnotics should be used only by prescription from a physician, and only for as long as necessary to "get over the hump" of sleeplessness, and this should be at the lowest clinically indicated dose for as short a time as possible. Hypnotics are an aid to achieve sleep schedule re-adjustment, not a preferred means for getting sleep over the long run.

Stimulants

Stimulants exert a physiological effect on the nervous system so that the effects of sleep loss can be temporarily reduced. Caffeine (discussed in a separate entry) is an example of a stimulant—one that does not require a prescription, and that does not have any significant adverse side effects unless consumed in very large quantities.

Stimulants are particularly useful to the relatively small population of individuals who suffer from narcolepsy or other debilitating sleep disorders. Military personnel sometimes use stimulants during sustained operations, under controlled conditions and supervised by a flight surgeon.

The effects of prescription stimulants such as dextroamphetamine and modafinil are clear-cut—alertness is increased and performance is enhanced, relative to sleep-deprived individuals. These effects are also observed to some extent with a number of over-the-counter decongestants containing pseudoephedrine, and herbal stimulants such as ephedra.

Synthetic stimulants such as amphetamine and modafinil are controlled substances and should only be used under the guidance of a physician for treatment of a specifically debilitating sleep disorder.

Herbal stimulants are unregulated, and the effects of many are unknown because of lack of proper evaluation. However, it is known that ephedra, in particular, is associated with heart attack and stroke. All herbal stimulants should be considered as unproven and a safety hazard. Decongestants are not designed for increasing alertness—this happens as a side effect, along with increased drying of mucous membranes.

Even under the guidance of a physician, stimulants can have unwanted and potentially dangerous side effects, including changes in blood pressure and pulse, headaches, irritability, appetite loss, insomnia, nervousness, talkativeness, and sweating. Extreme reactions include hallucinations and paranoid psychosis.

Prescription stimulants are not generally permitted in operation of public transportation vehicles in the U.S. and many other industrialized nations. Randomized drug testing is regularly carried out to cut down on the usage of most known stimulants, at the threat of loss of job. These prohibitions may also apply to certain job categories in highway construction.

Most stimulants have a high potential for addiction and abuse because of the rapid euphoria that results from high doses. This can lead to a cycle of binging and crashing, and long-term abuse can lead to mental and behavioral disorders.

Finally, possession and use of controlled substances without a proper physician’s prescription is illegal, and could result in fines and jail time.

Effectiveness

Hypnotics and stimulants have demonstrated effects on sleep and alertness. Due to the controlled nature of these substances and the potential for legal problems and abuse, we do not recommend systematic application in the highway construction environment.

Highway Construction Environment Implementation

Discussion of hypnotics and stimulants is usually a part of fatigue training in other domains, when discussed in conjunction with medical issues such as sleep disorder screening. Individuals should be encouraged to seek sleep disorder screening if they believe they have a problem, or if management notices specific fatigue-related job performance issues.

15. Model-Based Schedule Optimization

Using the knowledge of physiological processes controlling sleep and alertness to predict worker level of fatigue on the job.

Type of Countermeasure: *Preventive*

Level of alertness at any particular point in time is controlled by three basic factors: (1) circadian rhythm, (2) prior sleep/wake history, and (3) length of time awake. Specific alertness values can be predicted from knowing where an individual is in their circadian phase, when and how long they slept during the last few days, and how long it has been since they woke up most recently. This conceptualization conforms to biology and common sense: an individual is naturally sleepy toward the late evening hours, sleeping recovers alertness, and alertness decreases the longer an individual is awake.

It is possible to use the general nature of these models to predict how an individual is likely to be feeling during a schedule change, and through continued schedules such as night shifts and weekend closures. For example, if a worker is going to switch from day to night shifts, it is likely that he will wake up on the first day of the night shift at his usual time, e.g., 0700 hours. By the time he goes to work at 2300 hours, his alertness profile will be at the circadian high point, making it initially easier to stay awake, even thought he would be habitually going to bed at this time. As he stays awake throughout the night, his alertness will decrease as it follows the circadian rhythm process; there will be no increased value on his sleep recovery process to balance that out, and the recovery sleep that is obtained will be curtailed because it is during the day.

Using knowledge of how alertness is affected by internal physiology can help individual workers and schedule planners to anticipate how fatigue crews will be at certain points in time, and to think about other potential countermeasures they might use, such as caffeine or a nap, or to the extent possible, schedule adjustments that will promote adaptation.

Alertness models are useful to estimate periods of reduced alertness so that specific countermeasure can be identified and used. Additionally, alertness profiles from the models can be used to design fatigue-friendly work schedules.

There are many other variables contributing to momentary alertness levels, such as stimulation level, other countermeasures employed, and individual differences in sleep need. Therefore, model predictions should be used as guidelines rather than as indicators of absolute predictions of alertness. This is not really a limitation—model predictions can effectively be used to compare different schedule options to see which is the most fatigue-friendly option, and to identify the best times to deploy fatigue countermeasures.

Research with application of models in specific industrial settings has shown that there tends to be resistance to adopting model recommendations, which is predominantly due to a lack of training in how to interpret model predictions correctly. Models, like other tools, should be used with proper training on their inputs, interpretation of results, and appropriate uses. This training does not need to involve a major time commitment but, without any training, model predictions can be misunderstood, leading to bad scheduling or countermeasure decisions, and subsequent distrust of the modeling tool.

Effectiveness

Fatigue models are effective for providing estimates of risk of impairment under various schedules, can guide countermeasure application and timing, and can serve as an educational tool for understanding fatigue and its impacts. The limited evaluations of fatigue modeling in operational environments suggests that adoption and diffusion are limited at this time, and that organizational and work practice barriers may impede broad adoption.

Highway Construction Environment Implementation

Scheduling tools are used in highway construction, but primarily by designers and engineers to develop task sequences for construction, and for contractual compensation. Even the largest projects appear to be relatively “low-tech” when it comes to safety training and worker scheduling; it is performed more on the basis of standard practice and construction schedule needs than consideration of worker fatigue, although this does come into play over the long term. Construction projects that utilize software for worker scheduling could include fatigue prediction as an additional scheduling criterion at a relatively low investment cost, making model-based schedule optimization a promising technology for the near future.

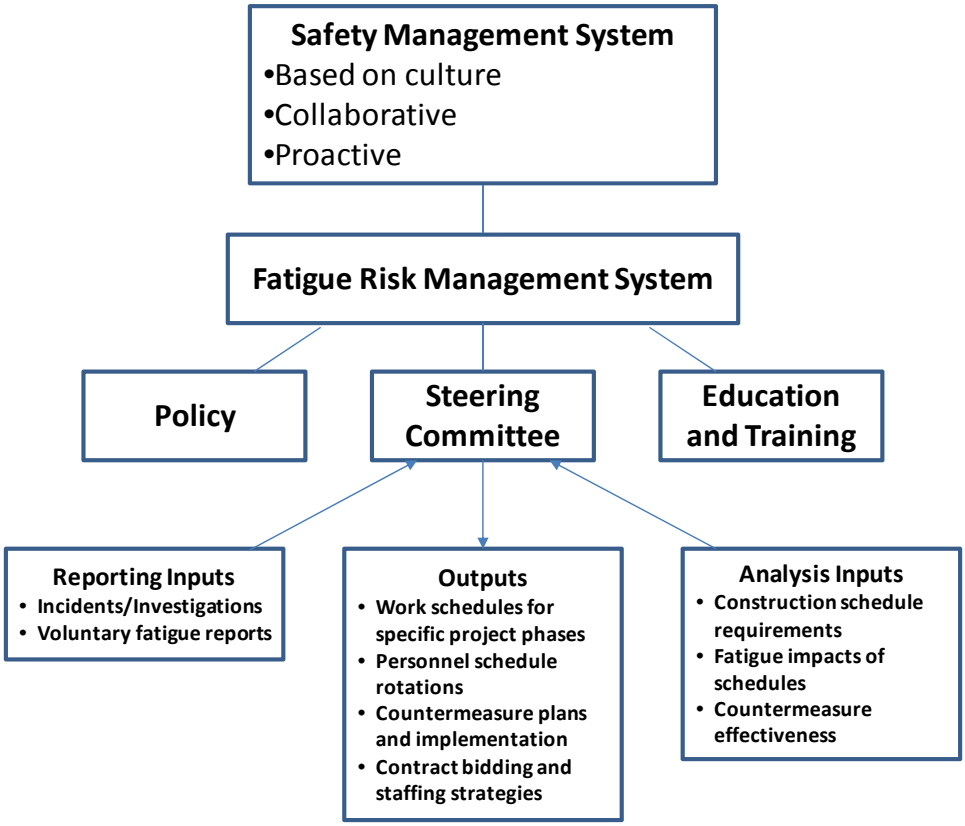
16. Fatigue Risk Management System (FRMS)

A comprehensive program for addressing worker fatigue that is a component of an overall safety management system.

Type of Countermeasure: *Preventive*

The concept of FRMSs has evolved with the advances in fatigue science, modeling, and theories of organizational risk and error. Fundamentally, an FRMS is part of a "defense in depth" strategy for addressing a broad range of safety issues within an organization. FRMSs are meant to be part of a safety culture, and to provide a flexible means to address fatigue that is an alternative to prescriptive hours-of-service rules.

The fundamental elements of a FRMS are shown in Figure 3-5.



Adapted from Gander et al., 2011

Figure 3-5. Elements of a Fatigue Risk Management System

Key elements of such a program include incident reporting, including voluntary reports by workers and crew; monitoring of fatigue related information (such as reports and safety trends); modeling and assessment of work schedules; and tracking of related information such as absenteeism. Education and training programs are a fundamental part, as is a steering committee of actively involved staff to keep the system functioning.

FRMSs have been implemented in a number of industries with round-the-clock operations, primarily transportation.

Effectiveness

The effectiveness of FRMSs is unknown, in terms of overall impact of fatigue-related safety problems. Evaluation data concerning education is mixed, and there is one study suggesting a positive trend of increased sleep in personnel participating in an alertness management program. Other evaluation studies report increased awareness of fatigue, but also problems related to organizational change/acceptance. There are no set criteria or regulatory standards for developing or evaluating FRMS program content, or for monitoring effectiveness of implementation. Transport Canada, however, has developed extensive toolkits for FRMS development in transportation, which can be easily adopted for other settings.

Highway Construction Environment Implementation

Safety programs and training seem to be the province of a single individual even in the very large programs, and the personnel/organizational infrastructure and the knowledge base for developing an FRMS, or for properly evaluating consultant offerings, does not appear to be available.

Instead of moving to full FRMS at this point in time, we recommend that contractors and states adopt a more practical approach to fatigue management by drawing on the various tools that are already available, such as training, countermeasures, and alertness modeling. These tools could initially be tailored to individual contractor needs, although we foresee the prospect of an industry association, offering standardized materials and approaches that address the range of highway construction environments.

17. Worker Status Monitoring and Alerting Technologies

Type of Countermeasure: *Operational*

Alertness monitoring involves tracking the performance or physiological measures of workers to determine if they are approaching drowsiness or impairment. *Operator status* monitors seek to measure and record, in real time, some physical or physiological features of the operator's eyes, face, head, heart, brain electrical activity, brain blood flow, muscular activity, reaction time, etc. *Embedded measure* technologies compare current operator state on some aspect of performance on the task at hand, e.g., lane deviation or steering variability in a vehicle.

Virtually all of these technologies are in the research stage. There is no research on how to best warn (alert) when a degraded state of impairment or drowsiness is detected. While some devices may be commercially available, there is not yet sufficient evidence about their reliability, validity, and effective use to warrant routine implementation.

Some of the questions that need to be answered include:

- What are "normal" versus safety critical "abnormal" values for the measures generated by the device?
- What constitutes acceptable performance for operators on a given task? Alternatively, are downward trends or gradual performance degradation seen?
- Could a perfectly safe operator be classified as "unacceptable" on occasions (e.g., score a false positive)?
- What measures are best for providing an "early warning" so that operators have not already gone too far into the impairment zone?

Suitable answers to these and other questions must be developed for each monitoring technology and for workers in each mode of operation.

Effectiveness

Although some reliability has been shown in laboratory situations, technological status monitoring for worker fatigue has not been effectively implemented in operational settings. Workers tend to find the technologies obtrusive.

Highway Construction Environment Implementation

This approach does not yet warrant consideration for implementation in the highway construction environment.

18. Bright Light or Melatonin for Circadian Shifting

Type of Countermeasure: *Operational*

The use of bright light as an operational fatigue countermeasure refers to timing the exposure to outside or bright indoor light in order to shift the circadian rhythm to correspond to a new work schedule, or to acutely enhance alertness.

Melatonin is a hormone produced by the pineal gland in the brain, which is secreted during the evening and night hours. Synthetic or natural melatonin is used in high doses to induce sleepiness and/or adjust the circadian rhythm to new schedules.

Bright Light

One reason that shift workers are sleep deprived is that their circadian rhythms do not adjust from that of a day-oriented worker because of the constant exposure to day-oriented *time cues* such as bright light and social activity. Bright light can be used in several ways to help overcome fatigue:

- Bright light exposure in the evening shifts the circadian rhythm to a later time, such that maximum drive for alertness shifts from the evening to the night.
- Bright light exposure in the early morning shifts the circadian rhythm to an earlier time, such that maximum drive for alertness shifts from the evening to the afternoon.
- Day-to-day bright light exposure carefully adapted to the shifting circadian rhythm can result in further shifts to later or earlier times as desired.
- Bright light exposure at any time of day also results in an acute alertness boost, which lasts as long as the light exposure continues.

Achieving the desired effect from bright light, for example to adapt to a new work schedule, requires careful planning of the time of administration, knowledge of the present state of the circadian rhythm to figure this out, and avoiding bright light at times when it is not supposed to be administered. In practice, therefore, only the acute alerting effect of bright light can be effectively achieved. There may, however, be side-effects of unintended circadian shifts, which may make it difficult to readjust to a normal schedule, for instance after a weekend closure with much nighttime bright light exposure.

Use of light exposure for resetting the circadian rhythm is a complex undertaking, and should be guided by a person knowledgeable in circadian physiology. Additionally, the benefits of resetting the circadian rhythm can be maintained only through fairly rigid adherence to the procedure, and ensuring that other time cues (e.g., daylight) are minimized. That is, in addition to *light* exposure, it is also important to control the timing of *darkness*. This is especially true for those workers who may be traveling between work and home in the bright morning sun. In these cases, it is important to minimize exposure to the sunlight by wearing dark glasses (special goggles are recommended).

Melatonin

Melatonin in pharmaceutical doses (0.3 to 5 mg) has fairly rapid sleep inducing effects, and lowers alertness and body temperature following administration. When combined with proper timing and managed light exposure, melatonin can help to adjust the circadian rhythm to a new schedule by shifting the circadian rhythm.

Like bright light, melatonin can be used in several ways to help overcome fatigue:

- Melatonin administration in the evening shifts the circadian rhythm to an earlier time, such that maximum drive for sleep shifts from the night to the evening
- Melatonin administration in the morning shifts the circadian rhythm to a later time, such that maximum drive for sleep shifts from the night to the morning
- Day-to-day melatonin administration carefully adapted to the shifting circadian rhythm can result in further shifts to earlier or later times as desired
- Melatonin administration at a time of day when sleeping is normally difficult opens the gate for sleep

Note that the circadian rhythm-shifting effects of melatonin work in the opposite direction as those of bright light.

The timing of melatonin is an important factor—it needs to be taken in the proper relationship to the body's biological rhythm in order to achieve the desired effect. Using melatonin to *delay* the circadian rhythm is especially complicated because of the interaction with daylight, which is a more powerful adaptation mechanism. As with bright light, use of melatonin for resetting the circadian rhythm is a complex undertaking, and should be guided by a person knowledgeable in circadian physiology. Additionally, the benefits of resetting the circadian rhythm can be maintained only through fairly rigid adherence to the procedure, and ensuring that other time cues (e.g., daylight) are controlled.

The Food and Drug Administration does not regulate the sale of melatonin, so the quality of products available in health food stores and other outlets is uncertain.

Because use of melatonin can cause drowsiness, it should not be taken if an individual intends to drive or engage in other complex or potentially dangerous activity.

The sleep inducing effects of melatonin are temporary, so while an individual may be able to get to sleep at an unusual time by using melatonin, they may not be able to stay asleep for as long as desired. Additionally, various side effects of melatonin have been reported, including worsened fatigue, depression, coronary artery constriction (possibly increasing heart attack risk), and possible effects on fertility. For these reasons, it is important to only use melatonin under the guidance of a properly trained physician.

Effectiveness

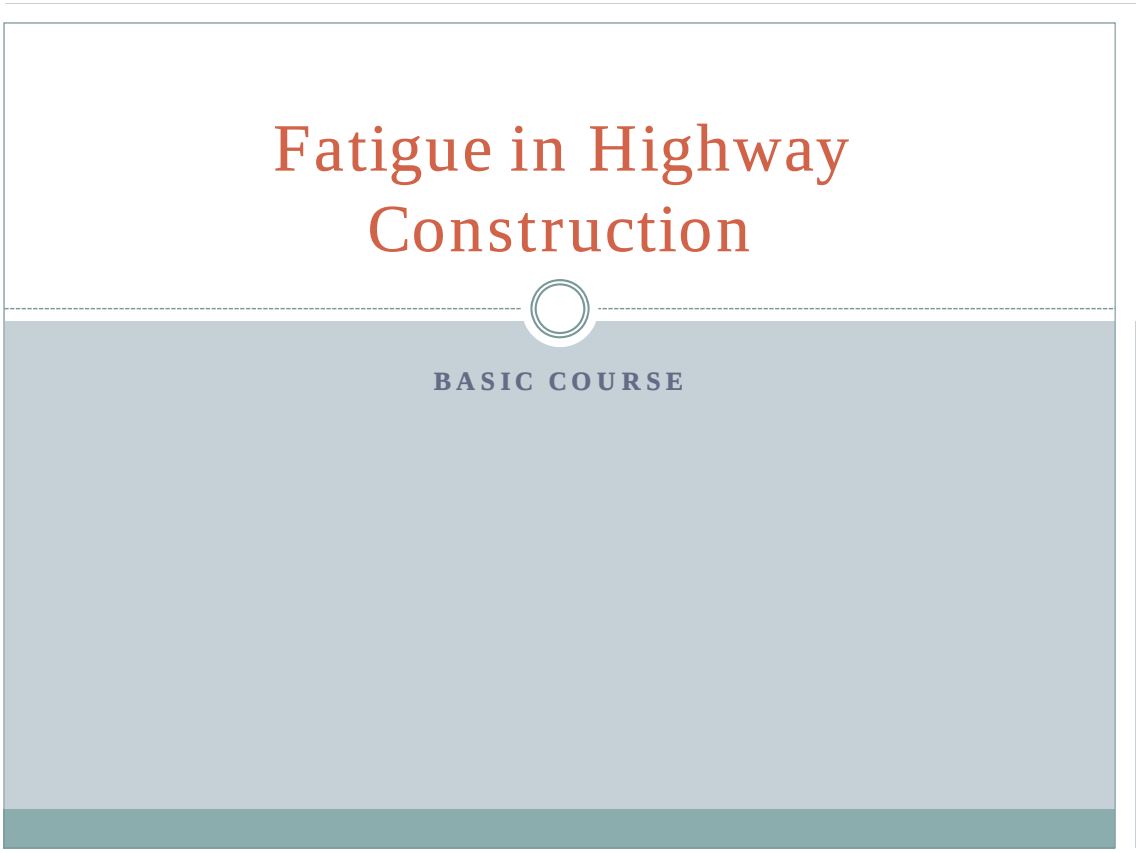
Both bright light and melatonin have been shown, under proper circumstances, to facilitate re-adjustment of the circadian rhythm. Light also has an acute alerting effect which is, however, transient. These countermeasures are difficult to deploy effectively and reliably in an operational environment; thus, they are not considered effective for the highway construction environment.

Highway Construction Environment Implementation

Bright light and melatonin are not recommended for use by highway construction contractors or state agencies. Individuals may seek medical advice regarding their application, but they should not be generally promoted by the organization.

CHAPTER 4 TRAINING MATERIAL

BASIC COURSE

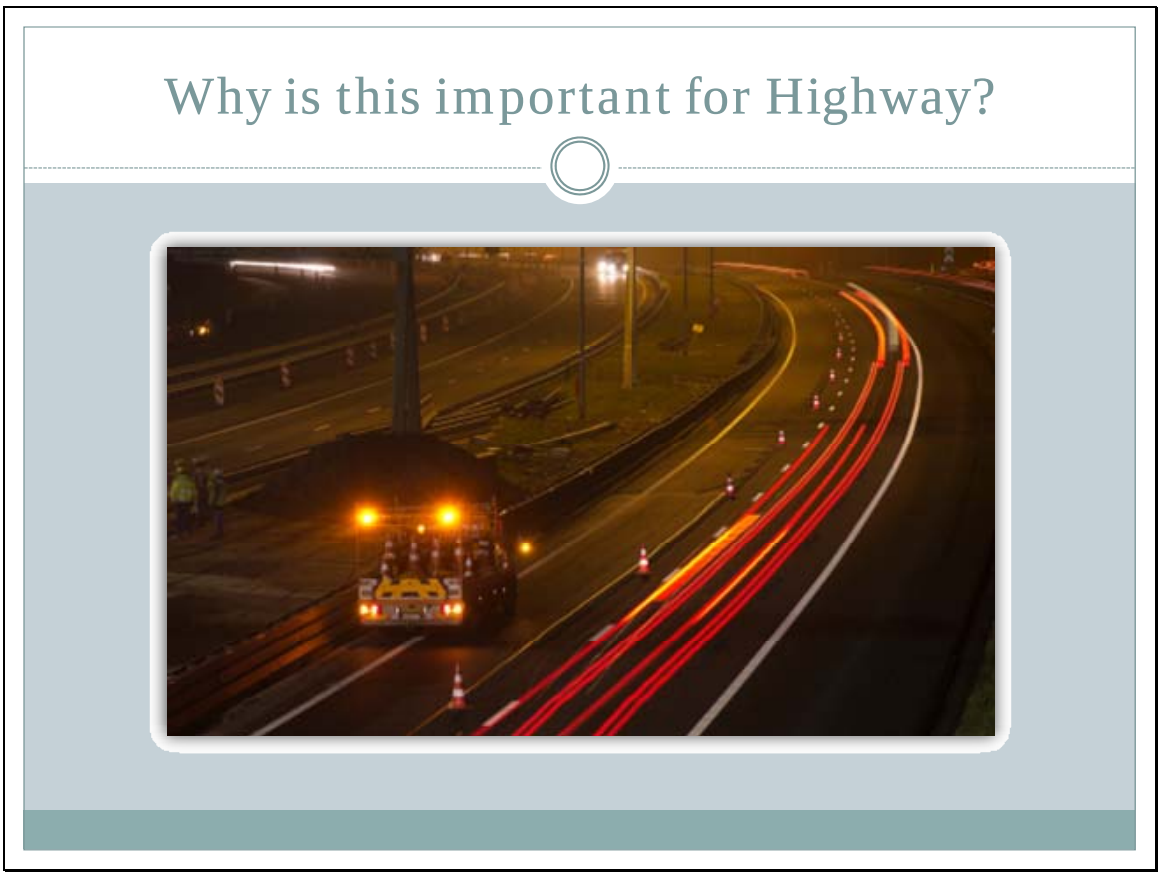


HOW TO USE THIS PRESENTATION

In most cases, the information presented on each slide can be verbally summarized for the audience. However, many slides are designed to draw focus to items and information that either (1) require particular or progressive emphasis, or (2) give you time to offer any necessary elaboration. Pay close attention to the instructor's notes for each slide so that you are aware of any special conditions or instructions that must be followed for that slide.

In each slide's speaker notes, sentences in ITALICS are instructions for how to present the information. Content that is not in italics should be presented as elaborative material for the audience.

At the end of the speaker's notes is a ******REFERENCES*** *section that provides the citation for the slide's source material, along with any supporting information necessary.*



Introductory remarks, presented to the audience verbally:

Why is fatigue important for Highway?

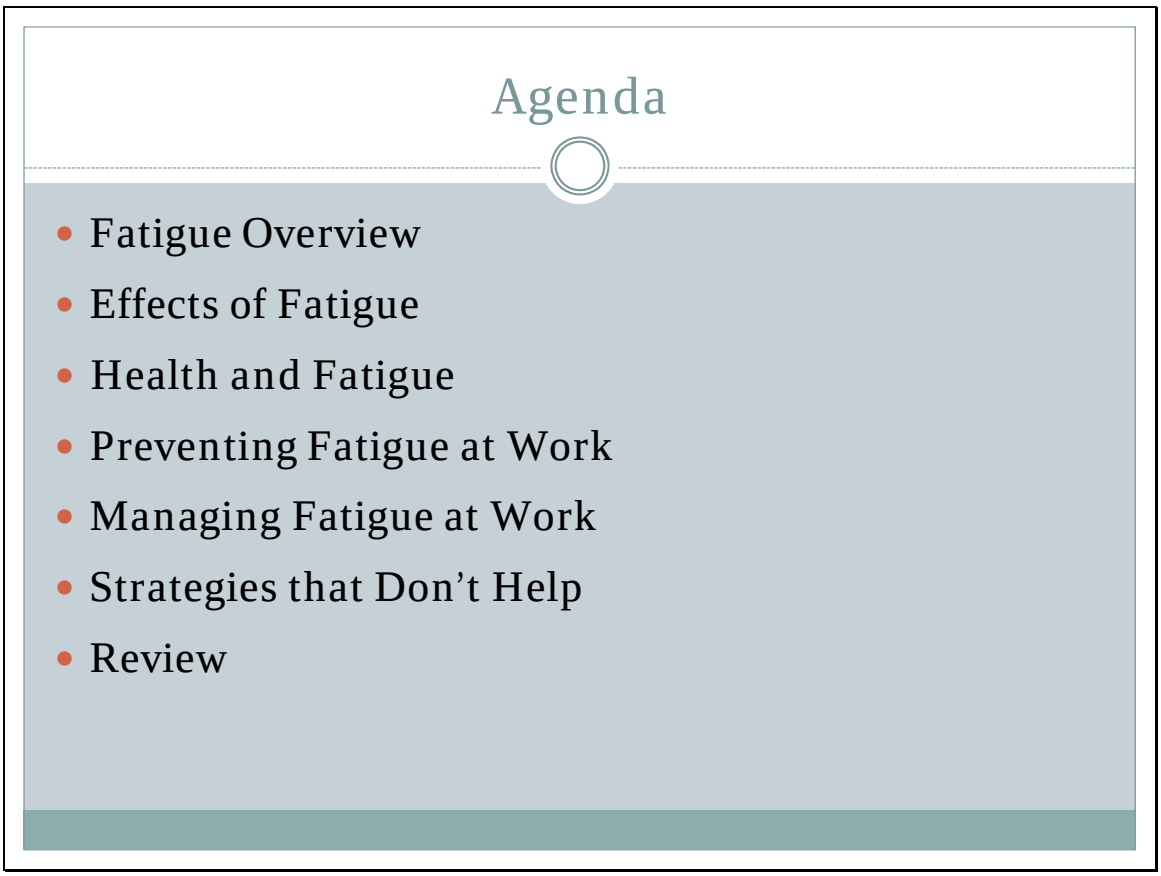
Our highways are aging, and at the same time they are growing more crowded.

Accelerated construction schedules that minimize the impact of construction on traffic flow, especially during peak periods, are becoming more and more common.

Working conditions associated with accelerated construction include conducting work during off-peak hours, continuous week-end construction, extended night-time operations, and conducting work in zones adjacent to traffic.

All of these working conditions have the potential to increase workforce fatigue and stress, resulting in reduced levels of workforce safety and construction productivity.

For this reason, training has been developed to alert workers and managers of the causes and effects of fatigue, as well as what can be done both to reduce fatigue at work and to mitigate the effects of fatigue on workplace safety.



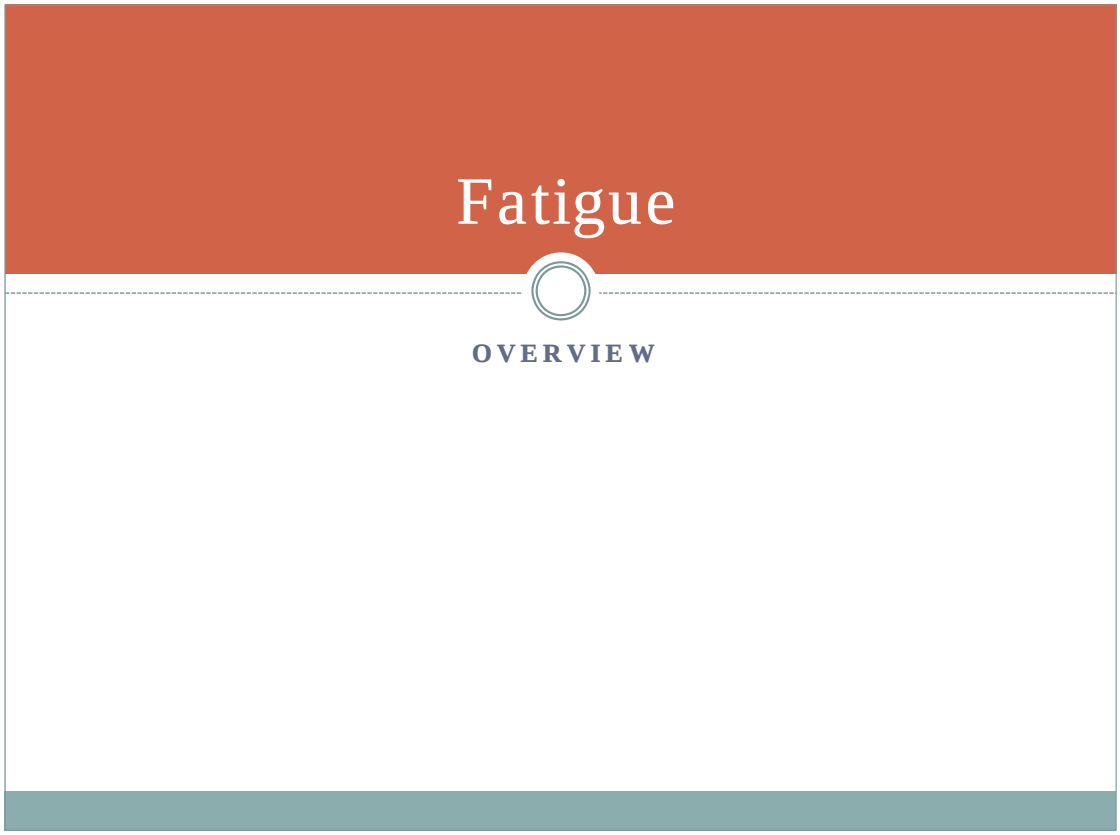
Summarize as shown.

Learning Objectives

Upon completion of this module, you will be able to:

- Identify the symptoms of fatigue
- Understand the ways fatigue can affect your work
- Understand how health and fatigue affect each other
- List ways to prevent and manage fatigue at work
- Understand things that *don't* help when you're fatigued

Summarize as shown.



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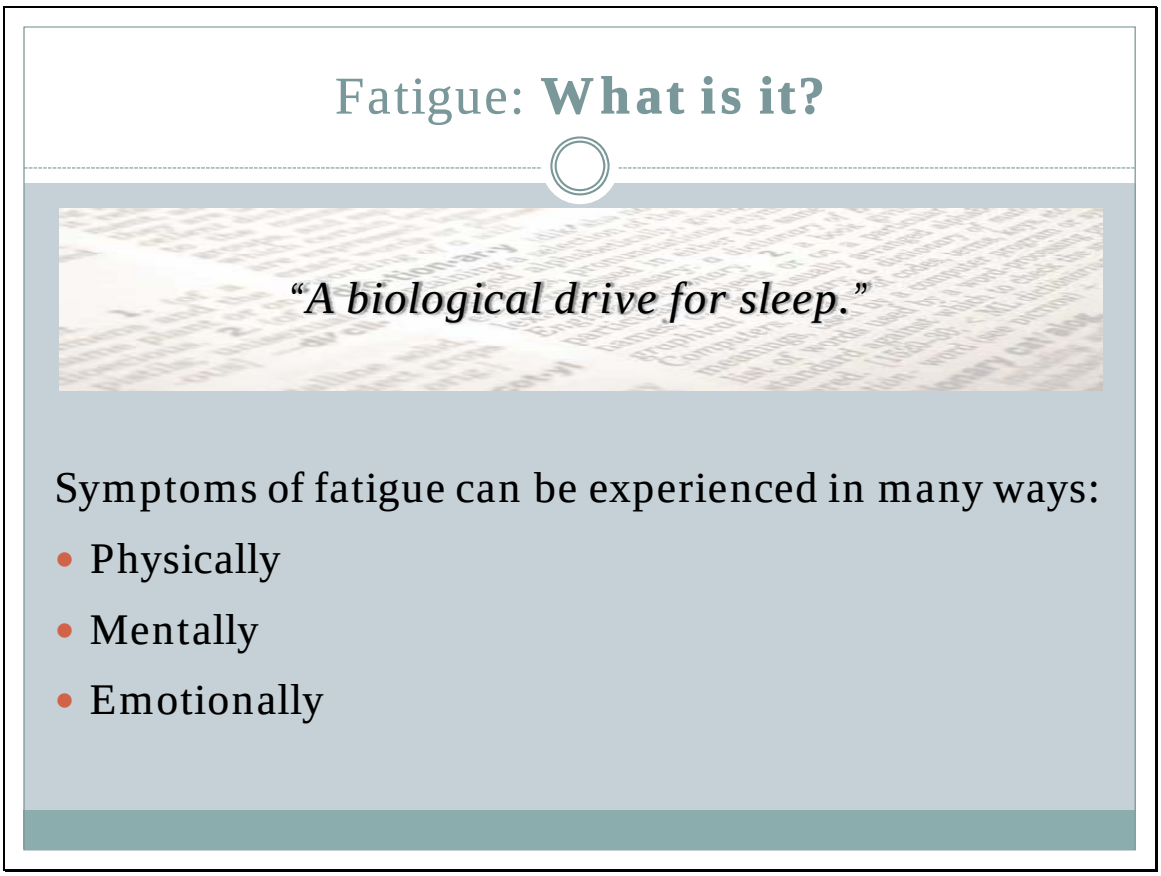


Summarize as shown, then introduce upcoming slides:

Symptoms of fatigue can be **physical, mental** or **emotional**.

***REFERENCES:

"Fatigue" definition in: Williamson, A., D. A. Lombardi, S. Folkard, et al. (2011). The link between fatigue and safety. *Accident Analysis and Prevention, 43*(2), 498-515.

Fatigue: **Physical Symptoms**

- Yawning
- Blinking
- Rubbing eyes
- Falling asleep by accident (“microsleeps”)

Summarize as shown.

Fatigue: **Mental Symptoms**

You may have difficulty with:

- Concentrating and paying attention
- Making decisions
- Remembering things
- Calculations or problem solving

Summarize as shown.

Fatigue: **Emotional Symptoms**

You may feel:

- Quieter or more withdrawn than usual
- Irritable
- Unmotivated

Summarize as shown.

Fatigue: **Level of Fatigue**

The amount of fatigue you feel depends on:

- Wakefulness

  Total time you have been awake

- Circadian cycle

  Your internal "body clock" that helps you sleep at night and stay awake during the day

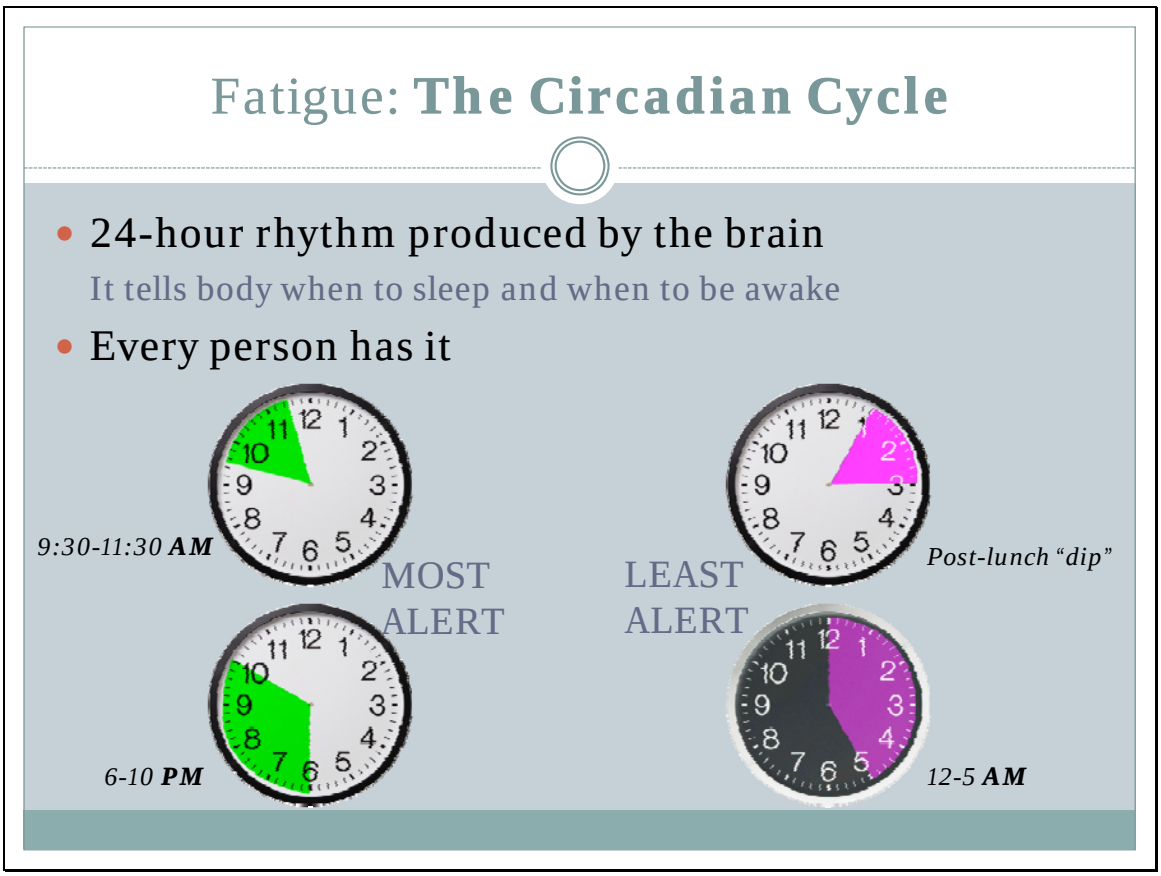
Summarize as shown. Each item will be summarized on upcoming slides.

Fatigue: **Wakefulness**

- Most people require 7 to 9 hours of sleep in a 24-hour period
- Every hour of sleep "buys" 2 hours of wakefulness
- If you get less sleep than you need, you create a ***sleep debt***
  - Sleep debt *builds up* over time
  - Once you have a sleep debt, you need *additional sleep* to catch up

Summarize as shown. Elaborate on concept of sleep debt :

For instance, if you require 8 hours of sleep, and you only get 6, you have a 2 hour sleep debt. Therefore, the following sleep period might require an extra 2 hours for you to "catch up."



Summarize as shown. Elaborate as follows:

Most people are **least alert** between midnight and 5:00 am, and in the early afternoon (the **"post-lunch dip"**)

Most people are **most alert** in the midmorning and early evening

Circadian cycle **can be disrupted** by travel between time zones **("jet lag")**, or **by working shifts that require you to be awake when you are primed to be sleeping**, and vice versa.

The circadian cycle is a little different for everyone. Not everyone will have the same low points and high points. For example, the "post-lunch dip" is felt most strongly by people who are not getting enough sleep.

Fatigue: **Hours At Work**

Work-related fatigue is caused by:

- The amount of sleep your work schedule allows
  - Your off-duty time is the time not spent working ***or*** commuting
  - The demands of your daily life will affect how much off-duty time you actually spend sleeping.
- The time of day you are working

Summarize as shown.

Elaborate on schedule and off-duty time:

If you work a 10-hour shift and your commute is an hour each way, you have 12 hours of time off-duty.

For a 12-hour shift, your off-duty time is only 10 hours.

Elaborate on what "demands of daily life" means:

Other "demands of daily life" include things such as:

- household chores and errands
- self-care (meals, exercise, personal hygiene, doctor's appointments)
- parenting
- socializing, etc.

"Time of day working" will be elaborated on the next slide.

Fatigue: **Work Shifts**

- Night shifts are more fatiguing than day shifts
  - Most people get less sleep during daylight hours (adding to *sleep debt*)
  - Circadian cycle makes you less alert at work
- Early morning starts (7:00 A.M. or earlier) can be fatiguing because your night's sleep may be cut short
  - You may get up at 5:00 A.M. or earlier, but…
  - You may not adjust for it by going to bed earlier

Summarize as shown, and elaborate:

Re: working night shift: Most people get less sleep during daylight hours because there is too much light or activity to sleep well, and also because the circadian cycle makes it difficult to sleep deeply during hours you are supposed to be awake. Most people also feel sleepier at work on night shift because the circadian cycle is trying to help them sleep.

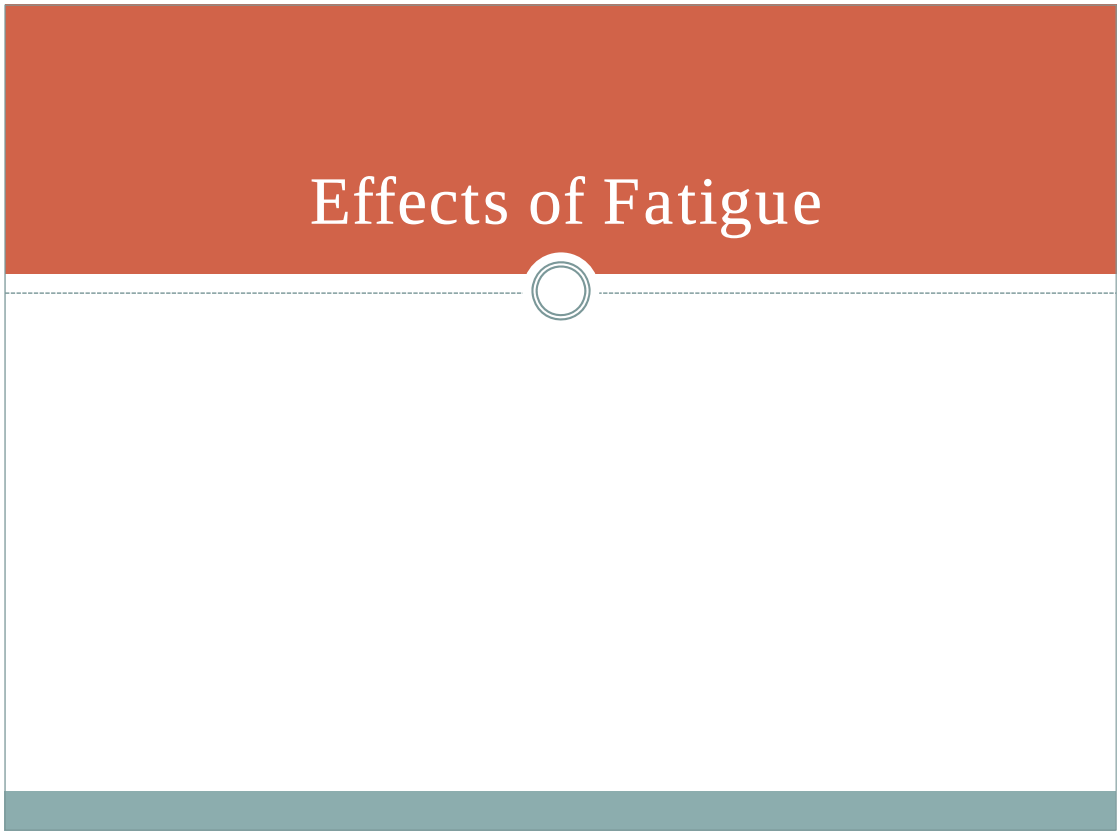
Introduce later sections:

We will talk more about work schedule and fatigue risk later in this training.

Fatigue: **Questions**

- What are some symptoms of fatigue?
- What times of day are you most alert? Least alert?
- How many *off-duty* hours do you have:
  - ...on most days?
  - ...today?

*These questions may be appropriate for either personal assessment **or** group discussion.*



Section heading.

Effects: **Mental Performance**

Fatigue affects your ability to perform work.

- Lack of sleep causes slow reaction times and impairs judgment
- You may not always admit how tired you are
- If you have a sleep disorder or other medical problem, sleep loss can affect you more

Summarize as shown. Elaborate as follows, by bullet point:

In laboratory experiments, people who are deprived of sleep have slower reaction times and do worse on basic neurological tests.

Workers may be motivated by a desire for overtime hours, and also by a desire to appear "in control" (competent, dependable) to coworkers and supervisors.

Not everyone responds to sleep loss the same way; you may have more or less impairment than other people because of individual differences in need for sleep, your sensitivity to caffeine, and sleep disorders or other medical conditions.

Effects: **Errors & Accidents**

Working long hours is related to increased accidents:

- Doctors are more likely to make medical errors
- People are more likely to have car accidents
- Many railway and airplane accidents are blamed on fatigue

Summarize as shown. Elaborate as follows:

Doctors working very long hours are also more likely to have accidental needle-sticks (they stick themselves with a needle intended for a patient).

People working longer hours are more likely to have car accidents while commuting .

Fatigue related to work schedule has been blamed for many railway and airplane accidents.

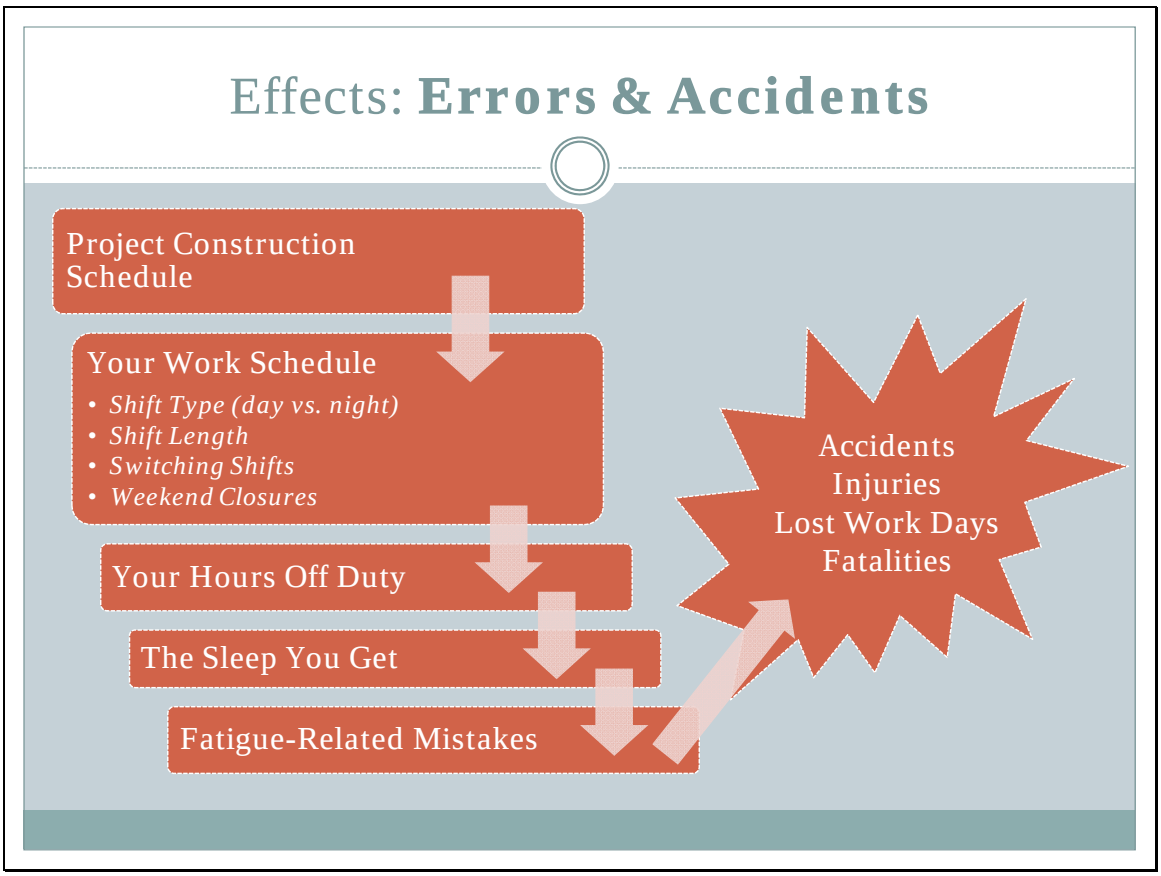
Effects: **Errors & Accidents**

In factories and on construction sites, your chance of an injury goes up when you:

- Work shifts longer than 8-10 hours
- Work 10 or more overtime hours per week
- Work a night shift

Construction workers are ***three times more likely*** than average to have an injury that requires time away from work

Summarize as shown.



Summarize as shown. Elaborate:

This figure shows **the relationship of fatigue to errors and accidents.**

The **project construction schedule** determines what kinds of crews are needed for the job, and what kinds of schedules they will work.

Your **work schedule** and commuting time determine your hours off-duty. Long shifts and weekend closures in particular can severely impact your off-duty time.

Your **off-duty time** partially determines the amount of sleep you get; the sleep you get is also affected by your other commitments, your personal choices, and how well you sleep once you go to bed. Night shifts and switching shifts can also affect the sleep you get even if you have enough off-duty time to get 8 hours of sleep, because it can be difficult for most people to adjust their sleep schedules.

Getting too little sleep increases your chance of making a mistake because it slows reaction time and impairs good judgment.

Not all **fatigue-related mistakes** lead to a serious problem, but if you make a mistake at a critical moment the effects can be disastrous, and may include injury or death.

**********For example: INSTRUCTOR TO PROVIDE EXAMPLE HERE.

Effects: Fatigue and **Construction Schedules**

Highway projects frequently have schedules that can contribute to fatigue:

- Shifts longer than 8 hours
- Frequent night work and switching day/night shifts
- Working more than 5 days in a row, especially if weekend closures are involved

Summarize as shown.

Effects: Fatigue in **Hazardous Environments**

Fatigue in highway construction can be more serious due to the more hazardous environment

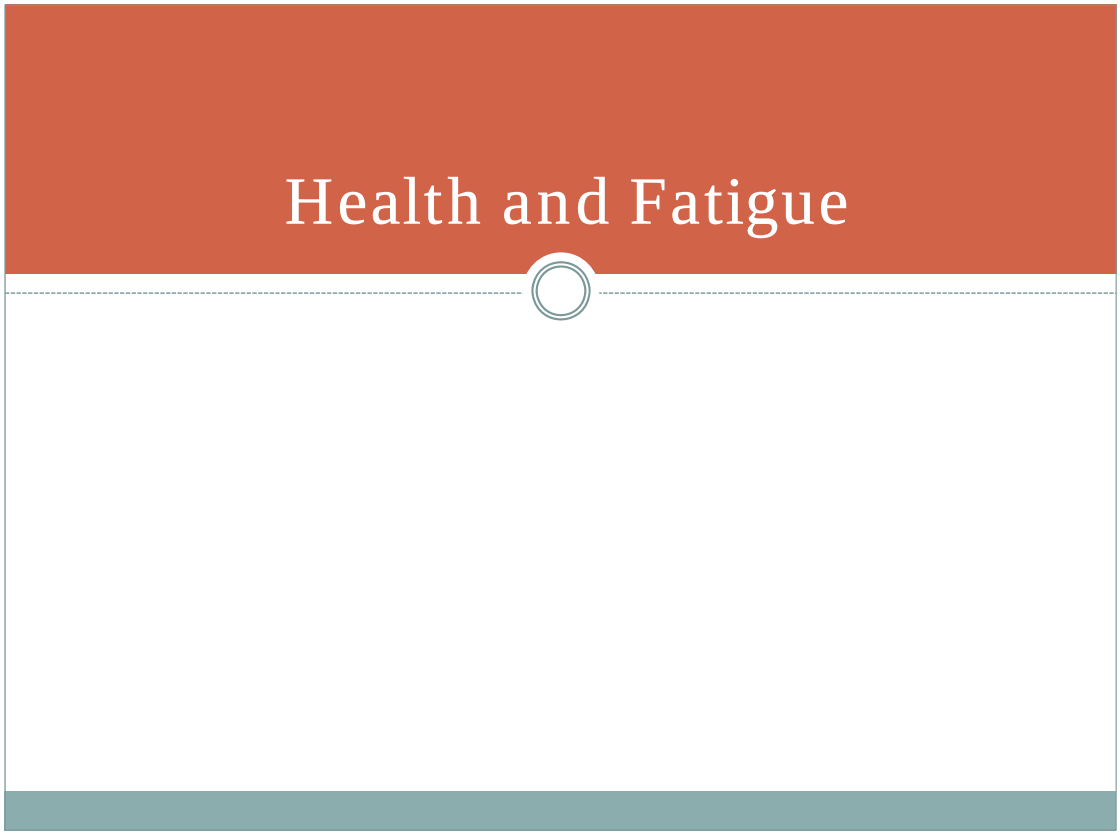
- Close proximity to car traffic
- On-site heavy traffic (trucks, for example)
- Operation of heavy equipment close to workers on the ground

Summarize as shown.

Effects: **Questions**

- What incidents at work have you seen that might have been caused by fatigue?
- What kinds of schedules have you worked where you might be more likely to make a fatigue-related mistake?

*These questions may be appropriate for either personal assessment **or** group discussion.*



Section heading.

Health and Fatigue: **Exercise**

Regular exercise can help you sleep better, because it:

- Reduces stress
- Improves mood

Avoid vigorous exercise before bedtime… it can keep you awake

Summarize as shown, and elaborate:

Try to exercise more than 6 hours before going to bed to avoid wakefulness.

***REFERENCES:

Sunao U., Shioda, K., Morita, Y., et al. (2012). Exercise effects on sleep physiology. *Front Neurol*, *3*, 48.

Zarcone, V. P. (2000). Sleep hygiene. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and Practice of Sleep Medicine* (pp. 657-662). New York: W. B. Saunders Company.

Health and Fatigue: **Diet**

- An unusual work schedule can disrupt healthy eating habits
  - You may not be participating in regular mealtimes
  - Hunger patterns are linked with your circadian cycle
- Night shift can affect how the food you eat makes you feel
- Make an effort to eat healthy foods, even when your schedule makes this difficult
  - Try to plan your meals at work ahead of time to avoid eating "junk foods"
  - Night shift makes some people crave junk foods

Summarize as shown, and elaborate:

Intro: There are issues related to diet that you should take into consideration when you are working very long hours or at night.

It can be hard to maintain a healthy diet when you are not sitting down with your family for regular meals. Also, since hunger and appetite are related to circadian cycle, you may not feel hungry when you have a meal break at work, or you may feel more hungry than normal.

How your stomach and other digestive organs function is also related to circadian cycle. This means that some people get upset stomachs, or even ulcers, while working nights shifts. Pay attention to how the food you eat makes you feel while working night shift, and avoid foods that you know will make you feel bad. Poor digestion can also affect your sleep quality, adding to fatigue.

Food that is available at or near job sites may not be the healthiest options. Packing your meals and snacks makes it less likely that you will eat junk food at work.

Health and Fatigue: **Sleep Disorders**

- Sleep disorders affect most shift workers
- Know the main types, and see a doctor if you think you have one:
  - ***Insomnia*** – difficulty falling asleep or staying asleep
  - ***Sleep Apnea*** – main symptoms are snoring, daytime sleepiness
  - ***Restless Leg Syndrome*** – the irresistible urge to move the legs, especially at night

Summarize as shown, and elaborate:

Not only do most shift workers, including construction workers, have a sleep disorder, some sleep disorders can even be ***caused*** by shift work. Sleep disorders can be hazardous to your health because they prevent you from getting enough sleep, and can contribute to fatigue at work.

It is important to know whether you have a sleep disorder so you can get treated for it, and reduce the chance of a fatigue-related incident at work.

Insomnia is usually related to stress and sleep schedules that changes frequently. The main symptoms are difficulty falling asleep or staying asleep.

Sleep apnea is common among men between the ages of 30 and 60, and is more common in people who are overweight, or who use alcohol excessively.

Health and Fatigue: **Sleep Disorders**

See a doctor, if:

You often feel tired at work or during the day, even when you try to get enough sleep.

You may have a sleep disorder.

For more information, visit the

National Sleep Foundation:

www.sleepfoundation.org

Summarize as shown, and elaborate:

Insomnia, sleep apnea and restless leg syndrome are very common sleep disorders, but there are many others.

The National Sleep Foundation provides detailed information about sleep and sleep disorders.

***REFERENCES:

Aldrich, M. S. (1989). Automobile accidents in patients with sleep disorders. *Sleep*, 12,487–494.

Bixler, E. O., Vgontzas A. N., Ten Have, T., et al. (1998). Effects of age on sleep apnea in men: I. Prevalence and severity. *Am J Respir Crit Care Med*, 157, 144–148.

Chau, N., Mur, J., Benamghar, L., et al. (2004). Relationships between certain individual characteristics and occupational injuries for various jobs in the construction industry: A case-control study. *Am J Ind Med*, 45, 84–92.

Findley, L. J., Unverzagt, M. E., and Suratt, P. M. (1988). Automobile accidents involving patients with obstructive sleep apnea. *Am Rev Respir Dis*, 138, 337–340.

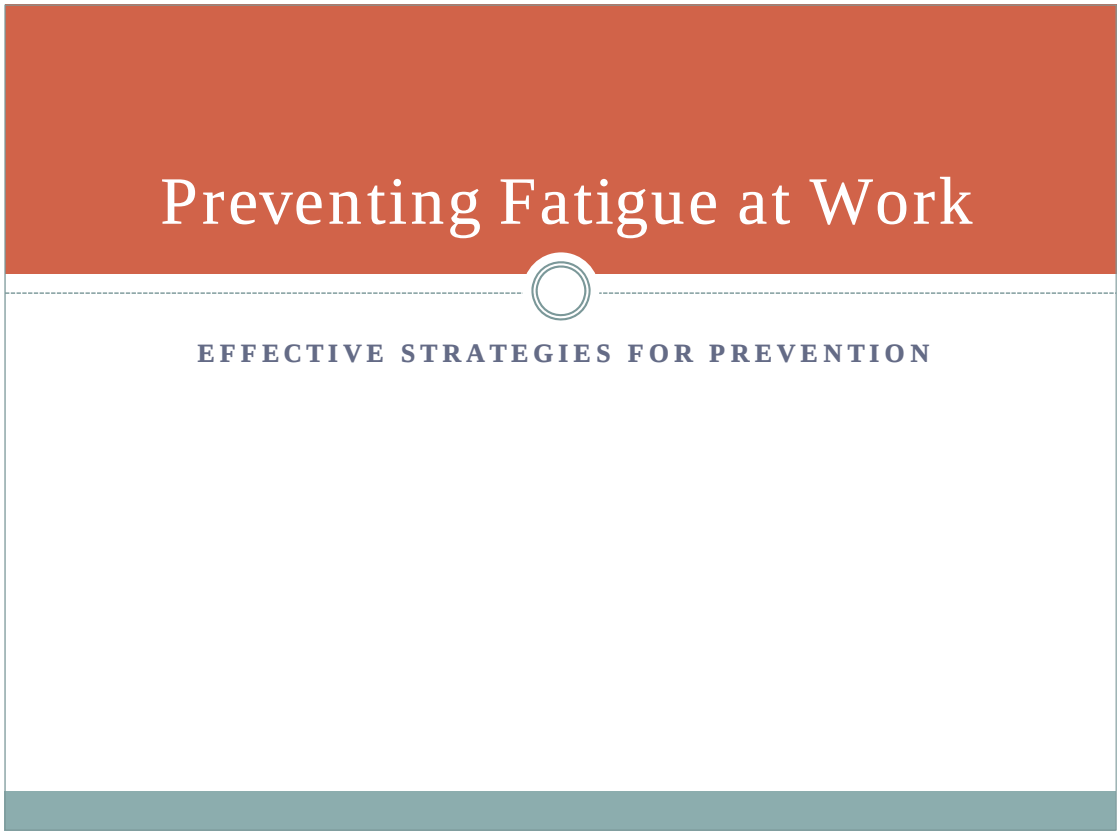
Guilleminault, C., Czeisler, C., Coleman, R., and Miles, L. (1982). Circadian rhythm disturbances and sleep disorders in shift workers. *Electroencephalogr Clin Neurophysiol Suppl*, 36, 709–714.

Leger, D. (1994). The cost of sleep-related accidents: A report for the National Commission on Sleep Disorders Research. *Sleep*, 17, 84–93.

Health and Fatigue: **Questions**

- Why is it important to be aware of my diet when working night shifts?
- What are some common signs of sleep disorders?

*These questions may be appropriate for either personal assessment **or** group discussion.*



Section heading.

Preventing Fatigue at Work

These strategies are your first line of defense against fatigue at work:

- **Get Enough Sleep** each night
- **Take Naps** at home on your days off
- Create a **Good Sleep Environment** at home

Remember –
nothing can replace getting enough sleep

Summarize as shown. Each item will be summarized on upcoming slides.

Preventing Fatigue: **Get Enough Sleep**

Sleep loss is the primary reason for fatigue.

Getting sufficient sleep is the best strategy for avoiding fatigue.

Summarize as shown.

Preventing Fatigue: **Get Enough Sleep**

Best ways to minimize sleep loss:

- Get enough sleep each day
  As much as possible, **sleep 7 - 9 hours** in a single block
- Have a regular routine
  Go to bed and wake up at the same times every day
- If switching to night shift, try to get ***two full nights of sleep*** before starting nights
- If you lose sleep for a night or two, get more sleep as soon as possible

Summarize as shown, and elaborate:

Most people need between 7 and 9 hours of sleep in a 24-hour period, and it is best to get this sleep in a single block whenever possible.

Having a regular sleep routine will help you get to sleep more easily.

For example, if you are switching to a night shift after a weekend off, get two full nights of sleep before starting the night shift. If you start night shift on a Monday, this means making sure you get full nights of sleep on Saturday and Sunday.

If you lose a few hours of sleep on one or two nights, it is important to make up this sleep as soon as you can, because short-term sleep loss can have a long-term affect on your level of fatigue. Take naps when you are able, and sleep in on the weekend, until you are caught up.

Preventing Fatigue: **Nap at Home**

Naps at home are:

- *Most effective* when taken about **8** hours after you wake up.
- *Least effective* when taken about **12** hours after you wake up.

Summarize as shown, and elaborate:

Most people experience the “post-lunch dip” about 8 hours after waking up, which is why this is a good time for a nap.

There is a period of high alertness in the early evening, which starts about 12 hours after most people wake up. This is why it is difficult to take a nap in the evening.

Taking naps on your day off is only recommended when you feel sleepy and you need to “catch up” on sleep you may have missed during the work week. Too much napping can interfere with your regular sleep times and should be avoided. In general, it is best to try and get your needed sleep during your main sleep period each day.

Preventing Fatigue: **Nap at Home**

When switching from day shift to night shift:

- Take a 2-hour nap in the early afternoon of the day you begin a night shift.
- *Don't* take a nap in the evening before your night shift starts.

Summarize as shown, and elaborate:

This long nap in the early afternoon should happen when your alertness is naturally low, starting between about 1 and 3 pm. Taking this long nap before your first night shift will help "take the edge off" of the fatigue you will feel your first night. It is also a good way to "erase" some of the sleep debt you may be carrying from the week before.

As with other naps you take on your days off, avoid taking a nap in the evening before your first night shift. It will be difficult to fall asleep, and you may feel groggy at the start of your shift.

Preventing Fatigue: **Sleep Environment**

Good sleeping conditions prevent fatigue.

Things ***To Do:***

- Keep your bedroom dark and quiet
  - Use blackout shades or earplugs as necessary
  - Remove interruptions (children, pets, phones, etc.)
- Keep your bedroom a comfortable temperature
- Go to bed and get up at the same time every day
- Face your clock away from the bed
- Practice a relaxing bedtime ritual

Summarize as shown, and elaborate:

Make your sleep environment as restful as possible. These strategies are good whether you are working day shift or night shift, but some of these strategies may require more planning when you are working nights.

If possible, remove children and pets from your bedroom; this may mean finding someone else to take care of them while you are sleeping, especially during the day.

Many people find it easier to sleep in a cool bedroom.

Having a regular sleep routine will help you get to sleep more easily; this routine primes your brain to be ready for sleep at bed time.

Turning your clock away from the bed may make it easier not to worry about getting to sleep.

Do something relaxing before bedtime, and make it a habit. Reading before bed time is fine as long as it is not about work.

Preventing Fatigue: **Sleep Environment**

Things ***To Avoid:***

- Don't use your bedroom for things other than sleeping
  No working, watching TV, playing video games, etc.
- No strenuous exercise within 6 hours of bedtime
- Don't eat heavy meals within 3 hours of bedtime
- No caffeine within 5 hours of bedtime (or after 4 pm)
- Don't use alcohol to get to sleep

Summarize as shown, and elaborate:

Using your bedroom only for sleeping primes your brain to be ready for sleep when you are there.

Avoid vigorous exercise near bedtime, but an evening walk may be relaxing.

Heavy meals soon before bedtime can interfere with digestion. If you tend to have indigestion or heart burn, you may want to sleep with your upper body elevated on pillows.

Some people may have to stop using caffeine even earlier in the day than this; pay attention to how caffeine affects you.

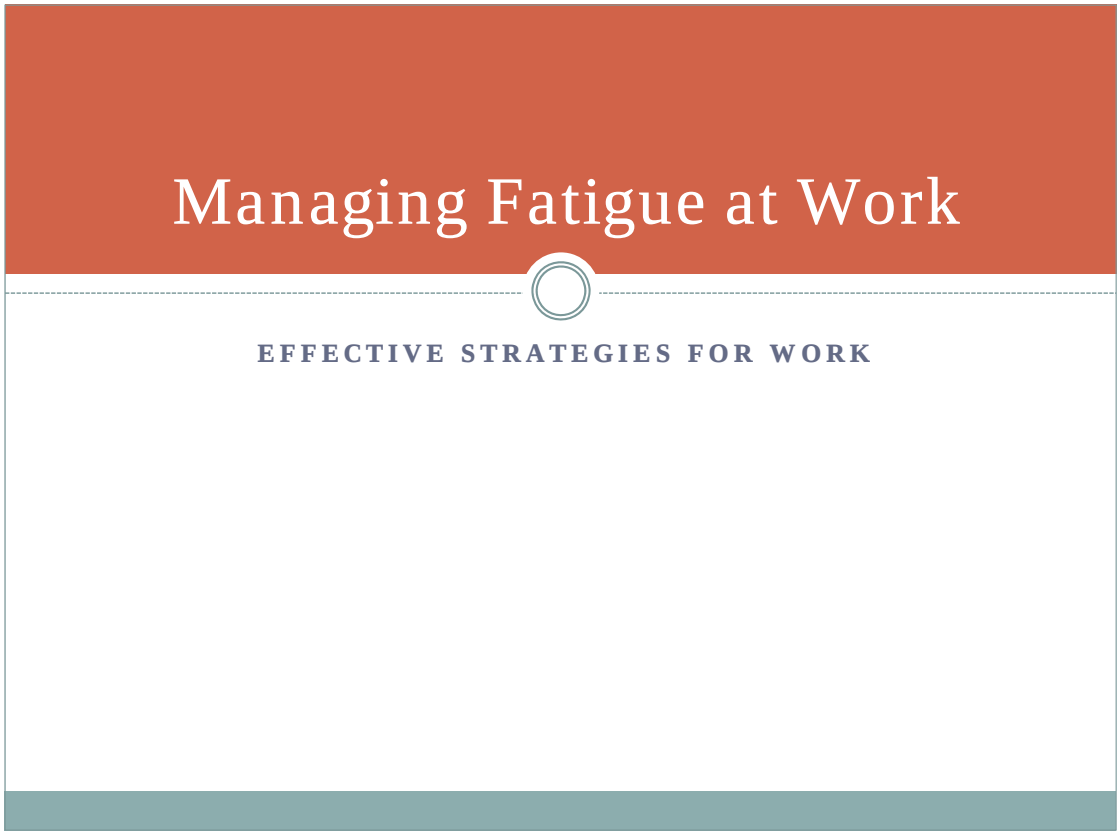
While alcohol may make you feel sleepy temporarily, there can be a "rebound" effect that causes you to wake up a few hours after you fall asleep.

Preventing Fatigue: **Questions**

- What can replace getting enough sleep?
- When could you fit a nap in at home?
- What are some things you could change about your:
  - ...sleep routine?
  - ...bedroom environment?

Answer to first question: NOTHING can replace getting enough sleep. The strategies outlined in this section will help you get enough sleep to arrive at work feeling rested.

*The other questions are intended for personal assessment, **not** group discussion.*



Section heading.

Managing Fatigue at Work

These strategies can help you deal with fatigue *at work:*

- Use **Caffeine** wisely
- **Take a Nap** during your break
- Use **Anchor Sleep** when necessary
- Take **Rest Breaks**
- **Pay Attention** to Yourself and Others

Summarize as shown.

These strategies are useful when you are feeling tired at work and need to get through the shift. They can be used every day, and things like napping may be particularly important when working a night shift. However, most of these strategies only relieve fatigue temporarily, and only sleep can help you recover fully from fatigue.

Each item will be summarized on upcoming slides.

Managing Fatigue: **Caffeine**

It is always best to reduce fatigue through obtaining sufficient sleep.

However, use of ***caffeine*** is an option when you need to boost alertness for several hours.

Summarize as shown. ***Caffeine*** *continues on the next slide.*

Managing Fatigue: **Caffeine**

Caffeine can improve alertness for short periods:

- Caffeine needs 15-2o minutes to start working, and the effects may last 4-5 hours
- You get the biggest benefit when you don't use caffeine all the time
- Coffee and tea are good sources
- Some medications contain large amounts of caffeine (Excedrin, Dristan, No-Doz, Vivarin, etc.)

Summarize as shown, and elaborate:

Caffeine is most effective if you use it only when you really need it. Save the boost for when you really need it by cutting back during times when you don't.

Coffee and tea have more caffeine than most soft drinks and energy drinks. Also, energy drinks and soft drinks usually have a lot of sugar.

Be aware of whether any over-the-counter medications you may be taking contain caffeine, and how much. Some can contain more caffeine than a regular cup of coffee.

Managing Fatigue: **Caffeine**

Times when it can be beneficial to use caffeine:

- Mid-afternoon on a day shift
  Counteracts the "post-lunch dip"
- In the middle of a night shift
- *Right before* a nap at work
  - Caffeine will "kick in" as the nap is ending, which reduces grogginess
  - This caffeine/nap combination can be very useful during a meal break, especially on night shift

Summarize as shown, and elaborate.

If time is short and you want to have caffeinated beverage before taking a nap on your meal break, a **cold** beverage may be easier to consume quickly than a hot one.

Managing Fatigue: **Caffeine**

Things to watch out for:

- Caffeine, if used too close to bedtime, can cause insomnia
- Using too much caffeine over time can reduce its effectiveness

Summarize as shown.

Managing Fatigue: **Napping at Work**

- Taking a 20-30 minute nap can significantly improve alertness
- Even a short (10-minute) "power nap" can help for a short period
- If you are so tired that you are falling asleep on the job, take an "emergency nap" as soon as possible
- Remember the caffeine/nap combination

Summarize as shown, and elaborate:

A nap of 20-30 minutes is probably taken most easily during a meal break.

Even very brief naps can help you feel more alert for short periods of time.

Remember from the section on caffeine: you can drink a cup of coffee right before your nap to help shake off the grogginess when you wake up.

Not all supervisors approve of employees taking naps on the job site, even if it is on a meal break. Consider talking to your foreman or superintendent if you believe napping might cause a problem for you or others.

Managing Fatigue: **Napping at Work**

Things to watch out for:

- Make sure your napping environment is safe:
  Never nap inside a hot vehicle or within the active work zone
- Do not use naps to extend your work shift

Summarize as shown.

Managing Fatigue: **Anchor Sleep**

***ANCHOR SLEEP** (or "split sleep"): A regular sleep period of at least four hours, obtained at the same time each day.*

- Use anchor sleep only when you cannot get 8 hours of sleep in a single block
  - Main sleep period should be **at least 4 hours long**
  - This sleep period should happen at the same time each day
  - You must supplement the main sleep period with additional sleep at other times
- Avoid trying to sleep during times of high alertness (mid to late morning, or evening)

Summarize as shown.

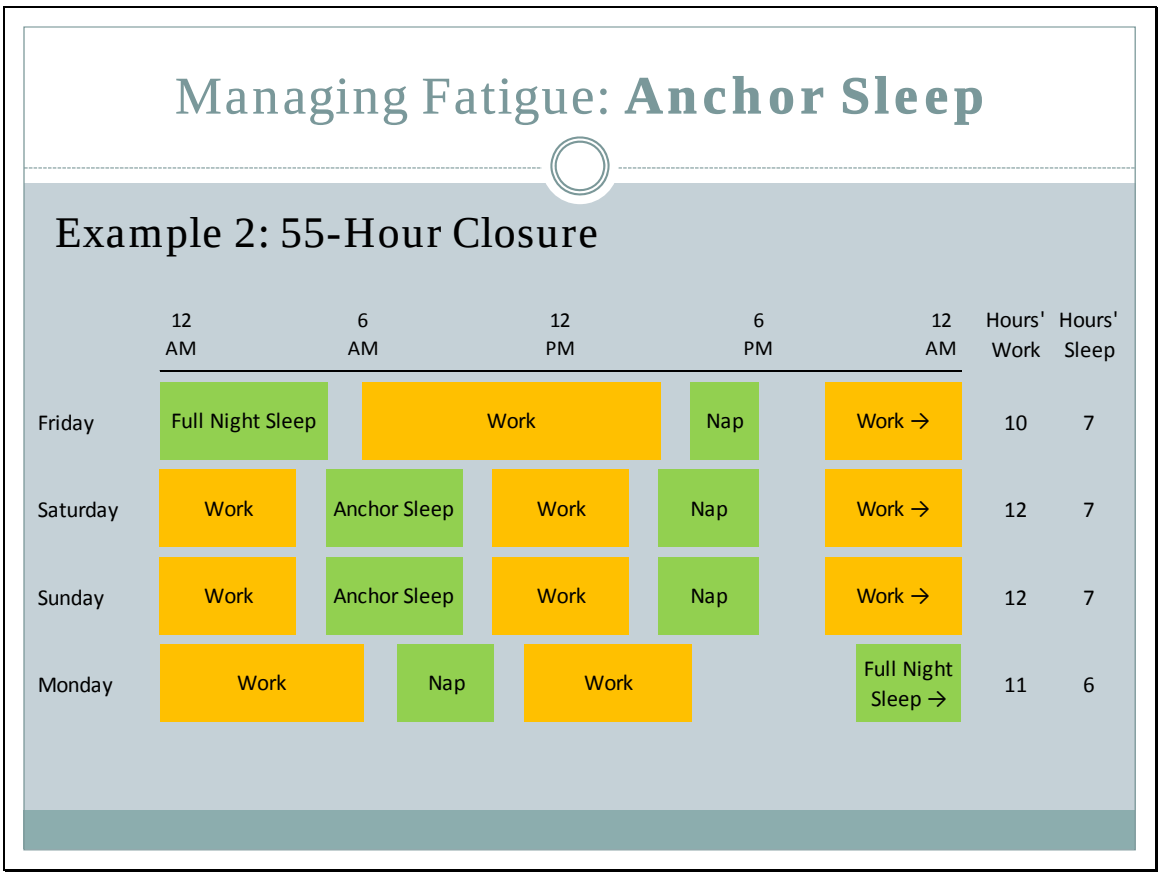
Managing Fatigue: **Anchor Sleep**

Example 1: Short Sleep Period

	12:00 - 4:30 AM	6:00 AM - 4:30 PM	5:30 - 6:15 PM	10:00 PM - 12:00 AM	Hours' Work	Hours' Sleep
Monday	Anchor Sleep	Work	Nap	Anchor Sleep →	10.5	7.25
Tuesday	Anchor Sleep	Work	Nap	Anchor Sleep →	10.5	7.25
Wednesday	Anchor Sleep	Work	Nap	Anchor Sleep →	10.5	7.25
Thursday	Anchor Sleep	Work	Nap	Anchor Sleep →	10.5	7.25
Friday	Anchor Sleep	Work	Nap	Full Night Sleep →	10.5	7.25

Explain as follows:

You usually go to bed at 10:00 pm and get up at 4:30 am, and then work a 10-hour shift from 6:00 am to 4:30 pm: you could take a short nap (30-45 minutes) before dinner every day; start the nap by 5:30 pm to avoid the high alert period that begins in the early evening; try for a total sleep time of **at least 7 hours per 24-hour period** during the work week; this figure shows a 45 minute nap from 5:30 to 6:15 pm every week night.



Explain as follows:

This anchor sleep schedule may be appropriate for managers who want to be available during a 55-hour weekend closure, and their work and sleep schedule could look something like this. They stop work a little early on Friday to take a long nap to prepare for being on site overnight; they take their anchor sleep in the early morning Saturday and Sunday, which they supplement with naps later in the day; they take a nap early Monday morning, then work a few hours Monday afternoon, and get a full night's sleep Monday night; on Tuesday morning they could sleep a little longer than usual to make up for getting only 6 hours of sleep on Monday.

Managing Fatigue: **Rest Breaks**

Rest breaks can temporarily reduce mental fatigue and help you work better.

- Breaks can be as short as 7 minutes, and can relieve fatigue for up to 25 minutes
- Your break should allow you to walk around, stretch, talk with friends and coworkers, etc.

Summarize as shown, and elaborate:

The point of a rest break is that it gives you a mental break from the task you are working on. It is important to “get away from work” mentally during this period of time.

Managing Fatigue: **Rest Breaks**

- Take a break whenever you find yourself losing focus during a critical task, especially if safety could be affected
- Try taking a break before a task that requires concentration
- Breaks may be more useful towards the end of the shift

Summarize as shown, and elaborate:

Rest breaks are a good way to improve alertness whenever you are performing a difficult task. Taking a break before a task can help you perform it better and more safely.

Rest breaks are most useful when you are feeling fatigued, so you may find that they are more important towards the end of your shift than at the beginning.

Managing Fatigue: **Pay Attention** to Yourself and Others

Your fatigue can affect your coworkers' safety, and vice versa.

- Pay attention to whether you or your coworkers are showing signs of fatigue
  - Symptoms of fatigue can be physical, mental or emotional
  - You or your coworker may be working more slowly or less accurately than usual
  - Not everyone will show obvious signs of fatigue
- Be mindful of your and your coworkers' sleep and work schedules

Summarize as shown, and elaborate:

Be aware of how much sleep you are getting and how that might affect your performance at work. If you know that a coworker has not been getting enough sleep, you should pay extra attention to how they are performing.

Managing Fatigue: **Pay Attention** to Yourself and Others

- Take action if you or a coworker is showing signs of fatigue:
  - Suggest taking a short break
  - Suggest trading tasks
  - Suggest drinking some coffee, followed by a short nap

Summarize as shown, and elaborate:

******SPECIFIC EXAMPLES HERE FOR SWITCHING TASKS; COULD INCLUDE OPERATORS OR FLAGGERS TRADING TASKS WITH LABORERS (E.G., PUSHING A WHEELBARROW FOR AWHILE INSTEAD OF FLAGGING). INSTRUCTOR TO IMPROVISE AS ABLE.*

Managing Fatigue: **Questions**

- When could a cup of coffee help you stay alert *without* affecting your sleep?
- Where and when could you take a nap at work?
- How could you use an "anchor sleep" schedule to get more sleep during the week?
- Do you take enough breaks at work?
  - ...when working a long shift?
  - ...when working nights?

*These questions are intended for personal assessment, **not** group discussion.*

Section heading.

Ineffective: **Temperature & Ventilation**

Fresh, cold air by itself will only make you feel more alert for a few moments.

- Getting fresh air ***while you are taking a break*** is better than just opening the window
- However, if the air quality is bad where you are working, take action immediately:
  - Improve ventilation in the area, or move away
  - Poor air quality can lead to fatigue, confusion, and other serious health problems

Summarize as shown, and elaborate:

If you think you need fresh air to stay awake, you probably need a rest break.

Poor air quality can include situations where you are near exhaust or other fumes.

Ineffective: **Food & Exercise**

A healthy diet and regular exercise are good for long-term management of fatigue and for improving overall health.

However, eating specific foods or getting exercise at work ***will not*** relieve fatigue for more than a few moments.

Summarize as shown, and elaborate:

Any benefit from eating a snack or taking a walk probably comes from **taking a rest break** to do these things, and not directly from the food or exercise.

Ineffective: **Drugs**

Drugs can cause problems if used incorrectly, and many require a doctor's guidance.

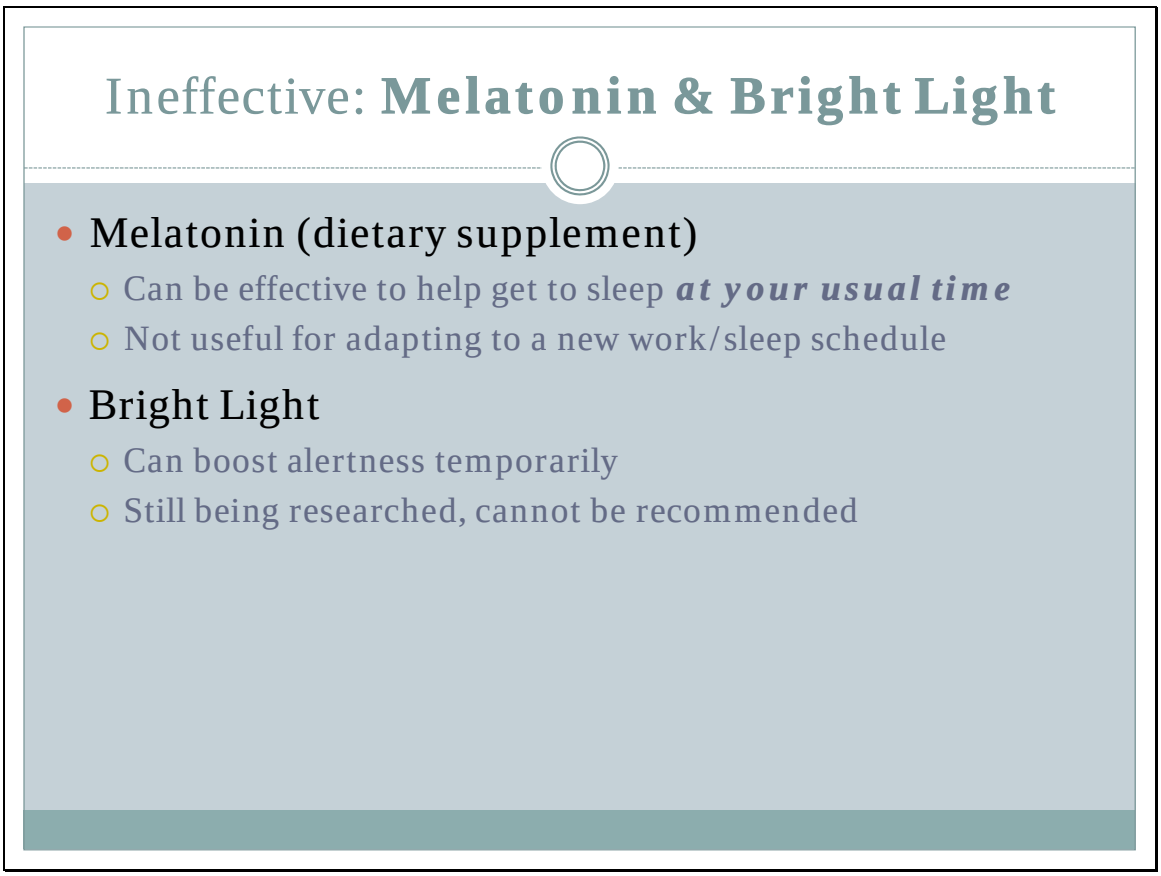
- Sedatives (used as sleep aids)
  - Can be habit-forming
  - "Hangover" effect the next day
  - Herbal remedies may not work as promised
- Stimulants (used for staying awake)
  - Rarely appropriate in a highway environment
  - Caffeine is the only recommended stimulant

Summarize as shown, and elaborate:

Sedatives and stimulants should only be used under a doctor's supervision, and many are not appropriate for use by people working in hazardous environments.

Because **sedatives** can be addictive, they should never be used for more than a few days. There is also the possibility of a "hangover" effect the day after using one, when you may have a hard time staying alert. Besides being unpleasant, this hangover effect can be a safety problem.

Many **stimulants** are illegal, and even some legal ones have potentially serious side effects. Caffeine is a safe and effective stimulant when used wisely.



Summarize as shown, and elaborate:

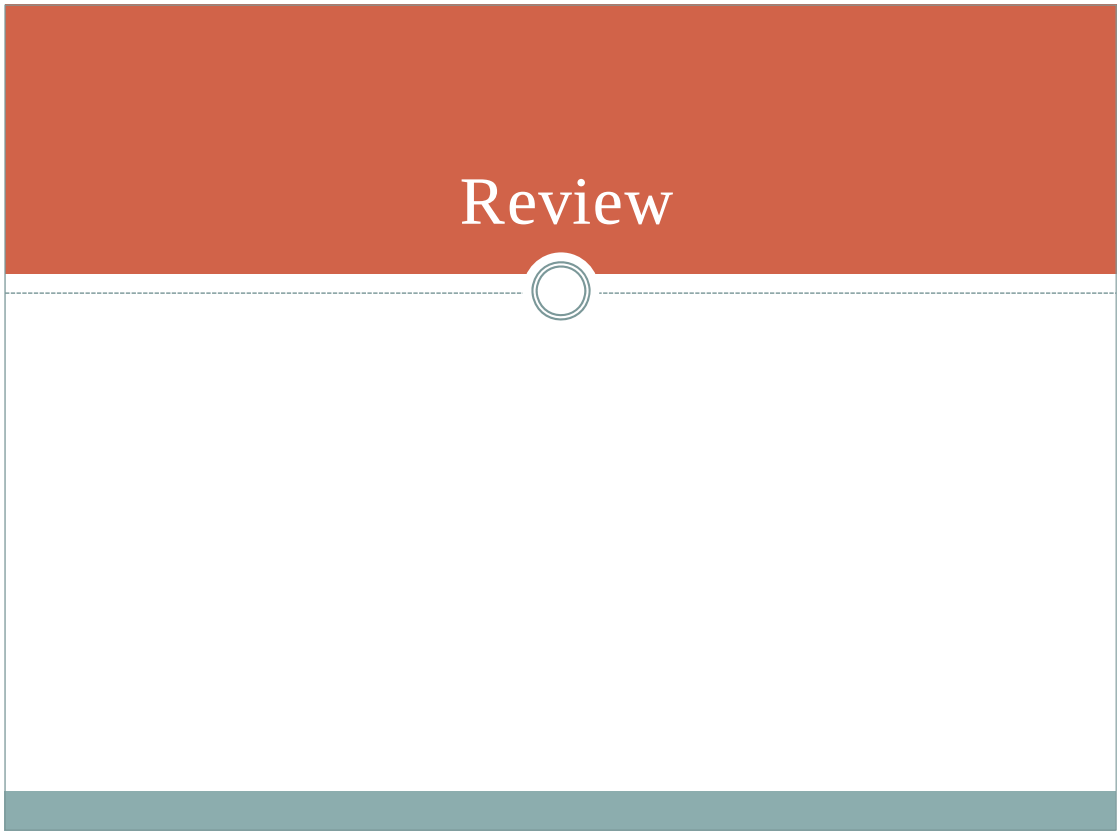
Melatonin, while effective for some people, is not currently regulated by the Food and Drug Administration (the FDA). This means that there are no guarantees of purity or concentration of the supplement.

Bright lights on a job site may help you stay alert while working a night shift, but there is currently not enough research on how light affects fatigue levels for it to be recommended as a good strategy for staying awake.

Ineffective: **Questions**

- Are you on medications that could affect your sleep or alertness at work? Should you consult your doctor?
- Are you relying on strategies that might be ineffective or harmful?

*These questions are intended for personal assessment, **not** group discussion.*



Section heading.

Review: **Fatigue and Schedules**

- Highway projects frequently have schedules that can contribute to fatigue:
  - Shifts longer than 8 hours
  - Frequent night work and switching day/night shifts
  - Working more than 5 days in a row, especially if weekend closures are involved
- On-the-job injuries are more common with these work schedules.
  - Less off-duty time (long shifts, OT)
  - Work/sleep schedule may be "opposite" your circadian cycle (night shift)

Summarize as shown, and elaborate:

Long shifts and weekend closures give you less off-duty time, and probably less time for sleeping, than shorter shifts.

Last bullet point:

On night shift you are opposite your circadian cycle:

> You are sleeping during the day when your circadian cycle is working to keep you awake, which means you get less sleep, even if you have enough time off.
>
> AND
>
> You are working at night when your circadian cycle is trying to help you sleep, which means you may be less alert at work and more prone to making mistakes that can cause injuries.

Review: **Recovering from Fatigue**

- There is no substitute for getting enough sleep
  Things like caffeine and rest breaks give only temporary relief
- Fatigue cannot be overcome by motivation or willpower
- There is no "one size fits all" solution
  But this basic course offers some effective strategies you can try
- Make sure you use these strategies correctly
  For example, more caffeine isn't the answer if you already use too much

The only way to recover from fatigue is to ***get more sleep****.*

Summarize as shown.

For More Information

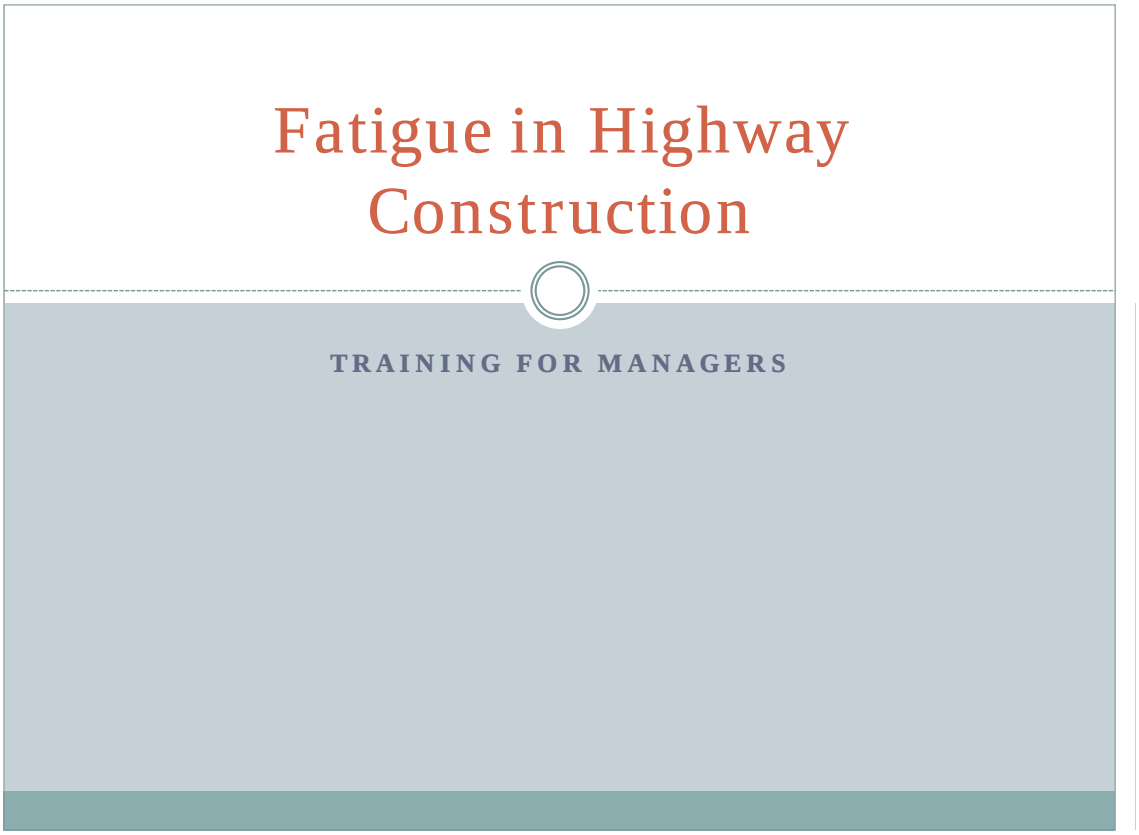
Visit the *National Sleep Foundation's* website:

www.sleepfoundation.org

[OPTIONAL:]If you are feeling unusually fatigued at work, or if you are concerned about your work schedule, see:

[SPECIFY CONTACT INFORMATION FOR SAFETY MANAGER, ETC.]

TRAINING FOR MANAGERS



HOW TO USE THIS PRESENTATION

In most cases, the information presented on each slide can be verbally summarized for the audience. However, many slides are designed to draw focus to items and information that either (1) require particular or progressive emphasis, or (2) give you time to offer any necessary elaboration. Pay close attention to the instructor's notes for each slide so that you are aware of any special conditions or instructions that must be followed for that slide.

In each slide's speaker notes, sentences in ITALICS are instructions for how to present the information. Content that is not in italics should be presented as elaborative material for the audience.

Organizational Practices

FATIGUE RISK MANAGEMENT

Section heading

Purpose

- This training is intended for:
  - Managers
  - Superintendents
  - DOT Project Managers
- You should have already taken:
  - “Fatigue in Highway Construction – Basic Course”

Learning Objectives

Upon completion of this module, participants will be able to:

- Identify their current organizational approach to fatigue
- Assess the risk of worker fatigue from various work schedules
- Implement selected fatigue risk management practices

Summarize as shown

Fatigue: What is it and what are the effects?

- Fatigue: a biological drive for sleep
- Impact of Work Factors: Sleep opportunity provided by schedule, time of day work is performed
- Effects:
  - Reduces concentration, memory problem solving, motivation
- Night shifts worse than day shifts even if regularly working them
- Early morning starts (before 7AM)
- One night of disrupted sleep can affect you all week

Fatigue is a complex concept, including biological rhythms and alertness, but is basically all about sleep. To the extent that you sleep the amount you need – usually about 8 hours, fatigue is less of a problem. Reduced and disrupted sleep leads to both acute and chronic fatigue.

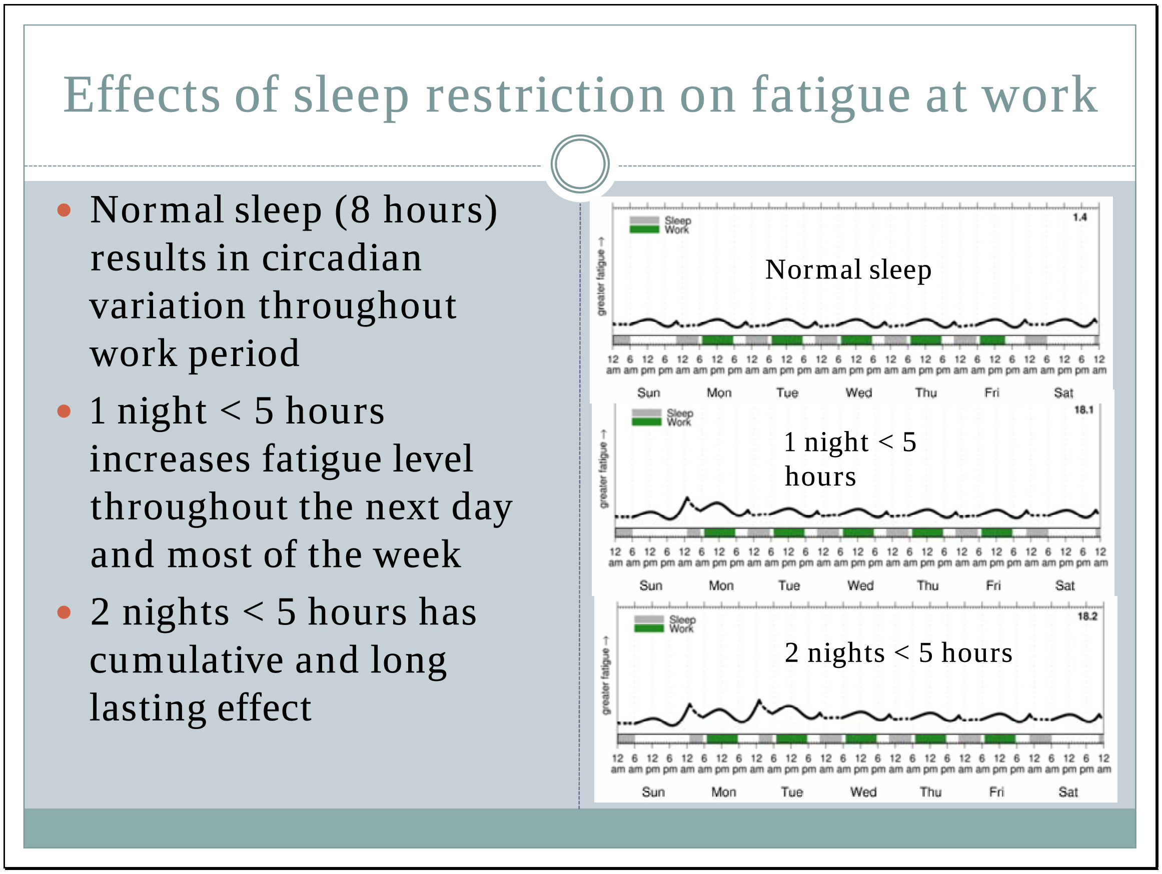
In the work environment, schedule has the largest impact on worker fatigue, by influencing the sleep opportunity, i.e., the time available off work for sleep.

Some of the work performance impacts of fatigue include impaired concentration, memory lapses, difficulty solving problems, and lowered motivation.

In general, night shifts result in worse fatigue problems for workers than days shifts, even when people are regularly working these shifts. The reason is that night shifts end in the early morning hours, e.g., 5 or 6AM, and this is the time at which overall sleep duration is reduced.

Early morning start times can also be problematic because of the need to awake at the circadian low point.

It has been known for some time that a single night of disturbed sleep can affect workers all week long.



Effects of sleep restriction on fatigue at work

- Normal sleep (8 hours) results in circadian variation throughout work period
- 1 night < 5 hours increases fatigue level throughout the next day and most of the week
- 2 nights < 5 hours has cumulative and long lasting effect

Normal sleep

1 night < 5 hours

2 nights < 5 hours

In this slide we show how sleep disruption can affect fatigue levels. The curves are based on a model that analyzes the impact of sleep obtained on fatigue levels across the day and week. The height of the curves indicates the magnitude of fatigue.

It can be seen that for a normal sleep period fatigue level is generally low throughout the day, with variations over the 24 hour period. There are increases in fatigue from waking through early afternoon, with a reduction toward early evening, then a rise and peak just before bedtime.

The middle graph shows the impact of 1 night of less than 5 hours of sleep. The result is a much higher level of baseline fatigue upon awakening, and throughout the work day, and for several days after.

The bottom graph shows the effects of 2 nights of less than 5 hours of sleep, and can be seen to have a cumulative impact on the second work day, and also throughout the week.

These patterns are important to understand because although workers may have enough time off according to scheduled hours, other activities such as commuting or just the activities of daily life can affect sleep, and it will have a carryover effect into the workplace.

Effects on the Construction Industry

Construction workers are ***three times more likely*** than average to have an injury that requires time away from work.

Fatigue in highway construction is particularly dangerous because:

- Odd schedules are common on highway projects
- Hazardous workplace environment can lead to serious consequences

Summarize as shown.

Fatigue in Hazardous Environments

- Fatigue in highway construction can be more serious due to the more hazardous environment
  - Close proximity to car traffic
  - On-site heavy traffic (trucks)
  - Operation of heavy equipment close to workers on the ground

Summarize as shown.

Task Type and Fatigue

Effects of fatigue are worse for certain tasks:

- Doing the same task for long periods
- Performing tasks that require high concentration
- Performing tasks that are monotonous, boring

Effect is magnified during night work, and when worker is experiencing sleep debt

Summarize as shown. Elaborate as follows:

Doctors working very long hours are more likely to have accidental needle-sticks.

People working longer hours are more likely to have car accidents while commuting.

Fatigue related to work schedule has been blamed for many railway and airplane accidents.

Effect gets worse when someone is behind on sleep.

Corporate Policy

- What is your corporate Safety Management Policy?
- Does company have formal safety management system (SMS)?
- If no formal SMS, what are roles and responsibilities for safety?
- Fatigue management is either explicit or implicit in SMS
- Self-regulation vs. mandated work hour limits

In addressing fatigue at the organizational level, managers and safety personnel should consider their corporate safety management policy.

Is there a formal safety management system in place? Different size organizations are likely to have varying approaches to this, from fairly informal, to centralized functions specific to safety management.

In smaller operations where no formal safety management system exists, how are the responsibilities for safety handled? Are they the responsibility of individual project managers or superintendents?

Fatigue management can be addressed in a safety management system with formal risk analysis procedures, schedule evaluation and reporting approaches, or more implicitly by ensuring that overtime or work hours are not excessive.

Fatigue management is addressed in many transportation industries through regulatory work hour limits. This approach is not used in highway construction, where there is little regulatory intervention. So, fatigue management is a matter of self-regulation.

Cultural Attitudes

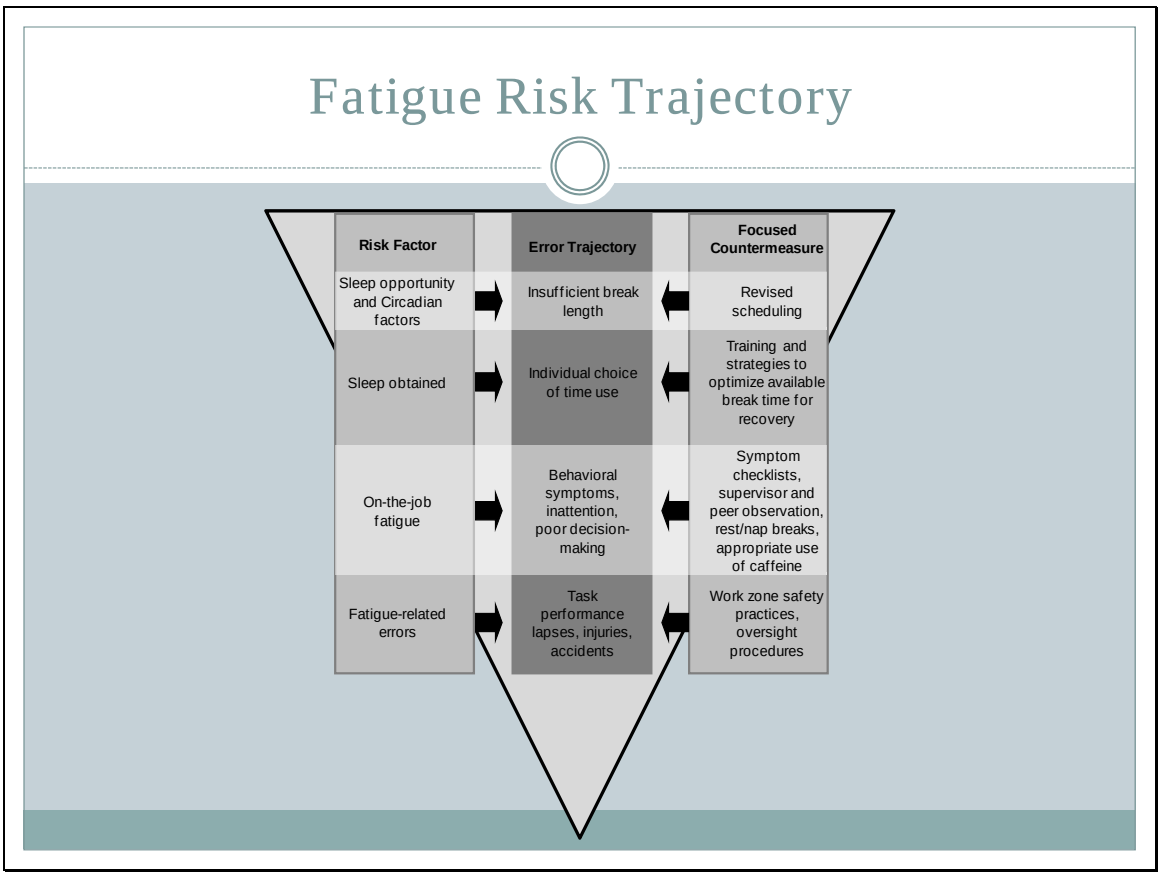
- Beliefs/Myths:
  - Fatigue is something to muscle through
  - Fatigue management is a personal responsibility
  - Fatigue is inevitable
  - Napping is not OK in the work place
  - Everyone has enough time off for recovery
- These attitudes need to be changed through education and awareness.
- Fatigue management is everyone's job (just like safety!)

Part of implementing an organizational approach to fatigue management is to recognize the influence of prevailing cultural attitudes. There are a number of beliefs or myths that pervade thinking about fatigue (SUMMARIZE AS SHOWN).

These beliefs are generally false, and can inhibit an intelligent, proactive approach to fatigue management.

The first step in fatigue management is changing these attitudes and erroneous beliefs with science-based education and awareness, including upper management.

Since worker fatigue is basically a safety problem, it needs to be addressed as that: safety is everyone's job.



An important part of fatigue management is understanding the basic fatigue risk trajectory and the pathway to performance errors or safety problems, and the related countermeasures that can be applied. (REFER TO PORTIONS OF DIAGRAM AS APPROPRIATE)

As mentioned earlier, the sleep opportunity is the main element in ensuring that workers' sleep is not overly affected by schedule. The countermeasure for this risk factor is schedule revision.

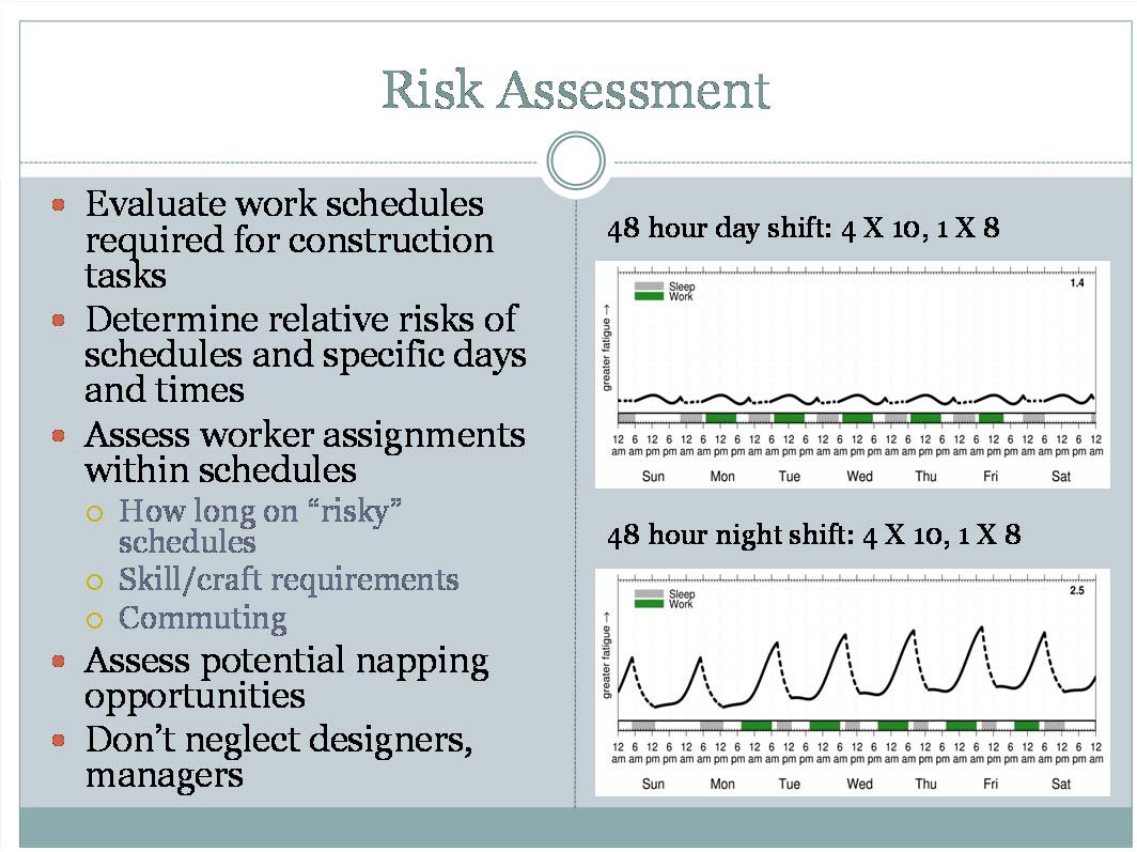
Sometimes sleep obtained is disrupted regardless of break length, either because of personal factors, or due to sleeping at the wrong time of day because of a night schedule. Countermeasures include training and sleep schedule approaches to optimize the break time available, such as using defensive (preventive) or strategic (on-the-job) naps

When on-the-job fatigue does occur, the result is behavioral symptoms such as inattention or poor decisions. Mitigations include caffeine, supervisory and peer observation, and strategic napping.

The final outcome of fatigue is the occurrence of fatigue-related errors, manifesting as lapses in job performance and injury. Countermeasures for this level includes use of work zone safety practices such as increased oversight, procedural checklists and double-checking.

***REFERENCE:

Figure adapted from: Dawson, D. and K. McCulloch (2005). Managing fatigue: It's about sleep. Sleep Medicine Reviews 9(5), 365 380.



One of the primary organizational strategies for fatigue management is risk assessment of schedules, based on the project phase and construction tasks required.

A systematic approach to risk assessment can utilize knowledge of how fatigue occurs over the course of work periods for staff on various schedules. This can be facilitated with a computer-based model, although for most construction firms some heuristics based on model outputs contained in the Work Scheduling Guidance will be sufficient.

The two graphs in this slide compare fatigue across a work week for a 48 hour day shift, and a 48 hour night shift. It is evident that the night shift experiences substantially more fatigue throughout the work period, and that the base level of fatigue increases throughout the week. So the night schedule is "riskier" during each work period, and toward the end of the work week.

The models can be used to determine likely fatigue levels for workers, based on the schedules they are assigned to, and how long they have been on those schedules. This information can be used to evaluate the recovery opportunities provided by existing and planned worker scheduling. Construction planning for specific skills and crafts across the 24 hour period in different phases of projects will influence worker scheduling. Planners should evaluate the impact of construction scheduling requirements in terms of worker fatigue impacts, and try to ensure that work schedules dictated by construction requirements do not adversely affect individuals or groups of workers. The models can also show when commuting is likely to be a safety issue, such as the night shift, where driving home occurs at the peak fatigue level.

Fatigue profiles such as this are also useful for evaluating napping opportunities – where they might occur in the work shift, and the impact on fatigue levels.

Finally, it is important to address the work hours of designers and managers, especially as they work night shifts following day shifts, or participate in long closures followed by a full week of day shift work.

Risk Assessment, continued

- Who is responsible for scheduling crew for various construction tasks?
- Are crew assignments and rotations considered in the construction planning or project proposal phase?
- What is the degree of regularity of assignments?
- What data are available and maintained to permit risk assessment?
- What are the training opportunities?
  - Initial employment training
  - Project-specific training
  - Pre-shift "toolbox talks"

This slide shows a set of important questions for the risk assessment process, and can help to identify the people and processes in the organization that need to be involved in managing fatigue.

For example, scheduling of crew involves interaction between construction engineering and crew superintendents, and to the extent that superintendents see certain work crew affected by too much night work, may involve negotiating the execution of various construction tasks so that crews are provided with recovery opportunities. This may involve work breaks, naps at the work site during night shifts, re-scheduling certain tasks for day work if possible, and generally providing relief from constant night work.

A consideration in risk assessment is the availability of data concerning safety incidents on various shifts – are particular operations prone to problems at specific times of day, such as early morning hours?

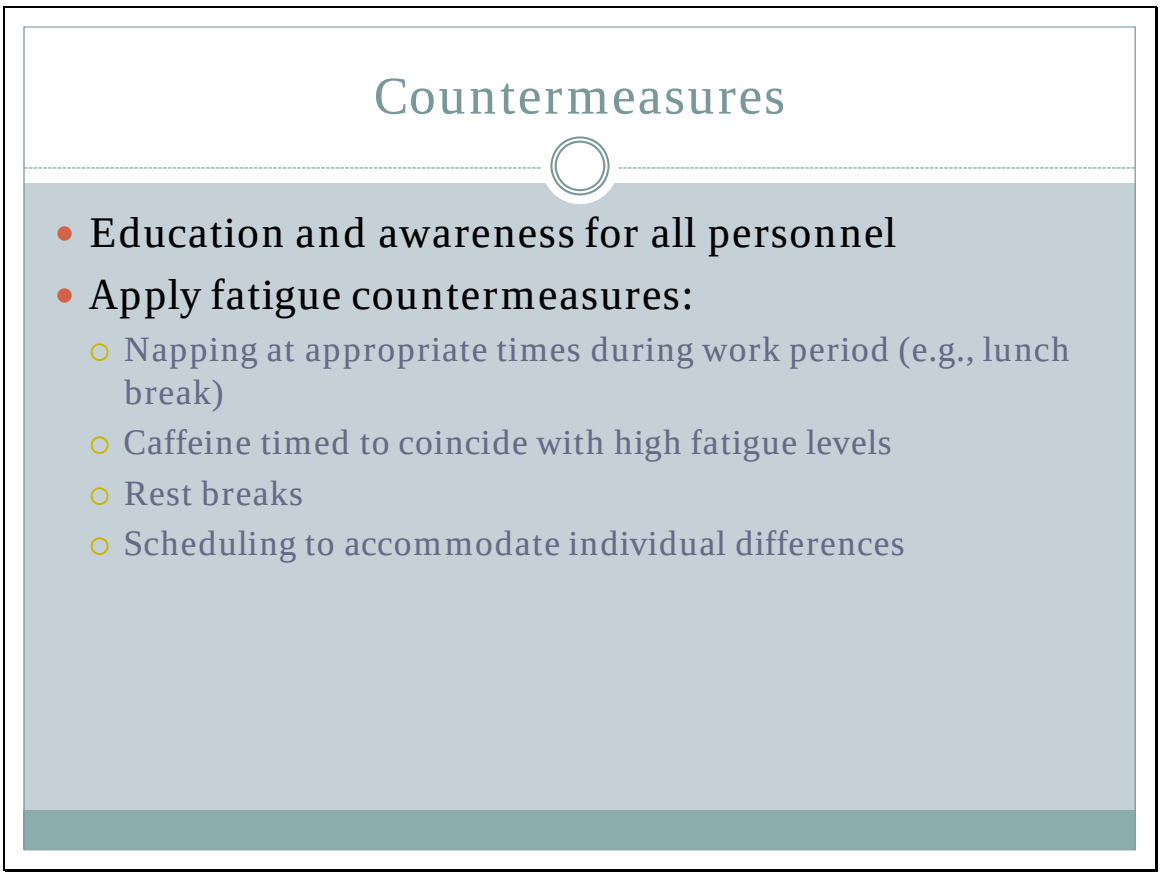
At a more global level, risk assessment should address the training opportunities to educate workers about fatigue and mitigation, such as initial employment, project—specific training, and periodic tool-box talks during crew mustering prior to work initiation.

Example: Weekend Closure, Manager

Day	Cumulative Hour	Time	Event	Sleep Duration
1-Fri	0 12 17	0600 1800 2300	Work in office Return home, eat, no sleep Return to job site	6 hours (prior night)
2-Sat	22.5 25.5 29.5 30 40.5	0430 0800 1200 1230 2300	Return home ***SLEEP*** Wake Return to job site Return home	4 hours
3-Sun	42.5 46.5 48 60 63	0100 0530 0700 1900 2200	***SLEEP*** Wake Return to job site Return home ***SLEEP***	4.5 hours 5.5 hours
4-Mon	68.5 69 70	0330 0400 0500	Wake Return to job site Closure ends	

Provide overview: this is a real example of a manager's schedule during a weekend closure. Point out totals: 14 hours' sleep in a period of 70 hours, and at intermittent times.

The figure shows that during the course of the weekend closure, the manager is very sleep deprived, and at risk for fatigue during the entire period. The work-week that follows the closure is generally a standard schedule, so there is no off-work recovery time.



Countermeasures for fatigue are an important component of an overall organizational approach.

The primary countermeasure is education and awareness for all personnel, including management, to both dispel the myths and erroneous beliefs about fatigue, to instill and understanding of the basic biological basis, of fatigue, and the things that can be done about it.

A few key countermeasures have been found to be effective in a variety of industrial environments, including napping at appropriate times during the work period (such as the lunch break), caffeine during periods of high fatigue, rest breaks from the work flow, and using scheduling to try to accommodate individuals who have varying susceptibility to fatigue.

One interesting approach to a work break nap is to consume a caffeinated beverage just before a 30 minute nap – this might work best with a cold beverage – and at the end of the nap the caffeine will be starting to take effect. This will have the dual impact of reducing sleep inertia (the fatigued feeling upon waking), and reducing fatigue for the following several hour period.

Fatigue Proofing

- Fatigue cannot be entirely eliminated
- Strategies for adding layers of defense
  - Increased supervisory oversight
  - Use of written procedures and checklists
  - Self and peer-monitoring during critical periods
  - Reduce monotonous or highly complex tasks during periods of high fatigue
  - Extra personnel for critical/dangerous tasks
  - Nap timing for best impact
  - Interaction with peers to identify personality changes
  - Self-selected rest breaks
  - Transportation assistance following extended shifts

We know that construction work needs to be done round-the-clock in many projects, and so fatigue cannot be entirely eliminated.

The concept of “fatigue proofing” involves using awareness of the problem to add various layers of defense:

SUMMARIZE AS SHOWN.

Reporting and Incident Investigation

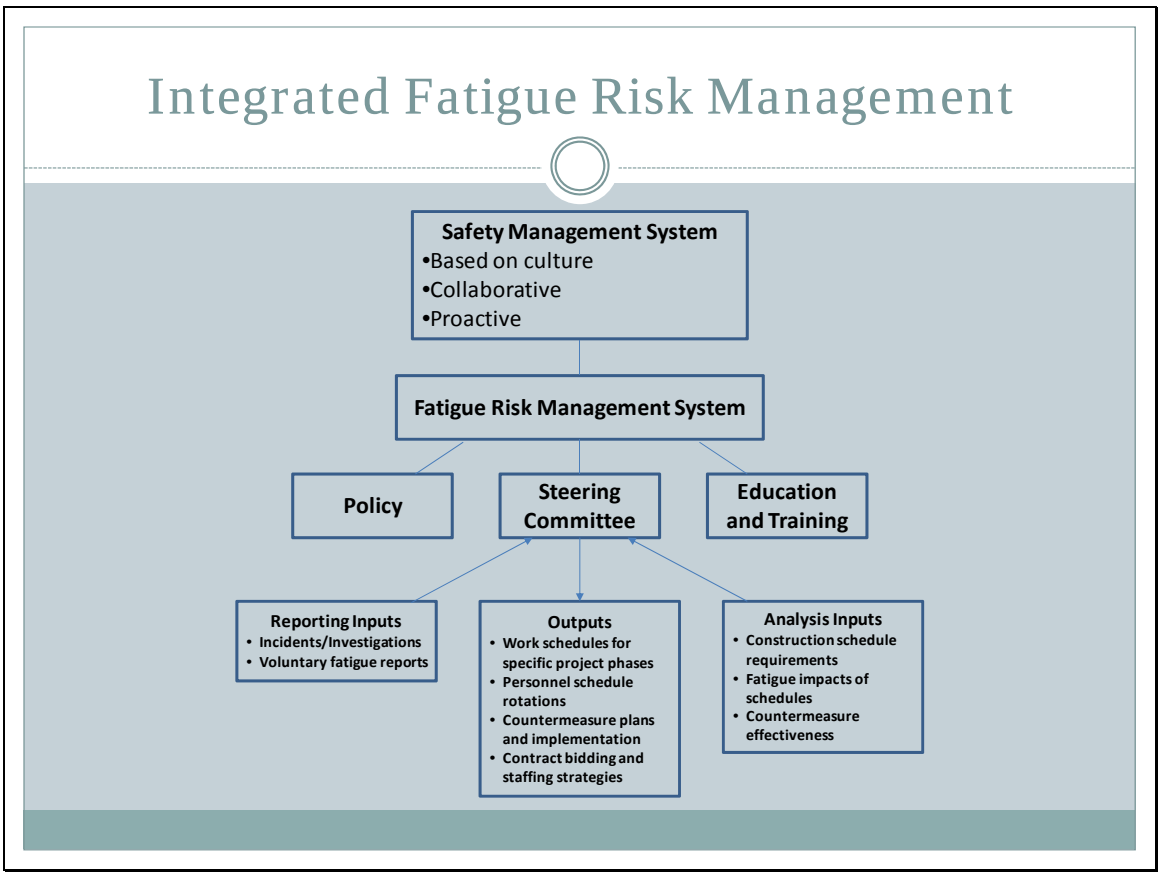
- Encourage workers to report fatigue problems
- Track safety incidents to identify potential fatigue issues
  - During accident investigation, pay attention to fatigue as a potential cause
  - Red flags: night work, many successive shifts without a break, work periods following a weekend closure, worker sleep issues
  - Commuting accidents sometimes related to fatigue
- Use data to modify work scheduling to extent possible

The role of fatigue in construction safety problems is probably under-represented due to lack of reporting and investigation.

A proactive management approach to fatigue should encourage workers to report problems, whether it is related to scheduling, specific tasks, or even other workers. Fatigue can be as dangerous as substance-based intoxication.

In order to better understand specific project fatigue problems, safety incidents should be investigated with the fatigue factor in mind, including whether night work was involved, individuals working many successive night shifts without a break, whether a weekend closure was involved, and whether the individual workers were experiencing sleep problems. Commuting accidents can sometimes be related to fatigue from night work.

Information collected in this way can be useful in modifying work schedules.



An integrated approach to fatigue management in organizations is portrayed in this slide, and is a component of the overall safety management system. Elements include a policy statement regarding fatigue risk management, a specific steering committee of appropriate personnel, and regular education and training on the subject.

Reporting is a key element, which can lead to responses (outputs in the figure) such as revised schedules. Proactive elements involve modeling of schedules for various construction phases to assess risk and establishing countermeasure plans for specific schedule and projects. Another potential output would be strategies for bidding on potential contracts using work schedule requirements as a decision criterion.

***REFERENCE:

Figure adapted from: Gander, P., Hartley, L., Powell, D., Cabon, P., Hitchcock, E., Mills, A. and Popkin, S. (2011). Fatigue risk management: Organizational factors at the regulatory and industry/company level. Accident Analysis and Prevention, 43(2), 573-590.

Implementing Fatigue Management

- Determine frequency and severity of problem
  - Will it increase with future contracts?
- Determine extent of coverage in corporate SMS and existing training materials
- Obtain "buy-in" from upper management – the leadership role is essential
- Deliver a consistent message about fatigue – it is a basic safety issue
- Establish mechanisms tailored to corporate size (e.g., risk assessment, training, reporting, tracking)

Implementation of fatigue risk management will vary with construction firm size and complexity. The critical issue to address is the frequency and severity of fatigue problems—if you think it is not there, then you probably haven't looked.

As rapid renewal construction practices increase, it is likely that most firms will be doing a larger amount of night and extended shift work. We estimate that over the next 10 years, up to 30,000 individuals will be exposed to rapid renewal schedules at some point.

As a consequence, it is important to address these issues in a right-sized safety management approach, and upgrade existing training materials to reflect fatigue issues.

Upper management needs to be supportive and provide leadership to address fatigue—it should be considered a basic safety issue.

CHAPTER 5 FATIGUE RISK MANAGEMENT SCHEDULE GUIDANCE AND WORK PRACTICES

HOW TO USE THIS GUIDE

This guide contains work schedule guidance and work practice recommendations for the range of shift schedules commonly encountered in rapid renewal construction. The guidance consists of fatigue models for each basic work schedule type (Day Shift, Night Shift, Weekend Closure, Switching Shifts, Manager and Designer), typical schedule variations for a few basic types, and both preventive and operational fatigue countermeasures tailored for each work schedule type. These shift profiles and countermeasures are intended as guidance only; they are meant to provide managers with information to make decisions about specific work assignments and for planning overall construction schedules to balance worker fatigue management with project schedule goals. There is no one-size-fits-all solution for a project or for an individual worker. This guidance is intended to assist managers in achieving a balance between project objectives and worker fatigue management.

MODELING SUMMARY AND WORK PRACTICE GUIDANCE IMPLICATIONS

In this section we discuss the most significant work practices for fatigue management such as scheduling decisions, shift start and stop times, closure lengths for various construction phases, and specific fatigue countermeasure implementation within a schedule. The technical basis for these recommendations can be found in the technical report for this project, *Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments Final Report*.

Daytime Construction

Daytime construction schedules are preferable as a means of minimizing fatigue and obtaining adequate recovery sleep. Models of daytime construction schedules (40 to 60 hours per week) show no differences in fatigue profiles across shift type or throughout the week, assuming 7.5 hours' sleep per night. Fatigue level peaks in the early afternoon and rises again sharply just before bedtime. In practice, however, fatigue is likely to increase as shifts get longer. The longer the shift, the less off-duty time is available for daily tasks (e.g., personal care, parenting, household chores), and sleep may be sacrificed to accomplish these.

Nighttime Construction

Nighttime construction schedules of all variations show fatigue levels substantially higher than day schedules due to reduced sleep opportunity based on circadian pressure for wakefulness during the day (see Figure 5-1 for an example). Fatigue rises continuously throughout the night shift work period and the commute home, peaking at bedtime (about one hour after arriving home in our models). Furthermore, nighttime construction schedules of all variations show a

cumulative fatigue effect since reduced sleep hampers recovery (as in Figure 5-2 and, especially, Figure 5-3).

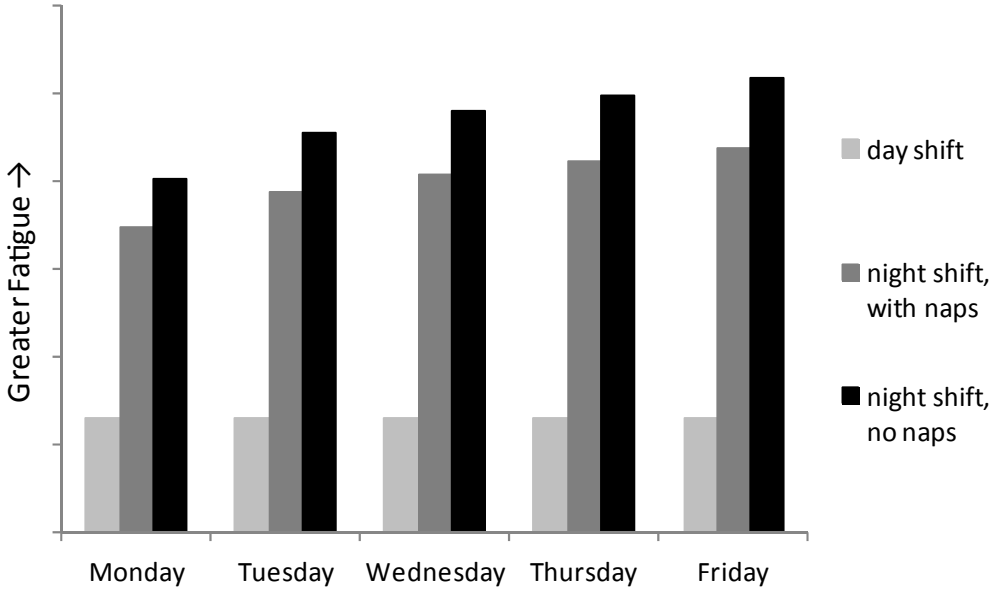


Figure 5-1. Peak fatigue: 5x10 (50-hour week) day shift and night shift with and without naps.

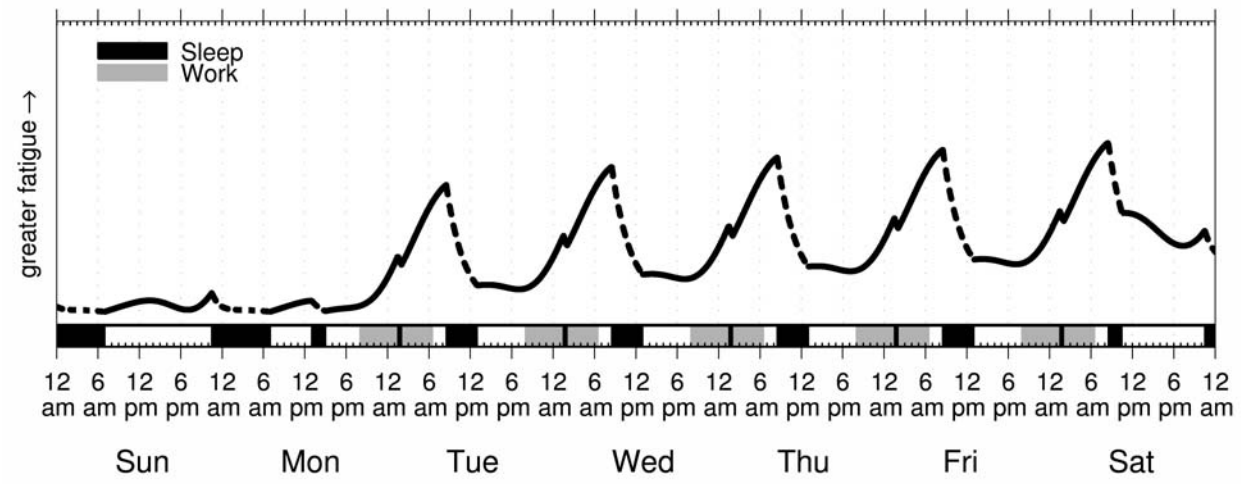


Figure 5-2. Fatigue profile: 5x10 (50-hour week) night shift with mid-shift and defensive naps.

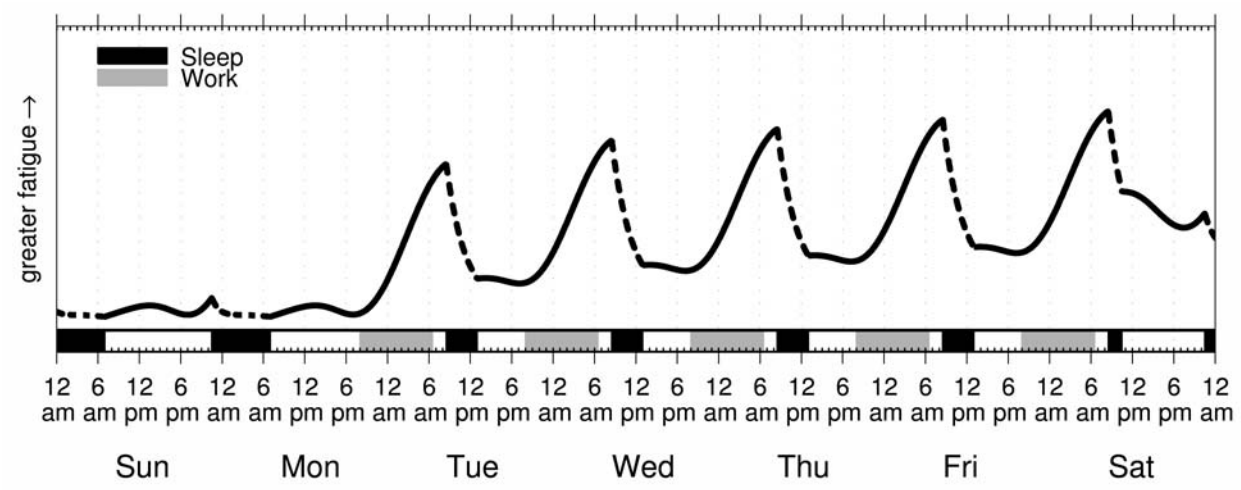


Figure 5-3. Fatigue profile: 5x10 (50-hour week) night shift without naps.

Fatigue in night schedules is exacerbated by later work stop times and can be reduced through earlier stop times, such as a 4:30 am stop (Figure 5-4). Extended night shifts (10 hours or more) tend to end later than shorter shifts, and can result in severe sleep restriction (5 hours or less) due to circadian pressure to wake around 1:00 pm. For this reason, extended shifts should not be used on a regular basis for the same crew.

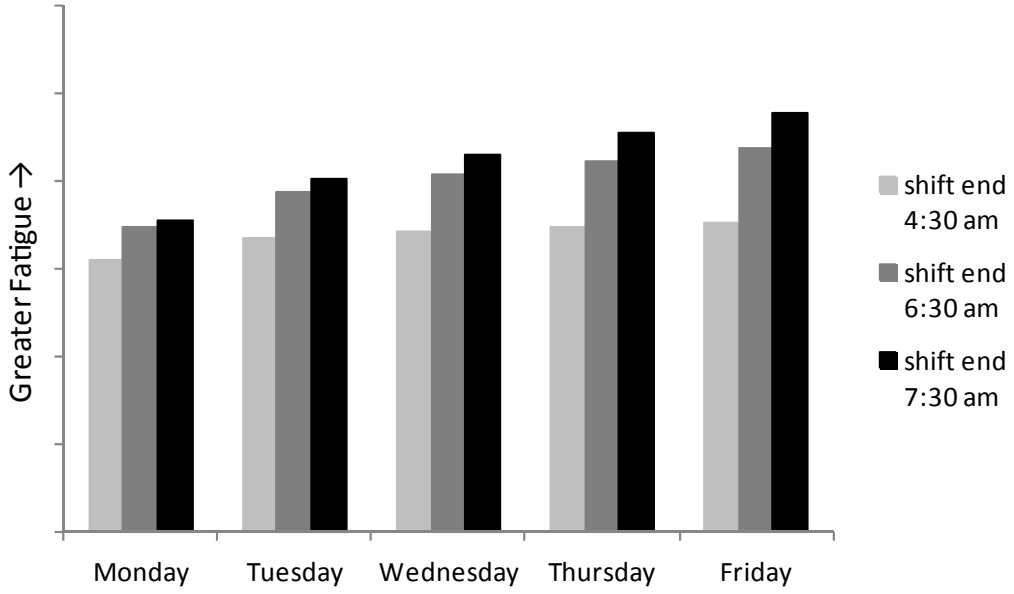


Figure 5-4. Peak fatigue: night shift with various work stop times.

Taking naps is effective in reducing fatigue while working night shifts. A mid-shift nap on night schedules, even when of short duration (30 minutes), is the single most effective fatigue countermeasure. It reduces peak fatigue and lowers the cumulative effect across days. A longer defensive nap (2 hours) in the afternoon before the first night shift in a week is also helpful in

reducing fatigue. Night shifts of any duration are substantially more fatiguing without these naps; a 5x10 night shift schedule is used as an example (Figure 5-5).

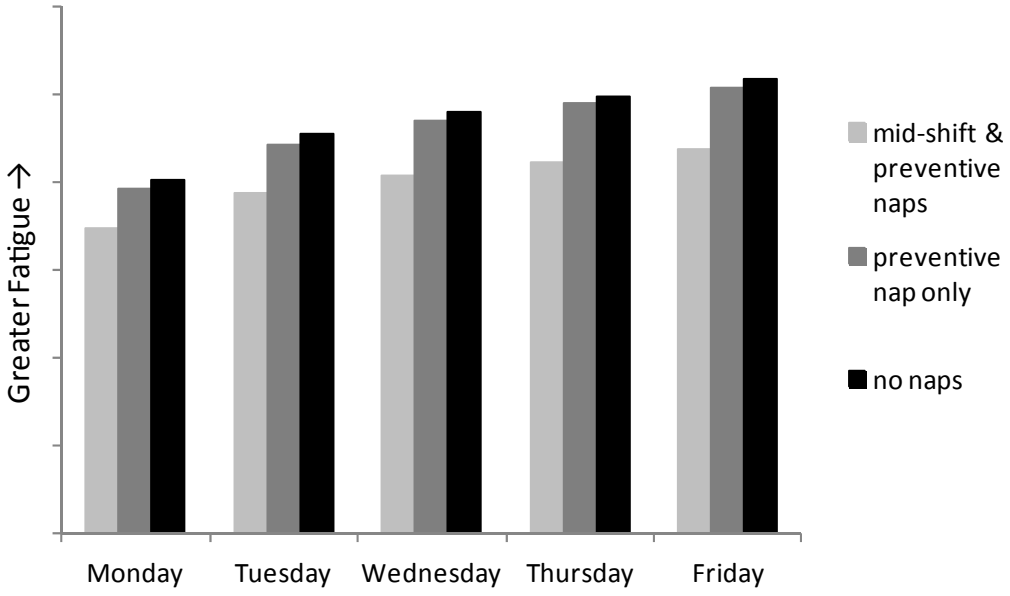


Figure 5-5. Peak fatigue: 5x10 (50-hour week) night shift with and without mid-shift and defensive naps.

In summary, a night shift schedule organized to accommodate maximum recovery opportunity would end early and allow workers to take naps. Figure 5-6 compares peak fatigue for a typical day shift with "best-case" and "worst-case" night shift scenarios, the best-case scenario being a shift that ends at 4:30 am and workers take mid-shift naps and a defensive nap, and the worst-case scenario being a night shift that ends at 7:30 am and workers take no naps. The best-case night shift scenario still results in peak fatigue that is at least double that of a typical day shift. However, by the end of the work week, the worst-case night shift scenario results in peak fatigue approaching twice that of the best-case night shift scenario, as well as a substantially more rapid accumulation of fatigue throughout the week.

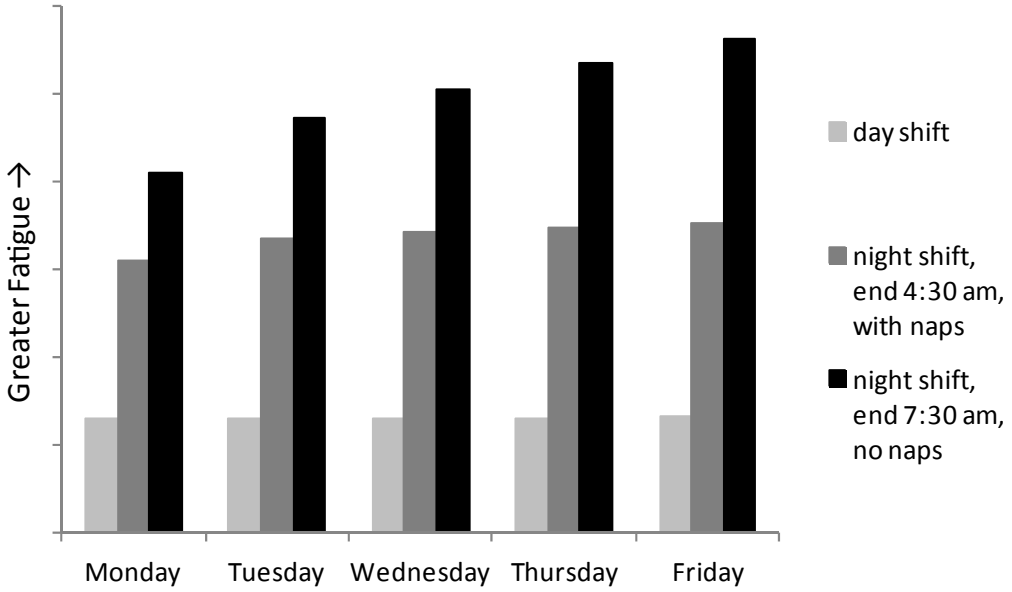


Figure 5-6. Peak fatigue: day shift vs. best-case and worst-case night shift schedules.

Finally, our fatigue models showed no substantive difference in fatigue levels for night shift schedules where the worker reverts to a day schedule on days off (sleeping at night following a long morning nap after the last night shift) relative to maintaining a night schedule (sleeping 8 hours during the day). However, it may be advantageous for workers to revert to a day schedule on days off, even if they will be returning to a night shift schedule the following week, for two reasons. First, keeping a more "normal" schedule on days off will allow them to participate in many activities that are difficult while on a night shift, including family and social activities. Second, sleep quality for most individuals is poor during the day, even when the number of hours in bed would seem sufficient for adequate recovery. Little, if any, adjustment of the circadian rhythm to a night shift schedule is expected unless such a schedule is maintained for many weeks and light/dark schedules can be reversed. Other than indoor on oil platforms and in space, this is usually not feasible (Van Dongen, Belenky, & Vila, 2011).

Shift Switching and Weekend Closures

Granting workers a day off (i.e., a full 24 hours between the end of one shift and the start of the next) when switching from a night shift schedule to a day shift schedule (or vice versa) is preferable to using double shifts or shifts with a very short break between. This is true for both mid-week shift switches and for short-term shift switching that occurs as a result of a weekend closure. For example, when workers who are usually on day shift are chosen to cover night shifts for a continuous weekend closure, a full 24-hour break at each switch provides the best recovery opportunity.

Managers and Designers

Managers wishing to maintain high levels of on-site presence during weekend closures can reduce fatigue by engaging in two separate sleep periods ("anchor sleep" or "split sleep")—a

longer one of at least 4 hours at night (the anchor sleep period), and a shorter period of 2.5 – 3 hours (a supplemental nap) during the day (Mollicone et al., 2008). A manager we interviewed reported his work and sleep periods during a recent weekend closure, and using this as a model, we constructed an anchor sleep schedule that would have allowed the same number of hours at work with regular presence on site during both day and night shifts. Peak fatigue could be reduced considerably using the alternative, anchor sleep schedule (Figure 5-7).

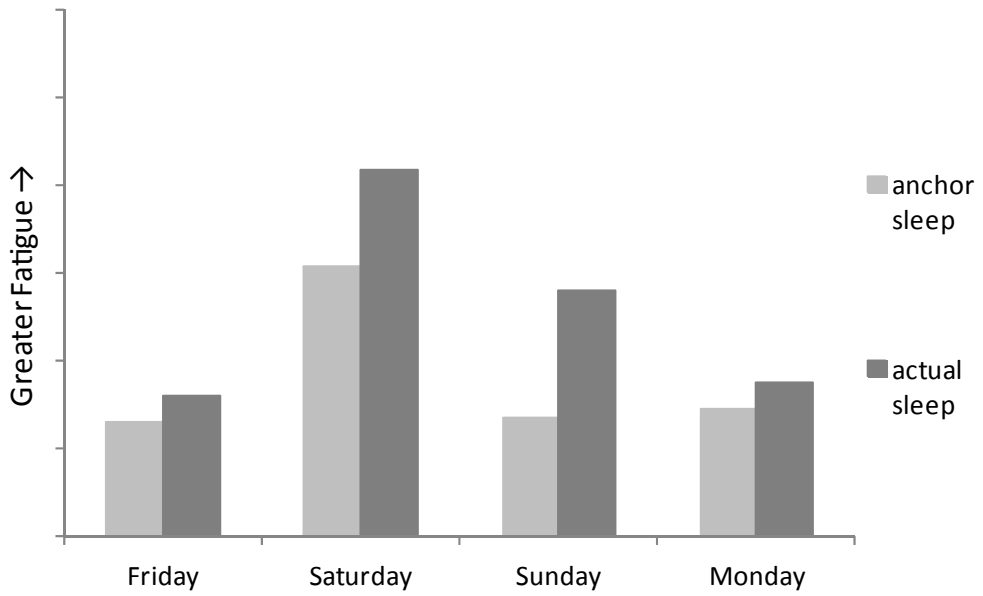


Figure 5-7. Peak fatigue: manager's actual vs. possible anchor sleep schedule for 55-hour weekend closure.

Designers (or engineers) working high production schedules of 80+ hours per week are vulnerable to cumulative sleep reduction and increasing fatigue. Fatigue levels are higher than for a standard day shift due to substantially reduced sleep opportunity while working very long (up to 14 hour) days, and peak fatigue increases gradually throughout the week (Figure 5-8). Tactical countermeasures such as strategic naps and self-selected breaks can reduce the immediate impacts, but this type of schedule should not be sustained.

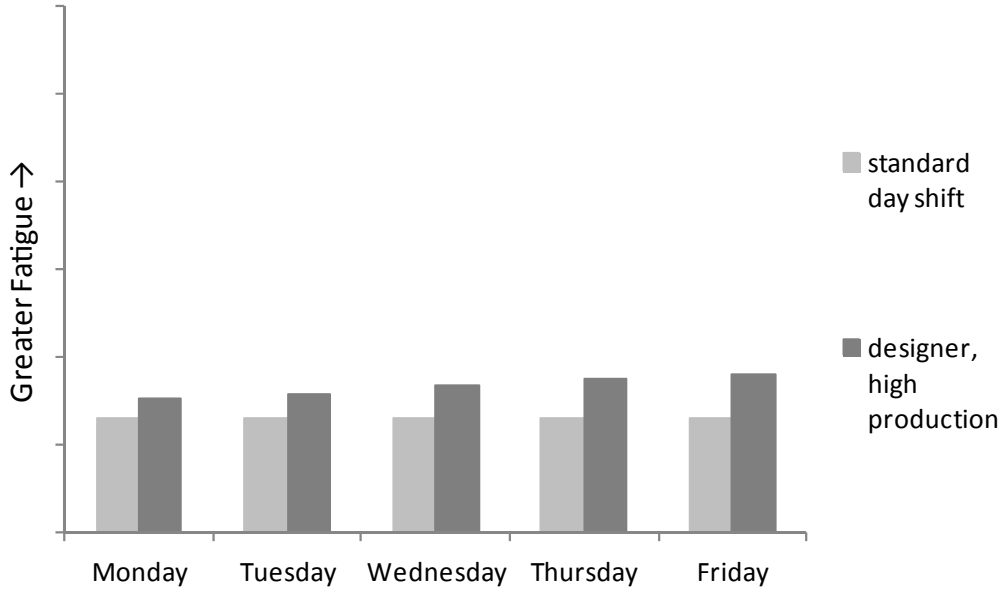


Figure 5-8. Peak fatigue: high production designer/engineer schedule vs. typical day schedule.

Restricted Sleep

A single night of sleep restriction leads to increased fatigue on the day shift for several subsequent days, and two nights leads to even greater fatigue (Figure 5-9). Acute sleep restriction (sleep loss) can occur for many reasons, including illness, household pressures or emotional stress. Recovery frequently takes more than a single full night of sleep.

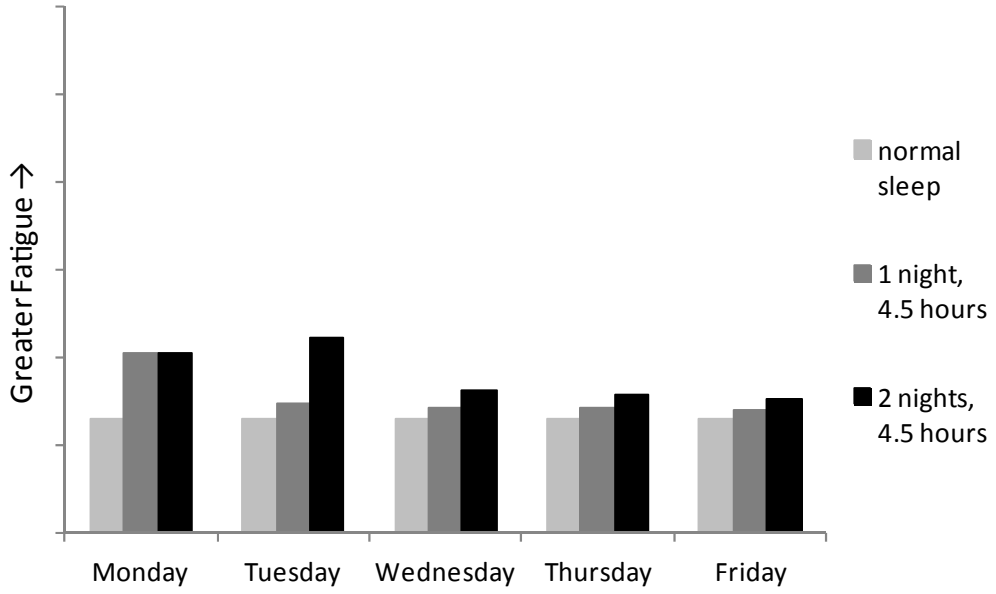


Figure 5-9. Peak fatigue: day shift with normal sleep (7.5 hours per night) and one and two nights' restricted sleep (4.5 hours).

Daytime construction schedules with unusually early start times (e.g., 6:00 am) or long shift durations (e.g., 12 hours) may result in curtailed sleep periods. Increased fatigue can be avoided by taking naps at mid-shift or after work. After-work naps should begin before 6:00 pm to avoid the circadian high-alert period that begins in the early evening. If naps are not used to alleviate excess fatigue, the peak fatigue trajectory of such a worker will be similar to that of high-production designers (Figure 5-8).

Caffeine Use

Caffeine can be used effectively before and during a shift for relief from acute fatigue. Caffeine is most effective when used sparingly; on day shift, it is most useful in the morning and during the “post-lunch dip” in early afternoon. Consumption should cease at least 5 hours before bedtime, though there are large individual differences in caffeine impact.

Sleep inertia experienced upon waking from mid-shift naps may be counteracted with consumption of a caffeinated beverage before the nap, which will take effect as the nap is ending (Reyner & Horne 1997; Van Dongen et al., 2001). This may be particularly useful on night shift, when a worker may be concerned about his/her ability to awaken fully from a mid-shift nap. A cold, rather than hot, caffeinated beverage may facilitate rapid consumption prior to the nap.

Table 5-1 provides a structured comparison of the schedules and countermeasure variations modeled, the major fatigue findings, and work practice implications.

Table 5-1. Structured comparison of the schedules and scenarios modeled, the major fatigue findings, and work practice implications.

Scenario	Major Fatigue Findings	Work Practice and Countermeasure Approaches
Day Shifts	• No substantive fatigue differences across week or shift types • Fatigue increases to mid-afternoon, declines toward evening, increases before bedtime	• Caffeine during day, but no later than 4:00 pm • Maintain consistent sleep and wake times throughout the week if possible • Maintain similar or identical sleep and wake times on weekend or non-work days • Strategic naps (on-the-job) to reduce impact of restricted sleep • Consume caffeine just before strategic naps to counteract sleep inertia on waking • Self-selected rest breaks to reduce fatiguing impacts of monotonous tasks or highly complex tasks
Night Shifts: 5, 7, 8, 11-hour closures	• Sleep durations significantly shorter than day shifts because of circadian rhythm influences – 3.5 to 6.5 hours due to circadian pressure to wake around 1:00 pm • Mid-shift nap substantially reduces peak fatigue within and across shifts, and reduces cumulative effects	• Minimize use of extended shifts (10 – 12 hours) due to reduced individual crew recovery opportunities • Caffeine during shift, but no later than 5 hours before bedtime • Consider returning to day schedule (sleeping at least 8 hours/night) on days off, following a morning nap on first day off from nights • Sleep in on the weekend to make up for sleep loss during the week • Strategic naps (on-the-job) to reduce impact of shortened sleep periods • Consume caffeine just before strategic naps to counteract sleep inertia on waking • Defensive nap in the afternoon before beginning night shift • Self-selected rest breaks to reduce fatiguing impacts of monotonous tasks or highly complex tasks • Supervisory monitoring for signs of fatigue and application of countermeasures

Scenario	Major Fatigue Findings	Work Practice and Countermeasure Approaches
Weekend Closure: 55 hours	• Modeling shows same effects as day and night shifts above • Field data suggest increased fatigue among day shift personnel in week following closure • Managers may feel they need to maintain a presence on the job site for as much as possible of the closure weekend; fatigue can accumulate during night shifts	• Consider selective half or full day off after closure to provide recovery opportunity • Anchor ("split") sleep schedule (nighttime anchor sleep and daytime nap) for managers to obtain 6 to 8 hours in 2 separate sleep periods • Avoid double shifts • Use countermeasures appropriate for shift worked, as described above
Switching Shifts	• Modeling shows same effects as day and night shifts above	• Avoid double shifts • Use countermeasures appropriate for shift worked, as described above
Manager and Designer	• Designers working high production can exceed 80+ hours per week	• Reduce high production designer workload through increased staffing and project planning. • Same countermeasures as for day shifts, above
Restricted Sleep	• Schedules regularly leading to 6.5 hours' sleep or less nightly will result in cumulative fatigue • Sleep restricted to 4.5 hours or less per night on one or two nights will result in increased fatigue levels, and this short-term sleep loss can affect fatigue long-term • In either case, fatigue level is higher than fatigue levels for standard extended day shift schedules	• For persons with consistently shortened sleep periods, a daily nap timed to avoid circadian high points (mid-shift or immediately after work) each work day will help maintain fatigue at low levels, and supplement the main sleep period • For individuals with acute fatigue from short-term sleep loss, sleep in on the weekend or take naps when able to make up for sleep loss during the week • Same countermeasures as for day shifts, above

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