Le, N., Stennett, S., Tran, D. (2026). Examining Safety Behaviors of Highway Construction Workers. *Lean Construction Journal* 2026 Special Issue CRC-CSCE pp 209-229 https://doi.org/10.60164/4a1vi215r
(Submitted 10Jan2026; Accepted 16Sep2026)
www.leanconstructionjournal.org

Examining Safety Behaviors of Highway Construction Workers

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Abstract

Purpose: Highway construction remains one of the most hazardous sectors in the U.S., with safety incidents frequently attributed to behavioral and procedural failures. To enhance compliance, safety incentive and disincentive programs have been implemented across state Departments of Transportation (DOTs), yet their effectiveness varies based on workers' perceptions of fairness, attainability, and relevance. This study examines which elements of these programs highway construction workers find most effective and develops a behavioral safety framework grounded in the Theory of Planned Behavior.

Research Method: The methodology includes a comprehensive literature review, an in-depth analysis of safety programs from all 50 DOTs, and structured interviews with six DOT safety experts. In addition, the study proposes a new safety framework, which is then verified through an iterative process involving expert feedback, refinement, and validation across multiple review cycles.

Findings: Analysis of safety programs across 50 state DOTs reveals that 32 state DOTs have safety incentive programs, with states like Arizona achieving a 20% reduction in work zone incidents through contractor bonuses, while Missouri's telematics-based enforcement led to a 99.5% decrease in speeding violations. Interviews with six DOT safety managers indicate mixed program effectiveness, with some states transitioning from punitive measures to education-focused models. The framework developed in this study consists of five stages: need identification, worker engagement, program assessment, strategic deployment, and continuous evaluation. Key findings emphasize the importance of financial incentives, real-time monitoring technologies, and continuous training in improving compliance and reducing incidents.

Limitations: This research has several limitations that warrant future research. First, there is a need to conduct case studies to further verify the framework results and suggestions for implementation. Second, the effectiveness of the framework is contingent upon the availability of timely, accurate, and consistent feedback from

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both field workers and management personnel. However, such feedback mechanisms may be compromised by communication gaps, limited technological integration, or inconsistencies in data collection and reporting practices. Third, while the framework is grounded in effective practices and verified through secondary data sources, it has not yet been extensively tested under real-time, high-risk construction environments, conditions that often reveal operational complexities not evident in theoretical or small-scale applications.

Implications: This study offers DOTs an adaptable, data-driven framework to foster proactive safety behaviors and achieve sustainable safety improvements in highway construction. The development of this framework is grounded in a comprehensive synthesis of scholarly literature, best national practices from desk scans, and in-depth interviews with state DOT officials.

Keywords: safety behavior, highway construction, injury, and fatality
Paper type: Full paper

Introduction

The construction industry consistently reports one of the highest rates of workplace injuries and fatalities in the United States, particularly in highway construction, where workers face hazardous conditions such as high-speed traffic, heavy machinery, and unpredictable site environments (Ahmed & Faheem, 2021; Chen et al., 2021; FHWA 2025). Despite ongoing efforts to reduce risks, highway construction workers continue to experience high rates of accidents and fatalities (Census of Fatal Occupational Injuries Summary, 2022). To address these safety concerns, many state Department of Transportation (DOTs) implement safety incentive and disincentive programs, which encourage workers to follow safety protocols by rewarding safe behaviors and penalizing unsafe ones. Research suggests that well-designed incentive programs can enhance safety awareness and compliance (Ahmed & Faheem, 2021). However, their effectiveness varies significantly across different worksites. There is limited research on which specific elements of these programs' workers find most effective in promoting safe behaviors. Without this understanding, programs may struggle to engage workers, resulting in minimal behavioral change and continued safety risks on job sites. Worker perceptions of fairness, attainability, and relevance are critical to the success of safety incentive programs (Bhandari et al., 2019). If workers view a program as unfair or unattainable, they may resist participation, ultimately reducing its effectiveness. Therefore, it is essential to explore not just the presence of safety incentive programs, but also how workers interact with them, perceive them, and respond to them in practice.

Previous research highlights multiple factors that influence the effectiveness of safety incentive programs for highway construction workers. These include psychological, organizational, motivational, and data-driven elements, each of which plays a distinct role in shaping worker behavior. Intrinsic motivation and autonomy drive long-term behavioral change (Deci & Ryan, 2013). Positive reinforcement is more effective than punitive measures in encouraging compliance (Geller & Geller, 2020). From an organizational perspective, a strong safety climate, clear communication, and management support are essential for fostering trust and engagement in safety programs (Bhandari & Hallowell, 2022; Chen et al., 2021). Psychological contracts between workers and management further reinforce this engagement (Newaz et al., 2019). However, financial incentives alone often fail to sustain long-term safety improvements (Ahmed & Faheem, 2021). A

balanced approach, combining financial rewards with personal recognition and intrinsic motivation, proves more effective (Azeez et al., 2019; Maslen & Hopkins, 2014).

In addition to psychological and organizational factors, leadership and data-driven safety management also play crucial roles in ensuring the success of incentive programs. Strong site leadership fosters a safety-first culture. Concurrently, data-driven approaches offer critical insights that refine and optimize safety incentives (Grill & Nielsen, 2019; Liu & Liu, 2022). Additionally, advancements in predictive analytics help identify high-risk behaviors and safety trends (Sohail et al., 2023; Koc et al., 2023). These insights allow for continuous refinement of safety incentive structures, making them more effective in reducing workplace injuries. The integration of active and passive safety indicators further enhances program evaluation, ensuring that incentive programs are empirically guided and continuously refined to improve effectiveness (Alruqi & Hallowell, 2019; Gambatese et al., 2017). This study identifies incentive and disincentive programs, perceptions and effectiveness of existing safety programs, training and communication of safety program, and proposed a framework for safety behaviors of highway construction workers.

Background

This section presents a thorough examination of findings from an extensive literature review focused on the safe behaviors of highway construction workers. Its primary aim is to establish a robust foundation and framework that enhances our understanding of the benefits and success metrics associated with safety performance, particularly in the context of implementing incentive and disincentive programs within state DOTs. The breadth of literature on this subject is extensive, encompassing a wide range of studies and analyses that explore the complexities of safe behaviors and the effectiveness of incentive/disincentive programs in the construction industry. To synthesize this diverse knowledge, the chapter focuses on key themes related to safety incentive programs, particularly their impact on promoting safer work practices among highway construction and maintenance crews. The section also explores the current state of practice of the psychological, motivational, and organizational factors that significantly influence safety behaviors in construction settings. This foundational analysis underscores how individual attitudes, group dynamics, and organizational culture can either promote or impede safe working practices.

Psychological factors such as motivation, risk perception, and behavioral reinforcement play a crucial role in shaping safety behaviors among highway construction workers. Intrinsic motivation, driven by autonomy and perceived competence, fosters long-term safety engagement, while extrinsic motivators, such as incentives, often yield temporary compliance (Deci & Ryan, 2013). Risk perception, influenced by past experiences and environmental hazards, significantly impacts workers' decision-making and adherence to safety protocols (Xia et al., 2020). Reinforcement strategies that emphasize positive consequences over punitive measures enhance compliance with safety standards and foster a proactive safety culture (Geller & Geller, 2020). Additionally, psychological safety—where workers feel comfortable reporting hazards without fear of punishment—strengthens safety commitment and hazard recognition, reducing workplace incidents (Hasanzadeh et al., 2019).

Organizational factors, including safety climate, leadership, and policy implementation, form the foundation for effective safety management in highway construction. A strong safety climate—where management visibly prioritizes safety through

consistent communication and enforcement—encourages worker compliance and reduces risk tolerance (Chen et al., 2021). Transformational leadership fosters trust by emphasizing safety as a shared responsibility and motivating workers to adopt safe behaviors (Bhandari & Hallowell, 2022). However, inconsistencies in policy implementation, such as unclear accountability and fragmented communication, can undermine safety initiatives and create gaps in compliance (Newaz et al., 2019). Organizations that promote fairness and worker autonomy achieve higher safety adherence, as employees who perceive equitable treatment and control over their work are more likely to engage in safe behaviors (Jung et al., 2020).

Motivational strategies, including incentives, recognition, and performance-based rewards, are critical in reinforcing safe behaviors. Financial incentives can initially improve compliance, but their effectiveness often diminishes over time unless integrated with intrinsic motivators such as peer recognition and career development opportunities (Ahmed & Faheem, 2021). Training programs that evoke emotional arousal, such as immersive injury simulations, enhance worker engagement and long-term retention of safety knowledge (Bhandari et al., 2019). Additionally, predictive analytics and real-time monitoring systems help identify high-risk behaviors, enabling organizations to refine safety interventions proactively (Koc et al., 2023). Leading indicators, including regular safety training, proactive hazard identification, and near-miss reporting, provide a forward-looking approach to preventing workplace incidents (Hinze et al., 2013). Thus, an integrated framework that combines behavioral reinforcement, leadership support, and technological interventions is essential for sustainable safety improvements in highway construction.

Research Method

This study employs a mixed-method research approach to examine safety behaviors among highway construction workers (Figure 1). The methodology includes a comprehensive literature review, an in-depth analysis of safety programs from all 50 DOTs, and structured interviews with six DOT safety experts. The literature review synthesizes existing research on behavioral safety approaches, safety incentive programs, and risk mitigation strategies in the construction industry. The in-depth analysis evaluates the structure, effectiveness, and variations in incentive and disincentive policies, identifying best practices and gaps. This systematic analysis provides insights into diverse strategies used by DOTs to enhance safety compliance and reduce workplace incidents.

Additionally, interviews with six DOT safety experts provide insights into the real-world implementation and perceived effectiveness of these programs. The interviewees, including safety managers, risk management officers, and program coordinators, offered detailed perspectives on success factors, challenges and recommended improvements for safety initiatives. The collected data were analyzed thematically to identify recurring patterns in program effectiveness, worker engagement, and policy adaptation. By triangulating findings from the literature, program analysis, and expert interviews, this study develops a refined, worker-centered framework to enhance safety behaviors in highway construction zones.

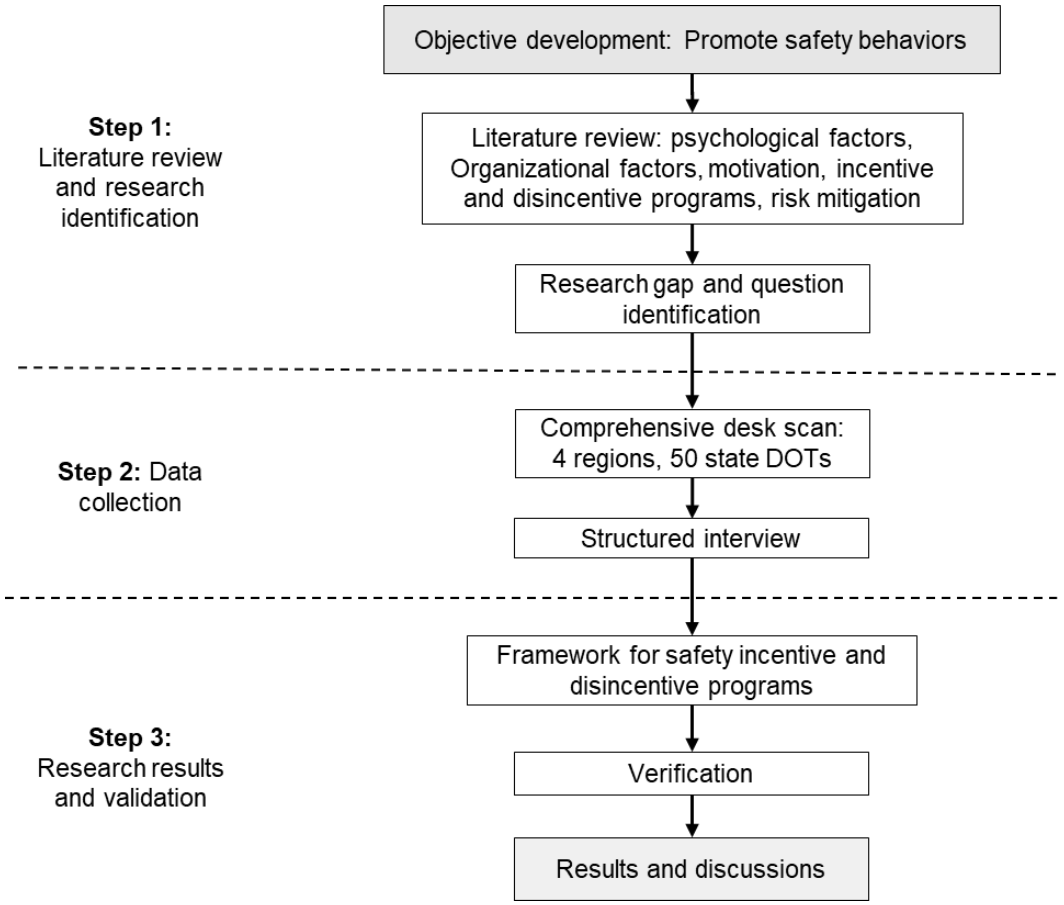

Figure 1. Research Method

Literature Review and Research Identification

This step involved a comprehensive literature review of incentive and disincentive programs aimed at enhancing safety performance from both the public and private sectors. While a preliminary scan of available literature indicates that there is very little guidance for state DOTs to evaluate and measure the effective incentive and disincentive programs for their highway construction workers, the aggregation of information on basic construction management principles and practices has provided background on the data collection process necessary for the framework development. The literature review involved researching, gathering, reading, note-taking, and processing information and literature relating to incentive and disincentive programs to enhance safety performance as well as the benefits, drawbacks, challenges, and lessons learned of deploying incentive and disincentive programs to motivate workers' safe behaviors. For example, the Occupational Safety and Health Administration (OSHA) states that "incentive programs can be an important tool to promote workplace safety and health." Examples of incentive programs include rewarding workers for reporting near-misses or hazards and encouraging the use of safety committees. In opposition, disincentive strategies can be used to discourage unsafe behaviors, such as disciplinary actions or special assignments for unsafe behaviors

Data Collection

The second step of the study involved gathering data, practical evidence, and information that would inform the development of the framework. The research team collected and analyzed publicly available documents, safety manuals, policy statements, and DOT program reports to understand how various agencies approach safety incentive and disincentive programs. The research team used two primary tools for performing the data collection process, including desk scanning and interviews.

In this study, desk scan process began with a desk scan that targeted four U.S. regions and reviewed current practices from all 50 state DOTs. The purpose of this scan was to: (1) identify the unique challenges faced in deploying incentive and disincentive programs by DOTs; (2) identify program success and how success is measured (e.g., performance metrics, documented change in worker safety behavior); (3) identify program training requirements (e.g., enforcement of safety practices, motivational skills for supervisors); (4) describe other safety motivational approaches (e.g., awareness, reminders, safety stand downs, safety training, safety accountability, leadership training), (5) identify and document critical success factors; (6) obtain contact information for successful implementation strategies; and (7) obtain examples of process innovations for incentive and disincentive programs used by DOTs, (e.g, worksheets, templates, guidelines, and policies).

Following the desk scan, a series of six structured interviews were conducted with key stakeholders, including DOT officials, project managers, and safety officers, to capture their perspectives on the effectiveness and challenges of existing safety programs. The DOT interviews aimed to exam the perspectives of DOT personnel regarding issues related to incentive and disincentive programs to enhance safety performance and motivate workers' safe behaviors across the nation. An interview protocol specifically focused on DOTs was developed based on the literature review, data from the desk scanning, and internal discussions with the project team. The data collected from the desk scanning was used to identify DOT representatives for qualitative interviews using the following criteria:

- Available documents and guidance related to safety motivational approaches (e.g., awareness, reminders, safety stand downs, safety training, safety accountability, leadership training)
- Novel or innovative practices related to safety incentive and disincentive programs;
- Readiness to deploy incentive and disincentive programs; and
- Requirements for safety training programs (e.g., enforcement of safety practices, motivational skills for supervisors)

The interview questions were structured around four areas: (1) Program Details; (2) Perceptions and Effectiveness; (3) Training and Communication; and (4) Lessons Learned and Future Challenges. Table 1 summarizes a sample of interview questions across these four areas.

Table 1: Samples of Interview Questions

Category	Interview Questions
Program Details	• What is your role in promoting safety among highway construction workers? • Which type of program does your DOT primarily use? • Can you describe the incentive and disincentive programs your DOT has implemented? • What specific training, if any, do you receive related to safety incentive and disincentive programs? • How long have the safety incentive and disincentive programs been in place within your organization?
Perceptions and Effectiveness	• How effective do you find your current safety programs in promoting safe behaviors? • In your experience, how have these programs influenced safety behaviors among workers? • Can you share a specific example where an incentive or disincentive program directly impacted safety on a project? • How does your organization feel about the effectiveness of these programs in promoting safety?
Training and Communication	• How frequently does your DOT offer training related to safety programs? • How are the objectives of the safety programs communicated to the workforce? • How are successes within these programs communicated to the workforce? • Do the safety programs include input or feedback from the workers?
Lessons Learned and Future Challenges	• What challenges has your organization faced in relation to these programs? • What improvements would you suggest for these programs? • Do you believe the current safety incentive/disincentive programs are sustainable in the long term? • Has your organization benefited from the safety incentive/disincentive programs? • What type of incentive is most appreciated by workers? • How often are workers recognized or penalized under these programs? • Do you have any documents or resources that you can share that will help in our study?

Results

This section presents the results derived from a comprehensive desk scan and interviews with representatives from various state DOTs, focusing on six key areas: (1) framework development, (2) desk scanning, (3) incentive and disincentive programs, (4) perceptions and effectiveness of existing safety programs, (5) training and communication of safety program, and (6) lessons learned. The desk scan involved a systematic review of publicly available DOT documents, safety manuals, and program reports, while the

interviews provided firsthand insights into the practical realities of managing and evolving safety programs at the agency level. Ultimately, this section synthesizes these findings to inform future safety framework development, with a focus on adaptability, effectiveness, and long-term sustainability.

Framework Development

The framework developed in this study was based on behavioral and planned safety approaches. The Behavioral Safety Approach for Highway Construction Workers is a structured framework designed to improve safety behaviors by addressing psychological, social, and operational factors specific to construction environments. Grounded in the Theory of Planned Behavior (TPB), the framework enhances workers' safety attitudes (belief in the importance of safety), reinforces safety influences (peer support, supervisory expectations, and organizational commitment), and strengthens safety controls (adequate safety equipment, comprehensive training, and safe working conditions). TPB posits that attitudes, social norms, and perceived behavioral control shape individuals' intentions and actions, making it a reliable model for promoting safe behaviors (The Theory of Planned Behavior, 2020). When TPB principles are integrated into structured safety programs, aligning with organizational goals and leveraging real-time safety data, workplace incidents can be reduced by up to 22% (Chen et al., 2021).

The framework is developed through four key stages. The need identification stage assesses safety challenges by collecting data from DOT safety programs and worker feedback (Newaz et al., 2019). The worker engagement stage fosters participation through incentive-based rewards, training initiatives, and peer accountability measures (Dadi et al., 2023). The program assessment stage evaluates effectiveness using safety audits, behavioral analytics, and feedback loops to measure program impact and identify areas for improvement (Kim et al., 2019). The strategic deployment stage scales safety measures from pilot projects to full district-wide implementation, ensuring adaptability across various construction environments (Muñoz-La Rivera et al., 2021). Finally, the continuous evaluation stage integrates real-time hazard detection and feedback systems, allowing for ongoing refinement and optimization of the framework (Sohail et al., 2023).

To improve clarity, consistency, and implementation efficiency, the research framework for highway construction worker safety was enhanced and streamlined into four stages. Stage 1: Develop & Launch Safety Program combines the initial need assessment, program creation, and worker engagement strategies to ensure a structured and well-communicated safety initiative. Stage 2: Assessment evaluates program effectiveness through safety audits, behavioral analytics, and worker feedback, ensuring that interventions are data-driven and responsive to workforce needs. Stage 3: Deployment scales the safety program from pilot projects to broader district-wide applications, promoting adaptability across varying construction environments. Finally, Stage 4: Evaluation & Implementation focuses on continuous monitoring, reporting, and lessons learned to refine safety strategies over time. Figure 2 presents this enhanced framework, integrating established DOT practices with behavioral safety principles, such as intrinsic motivation and emotional engagement, to foster sustainable safety behaviors among highway construction workers. This structured approach aligns safety programs with worker psychology, improving long-term compliance and reducing workplace incidents.

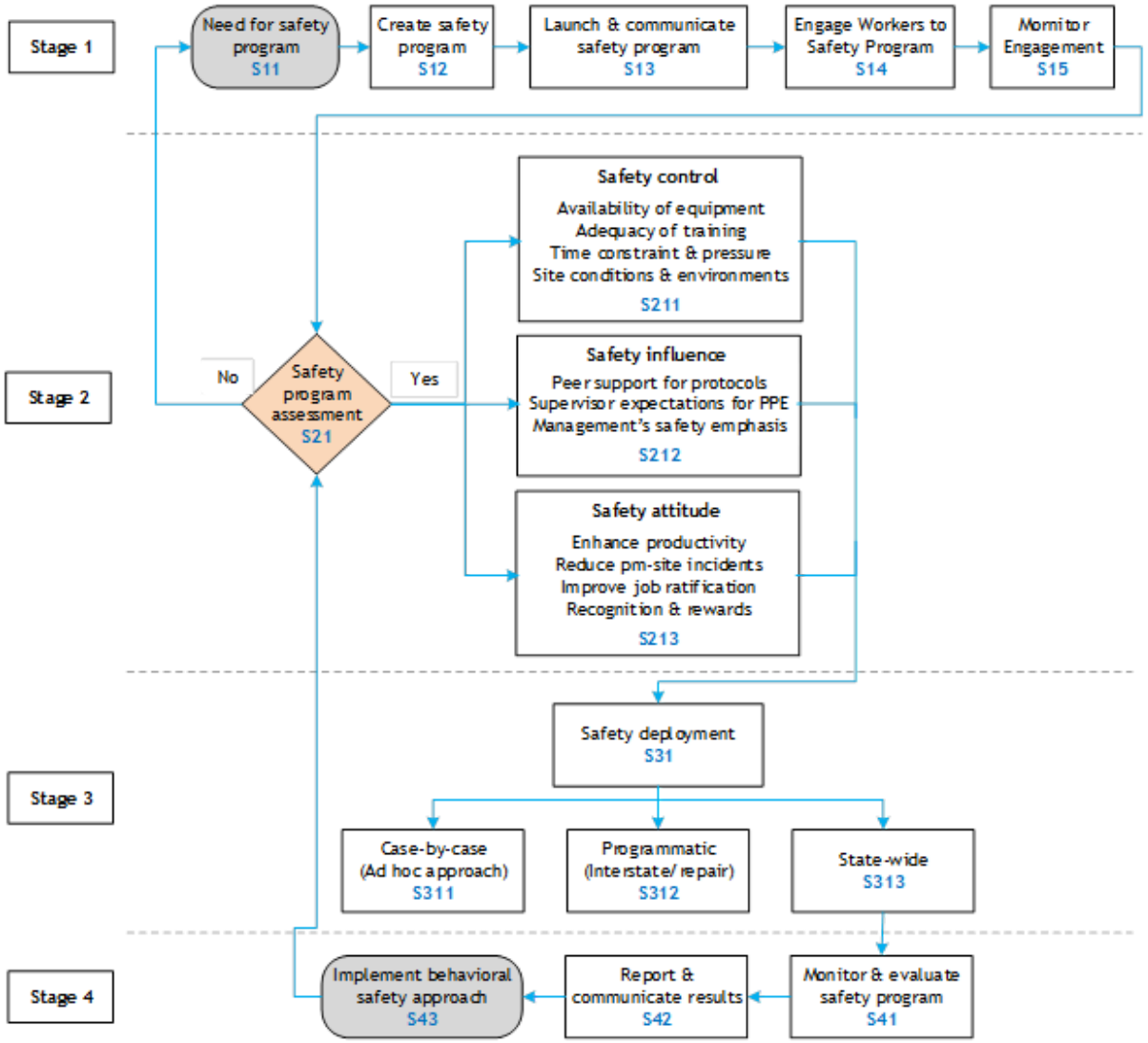

Figure 2. Enhanced Framework for Highway Construction Worker Safety

Stage 1: Develop & Launch Safety Program

Stage 1 establishes the foundation for an effective safety framework through five key components (Figure 2). It begins with identifying the Need for a Safety Program by assessing existing gaps and risks. Next, creating the Safety Program, incorporating structured training, incentives, and compliance measures tailored to workforce needs. The Launch & Communication phase ensures that the program's goals and expectations are clearly conveyed to workers and stakeholders through meetings, training sessions, and visual aids. Worker Engagement then fosters active participation through behavioral safety principles, peer accountability, and incentive-based motivation. Finally, Monitoring Engagement tracks participation and identifies areas for improvement. This structured approach ensures a well-integrated safety framework, setting the stage for assessment and deployment.

Stage 2: Assessment

Stage 2 evaluates the effectiveness of the safety program through three key components: Safety Control, Safety Influence, and Safety Attitude (Figure 2). Safety Control examines external factors that impact compliance, such as the availability of safety equipment, site conditions, time constraints, and work pressure. Safety Influence assesses how supervisors, peer support, and management commitment shape workers' adherence to safety protocols, emphasizing the role of leadership in fostering a safety-driven culture. Safety Attitude focuses on individual perceptions, job satisfaction, and motivation, highlighting how personal beliefs influence safe behaviors. It also considers the impact of recognition and rewards, which reinforce positive safety practices by incentivizing adherence to protocols. Together, these components provide a structured approach to identifying program strengths and areas for improvement, ensuring continuous enhancement of workplace safety.

Stage 3: Deployment

Stage 3 focuses on implementing the safety program across different project scales through three key components: Safety Program Deployment Level 1, Level 2, and Level 3 (Figure 2). Level 1 begins with pilot projects, where safety measures are tested on a smaller scale to assess feasibility and effectiveness before broader application. Level 2 expands the program to various work environments, including both high-risk and low-risk highway construction sites, ensuring adaptability across different operational conditions. Level 3 represents full-scale deployment, where safety measures are standardized and implemented across all relevant projects within a district or statewide. This tiered deployment strategy allows for gradual refinement, ensuring that lessons learned from earlier stages contribute to optimizing the program. By systematically scaling safety initiatives, this stage enhances consistency, strengthens worker adherence, and ensures long-term integration of safety practices in highway construction projects.

Stage 4: Evaluation & Implementation

Stage 4 ensures the continuous improvement of the safety program through three key components: Monitor & Evaluate Safety Program, Report & Communicate Results, and Implementation & Lessons Learned (Figure 2). Monitoring & Evaluation involves tracking safety performance metrics, analyzing incident reports, and assessing worker compliance to determine the program's effectiveness. Reporting & Communicating Results ensures that findings are shared with key stakeholders, including safety managers, supervisors, and workers, fostering transparency and informed decision-making. Finally, Implementation & Lessons Learned focuses on refining safety initiatives based on evaluation outcomes, addressing identified gaps, and integrating best practices for continuous improvement. This structured approach helps create a dynamic safety framework that adapts to changing work conditions, enhances worker engagement, and promotes a proactive safety culture in highway construction projects.

Desk Scanning

The comprehensive scan of safety incentive and disincentive programs reveals diverse approaches and strategies employed by various state DOTs. Out of the 50 state DOTs, 32 have implemented formal programs, while 18 rely on informal programs. Key results from the desk scan are as follows:

Widespread Adoption of Formal Programs: Over half of U.S. state DOTs have moved beyond formal safety efforts and adopted structured safety incentive/disincentive programs. This suggests increasing institutional recognition of the value of formalized safety systems in improving worker safety behavior and performance outcomes.

Persistence of Informal Practices: A portion (36%) still operates under informal or less standardized frameworks. This could reflect barriers such as limited resources, lack of policy mandates, or early stages of program development. These agencies may benefit from technical assistance or model frameworks to transition toward formalized systems.

Need for Capacity Building: States without formal programs may lack the necessary leadership support to implement comprehensive safety measures. This underscores the need for outreach, training, and best practice sharing among DOTs to foster more uniform safety standards nationwide.

In summary, while a majority of DOTs demonstrate proactive safety management through formalized programs, 36% of state DOTs continue to rely on informal mechanisms. The findings highlight the importance of adaptable safety frameworks that can bridge this maturity gap and support all DOTs in enhancing construction site safety culture and outcomes.

Incentive and Disincentive Programs

The six state DOTs, PennDOT, NMDOT, GDOT, McDOT, MiDOT, and MoDOT, reveal distinct yet overlapping approaches to implementing safety programs for highway construction workers, categorized broadly into three strategies: those that use both incentives and disincentives, those that primarily emphasize incentives, and those that focus more heavily on disincentives, as shown in Table 2. PennDOT has applied both strategies since 2011, offering individual and group awards such as non-monetary products for injury-free service and funding for equipment valued between $180,000 and $250,000 when counties meet safety targets. On the disincentive side, they use pre-disciplinary conferences (PDCs) for employees involved in accidents or unsafe acts. However, due to negative stigma, especially among union employees, PennDOT is currently working to reduce reliance on automatic PDCs and instead place more emphasis on positive recognition. Similarly, NMDOT uses a combination of annual awards and informal recognitions, such as small tokens (e.g., keychains, Gatorades), to motivate safe behavior. Formal recognitions include Carhartt jackets for 20 years of accident-free service and Yeti mugs for five years. Additionally, NMDOT awards industrial crews based on exposure hours and grants administrative leave and public recognition. Supervisory training is also used to keep safety priorities clear across all roles. These programs, in place for over two decades, have proven sustainable and continue to be appreciated by employees.

The safety, insurance, and compensation manager explained that GDOT employs both incentive and disincentive programs, with a recent stronger push towards incentivizing safe behavior. The interviewee stated, "They are now recognizing what the effect of employee engagement and rewarding employee engagement is." For instance, incentives include providing employees with safety gear and tools such as helmets, soft caps, vests, safety glasses, and earplugs, packaged in duffel bags, to underscore the value of their equipment and safety. Conversely, disincentives have been restructured, notably doing away with injury-related disincentive programs while maintaining those for vehicle crashes, adjusted to consider individual culpability. This shift reflects a broader effort to move towards

human performance improvement, recognizing the complexity and context of incidents rather than applying blanket punishments.

Table 2: Program details

DOT	Program Type	Program Details	Duration
PennDOT	Both Incentive and Disincentive	Individual awards based on service years, group awards for meeting safety goals, and pre-disciplinary conferences (PDCs)	10 years
NMDOT	Both Incentive and Disincentive	Annual safety awards, 'catch you doing right' initiatives, and supervisor-led recognition	10 years
McDOT	Disincentive	Focus on education, verbal and written warnings for violations, and project shutdowns for major safety breaches	10 years
MiDOT	Incentive	Safety Excellence Awards, educational programs, and traffic control training	5 years
GDOT	Both Incentive and Disincentive	Incentive programs providing tools and equipment, based on lean metrics	3-5 years
MoDOT	Both Incentive *Disincentive*	Long-term recognition programs, peer-to-peer observation, and progressive discipline	10 years

McDOT primarily employs disincentive strategies, largely influenced by budget constraints and a commitment to aligning with OSHA guidelines. The department enforces strict compliance with safety regulations, including the use of personal protective equipment (PPE), with violations resulting in disciplinary measures ranging from verbal warnings to potential project shutdowns. Initially, this approach faced resistance and was perceived as overly punitive; however, it has evolved into a more educational focus over time, bolstered by annual OSHA updates and safety conferences. In contrast, MiDOT and MoDOT emphasize incentive-based recognition programs. MiDOT offers Safety Excellence Awards, which honor employees with plaques and sponsored lunches based on performance criteria that have recently been elevated to reflect higher standards. The department also prioritizes ongoing training, including traffic control education, to tackle field-level safety issues such as the improper use of attenuators. MoDOT recognizes individual contributions through its Long-Term Safety Award Program, which includes jackets awarded for 15 years of injury-free service, and acknowledges exceptional safety actions through just-in-time programs. A notable example is a meritorious safety award given to maintenance workers who intervened to save a child from a dog attack. However, due to concerns regarding injury underreporting tied to team awards, MoDOT has shifted away from traditional incentives and now promotes hazard identification through its Good Catch program. Safety training at MoDOT is continuous, commencing with employee orientation and reinforced through daily safety briefings. Overall, while each agency tailors its approach based on internal limitations, operational objectives, and workforce requirements, they all share a common goal: to minimize incidents and foster a stronger safety culture through a blend of rewards, training, and enforcement.

Perceptions and Effectiveness of Safety Incentive and Disincentive Programs

The effectiveness of safety incentive and disincentive programs varies across different DOTs in the United States. Each DOT faces unique challenges and successes, reflecting their specific organizational cultures and external factors such as employee turnover and economic conditions. Programs are generally rated from neutral to somewhat effective, with some DOTs highlighting high turnover and COVID-19-related hiring challenges as significant barriers. Despite these issues, workers often appreciate safety awards. In some cases, programs focus more on compliance than on the frequency of awards, with state-level recognition being highly valued. Transitioning from fear-based models to educational approaches has been noted to positively influence worker behavior. Optimism exists for the improvement of safety programs with new criteria and strong communication practices. Disincentive programs, particularly those emphasizing strict accountability measures, have shown high effectiveness in reducing safety incidents, although incentive programs may need more frequent implementation and better perceived value. Table 3 presents safety managers' insights into the effectiveness of their programs, offering a nuanced view of how these initiatives are received at the ground level.

Table 3: Perceptions and Effectiveness

DOT	Perceived Effectiveness	Key Insights
PennDOT	Neutral	High turnover rates impact program effectiveness; a planned increase in award values to improve morale
NMDOT	Somewhat Effective	Supervisors value state awards more; initiatives have reduced incident rates
McDOT	Somewhat Effective	Initial negative impact due to fear-based approach; improved with focus on education
MiDOT	Neutral	Positive reception to safety excellence awards; new criteria expected to enhance program effectiveness
GDOT	Somewhat Effective	Effective but occasionally hindered by slow rollout and communication gaps
MoDOT	Neutral to Very Effective	Disincentive programs are very effective in reducing incidents; recognition programs need more frequency

The six state DOTs, PennDOT, NMDOT, McDOT, MiDOT, GDOT, and MoDOT, share a common goal of improving safety performance, but their programs vary in perceived effectiveness and employee reception. PennDOT and MiDOT both described their safety programs as "neutral" in effectiveness. At PennDOT, while awards promote pride among workers, issues such as low award value and stigma associated with pre-disciplinary conferences have limited their overall impact. The lack of direct examples tying incentives or disincentives to improved project-level safety outcomes also weakens perceptions of program success. Similarly, MiDOT sees its current program as moderately effective but anticipates improvement with recent updates to the Safety Excellence Awards criteria. The interviewee noted optimism due to visible impacts like enhanced crew safety practices following facility assessments and increased supervisor engagement. Although both agencies see potential for growth, they recognize that better alignment of program design with worker motivation, and clearer documentation of outcomes are needed to improve impact and perception.

In contrast, NMDOT, McDOT, and GDOT each described their programs as "somewhat effective," though for different reasons. NMDOT emphasized that while their safety awards are appreciated and contribute to a sense of pride, the focus remains on overall compliance rather than award quantity, and again, no project-specific impacts were cited. During the COVID-19 pandemic, the absence of awards underscored their value among staff, signaling their role in morale and motivation. McDOT reported a significant shift in perception after moving away from a fear-based compliance model toward education-focused strategies. Disincentives such as site shutdowns for violations have proven effective, and over time, the approach has fostered more open communication and a proactive safety culture. GDOT highlighted progress through regular safety meetings, improved two-way communication, and stronger leadership support. In particular, the Safety Excellence Awards have helped reinforce behavioral change during high-risk situations like disaster response. While rating overall effectiveness as neutral, MoDOT found disincentives highly effective—especially through the use of telematics to monitor

driving behavior, leading to measurable reductions in violations like speeding. Their leadership strongly supports the program, with safety messaging embedded into training and quarterly meetings. These findings suggest that programs are more effective and better perceived when they are well-supported by leadership, consistently reinforced, and clearly linked to measurable behavior changes, especially when combined with meaningful feedback and two-way communication.

Training and Communication of Safety Programs

Training and communication are crucial for the success of safety programs, ensuring that workers are informed about protocols and best practices, and keeping all stakeholders engaged. Various DOTs in the United States employ different training frequencies and communication methods tailored to their needs, as shown in Table 4. Training is sourced from conferences, supervisory training, OSHA updates, and specialized courses. Safety objectives are communicated through annual letters, manuals, new employee orientations, and regular meetings. Successes are shared during Safety Stand Down Days, award ceremonies, and quarterly meetings. Worker input is integrated via policy committees, safety officers, and advisory councils. Despite challenges such as hesitancy in providing feedback, DOTs aim to uphold safety standards through open communication and continuous training. These practices are essential for building trust and fostering a culture of safety and compliance.

Table 4: Training and Communication

DOT	Training Frequency	Communication Methods
PennDOT	Annually	Letters from the Secretary of Transportation, monthly safety meetings
NMDOT	Annually	Safety meetings, administrative directives, and annual award ceremonies
McDOT	Monthly	New employee orientation, monthly meetings, and quarterly statewide safety committee meetings
MiDOT	Monthly	Safety officers direct to safety manuals, recognition at maintenance meetings, and random thank you calls.
GDOT	Monthly	New employee training, quarterly metrics meetings, and staff meetings
MoDOT	Never (safety program structured)	New hire orientation

Table 4 shows the variability in training and communication practices among the six state DOTs, each adopting unique approaches to support their safety programs. While some agencies offer structured and ongoing training, others rely more on informal learning, periodic meetings, and peer-to-peer knowledge sharing. PennDOT gathers most of its training content through conference attendance, with relevant insights shared with executive leadership to guide program development. Communication of program objectives is delivered through annual letters from the Secretary of Transportation and monthly safety committee meetings, with program achievements highlighted during the biannual Safety

Stand Down Day. Similarly, NMDOT does not prioritize formal training on incentive programs but instead focuses on supervisory training in areas such as risk management and communication. Safety policies and expectations are communicated through administrative directives and manuals, while employee feedback is gathered through a policy procedures committee that reviews safety documents every five years.

In contrast, McDOT and GDOT provide more formal and frequent training opportunities. McDOT relies on OSHA updates, safety conferences, and university courses to keep staff informed, with safety expectations introduced during onboarding and reinforced annually. Program outcomes are shared quarterly during Statewide Safety Committee meetings, and worker feedback is actively used to support ongoing improvement. GDOT offers monthly flagger and first aid/CPR training and quarterly fire extinguisher instruction, with safety goals communicated during new employee orientation and quarterly metrics meetings. Successes are shared during district-level reviews, though some employees remain hesitant to provide feedback due to concerns about retribution. Meanwhile, MiDOT and MoDOT offer minimal formal training for safety incentive or disincentive programs. MiDOT emphasizes general safety education through traffic control and safety manuals, with recognitions shared during maintenance meetings. Safety officers encourage continuous communication and feedback from field staff. MoDOT uses department-wide seasonal meetings and events like Stand Up for Safety Day to communicate safety goals, with progress measured through performance metrics such as seatbelt usage. Employee input is regularly collected through mechanisms like the Employee Advisory Council and steering teams. While training depth varies, all six DOTs use regular communication and worker feedback as key elements in supporting and adjusting their safety initiatives.

Lessons Learned

Implementing safety incentive and disincentive programs across various DOTs has revealed several common lessons and challenges. Key issues include negative perceptions of disciplinary measures, budget constraints, inconsistent enforcement, and communication barriers. Improvements suggested include increasing transparency, enhancing tracking and reporting, mandatory participation, and full leadership support, as seen in Table 5. Despite these challenges, the programs have improved safety behaviors, reduced incident rates, and enhanced safety compliance. Workers most appreciate public recognition, monetary bonuses, and additional leave. Regular recognition and penalties are crucial for maintaining motivation and compliance, highlighting the need for continuous improvement and adaptation in safety programs across these DOTs.

The lessons learned from the six state DOTs reveal common challenges and valuable insights into the implementation of safety incentive and disincentive programs. A key takeaway is the importance of consistent communication, leadership support, and clear enforcement. PennDOT and NMDOT both experienced initial resistance and mixed perceptions due to inconsistent application of disciplinary actions and limitations in financial incentives. Both agencies stressed the need for increasing transparency in the recognition process, improving communication with workers, and rethinking punitive measures such as pre-disciplinary conferences, which were viewed negatively. McDOT, while focusing more on education than discipline, identified a communication gap, described as a "layer of clay", where messages fail to reach frontline workers effectively. This highlights the need for dedicated safety personnel, better training, and consistent program messaging to maintain effectiveness over time. Across all three agencies, there

was a strong recognition that financial constraints limited the use of bonuses or additional leave, leading to a reliance on lower-cost recognition like public praise or small gifts, which, while appreciated, may not always maintain long-term motivation.

Table 5: Lessons Learned

DOT	Challenges Faced	Suggested Improvements
PennDOT	Budget constraints, stigma of Pre-disciplinary Conference (PDCs)	Increase budget, educate on proper disciplinary actions, and raise the value of safety awards
NMDOT	Underreporting, balancing recognition	Move towards one true state winner, increase the frequency of feedback and recognition
McDOT	Initial negative perception, implementation	Enhance communication, provide additional resources for training, and focus on education rather than punishment
MiDOT	Participation reluctance among older workers	Ensure leadership support, improve participation, and continuously raise safety standards
GDOT	Equipment funding, slow rollout	Engage safety committees for program enhancement, streamline communication, and ensure timely rollout of initiatives
MoDOT	Lack of structured training	Incorporate structured training sessions, utilize technology for program expansion, and maintain aggressive discipline approach

For MiDOT, GDOT, and MoDOT, district-level inconsistency and uneven participation were major challenges. In both MiDOT and GDOT, allowing optional district participation led to gaps in engagement, with some districts opting out entirely. To address this, both agencies recommended mandatory participation and stronger top-down leadership support to ensure program consistency. Despite these challenges, all three agencies noted positive outcomes, such as improved safety behaviors and a stronger safety culture, particularly among newer generations of workers. In MoDOT's case, the use of disincentive measures such as telematics has been especially effective, leading to measurable reductions in incidents and stronger compliance. Frequent meetings to discuss incidents and assign discipline reinforced accountability. While monetary rewards remain the most valued by workers across all six DOTs, most agencies rely on public recognition, plaques, stickers, and non-monetary tokens due to state policy limitations. A clear takeaway is that frequent, visible recognition, paired with fair and well-communicated enforcement, can be a powerful driver of safety performance, even in the absence of high-value financial incentives.

In summary, state DOTs across the U.S. face varied challenges in implementing effective safety programs. PennDOT struggles with budget constraints and the negative stigma around Pre-disciplinary Conferences (PDCs), prompting suggestions to increase funding, improve education on disciplinary practices, and elevate the prestige of safety awards. NMDOT contends with underreporting and difficulty balancing recognition, recommending a shift to a single state winner and more frequent feedback. McDOT has faced initial resistance and implementation issues, which could be mitigated through

better communication, enhanced training resources, and educational sources. MiDOT experiences participation reluctance among older workers, highlighting the need for stronger leadership support and efforts to raise safety engagement and standards. GDOT's issues stem from equipment funding and slow program rollout, suggesting a need for safety committee engagement and clearer communication. Finally, MoDOT's lack of structured training calls for incorporating formal training, leveraging technology, and upholding firm disciplinary protocols to support safety culture, as shown in Table 5.

Verification and Discussion

The verification of the proposed framework was conducted through an iterative process involving five state DOTs, MoDOT, McDOT, MiDOT, PennDOT, and NMDOT. The initial framework was presented to each DOT, and their feedback led to progressive refinements at each stage. With every round of feedback, adjustments were incorporated and presented to the next DOT, ensuring continuous improvement and alignment with real-world safety practices. This iterative validation process led to the final Behavioral Safety Approach for Highway Construction Workers, incorporating key refinements like improved assessment metrics and real-time safety monitoring technologies. Successful implementation of the Behavioral Safety Approach requires strong leadership commitment and alignment with existing safety policies (Grill & Nielsen, 2019). Additionally, digital tools like wearable sensors and mobile reporting applications enable real-time hazard detection (Sun et al., 2020), while engagement strategies such as recognition programs, peer feedback, and continuous training foster worker participation and compliance. This structured, adaptable framework enhances safety management strategies and reduces incidents on highway construction sites (Bitar et al., 2022; Ahmed & Faheem, 2021).

The verification process began with MoDOT, which emphasized the importance of balancing safety incentives and disincentives to ensure sustained worker engagement. Feedback from MoDOT highlighted the need to integrate both behavioral and disciplinary measures, leading to refinements in how the framework addressed safety culture and compliance tracking. Next, McDOT provided valuable insights into the structural flow of the framework, suggesting modifications to the decision-making process within the safety program assessment stage. Their recommendations improved clarity in distinguishing between safety program evaluations and decision points, ensuring that DOTs could systematically determine necessary refinements based on real-time data. Additionally, McDOT stressed the importance of replacing the term accidents with incidents to align with modern safety terminology and regulatory standards.

As the framework progressed through validation, MiDOT emphasized the importance of continuous training and education in reinforcing worker safety behaviors. Their input led to the inclusion of structured training cycles and proactive hazard identification strategies. PennDOT further refined the approach by advocating for stronger alignment between safety incentives and existing organizational policies, ensuring that implementation did not conflict with union regulations or established workforce management structures. Finally, NMDOT reinforced the importance of defining the framework as a safety process rather than a safety program, highlighting the need for a dynamic, evolving system rather than a static set of guidelines. This shift emphasized ongoing improvement, real-time data integration, and adaptability to emerging safety challenges. These iterative refinements collectively strengthened the Behavioral Safety Approach for Highway Construction

Workers, ensuring its practicality, scalability, and effectiveness in mitigating safety risks across highway construction environments.

Conclusions

The findings of this study highlight the significance of integrating behavioral, organizational, and data-driven strategies to enhance safety behaviors among highway construction workers. While safety incentive and disincentive programs have been widely implemented, their effectiveness remains variable and largely depends on worker perceptions, program design, and organizational support. The study's analysis of safety programs across all 50 state DOTs revealed that structured incentive programs, when aligned with organizational goals, can significantly improve compliance rates. Furthermore, insights from interviews with DOT safety experts underscore the importance of balancing incentives with clear communication, leadership commitment, and real-time safety monitoring technologies to ensure sustained worker engagement and participation.

The proposed Behavioral Safety Approach framework, grounded in the TPB, provides a structured methodology for improving safety outcomes. The framework consists of five stages: need identification, worker engagement, program assessment, strategic deployment, and continuous evaluation. The integration of predictive analytics, leading safety indicators, and peer-driven accountability mechanisms has been shown to reduce workplace incidents and foster a proactive safety culture. Additionally, the study demonstrates that incentive programs incorporating both financial rewards and intrinsic motivators, such as peer recognition and leadership engagement, are more effective in promoting long-term safety behaviors compared to punitive-only approaches.

It is critical to establish a safety program that is strategically designed and integrated within a broader safety management framework that includes comprehensive safety training, effective communication, and strong leadership commitment. The findings suggest that safety incentive programs must be perceived as fair, attainable, and relevant by workers to achieve sustained effectiveness. Moreover, the study highlights the importance of understanding psychological, organizational, and motivational factors influencing safety behaviors.

Acknowledgments

The authors also extend their appreciation to the state Departments of Transportation (DOTs) that participated in the research, particularly the safety experts who contributed valuable insights through interviews and validation discussions. Their willingness to share experiences and perspectives significantly enriched the study’s findings and strengthened the proposed safety framework. Any opinions, findings, and conclusions expressed in this study are solely those of the researchers and do not necessarily reflect the views of the participating DOTs.

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