NIOSH Reports! Studies on Heavy Equipment Blind Spots and Internal Traffic Control

Presented by

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NIOSH, Division of Safety Research

2004 Roadway Work Zone Safety & Health Conference

Baltimore, Maryland

November 4, 2004
Outline

- Background
  - NIOSH Research
  - Worker Deaths
- Blind Area Diagrams
- Internal Traffic Control Plans
Building Safer Highway Work Zones:
Measures to Prevent Worker Injuries
from Vehicles and Equipment

Delivering on the Nation’s Promise:
Safety and health at work
For all people
Through research and prevention

To receive other information about occupational safety and health topics, call
1-800-35-S-NIOSH (1-800-35-64674), or
visit the NIOSH Website at:
www.cdc.gov/niosh

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Project Organization

Roadway Work Zone Intervention Evaluations

Morgantown, WV
- Worker Exposure Measurement
- Blind Area Determination
- Internal Traffic Control Plans
- Site Access / Partnering
- Case Definition
- HSRB/OMB/Photo Release
- Research Staff Safety

Pittsburgh, PA
- HASARD
- Work Zone Analysis System

Spokane, WA
- Proximity Warning Devices
- Detection Zones

State Transportation Departments
Construction Companies
Engineering Consultants
Labor Unions
Construction Trade Associations
Equipment Manufacturers
FHWA, OSHA

SAFER・HEALTHIER・PEOPLE™

CDC
The Problem

- Preventing workers from being run over by construction trucks and equipment.
The Project Goals

- Limit exposure of workers-on-foot to construction traffic.
- Focus on blind areas around construction vehicles and equipment.
  - Develop exposure monitoring system(s)
  - Evaluate injury prevention measures
The Interventions

- Proximity Warning Systems
- Internal Traffic Control Plans
Proximity Warning Systems

- Evaluate off-the-shelf technology including:
  - Radar
  - Sonar
  - Cameras
  - Tag-based systems
Camera Systems
Radar

Sonar

Sensors
Camera and Radar

![Diagram of Camera and Radar system with labels for Protective roof, Camera, Radar, and Cabling.]

Camera
Radar

[Image of a vehicle showing the installation of the camera and radar system.]
Proximity Warning Systems: Data collection methods

- Video
- Alarm overlay
- Alarm data

Warning system alarms
Field Trials

- Direct Observation
- GPS
- Video
GPS Installed on Equipment including:
- Asphalt Trucks
- Paver
- Rollers

GPS receivers worn by workers
Vermont GPS Data Paving Around a Rest Area
Background: Worker Deaths in Work Zones

- 910 worker deaths in work zones from 1992-2000
- 826 (91%) were vehicle or equipment-related (traffic vehicle, construction vehicle, or both)
Worker Fatalities in Roadway Construction

Trend from 1992-2000

(n=910)

Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)
Worker Fatalities in Roadway Work Zones, by Vehicle Type and Year, 1992-2000 (n=797)

Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)
Workers on Foot – Construction Vehicle Only

Deaths by Construction Vehicle Type, 1992-2000 (n=258)

- Dump truck: 41%
- Semi-truck: 6%
- Grading/surfacing machine: 14.3%
- Excavating machine: 6.5%
- Other/unspec truck: 14%
- Other machine: 10.4%
- Other vehicle/other source: 7.7%

Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)
City Worker Killed When Struck by a Dump Truck in Washington State

FATALITY INVESTIGATION REPORT

Investigation: # 06WA041
SHARP Report: # 52-11-2004

Release Date: August 5, 2004

FACE/WA
Fatality Assessment & Control Evaluation

WA FACE Program/SHARP
PO Box 4330
Olympia, WA 98504-4330
(888) 667-4277
http://www.lni.wa.gov/Safety/Research/FACE
Area where truck turned around

Location where workers were struck
Blind Areas
Definition of Blind Area

- A *blind area* is the area around a vehicle or piece of construction equipment that is not visible to the operators, either by direct line-of-sight or indirectly by use of internal and external mirrors.
Vehicle Blind Spots

- Running over people
- Running over materials
- Striking other equipment and vehicles
- Rollovers
- Contact with utilities
Non-Construction Vehicle Blind Spot Measurements

[Diagram showing blind spot measurements for various vehicles: Honda Accord, Dodge Grand Caravan, Toyota Sequoia, Chevrolet Avalanche. The diagram indicates the difference between average-height and short drivers.]
Methods

- International Organization for Standardization (ISO) 5006
- Manual methods
  - Light Bar
  - Operator
- Computer methods
  - Design Drawings
  - Laser Scans
  - Photographs
Manual Light Bar Method
<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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<tbody>
<tr>
<td>Dump Truck (Manufacturer and Model)</td>
<td>Ford 880</td>
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<tr>
<td>GVW</td>
<td>54,000 lb</td>
</tr>
<tr>
<td>Serial #</td>
<td>V00131</td>
</tr>
<tr>
<td>Machine Dimensions</td>
<td>7’ 10” wide 23’ 2” long</td>
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<tr>
<td>Operator Enclosure</td>
<td>Closed ROPS</td>
</tr>
<tr>
<td>Attachments</td>
<td>None</td>
</tr>
<tr>
<td>Other Information</td>
<td>None</td>
</tr>
<tr>
<td>Measurement Technique</td>
<td>Physical</td>
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</table>
Blind Area Diagrams - Ford 880

Ground ~3ft

Construction Barrel ~3ft

Worker partially bent over ~5ft
Manual Operator Method
Marking Blind Areas Within a Polar Grid
Caterpillar 672CH Blind Area at 900mm above Ground Plane
Blind Area Diagram Ford 880 Dump Truck

- Not Visible to Operator
- Visible in mirrors only
Comparison of Manual Methods

Field Crew Light Bar
Virtual Reality Method
Blind Area Diagrams

- Photo Generated
- Blind Areas
Contract Deliverable

Center for Disease Control and Prevention

Contract 200-2002-00563

“Construction Vehicle and Equipment Blind Area Diagrams”

Final Report
Blind Area Diagrams

- Caterpillar Contract
  - Shadow Method and Computer Generated Blind Areas
Web Page of Blind Area Diagrams

Blind Area Diagrams

Please click which type of vehicle:

- 2-Axle, Front Steer, Rear Dump Trucks
- 3-Axle, Front Steer, Rear Dump Trucks
- Articulated, 3-Axle, Rear dump Trucks
- Dozers
- Cold Planers
- Loaders
- Backhoe Loaders
- Graders
- Scrapers
- Transfer/ Shuttle Buggy
- Rollers
- Road Recyclers/ Reclaimers
- Hydraulic Excavators
## Blind Area Diagrams

| Grader (Manufacturer and Model) | Cat 12G  
|--------------------------------|--------  
| GVW                             | 31,410 lb  
| Serial #                        | 61  
| Machine Dimensions              | 9' 2" wide 28' long  
| Operator Enclosure              | Closed ROPS  
| Attachments                     | None  
| Other Information               | None  
| Measurement Technique           | Computer  

Click on an image below to enlarge.
Internal Traffic Control Plans
Why Develop an Internal Traffic Control Plan?

- Coordinate vehicle/equipment movement inside the work zone
- Limit exposure of workers on foot to construction traffic
- Reduce hazards for equipment operators
Definition of Internal Traffic Control Plans (ITCP)

“STRATEGIES TO CONTROL THE FLOW OF CONSTRUCTION WORKERS, VEHICLES AND EQUIPMENT INSIDE THE WORKZONE”
Traffic Control Plans
TCP – ITCP PARALLELS

TCP
TYPICAL
RESPONSIBLE PERSON
REQUIRED BY MUTCD

⇒
⇒
⇒

ITCP
MODEL
COMPETENT PERSON
CONCEPT
PRINCIPLES OF SAFE CONSTRUCTION

TRAFFIC CONTROL

- Reducing the need to back up equipment
- Limiting access points to work zones
- Establishing pedestrian-free areas where possible
- Establishing work zone layouts commensurate with type of equipment
PRINCIPLES OF SAFE CONSTRUCTION

TRAFFIC CONTROL

- Providing signs within the work zone to give guidance to pedestrians, equipment and trucks
- Designing buffer spaces to protect pedestrians from errant vehicles or work zone equipment
ITCP COMPONENTS

- NOTES PAGE
- LEGEND
- WORK AREA DIAGRAMS
SAFETY POINTS

1. Truck spotter stays at paver
2. Stage trucks to minimize backing
3. No walking behind backing trucks, in front of paving machine, across hot mat, or over trailer tongue.

PERSONNEL
- Truck Drivers
- Truck Spotter
- Paver Operator
- Roller Operators
- Inspector
- Superintendent
- Test Personnel

EQUIPMENT
- Oiler Trucks
- Dump Trucks
- Pavers
- Rollers
INTERNAL TRAFFIC CONTROL PLAN NOTES

Site #2 – Interstate 10 – Interchange with Jimmie Kerr Boulevard
Casa Grande, Arizona

GENERAL CONDITIONS

Safety Points

1. Pedestrian Worker Movement Patterns:
   a. In no case shall a Pedestrian Worker move outside the designated task corridor without approval of the designated Competent Person.
   b. Inspectors shall coordinate sampling frequency and location with the designated Competent Person. Sampling shall only occur when vehicle traffic has stopped or does not occur within 100 feet of said inspector.
   c. "Runners" shall maintain a location immediately between the rear of the paving machine and no more than 50 feet behind the paving machine.

2. Pedestrian Worker Identification:
   a. Pedestrian Workers shall use distinctive color clothing and headgear for designated personnel as approved by the Safety Officer. The designated competent person shall also wear a distinctive armband or hardhat. The purpose of different colored hard hats and or retro-reflective clothing is to distinguish ground personnel on the job site. It is important on paving/construction projects for the safety officer, competent person, and supervisor to be able to recognize laborers, operators, truck drivers, inspectors or other ground personnel.

3. Truck Spotter:
   a. Spotter shall maintain a location between truck traffic and the paving machine thereby allowing complete view and control of truck movement and staging.
   b. Communications should be maintained between the spotter and truck operators via hands-free radios or an approved equal. If such an equivalent method of communications is necessary, said method shall be submitted to the designated Competent Person for approval 48 hours prior to its use.
   c. A pedestrian worker may be employed if data collection (e.g., retrieval of tire tickets, etc.) from truck operators cannot be adequately completed by the spotter. Said pedestrian worker shall maintain a location outside and rear the truck depositing material.

Page 1
Safety Points

- No workers in traffic zone
- Spotter uses hands free radio to talk to trucks
- No workers on foot between a backing truck and the paver
- Truck spotter remains at paver until truck stops
- Inspectors remain away from paving train and notify spotter before obtaining samples
INTERNAL TRAFFIC CONTROL PLANS

- Light(s)
- Channeling device(s)
- Barrier
- Direction of temporary traffic or detour
- Direction of traffic
- Truck movement
- Sign (shown facing right)
- Portable lavatory
- Existing pavement
- New pavement

- On foot personnel classes -
  - Pedestrian worker
  - Spotter
  - Inspector
  - PEDESTRIAN-FREE ZONE
  - Foreman
  - Flagger
  - Surveyor
  - Other class

- Vehicle Types -
  - Roller
  - Grader
  - Backhoe
  - Dozer
  - Oil truck
  - Crane
  - Paving machine w/elevator/buggy
  - Paving machine
  - Front loader
  - Dump truck (empty)
  - DUMP TRUCK (FULL)
  - BOTTOM DUMP (EMPTY)
  - BOTTOM DUMP (FULL)
  - Sweeper
  - FORKLIFT
  - PICKUP TRUCK
  - MILLING MACHINE

Legend: Symbols used in plan
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>🌟</td>
<td>LIGHT(S)</td>
</tr>
<tr>
<td>🔴</td>
<td>CHANNELING DEVICE(S)</td>
</tr>
<tr>
<td>🚦</td>
<td>BARRIER</td>
</tr>
<tr>
<td>➡️ ⬅️</td>
<td>DIRECTION OF TEMPORARY TRAFFIC OR DETOUR</td>
</tr>
<tr>
<td>➡️ ⬅️</td>
<td>DIRECTION OF TRAFFIC</td>
</tr>
<tr>
<td>⬇️ ⬆️</td>
<td>TRUCK MOVEMENT</td>
</tr>
<tr>
<td>📦</td>
<td>SIGN (SHOWN FACING RIGHT)</td>
</tr>
<tr>
<td>🚁</td>
<td>PORTABLE LAVATORY</td>
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- On foot personnel classes -

- PEDESTRIAN WORKER
- SPOTTER
- INSPECTOR
- PEDESTRIAN-FREE ZONE
- FOREMAN
- FLAGGER
- SURVEYOR
- OTHER CLASS
<table>
<thead>
<tr>
<th>Vehicle Types</th>
<th>- Vehicle Types -</th>
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<tbody>
<tr>
<td>ROLLER</td>
<td>PAVING MACHINE</td>
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<tr>
<td>GRADER</td>
<td>FRONT LOADER</td>
</tr>
<tr>
<td>BACKHOE</td>
<td>DUMP TRUCK (EMPTY)</td>
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<tr>
<td>DOZER</td>
<td>DUMP TRUCK (FULL)</td>
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<tr>
<td>OIL TRUCK</td>
<td>WATER TRUCK</td>
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<tr>
<td>CRANE</td>
<td>FORKLIFT</td>
</tr>
<tr>
<td>SWEEPER</td>
<td>BOTTOM DUMP</td>
</tr>
<tr>
<td>PICKUP TRUCK</td>
<td>MILLING MACHINE</td>
</tr>
</tbody>
</table>
Paving Model Plan – Traffic Adjacent
Paving Model Plan – Site #2

Ingress

INTERNAL TRAFFIC CONTROL PLAN
"OBSERVED CONDITIONS" - INGRESS FOR MAINLINE PAVING
RECONSTRUCTION OF INTERCHANGE RAMPS
SITE NO. 2 - I-10 INTERCHANGE AT JIMMIE KERR BLVD.
CASA GRANDE, ARIZONA
FEBRUARY 2003

INTERSTATE 10 - ON RAMP

INTERSTATE 10 - OFF RAMP

JIMMIE KERR BLVD
STEPS IN PREPARATION OF ITCPS

- Review TCP and other contract documents
- Determine site-specific ITCP needs
- Draw work space
- Add pedestrian and equipment paths
- Locate staging areas
- Prepare notes and plan
Internal Traffic Control Plans – Questions

- Can the need for backing be reduced or eliminated?
- Can the number of vehicle access points into the work space be reduced?
- Can pedestrian-free zones be established?
- Can the work space accommodate the equipment being used?
- Do any physical features of the site place operators at risk?
Revised Internal Traffic Control Plan
Site 2

Internal Traffic Control Plans for Asphalt Paving Operations
On Freeway Segments
Task 7.1

Submitted to the
CENTERS FOR DISEASE CONTROL
and PREVENTION
CONTRACTS MANAGEMENT BRANCH

Submitted by
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4720 W. Maverick Lane, Suite #103
Lakeside, Arizona 85929

May 16, 2003

Internal Traffic Control Plan
Draft Development Guide

Internal Traffic Control Plans for Asphalt Paving Operations
On Freeway Segments
Task 8.1

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June 19, 2003
Fatality Investigations

http://www.cdc.gov/niosh/face/faceweb.html
Participating FACE States

- **State FACE**
- **Non-FACE states where investigations have been conducted**
- **In-House FACE**
- **States where no FACE investigations have been performed**

**Technical Assistance Visit**
Example Fatality Cases

Case 1: 45-year-old boom truck driver run over by dump truck that was backing during a repositioning maneuver.

Case 2: 31-year-old worker run over by front-end loader at the site of a crushing machine.

Case 3: 35-year-old laborer run over by dump truck at roadway resurfacing operation.
Concrete Paving Operation Layout

Turn-around

Truck Line

Paver

CDC

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Truck Queue Repositioning

Turn-around

New Truck

Last Truck

Truck Line

CDC

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Figure 1. Incident Site (Not To Scale)
Redesigned Site Layout

Crusher

Side Exit Ramp

Pedestrian Barriers

Earthen Ramp

Recommended Loader Route: Backed Down Earthen Ramp And Driven Forward Down Side Exit Ramp
Case 3

Two-lane County Road  --  Four-lane State Highway
Two-lane County Road

Victim's Work Area

Two-lane County Road

Victim

Roller

Truck

Paving Machine

Flagger

SAFER • HEALTHIER • PEOPLE™
View from the Street
- Highway paving operations (probably major recon or new const)
- Separated from traffic by more than cones and barrels
- Asphalt paving
Daytime operation

Control and treatment sites being paved by different crews

Room for research trailer

Three weeks of paving at site

Contractor and DOT cooperation
David E. Fosbroke
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