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A Tablet PC application for construction site safety inspection and fatality prevention

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A TABLET PC APPLICATION FOR
CONSTRUCTION SITE SAFETY INSPECTION AND FATALITY PREVENTION

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
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in

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Engineering Science

by
Prabhu Sunkara
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ABSTRACT

Construction industry accounts for the largest number of occupational injuries and fatalities every year. Occupational Safety and Health Administration (OSHA) is an organization responsible for regulating and enforcing standards for various occupations to ensure safe working conditions including construction industry. As an OSHA requirement, every construction employer should employ a safety program that involves both training of the employees and frequent site inspections. OSHA has provided an online ‘construction eTool’ as a training tool which also aids in the development of safety inspection procedures. Traditionally, safety inspections are paper based and usually designed to address a specific work area or procedure. The inspection reports did not include any detailed visual data which may increase the cost of maintenance and data mining for problem areas. This project explains the possibility of using Tablet PC’s as tool for performing safety inspections at a construction site to identify occupational hazards. As a part of the project, a Tablet PC application, Hazard Prevention Tool (HPT), is developed that concentrates on the four prime hazard areas, Electrical, Falls, Struck By, and Trenching and Excavation, hazards. The application makes it possible to capture the image of the worksite and marking the problem areas on the image. After each site inspection, a report is generated which includes the worksite image with problem areas marked and possible solutions for each problem area based on the OSHA recommendations. A usability test is also conducted as a part of the project using three sample work sites.
CHAPTER 1. INTRODUCTION

Construction industry accounts for high number of occupational injuries and fatalities every year. The dynamic nature of construction is one of the major causes for various types of incidents resulting in injuries and fatalities in the construction industry [OSHA, 1990]. According to the Bureau of Labor Statistics, 13,502 construction workers died due to work-related injuries from 1992 through 2003 in the United States while the construction industry accounts for 19 percent of all workplace injuries and fatalities. [Blotzer, 2005]. Serious work-related injuries cost employers almost $1 billion per week in 2002 in payments to injured workers and their medical care providers, growing to $49.6 billion from $46.1 billion in 2001 [LM, 2004].

The high number of injuries and fatalities and cost associated to them led to the evolution of Occupational Safety and Health Act of 1970. The purpose of the act was to assure safe and healthful working conditions for working men and women by authorizing enforcement of the standards developed under the act. The act created both National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) to attain the above objective. Today, OSHA is one of the organizations under the U.S. Department of Labor and is responsible for developing and enforcing workplace safety and health regulations.

OSHA Standard 1926 (29 CFR 1926) defines the safety and health regulations for the construction industry. The regulations apply to all that are involved in construction work including contractors, subcontractors and suppliers. According to general safety and health provisions (1926.20), it is the responsibility of the employer to initiate and
maintain programs for safe working conditions for employees. It further states that any such programs shall provide for frequent and regular inspections of the job sites, materials, and equipment to be made by designated competent persons. The safety training and education regulations (1926.21) create a responsibility for the employer to avail himself of the safety and health training programs and instruct each employee of any unsafe conditions and regulations applicable to employee’s work environment to prevent any hazards.

In the recent years, OSHA started to provide various eTools through internet and digital media (CD-ROMs, DVDs, etc), which made a remarkable contribution to occupational safety training. eTools are "stand-alone, interactive, web-based training tools on occupational safety and health topics” [OSHA, 2003] and are highly illustrated utilizing graphical menus and various figures. Some also use expert system modules, which enable the user to answer questions, and receive reliable advice on how OSHA regulations apply to their work site. [Cronin, Curtis, Wheatley, 2001].

Among the list of eTools, OSHA has provided a “Construction eTool” to help in identifying and controlling the hazards that commonly cause the most serious construction injuries and fatalities. This eTool was released in both English and Spanish. It aids in educating employers as well as construction workers with necessary precautions and guidelines to avoid serious injuries.

While the construction eTool provides training and education opportunity for the workers, inspection of the job site is equally essential to avoid or prevent injuries and fatalities. Construction industry utilizes various safety and health programs for both training and site inspections. These programs can be either internal or external where the
program is often limited only to a particular area of the organization because of the associated cost.

The traditional process of a site inspection is paper based where the records are to be filed manually. However, there are new technologies available that use portable computers for information collection and management. This project is an effort to complement the traditional paper based safety inspection process with an affordable electronic based inspection to increase accuracy in identifying hazards, ease communication, ease record maintenance, and reduce inspection time. To achieve this, a Tablet PC application, Hazard Prevention Tool (HPT) is developed using Microsoft Visual C# language. The HPT is designed for “competent” person with sufficient safety knowledge to perform safety inspections at a construction site and aid in identifying the hazards and solutions to avoid them. The application also generates a detailed inspection report supported with pictures of jobsite. The following chapters of this document include review of related literature, goals and objectives, module development approach, application development, performance evaluations and conclusions. As a part of the literature review, a detailed summary of OSHA requirements, and applications of Tablet PCs are presented.
CHAPTER 2. LITERATURE REVIEW

It is important to have a clear understanding of the working conditions in construction industry and safety organizations to develop an efficient tool for safety inspections. Therefore, in the first section of this chapter, the safety facts and safety organizations related to construction industry are summarized. In addition, OSHA construction eTool and properties of Tablet PCs with sample applications in various industries including construction are summarized.

2.1 CONSTRUCTION INDUSTRY AND OSHA

In 2003, the largest number of fatal work injuries was in the construction industry. The 1,126 fatal work injuries in private construction accounted for more than one out of every five injuries and fatalities in 2003. Specialty trade contractors recorded 626 injuries and fatalities or about 56 percent of the construction total. Another 226 construction workers were fatally injured while working in building construction including 128 injuries and fatalities in residential building construction [Staff, 2004]. Figure 1 illustrates the number of injuries and fatalities, blue bars, and fatality rate per 100000 employed, red bars, in each of the industrial sectors. These figures are as given in census of fatal occupational injuries 2003, published by Bureau of Labor Statistics. The statistics clearly show how critical safety training and inspections are in construction industry. Government’s initiative towards ensuring safety in every occupation has led to the evolution of many organizations. These organizations work to improve safety conditions by forming regulations, conducting research, training, and conducting various other activities. The most important organizations are Centers for Disease Control and
Figure 1. Fatality Rate and Number of Fatalities in 2003

Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH) and Occupational Safety and Health Administration (OSHA).

CDC provides national and world leadership to prevent work-related illness, injury, disability, and death by gathering information, conducting scientific research, and translating the knowledge gained into products and services. NIOSH is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH is part of the CDC in the Department of Health and Human Services. OSHA’s mission is to assure the safety and health of America's workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health. OSHA is agency of US Department of Labor (USDOL).

OSHA and its state partners have approximately 2100 inspectors, in addition to complaint discrimination investigators, engineers, physicians, educators, standards writers, and other technical and support personnel spread over more than 200 offices throughout the country. This staff establishes protective standards, enforces those standards, and reaches out to employers and employees through technical assistance and consultation programs [Staff, 2004].

OSHA uses Special Emphasis Programs (SEPs), Local Emphasis Programs (LEPs), and National Emphasis Programs (NEPs) to find ways to help control accidents, injuries, and illnesses in occupations where employee exposure to physical or health risks exist. Employers may use these programs to assess the actual extent of suspected or potential hazards, determine the feasibility of new or experimental compliance procedures, or evaluate other legitimate reasons. However, the programs are limited in
scope and time, are usually established before a program is implemented, and include employer awareness training. For example in 2002, SEP was developed to prevent workers over exposure to crystalline silica in the construction industry. OSHA also developed a National Emphasis Program to examine injuries and deaths associated with trenching and excavation. This program requires compliance officers to be on the lookout for excavations and make inspections if they identify hazards [Chao, Henshaw, 2002].

OSHA standard 29 CFR 1926.20(b) (2) requires that contractors "provide for frequent and regular inspections of the job sites, materials and equipment to be made by competent persons designated by the employer". 1926.32(f) defines a "competent person" as someone who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them [Rekus 2003]. OSHA imposes regulations for various industries to ensure safety and health of the employees. It is mandatory that for any industry these regulations be maintained.

In the construction industry, the OSHA regulations or standards apply to all of the below.

• All contractors who enter into contracts which are for construction, alteration, and/or repair, including painting and decorating (OSHA, 1926.10a).

• All subcontractors who agree to perform any part of the labor or material requirements of a contract (OSHA 1926.13C).

• All suppliers who furnish any supplies or materials, if the work involved is performed on or near a construction site, or if the supplier fabricates the goods or
materials specifically for the construction project, and the work can be said to be a construction activity (OSHA, 1926.13c).

- The controlling contractor assumes all obligations under the standards, whether or not the subcontracts any of the work (OSHA, 1926.16b).

- To the extent that a subcontractor agrees to perform any part of the contract, he assumes responsibility for complying with the standards with respect to that part (OSHA, 1926.16c).

- With respect to subcontracted work, the controlling contractor and any subcontractors are deemed to have joint responsibility (OSHA, 1926d).

The safety and health programs as required by OSHA 29 CFR 1926.20 demands management’s commitment to safety and health along with many other responsibilities such as hazard identification and determination, hazard elimination and control, emergency response planning, training and record keeping. An effective safety and health program is one that provides adequate training and employs frequent safety inspections. OSHA has provided a Construction eTool that aids in educating employers as well as construction workers with necessary precautions and guidelines to avoid serious injuries.

2.2 CONSTRUCTION ETOOL

Construction eTool was developed both in English and Spanish. In Figure 2, the grouping of the most frequent hazards of construction industry as defined in the OSHA construction eTool is illustrated. The hazards are grouped into four prime hazard categories namely Electrical, Falls, Struck By, and Trenching and Excavation. The OSHA construction eTool is available online and can also be downloaded for offline use.
Figure 2. Most Common Hazards Categories as Described in OSHA Construction eTool
It is available for download at http://www.osha.gov/sltc/etooldownloads/setup-
construction.zip. The screen shots of the OSHA construction eTool are illustrated in
Appendix C. The following subsections summarize the contents of each of the hazard
areas.

2.2.1 ELECTRICAL HAZARDS

   Electrical accidents rank high on the list of construction accidents and are the
second leading cause of death or serious injury in some parts of the country [Kovacic and
Kovacic, 2002]. In general, OSHA requires that employees not work near any part of an
electrical power circuit unless protected. The following hazards are the most frequent
cause of electrical injuries [Cronin, Curtis, Wheatley, 2001].

   • Contact with Power Lines
   • Lack of Ground-Fault Protection
   • Path to Ground missing or Discontinuous
   • Equipment Not Used in Manner Prescribed
   • Improper Use Of Extension And Flexible Cords

2.2.2 FALL HAZARDS

   Falls are the leading cause of death among construction workers. They account
for one-third of all construction injuries and fatalities and cause more than 68,000 serious
injuries each year [Rekus, 1999]. The following hazards cause the most fall-related
injuries: [Cronin, Curtis, Wheatley, 2001].

   • Unprotected Sides, Wall Openings, and Floor Holes
   • Improper Scaffold Construction
• Unguarded Protruding Steel Rebars

• Misuse of Portable Ladders

2.2.3 STRUCK BY HAZARDS

The second highest cause of construction-related deaths is being struck by an object. Approximately 75% of struck-by injuries and fatalities involve heavy equipment such as trucks or cranes. The number of workers fatally struck by a vehicle was at a seven-year high in 1998. The following related hazards cause the most struck-by injuries: [Cronin, Curtis, Wheatley, 2001].

• Vehicles

• Falling /Flying Objects

• Constructing Masonry Walls

2.2.4 TRENCHING AND EXCAVATION HAZARDS

Cave-ins are perhaps the most feared occupational hazard. In addition to the caught–in-between, other potentially fatal hazards exist including asphyxiation due to lack of oxygen in a confined space, inhalation of toxic fumes, and drowning. OSHA requires that workers in trenches and excavations be protected, and that safety and health programs address the variety of hazards they face. A competent person must inspect the trench, adjacent areas, and any protective systems for possible cave-ins, failure of protective systems, hazardous atmospheres, or other hazardous conditions. Inspections must be performed daily: before work begins, throughout the shift, and after every rainstorm or other hazard-increasing occurrence [GTRI, 2001]. The following hazards cause most trenching and excavation injuries: [Cronin, Curtis, Wheatley, 2001].
• No Protective system
• Failure to inspect
• Unsafe spoil placement
• Unsafe access/egress

2.3 TABLET PC

Tablet PCs are computers powered by the Windows XP Tablet PC Edition operating system, and equipped with a sensitive screen designed to interact with a complementary pen [Microsoft, 2005b]. One of the key advances in the Microsoft® Windows® XP Tablet PC Edition operating system is the ability to allow developers to add support for pen based input to applications [George, 2002]. The Tablet PC has two coordinate systems; device coordinates, which are typically referred to as pixel coordinates, and ink coordinates [George, 2002].

A pen (stylus) can be used directly on the screen as a replacement for a mouse. Unlike a touch screen, the Tablet PC screen only receives information from a stylus. It will not take information from finger or other objects thus enabling to write naturally by resting the hand on the screen. A Tablet PC can be used while standing up, which is perfect for professionals on the move such as doctors, supervisors, and sales managers [Microsoft 2005b].

The Tablet PC Input Panel (TIP) makes it quick and easy to convert your handwriting to text, dynamically recognizes characters, and allows corrections before inserting text. Tablet PC's context awareness recognizes familiar formats, so it will not change the @ sign of an email address to "a". One of the compelling features for users of
a Tablet PC is the ability to work in either portrait or landscape orientation [Graff, 2003]. In some scenarios, an application may change the screen orientation if a feature has been designed to run best in specific mode in Tablet PC [Wick, 2004].

The Windows XP Tablet PC Edition Software Development Kit (SDK) facilitates building ink-enabled applications for Tablet PC [Wick, 2005]. The combination of software and hardware in a Tablet PC enables these methods of user interaction and allows for a rich, interactive, and productive computing experience for users. The Tablet PC platform encompasses Windows XP and its extensions that enable input and output of handwriting and speech data on a Tablet PC as well as interchange of this data with other computers [Tapang, 2003].

The Tablet PC’s are now widely used for various applications and are fast substituting for Laptops and Desktop PC’s. Real companies in specific industries are putting Tablet PCs with Windows XP Tablet PC Edition to work and realizing the benefits of this evolution in mobile computing. The fields range from education, financial services, health care, transportation, and even to manufacturing and construction. Few examples of their presence and advantages in some large firms are briefed here.

The Nassal Company is a specialty contractor for entertainment-related projects with an annual construction volume of $20 million and a team of 80 project managers, artisans, and support personnel. It recently wanted to strengthen the communication of project field visual information to remote team members. The Nassal Company deployed the new digital note-taking program, on Tablet PCs, so that managers could share visual information more efficiently, leading to faster decision making. This reduced downtime
for construction workers, decreased time lag between approvals by 37 percent and increased project productivity by 10.7 percent. [Microsoft, 2004a]

The Boeing Company is the premier aerospace company and has 167,000 employees in locations spanning the globe. Boeing wanted to investigate technology that could eliminate the need to transfer information from paper to a computer, and give employees access to information anytime, anywhere. Select Boeing employees evaluated Tablet PCs in various departments, including manufacturing units and the training department. This resulted in enhanced time that is spent in meetings, enabled a richer learning experience for in-house training classes, and supported access to information anytime, anywhere [Microsoft, 2002].

British Gas, a division of Centrica, is Great Britain’s largest residential gas, and electricity supply and service company. It employs 27,000 workers, including 8,000 field engineers to provide on-site installation, maintenance, and emergency repairs. British Gas is transforming its business process from paper-based to digital systems in an effort to improve customer service and efficiency. Tablet PCs, running Microsoft® Windows® XP Tablet PC Edition, allowed service engineers at British Gas to take advantage of product documentation, expert help systems, and electronic forms for service call documentation while working in customers' homes. This brought about 25% increase in service calls completed per day and improved service call documentation [Microsoft, 2004b].

Eurovia, part of the Vinci group in France, and a world leader in road design and construction, operates in 18 countries. Eurovia designs, builds, and maintains road infrastructure. Eurovia wanted to create a real-time communications network for its 2,500
site managers to send and receive business information about their projects to its head office. To achieve this Alsy recommended Tablet PCs and an application developed using the Microsoft® .NET Framework and Microsoft Visual C#® development tool for entering daily reports and sending them to the head office by a general packet radio service (GPRS). This brought in increased visibility of income and reduced re-entry data and errors [Microsoft, 2005].

The Iowa Department of Natural Resources (DNR) Law Enforcement Bureau protects the state's natural resources, provides public safety, and educates the public. The bureau has more than 80 law enforcement field officers. DNR’s law enforcement officers complete most of their documentation in remote environments, typically in or near their patrol vehicles. DNR has traditionally used paper forms, and most computer-based solutions have not offered enough mobility to make conversion feasible. The new Tablet PC application eliminated the need for any paper entry by field officers, and it made the activity report information available to supervisors via a back-end intranet web server. This application reduced the number of paper documents by 1,600 per year and speed of both submission and review of documents [DNR, 2003].

The above cases have shown that Tablet PC has brought increases in efficiency both in time and in communication of data. The main advantages are its portability and note taking facilities. This also makes Tablet PC as the premier tool for digital forms-based data collection processes [LG, 2004].
2.4 CRITIQUE ON EXISTING CONSTRUCTION SAFETY INSPECTION METHODS

Safety inspections at a construction site can be classified in two major categories, OSHA inspections to ensure compliance and those conducted by an employer as OSHA requirements. Before 1994, all OSHA inspections were comprehensive in scope, addressing all areas of the workplace and, by inference, all classes of hazards [Chao, Henshaw, 2002]. This guidance caused compliance safety and health officers (CSHO) to spend too much time and effort on a few projects looking for all violations and, thus, too little time overall on many projects inspecting for hazards which are most likely to cause injuries and fatalities and serious injuries to workers. Consequently, a contractor was likely to be cited for hazards that were unrelated to the four leading causes of death that make up 90% of all construction injuries and fatalities (falls from elevations - 33%; struck by - 22%; caught in/between - 18%; electrical shock - 17%). Although the other conditions are also important, the time and resources spent to pursue them on a few projects can be better spent pursuing conditions on many projects related to the four hazard areas most likely to cause injuries and fatalities or serious injuries. The goal of OSHA's construction inspections is to make a difference in the safety and health of employees at the work site [Staff, 1996].

The Focused Inspections Initiative that became effective October 1, 1994 is a significant departure from how OSHA had previously conducted construction inspections [Chao, Henshaw, 2002]. This initiative recognizes the efforts of responsible contractors who have implemented effective safety and health programs, and encourages other contractors to adopt similar programs. The measure of success of this new policy will be
an overall improvement in construction jobsite safety and health. [Chao, Henshaw, 2002]. The Focused Inspection initiative enables OSHA to focus on the leading hazards that cause 90% of the injuries and deaths.

Inspections, conducted by an employer, are part of safety program and are required as an OSHA requirement under 29 CFR 1926.20. A safety program can be either external or internal. Often the size of organization plays a decision factor in choosing the type of safety program. Most of the large organizations employ their own internal safety program. This requires hiring safety personnel and comes with a cost factor because of both record keeping and maintaining the personnel. Safety programs are often not comprehensive and are limited to a particular hazard area. The construction site safety inspections are paper based and require records to be maintained. Most of inspection reports lack the visual data and information about the recommended solution and specific location where solution is to be implemented.
CHAPTER 3. GOALS AND OBJECTIVES

The goal of this project was to develop a Tablet PC application that can complement the traditional paper-based safety inspection process and aid in identifying hazards to prevent injuries and fatalities and injuries at a construction worksite. The application was intended for a “competent” person with sufficient safety and construction knowledge but not an safety professional. Several objectives were completed to accomplish this goal summarized as:

- Develop HPT Application for Tablet PC Platform.
- Test and Evaluate the Usability of the Application.
- Analyze the Test and Evaluation Results.
- Identify Improvement Areas for the Application and Future Development Directions.

A form based windows application was developed using C# to work on a Tablet PC platform. This application covers 90% of occupational hazards in construction industry in check list form. To test and evaluate the application, a group of students who have completed safety council’s Certified Construction Site Safety (COSS) training are COSS certified were selected.
CHAPTER 4. DEVELOPMENT APPROACH

In this section, the development approach is described step-by-step that includes application design, software chosen for development of application and the hardware specifications.

4.1 APPLICATION DESIGN

The first step of the HPT application design was to identify and group the hazard areas. The OSHA construction eTool was taken as a reference for this purpose. The injuries and fatalities were grouped into four modules: Electrical, Falls, Struck By, and Trenching and Excavation. In the inspection process, the site and inspector information along with site pictures are obtained prior to the inspection while the output of the inspection is a detailed report. The application structure is illustrated in Figure 3. The site and inspector information is maintained in a database and this information is obtained ahead of inspection thus removing any typing or entering of data. Similarly, the picture of the work site is captured at the start of inspection. The process flow starts with the Electrical module, a checklist covering all the potential hazards as in the electrical section of the OSHA construction eTool. At the end of the Electrical module the Falls module is activated and checklist for Falls is run followed by the next module Struck By and the finally Trenching and Excavation. At the end of all the modules, the inspection is said to be completed, and report of the inspection is generated. The modules are arranged in a tab structure, one tab page for each module, and designed as a continuous question and answer style process to create a controlled inspection. Figure 4 illustrates the information flow of the application.
Figure 3. HPT Application Structure
Each hazard in the checklist is posed as a yes or no question. If there is a possibility of that hazard, the user has to choose one or more possible OSHA recommendations and mark the hazard area/areas on the picture. The selection and related information is added to the inspection report while the application moves to the next question.

4.2 HARDWARE PLATFORM

The hardware required for development and testing of HPT was a Tablet PC that is light weight and durable considering the mobility and construction site conditions.
Visionary V800 XPT was Tablet PC chosen for this project mainly for three reasons: affordability (under 1000 US dollars), light weight, and a built-in camera. The picture of Tablet PC chosen for this project is shown in Figure 5. The picture is obtained from http://www.tdvvision.com/productdetailsid121.asp.

**Figure 5.** Visionary V800 XPT- Tablet PC (ref tdvision.com)

Key Features of V800 XPT can be listed as [TDVision, 2003]:

- Portable design
- 8.4 inch SVGA Digitizer display
- Processor: Transmeta Crusoe 800MHz
- O/S: Powered by Windows XP Tablet Edition
- Memory: 512 DDR RAM
• Battery: up to 3 hours battery life

• PC camera: built-in CCD camera with 600x480 resolution

• Internal 802.11b Wireless LAN

• Built in 4-in-1 Card Reader

Other technologies like integrated wireless internet, Bluetooth etc, although not necessary, provide an added advantage to the tool.

4.3 SOFTWARE PLATFORM

The software chosen to develop this application was C# using Visual Studio 2005 Express Beta 2 (CSHARP). The application was designed to be a form based windows application where Microsoft Access was used for the site and inspector information database. The software required for application to run on a Tablet PC is .NET frame work 2.x and Microsoft Data Access Components (MDAC 2.8). The application was packed as an installer using the Install Shield 11 trial version. CSHARP was chosen for this project because windows controls like buttons, textboxes, radio buttons, forms, tab structure etc, are built in and is ideal for developing form based applications. The function of the controls used in HPT application was customized. The important CSHARP components used in this HPT application are

• RadioButton for yes or no selection

• TabControl for structuring modules and module separation

• WebBrowser for internal viewing of report

• DataGridView for displaying inspection data and selecting report for viewing
• TextBox, ComboBox, CheckBox for data input or selection

In addition, various classes and controls were used in this application. System.IO is used for file writing and System.Data.OleDb for database connectivity and access. OpenFileDialog control is used for selecting pictures. JavaScript is used to dynamically fill report data in a pre created HTML report template.
CHAPTER 5. APPLICATION DEVELOPMENT

The structure and information flow illustrated in chapter 4 formed the basis for tool development and application. OSHA construction eTool was used to develop the checklists for each of the modules. This chapter includes the modules checklist and illustrates the application interfaces. In addition, the report structure and report generation are also described and illustrated.

5.1 APPLICATION CHECKLISTS

The most common hazards in construction industry were grouped into four categories with a module for each category. The specific hazards within each category were used to develop checklists for each of the modules. The following subsections illustrate the checklist for each category. It should be noted that, in the inspection process, it is possible to select more than one solution can be chosen for a given hazard.

The electrical checklist developed along with recommended solutions for the hazards is illustrated in Table 1. The Falls checklist developed along with recommended solutions is illustrated in Table 2. The Struck By checklist developed along with recommended solutions is illustrated in Table 3. The Excavation checklist developed along with recommended solutions is illustrated in Table 4. The checklists illustrated in the tables 1 through 4 are used to develop the application interface of HPT.

5.2 APPLICATION INTERFACES

The application process was developed with detailed on-screen information including a thumbnail view of the jobsite. During the inspection process, the options chosen on
previous hazards are also noted on-screen. By clicking on the thumbnail view, a larger view of the jobsite pops up along with the previous markings.

**Table 1:** Checklist and Possible Recommendations - Electrical

<table>
<thead>
<tr>
<th>No</th>
<th>Problem Description: Electrical Hazards</th>
<th>Possible Solutions / Recommendations</th>
</tr>
</thead>
</table>
| 1  | Contact with power lines              | • Look for overhead and buried power lines and post signs.  
                                 | • Identify contact utilities for buried power lines and advise employees of such locations  
                                 | • De energize and ground when working near them  
                                 | • Provide employees using metal tools with protective gloves |
| 2  | Ground fault protection                | • Use GFCI on all single phase 15-20 ampere receptacles  
                                 | • Have Assured Equipment Grounding Conductor Program  
                                 | • Use double insulated and distinctively marked tools  
                                 | • Avoid use of defective tools until problem is corrected |
| 3  | Discontinuous or missing path to Ground | • Ground all exposed metal parts of equipment  
                                 | • Visually inspect to take defective equipment out of service  
                                 | • Use double insulated and distinctively marked tools |
| 4  | Improper use of equipment or power tools | • Use equipment that is approved to meet OSHA standards  
                                 | • Use equipment according to the manufacturer instructions  
                                 | • Make sure cords are not modified or used incorrectly  
                                 | • Make sure equipment altered is in compliance |
| 5  | Improper use of Extension and flexible Cords | • Use extension cords marked for hard and extra hard usage  
                                 | • Continual audit of cords on site  
<pre><code>                             | • Discard modified or non compliant cords |
</code></pre>
<table>
<thead>
<tr>
<th>No</th>
<th>Problem Description: Fall Hazards</th>
<th>Possible Solutions / Recommendations</th>
</tr>
</thead>
</table>
| 1  | Exposure to Fall of 6 feet or more | • Use guard rail systems  
|    |                                   | • Use safety net systems  
|    |                                   | • Use fall arrest systems          |
| 2  | Wall openings, Unprotected sides or Floor holes | • Cover or guard floor holes  
|    |                                   | • Survey before working and continually audit  
|    |                                   | • Construct floor hole covers that effectively support imposed weight |
| 3  | Improper Scaffold Construction | • Construct scaffolds according to manufacturer's instruction  
|    |                                   | • Install guard rail systems along all open sides and ends of platforms  
|    |                                   | • Provide safe access to scaffold platforms  
|    |                                   | • Use guard rail or fall arrest if scaffold more than 10 feet |
| 4  | Unguarded, Protruding Steel Rebars | • Guard all protruding ends with rebar caps or wooden troughs  
|    |                                   | • Bend Rebars so exposed ends are no longer upright |
| 5  | Misuse of Portable Ladders | • Position ladders so that side rails extend at least 3 feet above land  
|    |                                   | • Secure side rails at top to a rigid support  
|    |                                   | • Inspect ladders for cracked / broken parts or non OSHA compliant  
|    |                                   | • Use grab device if 3 feet extension is not possible |
### Table 3: Checklist and Possible Recommendations- Struck By

<table>
<thead>
<tr>
<th>No</th>
<th>Problem Description: Struck By Hazards</th>
<th>Possible Solutions / Recommendations</th>
</tr>
</thead>
</table>
| 1  | Improper Vehicle Condition             | • Check before each shift to assure safe operating conditions  
• Haulage vehicles must have cab shield or canopy  
• Check parking brakes and chock vehicles when incline  
• Provide vehicles with adequate braking systems /safety devices |
| 2  | Improper Vehicle Operation             | • Wear seat belt  
• Don't drive reverse with obstructed rear view and without alarm  
• Drive only on safely constructed roadways or grades  
• Don't exceed vehicle load or lift capacity |
| 3  | Unprotected Vehicle Operation location | • Use traffic signs barricades or flags  
• Provide warning clothing |
| 4  | Falling or Flying objects              | • Wear hard hats  
• Stack materials to prevent slides, falling or collapse  
• Use protective measures such as toe boards or debris net  
• Barricade hazard areas and post warning signs |
| 5  | Flying Objects From Power Tools        | • Use safety glasses goggles face shields  
• Inspect tools to ensure that guards are in good condition  
• Provide adequate training for proper operation of tools |
| 6  | Falling Objects of Cranes or Hoists    | • Avoid working underneath loads being moved  
• Barricade hazard areas and post warning signs  
• Inspect cranes and hoist components if in good condition |
| 7  | Compressed Air                         | • Reduce compressed air for cleaning to 30 psi  
• Only use with appropriate protective equipment |
| 8  | Construction of Masonry Walls          | • Do not place construction loads until qualified person indicates  
• Adequately shore or brace structures  
• Take measures to prevent unrolled wire mesh from recoiling  
• Use automatic holding devices to support forms. |
Table 4: Checklist and Possible Recommendations- Trenching and Excavation

<table>
<thead>
<tr>
<th>No</th>
<th>Problem Description: Trenching Hazards</th>
<th>Possible Solutions / Recommendations</th>
</tr>
</thead>
</table>
| 1  | Lack of Protective System               | • Evaluate soil conditions and select appropriate protective system  
   |                                         | • Construct in accordance with OSHA requirement [1926.652]  
   |                                         | • Pre plan contact utilities to locate underground lines  
   |                                         | • Provide adequate ventilation or respiratory protection |
| 2  | Unsafe Protective System                | • Provide safe access into and out of excavation  
   |                                         | • Keep excavation open for minimum amount of time  
   |                                         | • Remove employees from work area |
| 3  | Failure to Inspect                      | • Inspect before construction begin, daily and as needed  
   |                                         | • Person who inspects should be competent |
| 4  | Unsafe Spoil -Pile placement            | • Set spoil and equipment at least 2 feet back from the excavation  
   |                                         | • Use retaining devices such as trench box |
| 5  | Unsafe Access /Egress                   | • Provide stairways, ladders or other means if more than 4 feet  
   |                                         | • Position egress within 25 lateral feet or workers  
   |                                         | • Structural ramps should be designed by competent person  
   |                                         | • Components of ramp must be connected and of same thickness |

Each of the inspection modules is maintained differently in a tab structure. The green radio button indicates yes for the potential hazard question posed on the other hand selecting red radio button indicates that the potential hazard doesn’t exist. If there is a potential hazard, the users selects green radio button which opens recommended solutions panel. The user selects one or more recommended solutions by clicking on the checkbox beside the solution. Once the recommended solutions are selected, the user can mark the problem area, where solution has to be implemented by clicking Mark Solution button on
the possible recommendations panel. A typical inspection window is illustrated in Figure 6.

The tab structure segments each inspection area into different modules. The active question box displays the hazard for which user has to make a decision. If the possible hazard displayed in active question box exists, user selects green radio button. On selecting green radio button recommendations panel is made visible with all possible recommendations for preventing the hazard. The users select one or more possible recommendations and clicks mark solution button for marking the area where selected solution has to be implemented. In case of user selecting a red radio button, user will be prompted to confirm his decision to proceed to next hazard question. Other application user interfaces or windows are illustrated in Appendix A.

An important feature of this application is marking recommended solutions on the picture of the jobsite for any potential hazards. On clicking the Mark Solution button, mark up window pops up with the larger picture of the job site. The user can now mark the solution by a simple tap on the problem area where the solution has to be implemented. The marking is a text box bearing the hazard number in the check list. Figure 7 shows a sample of the marking process where the potential hazard areas are noted with a number that corresponds to its position in the checklist. After the end of the inspection the report for each of the inspection areas is displayed as a single document in a dynamically created tab of the HPT structure.

5.3 REPORT DESIGN

The report is structured with four different sections for each of the prime hazard areas. Each section of the report has the picture of the jobsite and the markings of
Figure 6. HPT Inspection Window Components

- Tab Structure
- Yes or No Selection.
- Active Question Box
- Recommendations Panel
- Thumbnail of Jobsite
- Screen Help
Place where solution is to be implemented and corresponds to problem 5 in checklist

Figure 7. HPT Marking Window
locations where recommended solutions are to be implemented. The textual part of the report is a table with three columns similar to the checklist tables described in previous sections. The report is a HTML page and can be viewed internally in the application or externally with any web browser. Appendix B illustrates a sample report generated after an inspection.

The report is generated in two stages; initially the report is copied from a pre-designed template embedded into HPT application. This is a blank report with no data, as the inspection process proceeds the data is written into this report as JavaScript. The reports generated and information related to them is archived in a database and a table with a list of all inspections is available within the application. The table can be sorted based on date, inspector and site name. Detailed site and inspector information are also stored in the database and the application provides interface to add and delete the records. The reports can be opened in any external web browser like Internet Explorer or Netscape. These files can be archived in a virtual ftp server and can be viewed by any persons concerned whenever required. The reports could be posted as a mail attachment using a mail agent like hotmail but visual data of the report would be lost.
CHAPTER 6. PERFORMANCE EVALUATION

This chapter details the evaluation procedure for HPT application along with the three test cases and their results. In addition the evaluation form including user ratings and comments are discussed.

6.1 EVALUATION PROCEDURE

Nine construction management students at Louisiana State University, Department of Construction Management were chosen as the evaluation group. These students had completed safety council’s Certified Occupational Safety Specialists training and are COSS certified. They represent future construction managers that might work in construction industry to ensure safety at a construction jobsite.

HPT was used by each student for inspecting three different test cases. The evaluation group was provided with a training session that involved a 5-minute video and an inspection on a warm up site. For safety reasons, in the testing phase, the users were given a picture of the construction job site instead of inspecting a real worksite.

At the end of the inspections, the reports generated are scored based on the hazards identified. For each test case, number of users that identified proper hazards involved in that case was noted. Each of these test cases and their results are further detailed in the following sections. In addition to scoring of reports, the students were asked to complete an evaluation form.

6.2 TEST CASE 1 AND RESULTS

The first test case is a picture of a jobsite with potential Electrical and Struck By hazards. The picture was taken from Electrical Safety- Students Manual published by
NIOSH. Figure 8 illustrates the picture of the job site used for test case 1. This job site has workers using power tools without hardhats or proper protection equipment which is a potential Struck By hazard from flying objects. There is also a potential Electrical hazard from the misuse of extension cords. It should be noted that, there are other possible hazards from misuse of portable ladders and lacks proper housekeeping at this job site, but the evaluators were not required to identify those hazards as the picture doesn’t convey detailed information. In this case, only four of the nine users identified any electrical hazard, while all except one identified the Struck By hazard. Although not required for this case, few of them identified the potential hazard from improper use of portable ladders. The number of users that identified hazards involved in the first test case is illustrated in the Figure 9. The poor identification of the electrical hazard for the test case 1 is interesting and limited resolution of the picture provided may be a cause for the low score.

6.3 TEST CASE 2 AND RESULTS

The second test site was selected from pictures of hazardous jobsites captured by MNOSHA (Minnesota OSHA) available on its website at http://www.doli.state.mn.us. The job site shows a worker in a trench of about six feet depth without a hardhat. The picture of the jobsite used for the test case 2 is illustrated in Figure 10.

The trench has no protective system and there is no proper access in and out of the trench. There is a potential Struck By hazard from falling objects. This test case aims at identification of both these hazards. In addition, there is a possible hazard from lack of access control or missing barricades, but was not required to identify as the picture is restricted in its scope. In this test case, the results showed that 7 of the 9 users identified
Figure 8. Picture of the Jobsite Used For Test Case 1

Potential Electrical Hazard

Potential Struck By hazard
Figure 9. Graph- Number of Users that Identified Hazards Using Tool in Test Case 1
Figure 10. Picture of the Jobsite Used For Test Case 2
the Struck By hazard while all except one identified the Trenching hazard. The results are plot similar to that in previous test case and are illustrated in the Figure 11.

![Figure 11. Graph- Number of Users that Identified Hazards Using Tool in Test Case 2](image)

The results in this case, considering the limited resolution of picture and limited knowledge of the job site, were considerable.

### 6.4 THIRD TEST CASE AND RESULTS

The third test case was concentrated on testing the Falls module of the application. The picture of the jobsite was taken form the presentation on Evaluation of Supported Scaffold Safety by Halperin and McCann (2002). The picture of the jobsite used for the third case is illustrated in Figure 12.

This job site has a potential for fall from elevation as the work surface is not guarded. There is also a potential Struck By hazard of falling objects from elevation. The
results of this test case are plot in a graph as illustrated in Figure 13. In this case, all of the evaluators identified the Fall hazard while only 6 of the 9 users identified Struck By hazard. The typical low score for identification of Struck By hazard might be a result of low resolution of the picture and restricted scope of the job site.

6.5 TOOL EVALUATION

At the end of the inspection of the three test cases, the users completed an evaluation form. The evaluation form was used to obtain the rating for various factors that determine the content and usability of HPT. In addition, it also facilitates to obtain the user’s opinions on the best and worst aspects of the tool. The page 1 of the tool evaluation form is illustrated in Figure 14. The content rating is based on a five point scale for four factors including information flow, accuracy, organization, and comprehensiveness. The second page of the evaluation form, as illustrated in the Figure 15, provides for users comments on the best aspects and worst aspects of the HPT. In addition, it also provides for user information of any other possible application areas and additional comments.

The filled evaluations are analyzed and the ratings are plot as graphs for better understanding. The graph illustrated in Figure 16, shows the average ratings for various factors that determine the content rating of HPT.

The over all average score for content is around 4. HPT being the first of its type for safety inspection this score is more than considerable. Information flow of the contents scored an average of 4.1, Accuracy scored an average of 4 and organization of the content obtained a rating of 4.3 and comprehensiveness of the content scored the least of 3.8. The low score is expected since only 90% of the occupational hazards are covered.
Figure 12. Picture of the Jobsite Used For Test Case 3
Figure 13. Graph - Number of Users that Identified Hazards Using Tool in Test Case 3
## TOOL EVALUATION FORM

**NAME:** __________________________  **DATE:** ____________

### CONTENT RATING:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehensiveness</td>
<td></td>
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</tr>
</tbody>
</table>

### USABILITY RATING:

<table>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appropriateness for Safety Inspections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skills Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Help and Directions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report Generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report Structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color Combinations</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Text Resolution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Resolution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 14. Evaluation Form - Page 1*
COMMENTS:

Three **best** aspects of this tool:

__________________________________________________________________

__________________________________________________________________

__________________________________________________________________

Three **worst** aspects of this tool:

__________________________________________________________________

__________________________________________________________________

__________________________________________________________________

Any Other Application Areas where this Tool can be used (w/ Content Modifications):

__________________________________________________________________

__________________________________________________________________

__________________________________________________________________

Other Comments:

__________________________________________________________________

__________________________________________________________________

__________________________________________________________________

Figure 15. Evaluation Form - Page 2
The important factors that determine usability rating are the ease of use, appropriateness for safety inspections, resolution, report generation and report structure. Resolution is calculated as mean of the scores obtained for text resolution, visual resolution and color combinations. The graph depicted in Figure 17 illustrates the average scores obtained for each of these factors. The average score for usability rating is around 3.8 and all factors are nearly at the same level. The ratings obtained may not be significant for application purposes as they are not result of a comparison between paper based and Tablet PC based inspections. However, they give user’s opinion on the HPT. The user also comments about the best and worst aspects of the tool. This conveys important data and aid in identifying improvement areas. In the user comments section, the best aspects of the HPT were noted as portability, ease of use, and the instant report.
generation. On the other hand, the worst aspects of the HPT were the difficulty in using the stylus and lack of manual comment section for the report.

The following list summarizes the user comments received from the evaluation form. The number in brackets signifies number of persons that had similar opinion or comment.

The best aspects of the tool:

- Light Weight (4)
- Easy to Use (6)
- Instant Report (3)
The worst aspects of the tool:

- Pen was difficult to use (4)
- Needs a comment section (1)
- Can’t go back in the inspection process (1)

Other areas where this tool can be used with content modifications:

- DMV – Motor vehicle check (1)
- Daily Routine Check (1)
- Any industry where visual reporting is necessary (2)

The evaluations clearly showed the ease of use of the application and tool except for difficulty in using pen. This was expected as the users had no prior experience with a Tablet PC. The application style proved practical with suggested uses for almost all routine inspections.
CHAPTER 7. SUMMARY AND CONCLUSIONS

Safety inspections at a construction site are a critical element of a safety and health program which also is an OSHA requirement defined under CFR 1926. The high number of injuries and fatalities in the construction industry adds to the importance of frequent and detailed inspections. Traditionally, these inspections are paper based and there is a considerable cost associated with the maintenance of these records. The paper based reports usually lack detailed visual information and illustrations that make the communication of the hazards and status complicated and more difficult. To address these problems, this project proposes the use of Tablet PCs for safety inspections and reporting. The goal of this project was to develop a Tablet PC application to complement traditional paper based safety inspections. To achieve this goal, the project focused on the four hazard modules that address approximately 90% of the all construction injuries and fatalities. The OSHA Construction eTool was used as a guideline to develop the application modules. The application was evaluated for efficiency, content and usability.

To test the efficiency and performance of the tool, three test cases were chosen. The users who evaluated the tool were provided with a training session that includes a 5-minute video and an inspection on a warm-up site. The testing was conducted offsite by providing pictures of the construction test sites. The users completed evaluation form about the performance, content and usability of the tool. The reports generated from all the test cases were scored to calculate the efficiency.
7.1 CONCLUSIONS

The performance evaluations showed that the tool is appropriate for safety inspections and is easy to use. Overall, the usability and performance ratings scored over 3.7 / 5.0. The lowest scores were noted for resolution which is directly related to the Tablet PC model used in the testing. This limitation can be addressed by using a different model of Tablet PC and is purely a hardware problem. More importantly, the content ratings scored the highest with an average over 4.0 / 5.0. It should be noted that, the tool was evaluated by users with construction safety training and no previous experience with Tablet PCs. For the user’s safety reasons, the testing was conducted offsite which limited the knowledge about the entire construction operation but the efficiency results were acceptable addressing the hazard areas.

The user comments about the best aspects of the tool were its portability, ease of use, and instant report generation. The worst aspects of this tool were the lack of a manual comment section, where user can write his comments on the report, and not being able to go back in the inspection process. Both these were features were not implemented in the application with the purpose of avoiding any non OSHA recommended solutions and fool proofing the inspection data. These features can be implemented with additional security feature as a future enhancement. Several users also noted difficulty in using the pen or stylus. This is basically a comfort issue and can be potentially reduced with more exposure to the tool.

One of the major advantages of this tool is that it provides capability of embedding the visual data marked to show potential hazard areas as a part of the report. The inspection reports are easy to transfer and share with an external mail program like
hotmail or can be archived for future retrieval or data mining. The tool also provides mobility which is a requirement of the construction industry. The inspection process is designed to be a form based application with no textual input. The input is generally just a tap on a radio button. The recommended solutions can also be marked on the picture of jobsite with a simple tap on the screen. The resulting report is accurate, comprehensive, structured, and instantaneous. The recommended solutions in the report are associated with hyperlinks to help on the solution.

The Tablet PC used in this project costs under 1000 dollars which makes it an affordable tool even for small construction companies. This tool is more comprehensive in its scope of identifying hazard areas which is an added advantage for small contractors who usually employ safety program for a particular area.

7.2 FUTURE RESEARCH DIRECTIONS

The immediate development to the tool would be to develop an enhanced version with a comprehensive check list to cover all the hazards in OSHA 1926. The application can also be modified to be used by OSHA inspector to perform OSHA inspections.

Another enhancement may be to provide report sharing, printing and detailed record search options. This may benefit for data mining and record keeping purposes. The tool with content modifications can be extended to various occupations other than construction. If this concept were applied to industries with high fatality rates like agriculture, it can help reduce the rates by introducing regular and compressive inspections. Although the concept of Tablet PC application is illustrated for construction industry in this report, the checklists can be extended and modified for different
industries. This modification has to include appropriate content and identification of the important hazard areas.

The HPT was designed as a complement to traditional paper based safety inspections, which cannot produce 100% result for hazard identification because of limited content, however, it would help identifying the common hazard areas even with basic safety knowledge. The best approach for site safety is to develop a comprehensive checklist and conduct frequent inspections. As a further research option, a similar tool could be developed with wearable computer systems and speech command as input to conduct the inspection.

Another enhancement to this tool would be to replace Tablet PC’s with mobile phones or PDA’s that have built in cameras. It should be noted that Tablet PC’s offer stronger processing power compared to PDA’s and Smart Phones. A different version with limited graphics and processing requirements need to be developed. The concept and tool illustrated in this study can contribute to change in terms of data collection, specific inspections and technology applications.
REFERENCES


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Rekus, J. F., 1999, “Understanding OSHA's Fall Protection Standard.”, Occupational Hazards, April, 1999, Penton Media, Cleveland, Ohio, USA.


Smith, S., 2003, ‘Failure to Respect Hazards of Power Lines Sparks OSHA Fines.”, Occupational Hazards, March, 2003, Penton Media, Cleveland, Ohio, USA.


Figure 18. HPT Main Application Window
Figure 19. HPT Site Information Selection Window
Figure 20. HPT Site Information Database Window
Figure 21. HPT Picture Markup Window
Figure 22. HPT Report Database Window
### Hazard Prevention Report

**Site Name**: LSU1  
**Inspector**: SUNKARA_PRABHU_  
**Inspection Date**: 7/29/2005 10:54:54 PM

#### Electrical Report

There are no potential Electrical Hazards

<table>
<thead>
<tr>
<th>No</th>
<th>Problem Description: Electrical Hazards</th>
<th>Possible Solutions / Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Contact with power lines</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>2</td>
<td>Ground Fault Protection</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>3</td>
<td>Discontinuous or missing path to Ground</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>4</td>
<td>Improper use of equipment or power tools</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>5</td>
<td>Improper use of Extension and flexible Cords</td>
<td>There are no potential problems</td>
</tr>
</tbody>
</table>

**Figure 23**: HPT Sample Report – Electrical
### Falls Report

<table>
<thead>
<tr>
<th>No</th>
<th>Problem Description: Fall Hazards</th>
<th>Possible Solutions / Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exposure to Fall of 6 feet or more</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>2</td>
<td>Wall openings, Unprotected sides or Floor holes</td>
<td>Survey before working and continually audit</td>
</tr>
<tr>
<td>3</td>
<td>Improper Scaffold Construction</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>4</td>
<td>Unguarded, Protruding Steel Rebars</td>
<td>Guard all protruding ends with rebar caps or wooden troughs</td>
</tr>
<tr>
<td>5</td>
<td>Misuse of Portable Ladders</td>
<td>There are no potential problems</td>
</tr>
</tbody>
</table>

---

**Figure 24.** HPT Sample Report – Falls
### Struck By Report

There are no potential Struck By Hazards

<table>
<thead>
<tr>
<th>No</th>
<th>Problem Description: Struck By Hazards</th>
<th>Possible Solutions / Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Improper Vehicle Condition</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>2</td>
<td>Improper Vehicle Operation</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>3</td>
<td>Unprotected Vehicle Operation location</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>4</td>
<td>Falling or Flying objects</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>5</td>
<td>Flying objects from power tools</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>6</td>
<td>Falling objects of Cranes or Hoists</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>7</td>
<td>Compressed Air</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>8</td>
<td>Construction of Masonry Walls</td>
<td>There are no potential problems</td>
</tr>
</tbody>
</table>

**Figure 25.** HPT Sample Report – Struck By
**Trenching and Excavation Report**

There are no potential Trenching Hazards

<table>
<thead>
<tr>
<th>No</th>
<th>Problem Description: Trenching Hazards</th>
<th>Possible Solutions / Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lack of Protective System</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>2</td>
<td>Unsafe Protective System</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>3</td>
<td>Failure to Inhibit</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>4</td>
<td>Unsafe Spoil - Pile placement</td>
<td>There are no potential problems</td>
</tr>
<tr>
<td>5</td>
<td>Unsafe Access - Expose</td>
<td>There are no potential problems</td>
</tr>
</tbody>
</table>

*Figure 26. HPT Sample Report – Trenching and Excavation*
Figure 27. Main Window of Construction ETool
Figure 28. Electrical – OSHA eTool
Figure 29. Falls – OSHA eTool
Figure 30. Struck By – OSHA eTool
Cave-ins are perhaps the most feared trenching hazard. But other potentially fatal hazards exist, including asphyxiation due to lack of oxygen in a confined space, inhalation of toxic fumes, drowning, etc. Electrocaution or explosions can occur when workers contact underground utilities.

OSHA requires that workers in trenches and excavations be protected, and that safety and health programs address the variety of hazards they face. The following hazards cause the most trenching and excavation injuries:

- No Protective System
- Failure to Inspect Trench and Protective Systems
- Unsafe Spoil-Pile Placement
- Unsafe Access/Egress
VITA

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