CHAPTER 5

KEY SAFETY PERFORMANCE INDICATOR
MEASUREMENTS IN HSE

5.1 INTRODUCTION

In the previous Chapter 4 a total construction safety management model system had been developed. From Figure 4.1, Key Safety Performance Indicator measurement on HSE of the checking and corrective action phase is discussed in detail in the present Chapter 5.

In developing countries, safety rules are framed; the construction companies are usually very weak in implementing such rules effectively. In India many construction companies allot the work to the contractors. Construction in India is dominated by contracted labour arrangements within an open and competitive tendering environment, with contractors comprising around 85-90% of the workforce on a typical building construction project. The contract has been awarded to the contractor who quoted less than others. They usually lack safety commitment because of limited budget, time and human resources. This has resulted in an insufficient provision of on-the-job safety training to the employees, who have very limited knowledge to deal with safety matters. contractors would rarely employ safety professional and they have no interest in safety matters because most of them believe that safety should be the responsibilities of the principal contractors. Performance measurement provides the key to monitoring the effectiveness of safety systems. It can also provide the basis for continuous improvement in management systems and practices. There is a need of tools to be generic for application to any construction industry for measuring safety performance
positive performance and negative performance. A new model for safety performance measurement and outcome indicators has been developed in this research work.

5.2 DEVELOPMENT OF KEY SAFETY PERFORMANCE INDICATOR (KSPI) METHOD

In view of above the drawback in existing performance measurement tool, a tool has been developed in the present work based on the similar methodology used by past researcher (Site Safety Meter (SSM)) with a few modifications to address the above issues. Key Safety Performance Indicator (KSPI) method is developed with the following features:

i) Over all safety performance of the project site.
ii) Positive and negative performance of the site.
iii) Contractor-wise unsafe act/ unsafe condition at site and performance measurement.
iv) Trade wise hazards in the site.
v) Calculate the % reduction injuries due to repetitive hazard and random hazards.
vi) Improve the feedback process between client and contractors; contractor and workers.

The tool was based on a traditional regular workplace inspection method with appropriate checklist.

Steps to carry out the KSPI

1) Develop categories to measures
2) Develop a criteria to measure each category
3) Apprise the workplace using the developed criteria
4) Record the inspection
5) Calculate the overall score of the project
6) Feed back on positive and negative performance
7) Based on the feedback, sub-contractor performance is measured

i. Develop categories to measures

Categories for measurement using KSPI is developed based on past accident statistics in India, unable to identify the unsafe condition and unsafe act, to know the safety performance. In the present work, the following 15 categories are proposed to measure the performance of the construction site. 1) Excavation, 2) Blasting, 3) Piling, 4) Scaffolds, 5) Concreting, 6) Work at Height, 7) Material Handling, 8) Grinding, 9) Welding and Gas Cutting, 10) Plant and Machinery, 11) Electrical Safety, 12) Fire Protection, 13) House-keeping, 14) Personal Protective Equipment and 15) Working inside tunnel and shaft.

ii. Develop criteria to measure each category

Once the categories for measurement have been determined, criteria must be established against which each category can be measured. Based on 15 criteria observation sheet with checkpoints developed in the present work for each criteria had been developed for construction industry is shown in Table 5.1. The criteria are framed to satisfy the requirement of statutory body (i.e., Building and Other Construction worker's Act, 1996, India and other statutory requirements).

iii. Appraise the workplace using the developed criteria

Once the categories of measurement have been determined and prescribed criteria developed. So that average score of each zone and grand total can be obtained. To start inspection the person or persons conducting a measurement should proceed in a pre-determined logical sequence. Measurement is conducted by dividing a workplace into different areas or
zone, where those conducting the measurement can stand and observe the work or the condition of the workplace.

Table 5.1 Observation sheet

<table>
<thead>
<tr>
<th>Category</th>
<th>OBSERVATION</th>
<th>Max. Marks</th>
<th>Marks Awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excavation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Whether appropriate slope / shoring system provided</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Whether proper access and egress provided</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Work permit system implemented where needed</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Whether soil dumped sufficiently away from pit</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Barricade and lighting arrangement</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Excavation- TOTAL</td>
<td></td>
<td></td>
<td>25</td>
</tr>
<tr>
<td><strong>Blasting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Does the permit for blasting operation implemented</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Explosives stored, transported and used as per statutory requirements</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Procedure for drilling, blasting and handling misfire meets statutory requirements</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>System of evacuation of people, warning and preventing re-entry adequate</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Blasting- TOTAL</td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td><strong>Piling</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Are lifting tools and tackles (Cranes /winch /slings /D-shackles) inspected by Competent Person?</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Is tagline used while handling piles/casings?</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Are the moving and rotating parts of the piling system guarded?</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Piling- TOTAL</td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td><strong>Scaffolds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Scaffold erected as per standards</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Scaffold tag system implemented</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Proper access and egress provided</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Scaffolds- TOTAL</td>
<td></td>
<td></td>
<td>25</td>
</tr>
<tr>
<td><strong>Concreting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Practice of checking formwork by supervisory personnel prior to starting concreting</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Authorized banks men available and effective communication established among workmen</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety measures for concreting activity is followed</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concreting- TOTAL</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

**Work at Height**

<table>
<thead>
<tr>
<th></th>
<th>Is Safe access to work place provided?</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Working platform made as per standards</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Are the workmen screened for working at height?</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Adequate fall protection arrangement made (Static line, Double Lanyard harness, Fall Arrestor, Safety Net tying)</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Are hand tools and handling materials secured against accidental fall?</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Are height work areas cordoned and unauthorized entries are avoided?</td>
<td>3</td>
</tr>
</tbody>
</table>

**Material Handling**

<table>
<thead>
<tr>
<th></th>
<th>Is lifting machines/tools/tackles being used at site having 3 rd party test certificates?</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Is lifting machines/tools/tackles inspected by competent person at specified intervals?</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Are the storing of all lifting machines /tools /tackles done in a proper way and damaged lifting appliances/slings/wire ropes discarded</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Are all the wire ropes, web slings being properly maintained on periodical basis?</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Are suitable slings/lifting tools and tackles and other lifting appliances used by site while handling the material?</td>
<td>10</td>
</tr>
</tbody>
</table>

**Grinding**

<table>
<thead>
<tr>
<th></th>
<th>Is storage of grinding wheels as per requirement?</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Whether grinding operation is done as per safety norms?</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Is wheels properly labelled, checked for expiry date and ring tested before use?</td>
<td>5</td>
</tr>
</tbody>
</table>

**Welding and Gas cutting**

<table>
<thead>
<tr>
<th></th>
<th>Is storage of gas cylinder meets the requirement</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Is cylinder transported in trolleys?</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Is flashback arresters provided?</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>What are the condition of welding cables, cable joints and cable termination?</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Are the earthing of the welding equipment and routing of cables?</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>Is return path for welding as per standards?</td>
<td>4</td>
</tr>
</tbody>
</table>

**Material Handling- TOTAL** | **40**

**Grinding- TOTAL**      | **15**

**Welding and Gas cutting- TOTAL** | **25**
Table 5.1 (continued)

<table>
<thead>
<tr>
<th>Plant &amp; Machinery</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Is system of equipment fitness certificate implemented?</td>
</tr>
<tr>
<td>2</td>
<td>Is regular Inspection of plant, machinery and vehicles conducted?</td>
</tr>
<tr>
<td>3</td>
<td>Are the safety devices, accessories and guards provided?</td>
</tr>
<tr>
<td>4</td>
<td>Whether Plant, Machinery &amp; Vehicles being used safely?</td>
</tr>
<tr>
<td>5</td>
<td>Does all the operators / drivers have valid license</td>
</tr>
<tr>
<td></td>
<td>Plant &amp; Machinery- TOTAL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrical Safety</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are the sufficient no of qualified electrician (viz. ‘B’ license holder) available?</td>
</tr>
<tr>
<td>2</td>
<td>Is electrical connections routed through RCCB/ELCB and checked regularly?</td>
</tr>
<tr>
<td>3</td>
<td>Whether routing of cables meets the requirement?</td>
</tr>
<tr>
<td>4</td>
<td>Earthing provided meets the specifications</td>
</tr>
<tr>
<td>5</td>
<td>Weather protection for Electrical Installations and equipments?</td>
</tr>
<tr>
<td>6</td>
<td>Jointing of Cables and Usage of Plug tops</td>
</tr>
<tr>
<td>7</td>
<td>Lock out tag out system adopted for any maintenance</td>
</tr>
<tr>
<td></td>
<td>Electrical Safety- TOTAL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fire Protection</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fire prone operations, substances are identified, fire prevention and control measures implemented</td>
</tr>
<tr>
<td>2</td>
<td>Separate storages provided for flammable liquids, solids and gases?</td>
</tr>
<tr>
<td>3</td>
<td>Is the required quantity of fire fighting equipments/systems are available</td>
</tr>
<tr>
<td>4</td>
<td>Fire fighting equipment/systems are checked periodically and recorded?</td>
</tr>
<tr>
<td></td>
<td>Fire Protection- TOTAL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Housekeeping</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project work areas are clean and free of excess trash, debris</td>
</tr>
<tr>
<td>2</td>
<td>Whether walkways and passageways clear</td>
</tr>
<tr>
<td>3</td>
<td>Whether separate storage and scarp yards identified</td>
</tr>
<tr>
<td>4</td>
<td>Whether dust bins and debris chute provided for collection of debris</td>
</tr>
<tr>
<td></td>
<td>Housekeeping- TOTAL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Protective Equipment(PPE)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Appropriate PPEs are being used by all the employees</td>
</tr>
<tr>
<td>2</td>
<td>Fall Protection Equipment being used</td>
</tr>
</tbody>
</table>
Table 5.1 (continued)

<table>
<thead>
<tr>
<th>Working inside tunnel and shaft</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Permit is available to work inside and Persons entry and exit register, pep talk are given to all the workers before starting the job</td>
</tr>
<tr>
<td>2</td>
<td>Whether oxygen level is maintained as per standard(i.e., 19.5 to 23.5)</td>
</tr>
<tr>
<td>3</td>
<td>Whether proper illumination ventilation is provided</td>
</tr>
<tr>
<td>4</td>
<td>Whether personal protective equipment is available(include emergency resue arrangement Self Contained Breating Appratus is present)</td>
</tr>
<tr>
<td>5</td>
<td>Whether communications system is estabilised</td>
</tr>
<tr>
<td></td>
<td>Working Inside Tunnel and Shaft- TOTAL</td>
</tr>
<tr>
<td></td>
<td>GRAND TOTAL (Maximum)</td>
</tr>
</tbody>
</table>

iv. Record the inspection

As the above said examples, to measure category 1 “PERSONAL PROTECTIVE EQUIPMENT” the person conducting the measurement walks into an area and observes as many workers as practical. If each worker uses all the relevant safety equipments required for the task. They are undertaking and are not taking any obvious risk then they score the “Maximum” mark. If the persons are not using the PPE’s then score will be minimum or zero.

A Performa for KSPI Corrective Action Sheet is in the present work is shown in Table 5.2. Recording items for corrective action enables a more accurate picture of a workplace to be developed over time. In addition, repeated items that have not been compiled from the previous measurement can be identified and compliance in a formal way to provide an appropriate audit trail for management, contractor details can also be entered.

Table 5.2 Typical sheet used to record corrective actions

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Area or zone</th>
<th>Observations</th>
<th>Repeated observation</th>
<th>Action by</th>
<th>Target date</th>
<th>contractor</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
v. Calculate the overall score of the project

The KSPI score for a workplace as a whole is calculated by adding the total number of marks got in each category. The score is then calculated by using the formula by

OVER ALL SCORE OF THE PROJECT(KSPI)

\[ = \text{Average} \left( \text{score of member 1} + \text{member 2} + \text{member 3} \right) / 3 \]

If overall score of the project (KSPI) is high, that means number of unsafe act/ condition observations will be less. So that, we could conclude that construction site has good safety performance, awareness and implementation. But still construction site management can improve the score by review of minor observations continously and aim to achieve zero observation. If overall score of the project (KSPI) is low, that means number of unsafe act / conditional observations will be more. So that, we could conclude that construction site has poor safety performance, awareness and implementation. Site management should review internally on the observed points and action plan should be drafted for compliance. Project management should improve the overall score of project.

vi. Feedback on positive performance

One of the principal aim of KSPI is to report what is right and what is wrong. KSPI is intended to provide positive feedback to the workplace and involve personnel in the method of measurement and the development of strategies aimed at improvement. This can be done by displaying the score at a workplace in prominent location by using posters or briefing the workforce through the Safety Committee/Peptalk/Pre-job briefing.
vii. Based on the feedback, contractor performance is measured

Observation noted that during the inspection was segregated on contractor-wise and it is discussed during the safety committee meeting and contractor meeting. This will enhance the contractor to know the status on safety aspect in the project site. In turn, the contractors will disseminate the information to workers.

5.3 STEPS IN CARRYING OUT THE KEY SAFETY PERFORMANCE INDICATOR

![Flowchart](image)

Figure 5.1 Flow chart for carrying out the KSPI
From the Figure 5.1 flow chart for carrying out the KSPI in the present work, it is clear that sequence of activities to be carried is explained. Initially safety committe meeting will decide and divide the site into zone wise or areas wise. After that, the information is also disseminated in the contractor safety committe meeting and then the team will be chosen for carrying out inspection. The team will inspect the areas and note down the observations. The observations will be catagorised in area wise/factor wise/contractor-wise. Analysis will be carried out to calculate KSPI of the project and improvement made (i.e., positive indicators) will be reviewed once again whether any continuous improvement in implementation is possible or not. Then the observations (i.e., unsafe condition/act) noted are projected to site safety committe and then to contractor safety committee in the meeting. By following the above steps, we can monitor the safety performance effectively and it can give us the factor at which the contractor is weak in that area. Accordingly, we can strengthen the safety requirement by taking corrective action. By this, effective communication will develop between the client to contractors and contractors to workers.

5.4 COMPARISONS BETWEEN SITE SAFETY METER (SSM) AND KEY SAFETY PERFORMANCE INDICATOR (KSPI)

The comparisons between Site Safety Meter (SSM) and Key Safety Performance Indicator (KSPI) is presented in Table 5.3.

<p>| Table 5.3 Comparisons Between Site Safety Meter (SSM) and Key Safety Performance Indicator (KSPI) |
|---|---|---|
| Sl.No | Attributes | Site Safety Meter (Trehewy, 2003) | Key Safety Performance Indicator (Present Work) |
| 1 | Number of Factors | 6 Factors | 15 Factors |
| 2 | Factors | 1. Working habits. 2. Order and tidiness. 3. Electrical and lighting. | 1) Excavation 2) Blasting 3) Piling 4) Scaffolds 5) Concreting |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Required Manpower</td>
<td>Skilled</td>
</tr>
<tr>
<td>4</td>
<td>Checklist</td>
<td>Yes (Less Detail)</td>
</tr>
<tr>
<td>5</td>
<td>Quantitative</td>
<td>Overall safety level can be assessed.</td>
</tr>
<tr>
<td>6</td>
<td>Benefit</td>
<td>1) Macro level of inspection. 2) Improvement in site implementation towards safety culture.</td>
</tr>
<tr>
<td>7</td>
<td>Frequency of inspection</td>
<td>Twice in the month</td>
</tr>
<tr>
<td>8</td>
<td>Evaluation</td>
<td>Site management, project</td>
</tr>
<tr>
<td>9</td>
<td>Hazard identification</td>
<td>Random hazard and repetitive hazards</td>
</tr>
<tr>
<td>10</td>
<td>Outcome</td>
<td>Site performance evaluation, Positive indicator</td>
</tr>
<tr>
<td>10</td>
<td>Health hygiene of worker</td>
<td>Not evaluated</td>
</tr>
<tr>
<td>11</td>
<td>Evaluation of fire hazard</td>
<td>Not evaluated</td>
</tr>
</tbody>
</table>

On comparison, it is found that KSPI is found to be effective tool for evaluating the site safety performance, positive indicator, negative indicator and contractor performance.
5.5 CASE STUDY

The site had been chosen for carrying out pilot study on KSPI in the field to see the performance on safety. In India, a residential building construction site is chosen. The construction company 1 at construction site perform all type of works with their contractors. Around 29 contractors under them were engaged to perform different activities at construction site. The members conducted the study as per the observation sheet developed. There were 15 factors considered for assessment, but currently few activities were not carried out at construction site. So, the twelve factors were considered for assessment.

Before carrying out the study in the construction site, awareness program on KSPI tools was conducted to staff members in the site. Initially inspection teams consist of 3 members started the surveillance by area wise, the execution persons and quality person was initially involved in surveillance, all the team members in the team were well experienced in construction activities. Inspection teams had gone area wise and noted the points in the observations sheet. The observation noted are listed below in Table 5.4, which shows many unsafe acts / conditions which were existing in the construction. It was due to an improper monitoring of contractor, poor communication between client and contractors; contractors and workers. The Contractor-wise break up of unsafe acts/ conditions before KSPI tools introduced is shown in the Table 5.4.
| Contractors | BL | AC | EC | TH | GN | LN | NA | GN | DE | W | AG | CE | LE | EF | TO | NG | TAG | RR | AB | T |
|------------|----|----|----|----|----|----|----|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|
| Contractor 1 | 12 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Contractor 2 | 2 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Contractor 3 | 2 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Contractor 4 | 2 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Contractor 5 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Contractor 6 | 2 | 1 | 4 | 5 | 1 | 6 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Contractor 7 | 1 | 5 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Contractor 8 | 4 | 5 | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Contractor 9 | 8 | 3 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Contractor 10 | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Table 5.4 Contractor-wise break up of number of unsafe act / condition before KSPI implementation
Table 5.4 (continued)

<table>
<thead>
<tr>
<th>Contractor</th>
<th>9</th>
<th>4</th>
<th>2</th>
<th>1</th>
<th>4</th>
<th>1</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor 11</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Contractor 12</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Contractor 13</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Contractor 14</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Contractor 15</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Contractor 16</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Contractor 17</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Contractor 18</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Contractor 19</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Contractor 20</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Contractor 21</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49</strong></td>
<td><strong>63</strong></td>
<td><strong>29</strong></td>
<td><strong>17</strong></td>
<td><strong>34</strong></td>
<td><strong>28</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>
Negative performance indicator : 355

Overall score of the project (Before KSPI implementation): 75.11\% (Appendix -4 ).

The surveillance team had complied their unsafe acts /conditions according to areas wise and projected in the safety meeting held and then subsequently discussed in contractor safety committee meeting also. The above points of area wise were circulated to area incharges to initiate the action for complying it. The area incharges and contractors were involved in developing the awareness to workers in their respective areas (pre-job briefing and pep talk at morning given before starting of job). Initially, it was an introduction of a new tool in the site, it took lot of time to frame out a methodology (April 2009). So the next surveillance was not carriedout at 15 days of time, but were carried after one month (May 2009).

Different team members were chosen for carrying out inspections in area wise (same procedure had been followed ) and observations were noted. The Table 5.5 shows subcontractor-wise / factor wise observation noted after Key safety performance indicator implemented.

The Contractor-wise break up of Unsafe act / condition after introduction of KSPI tools is shown in Table 5.5.
Table 5.5 Contractor-wise break up of number of Unsafe act / condition after implementation of KSPI tool

<table>
<thead>
<tr>
<th>S/C NAME</th>
<th>DLOFFAC</th>
<th>TAKROW</th>
<th>THDEH</th>
<th>L4RETA</th>
<th>GNLDAH</th>
<th>GN DNG</th>
<th>GN-DLE W</th>
<th>GN-TUCSAG</th>
<th>ERF</th>
<th>NTCTERP</th>
<th>JSUOH</th>
<th>GNPEEK</th>
<th>EPP</th>
<th>LA0T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Contractor 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Contractor 3</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Contractor 4</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Contractor 5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contractor 6</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Contractor 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Contractor 8</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Contractor 9</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contractor 10</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Contractor 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Contractor 12</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
Table 5.5 (continued)

| Contractor 13 |  |  | 1 | 4 | 1 |  |  |  |  | 6 |
| Contractor 14 | 2 | 1 |  | 1 |  |  | 1 |  | 5 |
| Contractor 15 | 1 | 1 |  | 1 |  |  |  |  | 3 |
| Contractor 17 | 1 | 1 | 2 |  | 1 |  |  |  | 6 |
| Contractor 18 | 1 | 1 | 1 | 1 | 2 | 1 |  |  | 7 |
| Contractor 21 |  | 2 | 2 | 3 | 2 |  |  |  | 9 |
| Contractor 22 | 1 | 1 | 1 | 1 | 3 |  |  |  | 7 |
| Contractor 23 | 1 | 1 |  | 2 | 2 |  |  |  | 6 |
| Contractor 24 |  | 1 | 1 |  |  |  |  |  | 2 |
| Contractor 25 | 1 | 1 |  | 2 | 1 |  |  |  | 5 |
| Contractor 26 | 4 |  | 1 |  | 1 |  |  |  | 6 |
| Contractor 27 | 1 | 1 |  | 1 |  |  |  |  | 3 |
| Contractor 28 | 1 | 1 |  | 1 |  |  |  |  | 3 |
| Contractor 29 | 1 | 1 | 1 |  | 1 |  |  |  | 4 |
| Total          | 9 | 18 | 12 | 7 | 7 | 11 | 18 | 13 | 8 | 9 | 8 | 120 |
Negative performance indicator of the project after application of KSPI: 120.

Overall score of the project (After implementation of KSPI): 80.93% (Appendix-5). Detailed calculation and observation sheet is shown in Appendix-4 (Before KSPI implementation) and Appendix-5 (After implementation of KSPI).

5.6 ANALYSIS AND DISCUSSION

After the baseline observations were carried initially, an information meeting was organized for all the staff members in the site to disseminate the hazards evolving at site. The contractors were also present. The inspection team members had presented the observations before the committee meeting. Detailed presentation was made on the unsafe acts and conditions present at the site. Management had asked to prepare a compliance report for the above observations. In turn contractor had organised meeting with the worker representative for communicating the above points. The same copy had been given to area in-charges to take an immediate action and make aware of the workers. While we see on the factor wise and subcontractor-wise, there was a drastic improvement made by the site management.

5.6.1 Factor wise Unsafe Act/Condition Comparisons (i.e., Observations)

The factor wise unsafe act / condition comparisons from Table 5.4 and Table 5.5 is shown in Table 5.6.
Table 5.6 Factor wise number of unsafe act / condition comparisons

<table>
<thead>
<tr>
<th>Factor wise</th>
<th>SCAFFOLD</th>
<th>WORK AT HEIGHT</th>
<th>MATERIAL HANDLING</th>
<th>GRINDING</th>
<th>WELDING</th>
<th>GAS CUTTING</th>
<th>ELECTRICAL</th>
<th>FIRE PROTECTION</th>
<th>HOUSE KEEPING</th>
<th>PPE</th>
<th>BARRICADES</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before KSPI implementation</td>
<td>49</td>
<td>63</td>
<td>29</td>
<td>1</td>
<td>34</td>
<td>28</td>
<td>15</td>
<td>18</td>
<td>35</td>
<td>4</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>After KSPI implementation</td>
<td>9</td>
<td>18</td>
<td>12</td>
<td>7</td>
<td>7</td>
<td>11</td>
<td>18</td>
<td>13</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>120</td>
</tr>
</tbody>
</table>

Series 1- Before KSPI observation ; Series 2- After KSPI implementation

Figure 5.2 Factor wise number of unsafe act/ condition comparison -

Y axis - Number of unsafe act/ condition observations;  
X axis – factors

From the Figure 5.2 improvement made by site management after implementation of key safety performance indicator is seen. The graph also indicates that the electrical factor alone is observed as high, in a view of reducing the observation related to electrical factor site managment had analysed seriously to find the root cause of problem why it was not complied. The observation of the electrical points was not complied, because at that month, out of 5 electricians, 4 electricians resigned because of their personal
problems. As only one electrician was available at site, so he could not able to attend all the observation. Because to perform an electrical work, authorised and licenced electrician is required. So management had taken the immediate effort in recruiting the electrician for complying the above observations.

**Figure 5.3**  % wise factor wise comparison before and after implementation of KSPI (score given by inspection team)

_Y axis - % of score on each factors; X axis – factors_

The Figure 5.3 shows that % factor wise comparison before and after implementation of KSPI, the above data have taken from the score given by the team members. While analysing the above graph, it is also lies in the same path way of earlier graph drawn (factor wise(i.e., observation of unsafe act/ unsafe condition). So, from the above mentioned figures it was inferred, improvement was found in all the factors except electrical factor. So the management has to take action for the electrical factor, for compilation of all the observations. The above graph gives us the details on the repetitive observation scores, by this we could know the factors to be immediately addressed for compilation, and the factors which show improvement should be monitored for continual improvement.
5.6.2 Contractor-wise number of unsafe act/condition observations comparison analysis

The Contractor-wise unsafe observation comparison is shown in Table 5.7 and Figure 5.4.

Table 5.7 Contractor-wise observation comparison

<table>
<thead>
<tr>
<th>Contractors</th>
<th>Before KSPI implementation</th>
<th>After KSPI implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor 1</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>Contractor 2</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Contractor 3</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Contractor 4</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Contractor 5</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Contractor 6</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>Contractor 7</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Contractor 8</td>
<td>41</td>
<td>9</td>
</tr>
<tr>
<td>Contractor 9</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Contractor 10</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Contractor 11</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>Contractor 12</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Contractor 13</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>Contractor 14</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>Contractor 15</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Contractor 16</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Contractor 17</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Contractor 18</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>Contractor 19</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Contractor 20</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>Contractor 21</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Contractor 22</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Contractor 23</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Contractor 24</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Contractor 25</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Contractor 26</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Contractor 27</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Contractor 28</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Contractor 29</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>355</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>
Series 1- Initial observation ; Series 2- After KSPI implementation

Figure 5.4 Contractor-wise observation comparison (Y axis - Number of unsafe act/condition observations ; X axis – Contractors)

The Figure 5.4 shows unsafe act and unsafe condition observations between the contractors and we can also infer that improvement found between all contractors after implementation of KSPI. This graph gives details on each contractor’s safety performance at site. By this the contractor is able to know that in which areas they should concentrate and improve for achieving continual improvement.
5.6.3  Area wise Score Comparisons

1st floor

![Graph showing area wise score comparisons for 1st floor. Series 1 represents before KSPI implementation, and Series 2 represents after KSPI implementation.](image)

Series 1 represent before KSPI implementation; Series 2 represent after KSPI implementation

Figure 5.5  1st floor; score comparison between before and after implementation of KSPI (Y axis - % of score on each factors; X axis – factors)

The Figure 5.5 represents area wise graph of 1st floor. From the Figure 5.5, it is seen that except electrical factor remaining factors had improved after implementation of KSPI. Fire protection and health and hygiene scores remain same before and after implementation of KSPI. The first floor calculation is shown in Appendix-4a (before KSPI implementation) and Appendix -5a (after KSPI implementation).
2nd floor

Series 1 represent before KSPI implementation ; Series 2 represent after KSPI implementation

Figure 5.6 2nd floor; score comparison between before and after implementation of KSPI (Y axis- % of score on each factors; X axis – factors )

The Figure 5.6 represents 2nd floor area wise observations, it represents that almost improvement had been found in all the factors except fire protection factor. This site should take immediate action to compile on the fire protection factor. The second floor calculation is shown in Appendix-4b (before KSPI implementation) and Appendix-5b (after KSPI implementation).
3rd floor

![Graph showing 3rd floor metrics before and after KSPI implementation]

Series 1 represents before KSPI implementation; Series 2 represents after KSPI implementation.

Figure 5.7 3rd floor; score comparison between before and after implementation of KSPI (Y axis - % of score on each factor; X axis - factors)

The Figure 5.7 represents 3rd floor area wise observation, we could see visually from the graph that all the factors have continual improvement.

The third floor calculation is shown in Appendix-4c (before KSPI implementation) and Appendix-5c (after KSPI implementation).

Fabrication yard

![Graph showing Fabrication yard metrics before and after KSPI implementation]

Series 1 represents before KSPI implementation; Series 2 represents after KSPI implementation.

Figure 5.8 Fabrication yard; score comparison between before and after implementation of KSPI (Y axis - % of score on each factor; X axis - factors)
The Figure 5.8 represents fabrication yard observations. From the figure, we could observe that few factors like electrical safety, fire protection, housekeeping and environment are not yet improved. The safety committee should take immediate step to address this issue to concerned area in-charge for complying it. Immediately the project manager had asked area in-charge to take immediate action against these factors. The fabrication yard calculation is shown in Appendix-4d (before KSPI implementation) and Appendix-5d (after KSPI implementation).

**Plant and machinery**

![Graph showing plant and machinery score comparison]

*Series 1 represent before KSPI implementation; Series 2 represent after KSPI implementation*

**Figure 5.9** Plant and machinery; score comparison between before and after implementation of KSPI (Y axis- % of score on each factors; X axis – factors)

The Figure 5.9 represents plant and machinery observations. From the above figure, we could infer that a few factors like electrical safety, fire protection, health and hygiene and environment found that improvement was needed. The management had asked the area in-charge to compile the points within a week time. The plant and machinery calculation is shown in Appendix-4e (before KSPI implementation) and Appendix-5e (after KSPI implementation).
5.7 AREA WISE SCORES BEFORE AND AFTER IMPLEMENTATION OF KEY SAFETY PERFORMANCE INDICATOR (KSPI)

The Area wise scores before and after implementation of Key safety performance indicator (KSPI) is shown in Table 5.8.

Table 5.8 Area wise scores before and after implementation of Key Safety Performance Indicator (KSPI)

<table>
<thead>
<tr>
<th>Assessment Elements (as applicable)</th>
<th>Score in % (April 2009) Before KSPI Implementation</th>
<th>Score in % (May 2009) After KSPI Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area A</td>
<td>Area B</td>
</tr>
<tr>
<td>Scaffolds</td>
<td>80.94%</td>
<td>72.60%</td>
</tr>
<tr>
<td>Work at Height</td>
<td>75.56%</td>
<td>75.56%</td>
</tr>
<tr>
<td>Material Handling</td>
<td>82.50%</td>
<td>74.17%</td>
</tr>
<tr>
<td>Grinding</td>
<td>75.56%</td>
<td>68.89%</td>
</tr>
<tr>
<td>Welding and Gas Cutting</td>
<td>77.33%</td>
<td>70.67%</td>
</tr>
<tr>
<td>Plant and Machinery</td>
<td>80.95%</td>
<td>74.29%</td>
</tr>
<tr>
<td>Electrical Safety</td>
<td>70.48%</td>
<td>69.52%</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>83.33%</td>
<td>76.67%</td>
</tr>
<tr>
<td>Housekeeping</td>
<td>76.67%</td>
<td>63.33%</td>
</tr>
<tr>
<td>Personal Protective Equipment</td>
<td>86.67%</td>
<td>81.67%</td>
</tr>
<tr>
<td>Health and Hygiene</td>
<td>78.33%</td>
<td>73.33%</td>
</tr>
<tr>
<td>Environment</td>
<td>80.00%</td>
<td>70.00%</td>
</tr>
</tbody>
</table>
The Table 5.8 shows overall score of areas before and after the implementation of KSPI. The improvement found in certain factors on comparing before and after implementation of KSPI that indicates positive performance indicators; a few factors are yet to be improved in certain areas that indicates negative indicators.

5.8 ADVANTAGES IN KSPI

1. It is easy to use (i.e., user friendly).
2. Any body can carry out inspection, because it has a check-list.
3. Very easy to calculate, by entering the data in excel sheet.
4. It is used to find the overall safety performance of the site, positive indicator, negative indicator, contractor-wise violaters, factor wise comparison, and area wise comparison.
5. In addition, we could find an improvement in each factor after the application of KSPI in the site.

5.9 SUMMARY

After applying KSPI in the site, the drawback had been over come by sort out the system and following strict procedure, site management could reduce the unsafe acts /unsafe conditions by 50% Table No.5.6. There is a continuous improvement found in reducing unsafe acts and conditions exist in the site and contractor performance has been improved. Site managment could infer, factors lacking at the site in the implementation of standard methods of performing job and contractors safety performance.

The KSPI is applied to the site situated in India to improve the safety performance. It has clearly brought out the lapses involved in the site. This procedure was carried for two months continuously, nearly 50% (from 355 observation to 120 observations) of the unsafe acts /unsafe conditions had
been reduced in the construction site. We could see the continual improvement in safety performance. KSPI is an effective tool to be utilised in the site to monitor and improve the performance of contractor and reduce the accident rate. KSPI tools made an effective communication between the client and contractors. This tool had acted as the good feedback tool for client and contractors. KSPI clearly brings out the positive performance and negative performance of the site. A good safety culture was developed in the site.

In summary, a new key safety performance indicator with new factors on HSE measurement system for the total construction safety management system has been developed and a case study conducted. In the next Chapter 6, the electrical safety which is a major factor of Key Safety Performance at construction site is studied in detail, since it has been given lowest scores among the different factors of Key Safety Performance Indicator (KSPI).