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Research Article

Analysis of Safety Performance in State and Sector Wise in India by Using TOPSIS

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Abstract: The Factories Act, 1948 is a labor welfare legislation which was enacted in India with an objective to provide safe and healthy work environment to workers. The occupiers are responsible for strict compliance of the Act, to protect the workers against occupational hazards. The information on occupational accidents in India is available up to the year 2010 only. In this study the data of safety and health information is analyzed for eighteen states in India basing on latest information for the year 2010.The country wide information helps to compare different states in identifying improvements in safety performance. State and Sector wise data was also analyzed for the year 2010 by using Technique for Order Preference by Similarity to an Ideal Solution. Results of the analysis are useful to guide framing policies, amendments and decision making to improve safety performance.

Keywords: Analytic hierarchy process, average daily employment, Frequency Rate (FR), Severity Rate (SR), technique for order preference by similarity to an ideal solution

INTRODUCTION

Rapid industrial development and changed economic scenario have necessitated availability of reliable database for formulation of progressive labor policies to improve working conditions of labor, ensure adequate safety measures and to promote health and welfare of the workers employed in factories and evaluate their implementation. Labor is included in the concurrent list of the Indian constitution and the Governments are empowered to legislate on it. The legislations relating to aspects of labor are employment, wages, working conditions, industrial relations, social security, labor welfare and so on.

The difference in accident rates between developed and developing countries is remarkable. Proper accident recording and notification systems are non-existent in many developing countries (Hwang and Yoon, 1981). While many enterprises in developed countries are taking zero accident policy for their goal, construction of infrastructure and industrialization in developing countries bring new situations to surface. Enterprises in developing countries are unable to identify their hazards. Furthermore, nowadays many enterprises operate in several regions and countries and this often makes accident prevention programs more challenging and occupational safety and health management systems in corporate context should take into account cultural differences (Annamaria and Bela, 2006). Occupational accidents cause direct and indirect or hidden costs for the whole society. There are many variations of the proportion of the costs but usually the proportion of indirect costs is much bigger than direct costs. On the other hand, these economic calculations are made in industrialized countries that have established specific compensation and social security systems (Hasheem, 2002).

Yearly over 48000 workers die because of occupational accidents in India and almost 37 million occupational accidents occur which cause at least 3 days absence from work. The fatality rate is 11.4/100000 workers and accident rate is 8700/100000 workers. India did not actually report any occupational accidents to ILO (Hwang and Yoon, 1981). Prioritization of strategies for industrial accident prevention, factors effecting accident prevention, safety management, improved direction and job satisfaction in a safe work environment are critical to evaluate a firm's priorities to prevent industrial accidents and maintaining safety management (Mojahed and Dodangeh, 2009). Prioritization of safety training programs and compliance of safety regulations by both the employees and employers are the determinants for prevention of Industrial accidents in the Malaysian manufacturing sector (Saad Mohd *et al*., 2012). Employee attitudes, lack of knowledge relating to safety issues and poor supervision by the management are the contributing factors for industrial risks (Larsson and Betts, 1995). The causes of accidents are related to nature of the industry, human behavior, working conditions and poor safety management. The main causes of accidents in construction industry in Kuwait

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are related to management and project based; while human related factors are not significant and suggested ten factors to improve safety performance for construction organizations (Olson, 2004). The number of fatal accidents in construction sector is high compared to other industries in Srilanka. Although fatal accidents in all other industries show a decreasing trend, construction sector shows otherwise in certain periods. Enforcement of stringent legal requirements in Sri Lanka will certainly help in curbing construction accidents (Hamalainen *et al*., 2006).

Despite the importance of accident analysis, many industries still have accident reporting systems that are vulnerable to under reporting, have incomplete recordings and do not necessarily provide a complete picture of the conditions under which accidents take place (Rameezdeen *et al*., 2003). Efficient documentation by industry and public authorities can make an important contribution to the safe operation of dangerous establishments. There is not any consistent database in Hungary which would be suitable for statistical analysis of accidents. It would be essential to establish a database for any kind of accidents. The necessity of establish a database verifies that there were some accidents where people had been killed and causes of them were un-clarified.

The statistics of safety and health information such as employment, wages, working condition, industrial relations, social security, labor welfare and so on are published annually in India by labor bureau, Government of India, Ministry of Labor and Employment (2013) but reliable data is submitted by majority of the state governments. Labor bureau was recently finalized the statistics relating into Indian industries for the year 2010-11. The lagging in consolidation of data is owing to fact that few state Governments have not submitted the returns/submitted defective returns and four states have not implemented legislation relating to safety and health. The research presented in this study was carried out for the year 2010-2011. The aim was to analyze safety performance in different states and sectors based on the Statistics of Factories (2010). The aim of the research was to rank the states and sectors basing on various parameters relating to safety and health information by using TOPSIS.

METHODOLOGY

Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method in Multi-criteria Decision making tool, is a Technique for Order Preference by Similarity to Ideal Solution (Stoop, 1997; Kang *et al*., 2012; Wang and Lee, 2009). The principle behind TOPSIS is that the chosen alternative should be as close to the ideal solution as possible and as far from the negative-ideal solution as possible. The ideal solution is formed as a composite of the best performance values exhibited (in the decision matrix) by any alternative for each attribute. The negative-ideal solution is the composite of the worst performance values.

TOPSIS is very simple and easy to implement. For that it is used when the user prefers a simpler weighting approach. On the other hand, the AHP approach provides a decision hierarchy and requires pair wise comparison among criteria. The user needs a more detailed knowledge about the criteria in the decision hierarchy to make informed decisions in using the AHP. According to this technique; the best alternative would be the one that is nearest to the positive ideal solution and farthest from the negative ideal solution. The positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. In other words, the positive ideal solution is composed of all best values attainable of criteria, whereas the negative ideal solution consists of all worst values attainable of criteria. In this study, TOPSIS method is used for determining the final ranking of the construction segments in implementing BBS. Here, S = {S1, S2,….., Sn} is a discrete set of n possible key elements and Q = {Q1, Q2,….., Qθ} is a set of θ attributes. W = {W1, W2… Wθ} is the vector of attribute weights so that they must sum to 1, otherwise it is normalized (Stoop, 1997).

TOPSIS procedure: The following explain the procedure involved in TOPSIS:

Step 1: Arrange different behavior based safety program parameters which are collected from construction segments according to their preferences through questionnaire.

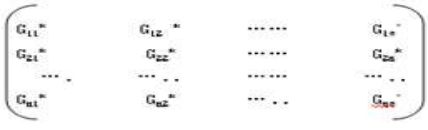
Step 2: Construct the decision matrix D as in Eq. (1):

(1)

A1, A2,…, Am are possible alternatives among which decision makers have to choose and C1, C2,…., Cn are criteria with which alternative performances are measured, xij is the rating of alternative Ai with respect to criterion Cj, weights, W = [W1, W2,…, Wn]; While Wj is the weight of criterion Cj.

Now prepare the pair wise comparison matrix (4)-(5).

Step 3: Standardize the evaluation matrix in Eq. (2), the process is to transform different scales and units among various criteria into common measurable units to along comparisons across the criteria. (D^*):



(2)

Table 1: Safety performance sector wise

Sector	Average daily employment (in, 000)	Accident rate/1000 workers	Average compensation case (in 000 of Rs.)	Compensation paid per worker (in 000 of Rs.)
Factories	668.945	4.240	100.682	0.427
Plantations	95.535	4.550	70.018	0.319
Mines	5.792	17.610	648.667	11.423
Ports and docks	14.545	0.340	237.400	0.081
Building and construction	177.594	3.230	102.791	0.332
Municipalities	20.319	0	0	0
Miscellaneous	81.072	22.380	240.242	5.380
SSQ	4,95,384.610	860.205	560448.060	159.830
SSRT	703.830	29.330	748.630	12.640

Assume G_{iY} to be of the evaluation matrix D of alternative I under evaluation criterion k, then an element G_{iY} of the normalized evaluation matrix D* can be calculated by Eq. (3):

$$G_{Iy}^{*} = G_{Iy}/\text{sqrt}\sum_{I=1}^{n}(G_{Iy}) \quad (3)$$

Step 4: Construct the weighted normalized decision matrix in Eq. (4). Considering the relative importance of each attribute, the weighted normalized evaluation matrix is calculated by multiplying the normalized evaluation matrix G_{Iy}^{*} with its associated weight W_Y to obtain the result V_{iY}:

So $V_{iY} = G_{Iy}^{*} \times W_Y$

$$\begin{pmatrix} V_{11} & V_{12} & \cdots & V_{1n} \\ V_{21} & V_{22} & \cdots & V_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ V_{n1} & V_{n2} & \cdots & V_{nn} \end{pmatrix} \quad (4)$$

Normalized Decision Matrix:

$$Rj = DIJ/\text{sqrt}(DIJ) *2 \quad (5)$$

Step 5: Construct the Weighted Normalized Decision Matrix V which is found by the following relation (5):

$$V = R \text{ X } RP \quad (6)$$

where, R is the Normalized Decision Matrix and RP is the relative priority.

Step 6: Calculate the separation of each alternative from the positive ideal solution and negative ideal solutions in Eq. (7) to (10), respectively. This means that Si^{+} is the distance in Euclidean sense of each alternative from the positive ideal solution and Si^{-} is the distance from the negative ideal solution and those are defined as followings:

$$Si^{+} = \text{sqrt}\sum_{Y=1}^{\theta}(V_{iy} - G^{max})*2 \quad (7)$$

$$Si^{+} = \text{sqrt}\sum_{Y=1}^{\theta}(V_{iy} - G^{min})*2 \quad (8)$$

where i = 1, 2,…, n.

In this Viy is the particular component or parameter value of a machine, G_i^{max} is the maximum value for that parameter and G_{ii}^{min} is the minimum value for that parameter in weighted normalized decision matrix. Ideal Solution is determined from Step-5:

A^{+} = Maximum weighted normalized value for a particular factor:

$$A+ = \{V1+, V2+, V3+, V4+, V5+, V6+, V7+, V8+, V9+\} \quad (9)$$

A^{-} = Minimum weighted normalized value for a particular factor:

$$A- = \{V1-, V2-, V3-, V4-, V5-, V6-, V7-, V8-, V9-\} \quad (10)$$

The relative closeness to the ideal solution is calculated in Eq. (11):

$$Ci* = \frac{Si-}{(Si- + Si+)} \quad (11)$$

where i = 1, 2,……., n and $0 \leq C_i^{*} \leq 1$.

Data collection: The data pertaining to information relating to safety performance in various sectors/states are available up to the year 2010-11. The statistics relating to all the state Governments was not available fully as five state Governments did not submit the returns (Uttar Pradesh Uttrakh and, A and N Island, D and N Haveli, Daman and Diu) and five states submitted defective returns (Delhi, Jammu and Kashmir, Himachal Pradesh, Karnataka and Madhya Pradesh). The Factories Act, 1948 was not implemented in four States/Union Territories namely, Arunachal Pradesh, Lakshadweep, Mizoram and Sikkim. The data is available from 7 sectors and 18 states for the year 2010-11 and is shown in Table 1 and 2.

Table 2: Safety performance state wise

State	Average daily employment	FR	SR	Factories inspected	Average amount of compensation paid (lakhs)
Andhra Pradesh	32.04	0.42	8.48	7185	3.95
Assam	49.29	0.84	15.15	713	0
Bihar	17.90	5.13	272.51	2336	0
Chhattisgarh	74.17	0.10	1.16	579	1.39
Goa	95.75	0.47	6.69	53	0
Gujarat	51.83	2.46	91.77	12220	0
Haryana	74.40	0.19	10.09	2692	0.83
Maharashtra	48.14	0	0	0	0
Manipur	10.57	0	0	192	2.55
Meghalaya	60.32	0	0	34	0.23
Nagaland	17.48	0	0	152	0
Odisha	101.96	0.70	16.75	2380	3.06
Punjab	35.55	0	0	2089	0
Rajasthan	48.07	0.95	17.77	5755	3.46
Tamilnadu	50.63	0.18	3.40	27288	0
Tripura	33.38	0.17	5.08	1121	1.30
Chandigarh	26.34	0.09	0.62	6	4.90
Puducherry	35.90	0.40	3.96	714	0
SSQ (sum of square)	52, 671.27	35.1394	83,782.55	1006541691	71.81
SSRT (square root of SSQ)	229.50	5.9280	289.45	31726.04	8.474

Table 3: Weights for five key elements

Daily employment	FR	SR	Inspections	Compensation
0.135	0.1993	0.1805	0.3401	0.1451

Table 4: Standardized evaluation matrix

State	Average daily employment	FR	SR	Factories inspected	Average amount of compensation paid (Lakhs)
Andhra Pradesh	0.1396	0.0708	0.0293	0.2265	0.4661
Assam	0.2148	0.1417	0.0523	0.0225	0
Bihar	0.0780	0.8654	0.9415	0.0736	0
Chhattisgarh	0.3232	0.0169	0.0040	0.0183	0.1640
Goa	0.4172	0.0793	0.0231	0.0017	0
Gujarat	0.2258	0.4150	0.3170	0.3852	0
Haryana	0.3242	0.0321	0.0349	0.0849	0.0980
Maharashtra	0.2098	0	0	0	0
Manipur	0.0461	0	0	0.0060	0.3009
Meghalaya	0.2628	0	0	0.0011	0.0271
Nagaland	0.0762	0	0	0.0048	0
Odisha	0.4443	0.1181	0.0579	0.0750	0.3611
Punjab	0.1549	0	0	0.0658	0
Rajasthan	0.2095	0.1603	0.0614	0.1814	0.4083
Tamilnadu	0.2206	0.0304	0.0117	0.8601	0
Tripura	0.1455	0.0287	0.0176	0.0353	0.1534
Chandigarh	0.1148	0.0152	0.0021	0.0002	0.5782
Puducherry	0.1564	0.0675	0.0137	0.0540	0.4661
SSQ (sum of square)	52,671.2700	35.1394	83,782.5500	1002177770	71.8100
SSRT (square root of SSQ)	229.5000	5.9280	289.4500	31657.1900	8.4740

RESULTS AND DISCUSSION

The analysis was carried out in two stages; state and sector wise.

Analysis of safety performance state wise: The important elements of safety performance as per data for the year 2010-11 are average daily employment per working factory, frequency rate, severity rate, factories inspected and average amount of compensation paid per case. The preference weights for the five elements are calculated by Analytic hierarchy process by consulting experts from the field of industrial safety and Government authorities. The weights are calculated for five elements and are shown in Table 3. Now the evaluation matrix is standardized or normalized, i.e., each element value of safety performance is divided by the corresponding SSRT in Table 1 and it is presented in Table 4 for adopting Step 3.

Weighted normalized decision matrix is obtained is shown in Table 5 to implement step 4 and 5.

The separation of each alternative from the positive ideal solution and negative ideal solution are calculated as shown in Table 6 for Step 6.

The relative closeness to the ideal solution is computed form Table 6 and it is shown in Table 7 for Step 7.

Table 5: Weighted normalized decision matrix

State	Average daily employment	FR	SR	Factories inspected	Average amount of compensation paid (in Lakhs)
Andhra Pradesh	0.0188	0.0141	0.0053	0.0770	0.0676
Assam	0.0290	0.0282	0.0094	0.0076	0
Bihar	0.0105	0.1725	0.1699	0.0250	0
Chhattisgarh	0.0436	0.0034	0.0007	0.0062	0.0238
Goa	0.0563	0.0158	0.0042	0.0006	0
Gujarat	0.0305	0.0827	0.0572	0.1310	0
Haryana	0.0438	0.0064	0.0063	0.0289	0.0142
Maharashtra	0.0283	0	0	0	0
Manipur	0.0062	0	0	0.0021	0.0437
Meghalaya	0.0355	0	0	0.0004	0.0039
Nagaland	0.0103	0	0	0.0016	0
Odisha	0.0600	0.0235	0.0105	0.0255	0.0524
Punjab	0.0209	0	0	0.0224	0
Rajasthan	0.0283	0.0320	0.0111	0.0617	0.0592
Tamilnadu	0.0298	0.0061	0.0021	0.2925	0
Tripura	0.0196	0.0057	0.0032	0.0120	0.0223
Chandigarh	0.0155	0.0030	0.0004	0.0000	0.0839
Puducherry	0.0211	0.0134	0.0025	0.0184	0
Max	0.0600	0.1725	0.1699	0.2925	0.0839
Min	0.0062	0	0	0	0

Table 6: Separation of each alternative from positive and negative ideal solutions

S_1^+	0.3172	S_1^-	0.1043
S_2^+	0.3685	S_2^-	0.0382
S_3^+	0.2848	S_3^-	0.2434
S_4^+	0.4467	S_4^-	0.0449
S_5^+	0.3796	S_5^-	0.0527
S_6^+	0.2340	S_6^-	0.1669
S_7^+	0.3592	S_7^-	0.0503
S_8^+	0.3901	S_8^-	0.0221
S_9^+	0.3836	S_9^-	0.0438
S_{10}^+	0.3884	S_{10}^-	0.0296
S_{11}^+	0.3908	S_{11}^-	0.0044
S_{12}^+	0.3462	S_{12}^-	0.0834
S_{13}^+	0.3743	S_{13}^-	0.0268
S_{14}^+	0.3159	S_{14}^-	0.0946
S_{15}^+	0.2526	S_{15}^-	0.2935
S_{16}^+	0.3738	S_{16}^-	0.0294
S_{17}^+	0.3808	S_{17}^-	0.0845
S_{18}^+	0.2632	S_{18}^-	0.0273

Table 7: Relative closeness to the ideal solution (state wise)

State	Relative closeness	Rank
Andhra Pradesh	0.2475	4 (15)
Assam	0.0939	12 (7)
Bihar	0.4608	2 (17)
Chhattisgarh	0.0913	13 (6)
Goa	0.1219	9 (10)
Gujarat	0.4163	3 (16)
Haryana	0.1228	8 (11)
Maharashtra	0.0536	17 (2)
Manipur	0.1025	10 (9)
Meghalaya	0.0708	15 (4)
Nagaland	0.0111	18 (1)
Odisha	0.1941	6 (13)
Punjab	0.0668	16 (3)
Rajasthan	0.2305	5 (14)
Tamilnadu	0.5374	1 (18)
Tripura	0.0729	14 (5)
Chandigarh	0.1816	7 (12)
Puducherry	0.0940	11 (8)

Analysis of safety performance sector wise: TOPSIS was to used to analyze safety performance sector wise for the shown in Table 2. The final results were shown in Table 8. The elements considered in the analysis are average daily workers employed (in, 000), accident rate per one thousand workers employed, average amount of compensation paid per case (in 000 of Rs.) and compensation paid per worker employed in the Industry (in 000 of Rs.)

Table 8: Relative closeness to the ideal solution (sector wise)

Establishments	Relative closeness	Rank
Factories	0.1407	3 (5)
Plantations	0.0503	6 (2)
Mines	0.8741	1 (7)
Ports and docks	0.1057	4 (4)
Building and construction	0.0671	5 (3)
Municipalities	0.0032	7 (1)
Miscellaneous	0.4607	2 (6)

The state wise results show that the states Nagaland, Maharashtra and Punjab are the ranked highest among other states. The states Tamilnadu, Bihar and Gujarat are in last three positions. The frequency rate, severity rate and number of inspections have an effect on overall safety performance of the states. Safety performance of any state/organization depends on several elements and in the present study five elements were considered from available data. For example in any state/organization, low frequency rate doesn't indicate safety performance is good and in other words if one fatal accident happens, it indicates frequency rate is low but the severity rate is quite high.

The sector wise results show that municipalities, plantations and building and construction are ranked highest among the sectors and mines was in last position. The sectors municipalities and plantations are not hazardous when compared to other sectors. The establishments included in miscellaneous sector were not clear as per labor bureau statistics due to which clarity in assessing safety performance is affected.

CONCLUSION

The analysis is based on the data available up to 2010-11. Safety performance in any organization/state or sector is to be reviewed continuously to implement corrective measures. It is the responsibility of the Government to collect and update data immediately after completion of financial year which will helpful to study and analyze the data to implement control measures. As on date, National standards of occupational safety was not framed by the Government. The study will help Governments to benchmark safety performance state and sector wise by implementing the measures adopted by top ranking states/sectors. Low ranked states/sectors must study and enforce the applicable legislations relating to safety to improve their performance. It is also useful for the Governments to amend safety legislations, focusing more towards low ranked states/sectors by strictly enforcing the legislations. Governments can apply the results to identify best performers in safety while declaring the national awards. Similar studies are to be conducted within states/sectors so as to improve safety performance of the country.

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