Evaluation of Activity Hazards in Marble Industry of Pakistan

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***Abstract*— Marble industry is one of the most labor intensive industry. In Pakistan even material handling in marble industries is done by labors. Pakistan is blessed with large reserves of high quality marbles which can have a significant impact on its Gross Domestic Product. Unsafe working environment affects the worker's morale and reduces the productivity and quality to an alarming level. Protection of labor increases their physical integrity and ultimately reduces the social costs associated with safety. A systematic approach needs to be evolved to identify potential hazards with in a working environment. This research paper utilizes Analytical Hierarchy Process to identify the significant hazards within a marble processing environment.**

***Index Term*— *Marble* Industry, Analytical Hierarchical Process (AHP), Safety, Hazards, Pair-wise comparison**

I. INTRODUCTION

Loss of life is more horrible than loss of property or investment. The impact of mineral industry is significant for socio economic development especially for developing country like Pakistan. Thousands of labors are directly involved from extraction to final usage of these minerals[1]. Marble industry is traced back to ancient Egyptian, which makes marble and granite industry one of the largest and oldest industries in the world[2]. With the introduction of technology based operations for marble industry around the globe, the labor intensive industry shifted to capital intensive [3]. Abundance of resources led Pakistan to rely on resource based marble industry for socio-economic development. Due to lack of technology, Pakistan marble industry can still be called as labor intensive [4]. It is estimated that more than 1500 marble processing units exists in Pakistan. Approximately 100 million sq. feet of dimension stone is processed annually, Its impact on GDP is significant [5]. It is resulted that the dimension stone industry of Pakistan has total product sustainability index value is 37% called normal value, which is at a very low level of sustainable development when comparing with international standard[6]. Involvement of labor without safety arrangements during extraction, transportation and processing can lead to an irreversible accident. Claims of organizations and government agencies providing safe environment need to be assessed through a scientific decision making tool. As indicated by news items and reports accidents related to marble industry are usually fatal [7]. The scientific and systematic analysis becomes more prompting. accidents disturb eco system around the site and also hamper the productivity significantly[8].

Production of marble passes through several stages. These include exploration and identification of a quarry location. Extraction, lifting and transporting, inventory management, cutting the stones into slabs and tiles, polishing and distribution to the end users are other significant gages [9].

Production of marble is accompanied by different incidents, injuries, loss of lives and property damage [10]. Safety affects the morale of the workers directly. Workers motivational level and their productivity is also related to their safety[11]. Accidents provoked to hands and feet are termed common by industrialist and project managers. The falls of block or a potato shape rock not only endanger the workers life but also obstruct transportation routes [12]. Like other processing industries in Pakistan, marble industry is also rapidly evolving [13]. Transfer of technology and international certification around the globe have made safe working environment mandatory. Exports are directly dependent on safety issues. Worker health as a societal indicator is the most significant indicator under consideration for sustainability in typical dimension stone industry because there are maximum chances of injuries in case if extraction is done by blasting process[14]. Accidents in Bangladesh textile industry have lowered their exports[15]. Pakistan carpet industry is also facing sanctions from European Union due to child labor and inadequate safety arrangements[16]. If increase in marble export is foreseen, safety issues must be tackled systematically. Keeping people, environment and property safe is not only mandatory by law but also from religious perspective[17]. Adequate safety not only enhances the integrity of workers and organization but also reduces the social costs i.e. medical, judicial trial, insurance etc [18]. Pakistan stone development company (PASDEC) highlighted hazards in Pakistan marble industry through GAP analysis. This research refines their findings through a decision making tool. Analytical Hierarchy Process

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(AHP) will help managers to assess their safety arrangements more rapidly and precisely. Through AHP, which is a pair wise comparison tool, hazards, severity, likelihood measures are compared.

II. RESEARCH METHODOLOGY

Finalizing problem statement led to hazards identification through literature review. The project is related to marble industry, the major source for data is Pakistan stone Development Company (PASDEC).

PASDEC in June 2011 published a technical assistance report related to Risalpur marble city. The report identified number of hazards related to marble operations, material handling equipment and labor. The results presented were analyzed from frequency calculations. It gives the insight knowledge but couldn't scientifically justify the impact of individual hazards on different performance indicators. The collected data compared to OSHA, American Marble Institute and Italian marble industry. The similar hazards in each are selected. The remaining frequency data of PASDEC is subjected to normalization. It normalization showed the data is true. The overall methodology is shown in Figure 1.

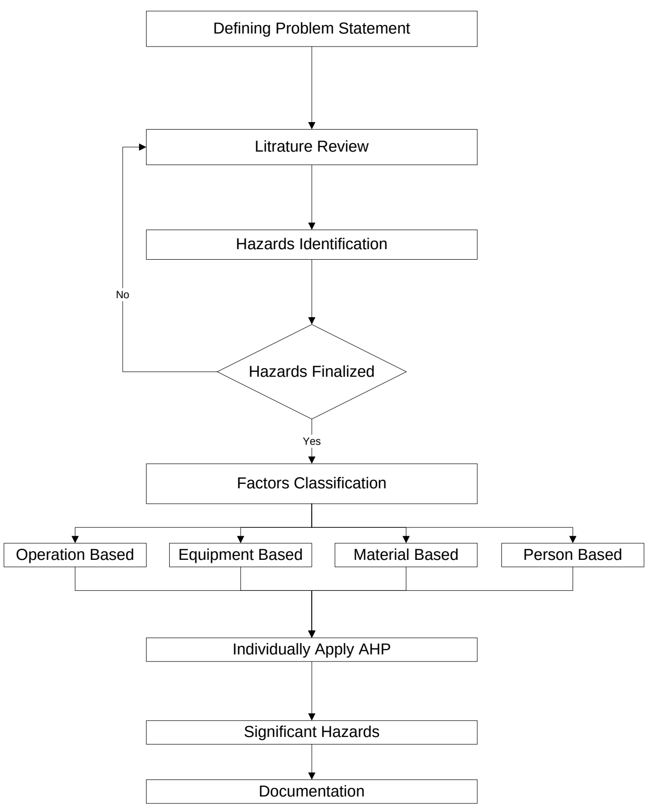

Fig. 1. Research Methodology

III. DATA COLLECTION AND ANALYSIS

For this paper only operations related hazards are considered. Table 1 enlists the different hazards associated with marble operation. The first column shows the hazards whereas the second column shows the respective likelihood of each hazard.

Table I
Hazards and its likelihood

S.No	likelihood of Activity Hazards	
1	Fall of potato blocks	8
2	Earthquake	3
3	Fall of blocks & slabs	8
4	Electric shock	8
5	Solid waste	10
6	Water pollution	10
7	Skin burn	10
8	Fall of slabs	8
9	Dust pollution	10
10	Air pollution	5
11	Road accidents	5
12	Traffic delays	5
13	Sludge	10
14	Drowning	7
15	Sanitary waste	9
16	Water contamination	8

Total Sixteen hazards are finalized at the operation level. In order to solve this data through Analytical Hierarchy Process (AHP), a 16x16 matrix is generated. The likelihood as mentioned in table I is considered as the weightage assigned to each hazard. Table II shows the From-To (Pair wise) matrix generated for the AHP. Each element at the diagonal is 1. The rest are calculated by dividing the likelihood of first hazard (From) by the next hazard (To). Eg. Likelihood of Earthquake is 3 whereas the likelihood of Fall of blocks is 8. So the From (Earth quake) To (Fall of blocks) will be 8/3 whereas From (Fall of blocks) To (Earth quake) will be 3/8. The respective values are 2.67 and 0.3 as shown in Table II. The other values are calculated in same way.

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Table II
Pairwise comparison matrix of hazards associated with the activities in marble industry

	Fall of potato blocks	Earth quake	Blok Falls	Elec shok	Solid wast	Water poll.	Skin burn	Slab Falls	Dust poll.	Air poll.	Road acc	Trafc delay	Sludg	Dro wing	Sanitary waste	Water contm
Fall of potato blocks	1.00	2.67	1.00	1.00	0.80	0.80	0.80	1.00	0.80	1.60	1.60	1.60	0.80	1.14	0.89	1.00
Earthquake	0.38	1.00	0.38	0.38	0.30	0.30	0.30	0.38	0.30	0.60	0.60	0.60	0.30	0.43	0.33	0.38
Fall of blocks & slabs	1.00	2.67	1.00	1.00	0.80	0.80	0.80	1.00	0.80	1.60	1.60	1.60	0.80	1.14	0.89	1.00
Electric shock	1.00	2.67	1.00	1.00	0.80	0.80	0.80	1.00	0.80	1.60	1.60	1.60	0.80	1.14	0.89	1.00
Solid waste	1.25	3.33	1.25	1.25	1.00	1.00	1.00	1.25	1.00	2.00	2.00	2.00	1.00	1.43	1.11	1.25
Water pollution	1.25	3.33	1.25	1.25	1.00	1.00	1.00	1.25	1.00	2.00	2.00	2.00	1.00	1.43	1.11	1.25
Skin burn	1.25	3.33	1.25	1.25	1.00	1.00	1.00	1.25	1.00	2.00	2.00	2.00	1.00	1.43	1.11	1.25
Fall of slabs	1.00	2.67	1.00	1.00	0.80	0.80	0.80	1.00	0.80	1.60	1.60	1.60	0.80	1.14	0.89	1.00
Dust pollution	1.25	3.33	1.25	1.25	1.00	1.00	1.00	1.25	1.00	2.00	2.00	2.00	1.00	1.43	1.11	1.25
Air pollution	0.63	1.67	0.63	0.63	0.50	0.50	0.50	0.63	0.50	1.00	1.00	1.00	0.50	0.71	0.56	0.63
Road accident	0.63	1.67	0.63	0.63	0.50	0.50	0.50	0.63	0.50	1.00	1.00	1.00	0.50	0.71	0.56	0.63
Traffic delays	0.63	1.67	0.63	0.63	0.50	0.50	0.50	0.63	0.50	1.00	1.00	1.00	0.50	0.71	0.56	0.63
Sludge	1.25	3.33	1.25	1.25	1.00	1.00	1.00	1.25	1.00	2.00	2.00	2.00	1.00	1.43	1.11	1.25
Drowning	0.88	2.33	0.88	0.88	0.70	0.70	0.70	0.88	0.70	1.40	1.40	1.40	0.70	1.00	0.78	0.88
Sanitry waste	1.13	3.00	1.13	1.13	0.90	0.90	0.90	1.13	0.90	1.80	1.80	1.80	0.90	1.29	1.00	1.13
Water contam.	1.00	2.67	1.00	1.00	0.80	0.80	0.80	1.00	0.80	1.60	1.60	1.60	0.80	1.14	0.89	1.00

After developing the pair wise matrix, squaring is done as shown in table III. The matrix is multiplied with its self and resultant matrix is subjected to normalization. The normalized row is assessed by dividing the sum of each row of the squared matrix. The squaring step and normalization row sum is repeated again. The difference between the two normalized row sum is zero. It is concluded that the matrix is normalized now.

Table III
Normalized Matrix of AHP

	Fall of potato blocks	Earth quake	Blok . Falls	Elec. Shok.	Solid wast.	Water poll.	Skin burn	Slab Falls	Dust poll.	Air poll.	Road acc.	Trafc. delay	Sludg .	Drow.	Sanit. waste	Water cont.
Fall of potato blocks	4096	10923	4096	4096	3277	3277	3277	4096	3277	6554	6554	6554	3277	4681	3641	4096
Earthquake	1536	4096	1536	1536	1229	1229	1229	1536	1229	2458	2458	2458	1229	1755	1365	1536
Fall of blocks & slabs	4096	10923	4096	4096	3277	3277	3277	4096	3277	6554	6554	6554	3277	4681	3641	4096
Electric shock	4096	10923	4096	4096	3277	3277	3277	4096	3277	6554	6554	6554	3277	4681	3641	4096
Solid waste	5120	13653	5120	5120	4096	4096	4096	5120	4096	8192	8192	8192	4096	5851	4551	5120
Water pollution	5120	13653	5120	5120	4096	4096	4096	5120	4096	8192	8192	8192	4096	5851	4551	5120

Skin burn	5120	13653	5120	5120	4096	4096	4096	5120	4096	8192	8192	8192	4096	5851	4551	5120
Fall of slabs	4096	10923	4096	4096	3277	3277	3277	4096	3277	6554	6554	6554	3277	4681	3641	4096
Dust pollution	5120	13653	5120	5120	4096	4096	4096	5120	4096	8192	8192	8192	4096	5851	4551	5120
Air pollution	2560	6827	2560	2560	2048	2048	2048	2560	2048	4096	4096	4096	2048	2926	2276	2560
Road accidents	2560	6827	2560	2560	2048	2048	2048	2560	2048	4096	4096	4096	2048	2926	2276	2560
Traffic delays	2560	6827	2560	2560	2048	2048	2048	2560	2048	4096	4096	4096	2048	2926	2276	2560
Sludge	5120	13653	5120	5120	4096	4096	4096	5120	4096	8192	8192	8192	4096	5851	4551	5120
Drowning	3584	9557	3584	3584	2867	2867	2867	3584	2867	5734	5734	5734	2867	4096	3186	3584
Sanitary waste	4608	12288	4608	4608	3686	3686	3686	4608	3686	7373	7373	7373	3686	5266	4096	4608
Water contam.	4096	10923	4096	4096	3277	3277	3277	4096	3277	6554	6554	6554	3277	4681	3641	4096

Each element of the normalized row sum as shown in Table IV is divided by the column sum of normalized row sum. The resultant is the significance values of respective hazards.

Table IV
Eigen vector of hazards

	Row Sum	**Normalized Row Sum**
Fall of potato blocks	75769.50	0.064516
Earthquake	28413.56	0.024194
Fall of blocks & slabs	75769.50	0.064516
Electric shock	75769.50	0.064516
Solid waste	94711.87	0.080645
Water pollution	94711.87	0.080645
Skin burn	94711.87	0.080645
Fall of slabs	75769.50	0.064516
Dust pollution	94711.87	0.080645
Air pollution	47355.94	0.040323
Road accidents	47355.94	0.040323
Traffic delays	47355.94	0.040323
Sludge	94711.87	0.080645
Drowning	66298.31	0.056452
Sanitary waste	85240.69	0.072581
Water contamination	75769.50	0.064516
Total	1174427.23	1

The 2nd and 3rd column of Table IV shows the row sum value and Eigen vector of the hazards. The sum of the Eigen values are equal to 1, which shows that these values of hazards are representing the percent impact e.g. The solid waste is having about 0.08 Eigen value mean that the solid waste is 8 percent significant on basis of likelihood and water contamination is having 6.4 percent impact. The Third column of Table IV is sorted in descending order to identify most significant hazards. The results of which are shown in Table V.

IV. RESULTS AND DISCUSSIONS

Table V shows the overall result with respect to hazards significance in descending order. Solid waste with a significance value of 0.08065 is the most significant hazard. As marble industry in Pakistan mostly uses blasting for extraction, the raw material is usually potato shape blocks. The waste is produced not only at the quarry but also at the processing area, which leads to Tuberculosis and cancer among the labours and managers.

The next most significant hazard is water pollution. Its significance value is same to first significant hazard. The water is polluted by the unskilled labour, as the slurry involved is drained out of the marble processing zone. It drastically affects the eco-system of humans and animals. It's been reported that because of this slurry the plants are even affected. The third significant factor is skin burn. It is associated with the polishing material. Usually the skilled labour is affected by the skin burn. No use of personal protective equipment leads to this hazard. Its AHP value is 0.08065.

Fourth significant hazard with an AHP value of 0.08065 is dust pollution. It affects not only the labours but all the inhabitants around the marble zone.

The fifth most significant hazard is the sludge. Its significance value is also 0.08065. It is related to the solid waste. It really disturbs the overall environment within and outside the marble processing zone.

Table V
Priority Matrix of Hazards

Sr. No	Hazards	Eigen Vector
1	Solid waste	0.08065
2	Water pollution	0.08065
3	Skin burn	0.08065
4	Dust pollution	0.08065
5	Sludge	0.08065
6	Sanitary waste	0.07258
7	Fall of potato blocks	0.06452
8	Fall of blocks & slabs	0.06452
9	Electric shock	0.06452
10	Fall of slabs	0.06452
11	Water contamination	0.06452
12	Drowning	0.05645
13	Air pollution	0.04032
14	Road accidents	0.04032
15	Traffic delays	0.04032
16	Earthquake	0.02419

Fig. 2. shows the bar-chart of the overall hazards considered in this project, along with their significance.

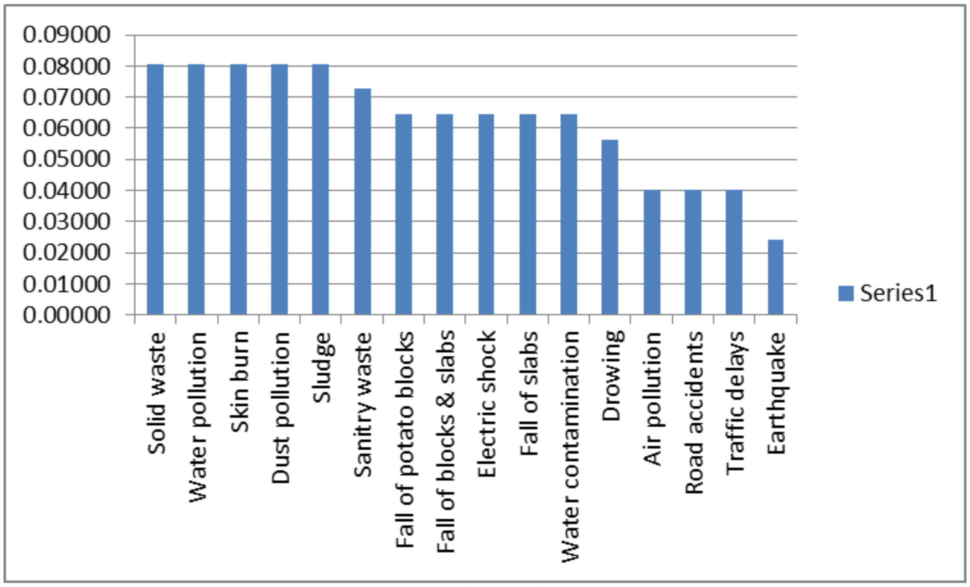

Fig. 2. Bar chart for significant hazards

V. SUGGESTIONS

The use of PPEs needs to be mandatory for each labour. The material handling system used should be calibrated regularly. Proper solid waste management techniques should be used to avoid slurry and sludge been drained in local drainage system and rivers. The reuse and recycling should be made mandatory for each of the marble processing zone.

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