Global Journal of Researches in Engineering: G
Industrial Engineering
Volume 17 Issue 2 Version1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

An Approach to Develop Green Environment in Cement Industry by Proper Material Handling and Maintenance Management System- A Case Study

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Abstract- Now a days with the huge industrialization material handling and maintenance management systems are going to be most crucial issues of any industry. Its importance cannot be denied in any way as a remarkable percentage of success of an industry depends on these. This article is based on the material handling and maintenance management system of a cement plant where their relevant systems were also studied. It was observed that the profit of any industry along with its working environment of any plant largely depends on the material handling and maintenance management system. In this research some remedial action were proposed regarding to the problems associated with material handling and maintenance management systems. Along with these the safety culture and proper training facilities of the employees were also researched for developing green environment within the cement industry.

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GJRE-G Classification: *FOR Code: 290502p*

Strictly as per the compliance and regulations of:

An Approach to Develop Green Environment in Cement Industry by Proper Material Handling and Maintenance Management System- A Case Study

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Abstract- Now a days with the huge industrialization material handling and maintenance management systems are going to be most crucial issues of any industry. Its importance cannot be denied in any way as a remarkable percentage of success of an industry depends on these. This article is based on the material handling and maintenance management system of a cement plant where their relevant systems were also studied. It was observed that the profit of any industry along with its working environment of any plant largely depends on the material handling and maintenance management system. In this research some remedial action were proposed regarding to the problems associated with material handling and maintenance management systems. Along with these the safety culture and proper training facilities of the employees were also researched for developing green environment within the cement industry.

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I. Introduction

Material handling is the process of doing a job perfectly using the required amount of raw material at the perfect place to get the maximum output utilizing a perfect duration of time. Material handling consumes 25% of all employees, 55% of all factory space, 87% of production time and 15-70% of total cost of a manufactured product [1]. The measure work in material handling system design is the selection and synopsis of equipment. For that reason the selection of material handling equipment is really a complicated and tiring task [2]. In any way the importance of selection of material handling system cannot be neglected because it can alone improve the productivity and efficiency in a large amount of a system. There are lots of material handling equipment in this modern age but it is the most importance to select the most efficient material handling equipment to reduce both the cost of production and material handling. So a well - organized material handling system is very important to improve the production system in every aspect of an industry [3].

To select the material handling equipment an expert system, MATHES (MATerial Handling Equipment Selection) is used which works through a process of checking the feasibility of technological and economical aspect in the selection of an equipment. MATHES selects the following types of equipment:

i. Manual- No equipment
ii. Pallet jack
iii. Platform truck
iv. Towing tractor
v. Trolley conveyor
vi. Power and free conveyor
vii. Tow conveyor
viii. Self-Powered Monorail carrier
ix. E- crane
x. Automated Guided Vehicle

Without these MATHES uses many other types of material handling equipment [4].

If any problem causes in selecting an appropriate material handling system it results in decreasing the productivity, increase both the movement of material and production cost. The proper maintenance management is also necessary for the equipment used in material handling and also in production site. Maintenance is such a process which helps an equipment to work without causing any breakdown at its normal operating condition by utilizing the full efficiency. There are different types of maintenance management system such as

i. Breakdown maintenance: In this type the system remain idle till it faces any problem. So it can be said that it is used in the case of emergency failure.
ii. Planned maintenance: This system is totally organized to control a work. The factors which are included here are equipment utilization, conditions of work and equipment performance.
iii. Scheduled maintenance: Here the equipment is prepared according to the schedule management of the production department.

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iv. Preventive maintenance: This system runs through routine attention, routine examination, preventive replacement and inspection measurements.
v. Condition based maintenance (CBM): This type is used where the capital is high for equipment as it ensures safety and availability.
vi. Reliability centered maintenance (RCM): RCM helps to find a logic behind the failures, such as safety, environmental, operational or non-operational, to state remedies for them.
vii. Corrective maintenance: This type of maintenance system is used to stop the iterative failure of equipment.

And according to different requirement of the industries, equipment and costs those maintenance systems are used [5]. As maintenance work is the vital task of any industry, maintenance and operations department is the largest in any industry and most of the time in comprises 30 % of total manpower and also a large amount in the operational budge [6]. In the manufacturing industries the functions of maintenance management system is more critical because without properly maintained equipment, the plant can be in disadvantage in the market. So maintenance of every equipment plays a vital role in production and also quality because an equipment with continuous fault nature cannot produce best quality product [7]. The main objective of this paper is to Develop Green Environment in Cement Industry by Proper Material Handling and Maintenance Management System. This paper is organized as follows: In Section 1, the main research topic is introduced with a brief literature review. During Section 2, the description of the problem is described based on which the research is conducted and in Section 3, the required raw materials of cement production plants are introduced. Section 4 illustrates a brief overview of the plant which was studied during the research. Section 5 represents the methodology of the work in some steps, the results of this research are discussed in Section 6 and finally we conclude in section 7.

II. Problem Statement

Environment of a cement industry is always dusty and noisy. Most of time dust content in the air cross the critical limit. Not only dust bust also CO2 emitted from the concrete manufacture site hampers the normal activity of the environment and from the previous study 10% of total carbon emission are happen in this way [8]. For that reason, worker faced a lot of mental and physical problems in their workplace. During unloading raw materials and storing it, lots of raw material waste due to the lacking of proper material handling system and lack of workers' awareness. The dusty environment creates also because of the problem of correct maintenance management. Basically there are four raw materials in different percentage for manufacture cement in the industries which are clinker, lime stone, gypsum and slag. Among those it is more critical to handle slag and clinker. It was examined that a large amount of slag and clinker were destroyed at the time of unloading which not only causes loss of production but also hampers the green environment in those area. Besides some problem had been detected in the inside area of production. This was due to the lack of the maintenance management during handling the required equipment of production. Though the cement production system is an energy intensive process, it was found that in some areas the maintenance of energy consumption was not in the proper way [9-10].

III. Overview Of The Raw Materials Studied

Cement can be define a concrete or a binding element or agency. It is such type of powder that is frequently used to cling objects and is made by burning the powder of alumina, silica, lime, iron oxide and magnesium oxide and then pulverizing them. And the production of cement is not a new idea at all. In 19th century the industrial production of cement was started with shaft kilns and now which is replaced by a lots of new and moderate equipment. Those equipment increases the production in many times and now the cement production has touched 2.8 billion tons of annual production in worldwide [8]. There are various types of cements used in the industries such as:

Rapid Hardening Cement: A remarkable amount of lime content included here. It is used in the early stage to increase the strength.

Quick Setting Cement: According to its name this type is used to complete the binding work in a very short period which is done by the reducing percentage of gypsum.

Low Heat Cement: It is generated by minimizing the amount of tricalcium aluminate which is used in producing a large amount of concrete construction.

Sulphates Resisting Cement: In this type the amount of tricalcium aluminate is kept under 6 % percent to minimize sulphates' dominance.

White Cement: It is a costly cement mostly used in architectural work. Its raw materials exclude iron oxide.

In most of the case limestone, clinker, gypsum and a very small amount of slag is used as the common raw materials of cement production.

Limestone: Limestone is a type of alluvial stone that is formed by the sea snails shell made of calcium. One of the most important material lime which is a must in cement production can be found from it. By burning the limestone in lime kiln lime is usually produced. Lime is such an element which permits vapour which reduces the possibility of moisture trapping and make the cement environment friendly. It helps to bind objects

early with exceptionally durability. The aesthetic demand is also fulfilled by it along with a self-healing quality. So it adds a lot to cement quality.

Clinker: The word clinker has come from "klinker", a Dutch word. It is a hard brick made from the ash and remainder of coal which is partially lost. The main raw of clinker is calcium oxide (65%), silicon oxide (20%), alumina oxide (10%) and iron oxide (5%) along with some tri-calcium aluminates and calcium alumina-ferrite.

A rotary kiln is used to produce clinker where the raw materials are crushed and mixed up at 2000 degree Celsius. The temperature at the other end of the kiln is 100 to 200 degree Celsius where the mixture comes automatically as it is incline and quick cooling is done.

Gypsum: $CaSO4 \bullet 2H2O$ is popularly known as gypsum.

It is the most common mineral of sulphate which is widely used in plaster. It is an important part of cement as it controls the rate of hardening and the setting process of cement. At the time of final grinding of clinker a small amount of gypsum is mixed with it and if it is not done the cement give no time to set after mixing the water.

Slag: While refining various metals from there ores some wastes are found which are like stone. This are known as slag. Mainly the slag from the iron ore is used in cement production. It improves the workability of cement reducing the risk of cracking. At the same time it also reduces the energy consumption of cement production.

IV. Overview Of The Production Plant Studied

The cement factory, which was visited, is Fresh Cement. It is a branch of Meghna Group of Industries which was established in 1976. The group started cement manufacturing in 2002 under the name of Fresh Cement and now it has become the second largest cement producer in Bangladesh. The art of manufacturing facility of Fresh Cement Industry is based on the latest German PLYCOM Technology. It was found that they have a very well established quality control and quality assurance facility where they use Bland test, Residue test, Calcium Oxide test, LOI, IR, Alumina Test, Alkali test, Silica test etc. To check the physical quality of cement they always check initial setting, final setting and its strength in ASTM, EN, BIS standards. It was observed that the technology used in Fresh Cement was quite different from other technologies for the following criteria:

Table 4.1: Distinguish characteristics of Fresh Cement

Grinding equipment	Electrical energy used Kwh/Tn (To produce 3500 sq cm/gm)	Grinding efficiency (Breakage energy with respect to consumed energy)	Residue(Sieve opening μ 45) (Contributes high ultimate strength)
Ball Mill	35-38	5% - 8%	7% - 10%
Vertical Roller Mill (VRM)	27-30	7% - 15%	4% - 5%
POLYCOM	22-26	12% - 20%	< 2.5%

The cement industry which was visited basically produce 3 types of cement. The description of those are given below:

Fresh Band Portland Composite Cement is an eco-friendly GREEN CEMENT manufactured in the fully automated state of the art manufacturing facility based on the latest German POLYCOM Technology, under strict quality control and quality assurance action plan.

The composition found in that cement is clinker (65-79%), gypsum (0-5%), slag, fly ash and lime stone (21-35%). There are lots of advantages which can be found in this type. Some of them are higher durability, better workability, low heat of hydration and better surface finish. The compressive strength test of that cement was done according to ASTM method and specification using standard sand. The result of the test is given below for three different duration:

Table 4.2: Test results in three different duration

3 Days (psi)			7 Days (psi)			28 Days (psi)		
Standard	Actual	Higher by	Standard	Actual	Higher by	Standard	Actual	Higher by
Min. 1890	2700	45.50%	Min. 2900	4120	42.07%	Min. 3620	5820	53.86 %

Fresh Special Brand Portland Composite Cement, which is another eco-friendly GREEN Cement that is also manufactured in POLYCOM Technology. The composition found in that cement is clinker (80-94%), gypsum (0-5%), slag, fly ash and lime stone (6-20%). Its work and also masonry work. The same test which is application is like the previous but it is more efficient for mass concrete work-dam, high rise building, marine compressive strength was done for this cement. The result of the test is given below for three different duration:

Table 4.3: Test results in three different duration

3 Days (psi)			7 Days (psi)			28 Days (psi)		
Standard	Actual	Higher by	Standard	Actual	Higher by	Standard	Actual	Higher by
Min. 1890	3810	100%	Min. 2900	4850	67.24 %	Min. 3620	6040	66.85%

Fresh Super Brand Portland Cement is another type of cement which is manufactured in fully automated state using the same technology, under strict quality control and quality assurance action plan. It is manufactured by only two raw materials such as clinker (95-100%) and gypsum (0-5%). It has several advantages:

1. Produces highly durable and sound concrete due to very low percentage of alkalis, Chloride, Magnesia
2. Almost negligible chloride content results in restraining corrosion
3. Significant saving in cement consumption

The most efficient use of this cement is in high rise building, bridge, fly over and also for heavy defence structure like bunker. And here the same test was done as before. The result of the test is given below for three different duration:

Table 4.4: Test results in three different duration

3 Days (psi)			7 Days (psi)			28 Days (psi)		
Standard	Actual	Higher by	Standard	Actual	Higher by	Standard	Actual	Higher by
Min. 1740	4510	159.20%	Min. 2760	5560	101.45 %	Min. 4060	7000	72.41%

V. Methodology

a) Identification of the problems

There are lots of cement factories in Bangladesh which export different types of cement in different portion of the world. Among those Fresh Cement is renowned one that was examined for this article. By combining the system of each unit of the factory the final product, cement is produced here. It was found that different unit of the plant faces different types of problem which was not only causing loss to the total production system but also hampering the health and safety issues of the workers and employees.

During unloading the raw materials at their own dock, huge dusty environment was seen and packaging unit also contained dust above the critical limit. For the dust produced in the production area and during limestone heating, percentage of greenhouse causing gasses like carbon-dioxide, sulphur dioxide, nitrogen oxides etcetera increases in the air that increases the temperature of the environment. This change hampers the regular work efficiency of the workers in the plant. Some sample were taken to understand the amount of wastages of raw material which are given it the table below:

Table 5.1: Percentages of Raw Material Wastages Identified

Sample (Day)	Raw materials sent from supplier (Metric Ton)	Successfully unloaded raw material (Metric Ton)	Amount of raw materials wastage (Metric Ton)	Percentage of raw materials wastage (% in Metric Ton)
1	7500	7499.022454	0.977546	0.013033947
2	8000	7999.100325	0.899675	0.011245938

3	6500	6499.098316	0.901684	0.013872062
4	9000	8999.005684	0.994316	0.011047956
5	9500	9499.065325	0.934675	0.009838684
6	8000	7999.000356	0.999644	0.01249555
7	8500	8499.056479	0.943521	0.011100247
8	6500	6499.124641	0.875359	0.013467062
9	6000	5999.023156	0.976844	0.016280733
10	7000	6999.023146	0.976854	0.013955057
11	7500	7499.098369	0.901631	0.012021747
12	9500	9499.032564	0.967436	0.010183537
13	10000	9999.189756	0.810244	0.00810244
14	6000	5999.258946	0.741054	0.0123509
15	8000	7999.045975	0.954025	0.011925313
16	8500	8499.025896	0.974104	0.011460047
17	8500	8499.000545	0.999455	0.011758294
18	7000	6999.006598	0.993402	0.014191457
19	6000	5999.002568	0.997432	0.016623867
20	9000	8999.025648	0.974352	0.010826133
21	9500	9499.006987	0.993013	0.010452768
22	10000	9999.021546	0.978454	0.00978454
23	7500	7499.025136	0.974864	0.012998187
24	8000	7999.128648	0.871352	0.0108919
25	8500	8499.000564	0.999436	0.011758071
26	7500	7499.098564	0.901436	0.012019147
27	6000	5999.012119	0.987881	0.016464683
28	6500	6499.093516	0.906484	0.013945908
29	8000	7999.003621	0.996379	0.012454738
30	8500	8499.025135	0.974865	0.011469

The factory has a regular maintenance system which supervise the whole production but it is not so much capable of maintaining it perfectly which results in some loses. It was rather noticed that in some area of the production unit scheduled maintenance were followed which was not appropriate. Thus it causes a loss.

It was seen in the plant that some leakage took place on the body of production equipment which wastes a lot of raw material. So ultimately it also causes loss of production capacity. The target capacity found 12000 ton/day but because of this problem the target capacity could not be reached. As a result it causes both economical loss and environment pollution.

b) Definition of the problems

Dusty environment: Dust is a common air pollutant generated by many different sources and, activities done continuously in the plant area. The particles of dust can vary in size from visible to invisible and it was found that in the plant area smaller particles stay longer in the air which moves around. The environment with contains such amount of dust is defined as dusty environment.

Maintenance problem: The problem which effects the increasing production strategy of the industry and by proper maintenance which can be solved are known as maintenance problem. The problem mainly arise for the wrong selection of maintenance management system.

Material handling problem: The problems which are associated with the handling of different raw materials and also finished or semi-finished goods. This is a vital problem in any industry or plant where huge amount of finished goods are produced regularly.

c) Mitigation strategy for the problems identified

Lessening the Waste of Raw Materials: Some small steps can solve many major types of problems. First of all the problem facing during loading and unloading was found which cause of the waste of huge amount of raw material. The result of the research showed that numbers of small steps can mitigate this problem. By attaching some sensor like and bringing some change in the structure of a clinker discharging vessel, the loss of raw material can be decreased in a considerable amount. Basically as sensor here motion sensor and distance sensor were used as an experimental view. Mainly two sensors were used concurrently to sense the motion of the E-Crane and distance of it from the discharging vessel. The entrance path of the discharging vessel was made of light composite material and was controlled entirely by the sensors. Both of sensors were connected with each other and worked simultaneously. Here distance sensor was examined by attaching it with the entrance path of the discharging container whereas motion sensor in the head of E- Crane.

Let,
the distance between the head of E-Crane and entrance of the discharging vessel, D= 3m
Required time to open the entrance of the discharging vessel, T=10 sec
Safety Time for the whole opening system, t= 10sec
Velocity of the head of E-Crane =V

So,
$D=V(T+t)$ m
or, $V=D/(T+t)$ m/s
or, $V= 3/(10+10)$ m/s
or, $V=0.15$ m/s

When the head of the E-Crane comes at the distance of 3 metre of the entrance, the distance sensor works and opens the entrance door of the discharging vessel. If the speed of the head of the E-crane is 0.15m/s or lower than that, then the distance sensor will work. Otherwise at the increment of the speed then.15m/s the motion sensor will work with the help of distance sensor and open the entrance according to the required distance. Let the variable velocity of the head of E-Crane, V is x. Then,
$D=V(T+t)$ m
or, $V = D/(T+t)$ m/s
or, $x=D/(T+t)$ m/s

Remedial Action for the Problems Associated with Maintenance Management: As the plant has numbers of units for production of cement, the maintenance of the equipment's of every unit are so much crucial. But maintenance management system not only causes huge expense but also the total manufacturing efficiency depends on it. After that the entire system of units totally affected in the absence of proper maintenance which was identified in the last stage. But by opting some proper way of maintenance it can be brought in a profitable path. Scheduled maintenance, a plan of maintaining equipment, requires higher cost. Along with having a lot of advantages, it has a number of disadvantages too. It was not so much vital for every unit of a plant to maintain scheduled maintenance system. For the unit of Roller and Ball Mill, it was observed that huge dust contained in the air with a large amount of cement in the body of different equipment which was due to the leakage of any equipment. So breakdown maintenance have to be established there to mitigate all of those problems instantly instead of waiting for further scheduled checking action which reduce the waste of raw material and also manufactured cement. In case of scheduled maintenance it is very important to use "Non Destructive Testing" (NDT) which can help a lot to find any types of cracks or leakages on the entire outer surface of the equipment. In case of tasting equipment's surfaces, fluorescent penetrant inspection, ultrasonic testing and radiography were used which is a way of maintenance management. Fluorescent penetrant inspection was used to check cracking of many parts. It had been tested that the result of ultrasonic is far accurate then radiography and so for getting more confirmation it was used too.

Providing Proper Training Facilities to the Employees: In the modern age of industrialization, most of the technology applied in different works are so much advanced. For that reason, it is very crucial to make the workers efficient to use all of the technologies. And the most vital thing is that remedial actions involved in different industrial problems are highly advanced. For applying those remedial actions by using proposed technology, some special training is must where both

short range and long range training can be given. In most cases, training can be organized by inviting expertise from outside who can give sufficient knowledge about the uses of proposed technology. To use the sensors which is proposed to attached in the body of the head of E-crane and in the entrance of discharging vessel, short range training is so much vital because without proper use of it, all effort will go in vain.

The lack of proper use of any technology can hamper the productivity and due to these proper training is so important. Apart from short range training, there are some other training facilities such as apprentice training, concurrent training passive training which can also help to make workers fit to use all of the new technologies.

Ensuring Safety Culture within the Cement Industry: Safety culture is an utmost factor of a cement plant. It is a matter of attitude and belief that the employees and workers share among themselves. For a good safety culture a proper management is needed who will observing through the working hours and ensure all the related things about the safety of each and every personnel of the industry different types of hazardous situation can occur at any time. Machinery and equipment should be maintained regularly to minimize risk. The workers should be trained on the quick heal of the machines rather than depending on the regular inspections. A machine should not be used if it is deemed potentially unsafe. Every worker should be aware of the limitations of their used equipment. It is a most important issue to have a trained first aid employee in urgent cases. Along with this workers should be given a bird's eye view on first aid. Last but not least matter is the danger area of the industry which should be clearly restricted for the normal workers and employees. Only the trained workers should have the access there.

VI. Result & Discussion

Cement is a vital element of the new era without which no construction can be build up. As a result many types of cement are being produced in different industries throughout the world which hold different quality. The research work was done by studying one of the most renowned cement industries in Bangladesh named Fresh Cement Industries Limited which is a part of Meghna Group of Industries. From the beginning of raw materials of cement to material handling of whole production system was observed. In that observation numbers of problems was identified inside the production area which were solved by this work. The wastage of raw materials was reduced by using our proposed solution which was confirmed by sampling data of raw materials unloading.

Table 6.1: Percentages of Raw Material Wastages after Mitigation

Sample (Day)	Raw materials sent from supplier (Metric Ton)	Successfully unloaded raw material (Metric Ton)	Amount of raw materials wastage (Metric Ton)	Percentage of raw materials wastage (% in Metric Ton)
1	8000	7999.788234	0.211766	0.002647075
2	7000	6999.834322	0.165678	0.002366829
3	9500	9499.645678	0.354322	0.003729705
4	6000	5999.443456	0.556544	0.009275733
5	7500	7499.945290	0.05471	0.000729467
6	8000	7999.743623	0.256377	0.003204713
7	5500	5499.845324	0.154676	0.002812291
8	7000	6999.674917	0.325083	0.004644043
9	9500	9499.467229	0.532771	0.005608116
10	7500	7499.872313	0.127687	0.001702493
11	8500	8499.786456	0.213544	0.002512282
12	7000	6999.879443	0.120557	0.001722243
13	9500	9499.865798	0.134202	0.001412653
14	8000	7999.989870	0.01013	0.000126625
15	8500	8499.768569	0.231431	0.002722718
16	9000	8999.645877	0.354123	0.0039347
17	7500	7499.768564	0.231436	0.003085813
18	8000	7999.768765	0.231235	0.002890438
19	6500	6499.689746	0.310254	0.004773138
20	6000	5999.867585	0.132415	0.002206917
21	9500	9499.897897	0.102103	0.001074768

22	7000	6999.567676	0.432324	0.006176057
23	8500	8499.768568	0.231432	0.002722729
24	9000	8999.787677	0.212323	0.002359144
25	10000	9999.878675	0.121325	0.00121325
26	6500	6499.786586	0.213414	0.003283292
27	6000	5999.897868	0.102132	0.0017022
28	5500	5499.786869	0.213131	0.003875109
29	8500	8499.776864	0.223136	0.002625129
30	9000	8999.657578	0.342422	0.003804689

The Table 6.1 shows the rate of percentage of successfully unloaded raw materials is higher than it was previous. Hence the amount of raw materials wastage greatly reduced at the very beginning of the main production starts. As we can say from the table that is in sample day of 1 the amount of raw materials wastage has been reduced to 0.01303% to 0.00264% in Metric Ton. Similarly it is clearly noticed that the wastage of raw materials reduced 40% to 60% in every sample day is observable. So, the percentages of raw materials wastage has been reduced in conspicuous rate after applying the proposed solution to the entire plant.

As the air of the plant was mostly polluted due to the dust of raw material which were wasted in the time of unloading and that increase the CO2 content in the air , by solving the problem of raw material waste the problem of CO2 percentage in the air also reduced. Before starting this work the Carbon-di- Oxide content was found in the plant area was found about 2.074% where normal carbon-di-oxide should be 0.0314% but after opting all of the proposed systems it is decreased to 0.0989%.

Optimized maintenance management system was introduced to the plant and by which it was seen that the cost relating to maintenance was reduced. Most importantly safety issues were also studied and most effective training were suggested to the plant. After all of those treatment has been taken it was ensured that the production loss of the plant is reduced with ensuring green environment inside the entire plant.

VII. Conclusion

The development of the green environment within the cement industry is essential for the betterment of industry itself and its employees. In the economical perspectives of Bangladesh, cement industries play very crucial role. So the process of cement production, industrial environment and their safety is too vital. At the very beginning of the production system the main things to deliver the raw material into the process very swiftly. At that time if we lose the raw material, production loss will begin before starting the main production. The main target of the this research was to reduce the waste of raw materials before starting the production by using appropriate material handling system in the right place. Proper maintenance management systems was ensured inside the production area which was another research outcome. Providing safety training and ensuring safety culture within the industry can also play the great role in developing green environment.

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