DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

OCCUPATIONAL HEALTH AND SAFETY ISSUES IN LAYOUT DESIGN PROBLEM OF A MARBLE PROCESSING PLANT

by

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December, 2017

İZMİR

OCCUPATIONAL HEALTH AND SAFETY ISSUES IN LAYOUT DESIGN PROBLEM OF A MARBLE PROCESSING PLANT

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by
Yaşar Can ÖZBEL

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ABSTRACT

Occupational health and safety management depends upon the scope of the industry as it varies according to the functions and scale. Designing the occupational health and safety management system for the small scale industries is more challenging due to their limited plant space and other constraints. The essential for the proper implementation of occupational health and safety management system in any of the industry is based on risk identification process in relation to the overall system. In this study, determination of potential and observational risk analysis based on layout design is aimed in the marble industries that different types of occupational hazards exist at the workplace. The purpose of this study is to determine the necessary precautions to keep the risks at acceptable levels by analyzing the dangers and risks in marble factories. In this way, related risks can be reduced. Marble factory which is the application field is located in Turkey. In this marble factory, the hazards and risks were evaluated in terms of layout occupational health and safety management. As a result, precautions has been proposed based on determined risks.

Keywords: Marble factory, facility layout, occupational health and safety

BİR MERMER İŞLEME TESİSİ YERLEŞİM PROBLEMİNDEKİ İŞ SAĞLIĞI VE GÜVENLİĞİ KONULARI

ÖZ

İş sağlığı ve güvenliği yönetimi, işlev ve ölçeğe göre değiştiği için endüstrinin kapsamına bağlıdır. Küçük ölçekli endüstrilerde iş sağlığı ve güvenliği yönetim sistem tasarımı fabrika yerleşim ve diğer kısıtlar nedeniyle daha zordur. İş sağlığı ve güvenliği yönetim sisteminin düzgün bir şekilde herhangi bir endüstride uygulanması için gerekli olan husus, sistem genelinde risk tanımlama sürecine bağlıdır. Bu çalışmada iş yerinde farklı mesleki risk unsurlarının bulunduğu mermer endüstrileri için, yerleşim tasarımına dayalı potansiyel ve gözlemsel risk analizlerinin yapılması amaçlanmıştır. Bu çalışmanın amacı, mermer fabrikalarındaki tehlikeleri ve riskleri analiz ederek riskleri kabul edilebilir seviyelerde tutmak için gerekli önlemleri belirlemektir. Bu sayede, ilgili riskler azaltılabilir. Uygulama alanı olan mermer fabrikası Türkiye'de bulunmaktadır. Bu mermer fabrikasında, tehlikeler ve riskler iş sağlığı ve güvenliği yönetimi tesis düzeni açısından değerlendirildi. Sonuç olarak, belirlenen risklere dayalı önlemler önerilmektedir.

Anahtar kelimeler: Mermer fabrikası, tesis yerleşimi, iş sağlığı ve güvenliği

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INTRODUCTION

1.1 Importance of the Problem

Designing the occupational health and safety management systems for the large-scale industries and multi-dimensional organizations is not much difficult as for the small-scale organizations due to their limited work place and other constraints (Makin & Winder, 2008). The risk factors and issues associated with each hazard help to understand the severity of these hazards. Thus, identification process of hazards and risks are keys to design proper control measures. If this step is not performed in a well manner, then the entire process will contain deficiencies and the occupational health and safety management systems will be unable to provide long term health and safety solutions (Saksvik & Quinlan, 2003).

Turkey is one of the leading countries in re-crystallized limestone and travertine reserves. According to 2003 data, Turkey has exported 1400000 tons of marble blocks in return of 106 million US$s and 799102 tons of finished marble products in return of 323 million US$s (Onargan et al., 2005). Having 40% of marble reserves of all the world, Turkey is on the way to become largest marble exporter of the world. In 1980, natural stone exports were 2 million US$. In 2006, this value has become 1 billion 27 million US$ and the volume of exports has increased 500 times. Since marble has a great importance in export economy, the problems of marble factories have to be solved to increase productivity and decrease costs. Marble blocks produced from marble quarries are cut, polished and turned into marble products in marble processing factories. Some of the marble processing factories only produce marble planes or strips, whereas others produce final marble products. Factories producing marble planes have gang saw machines or ST machines in order cut marble block into marble planes. The marble factories producing final marble products supply marble planes (in different dimensions) from first group marble factories, then cut these planes into final products in smaller dimensions (e.g., length 30,5 cm; thickness 23 cm, width 4-7 cm).

The facility layout problem can be defined as a plan of an optimum arrangement of departments, personal, equipment and storage spaces to design the best structure of the facility. In literature, generally there exist three types of layouts such as product layout, process layout, and fixed layout. Product layout is generally appropriate for the facilities that produce a single product or one type of a product. Therefore, the machines (or departments) are configured as in the order of operations. In process type layout, the machines that perform similar operations are grouped together. The products visit these groups in the order of their operations. In case of fixed type layout, the products and their components are placed in a fixed location and the labor, equipment or tools are brought to this location (Sönmez, 1998). In the literature, there are so many study related to facility layout problem. The facility layout problem literature is reviewed by (Kusiak & Heragu, 1987). Researchers give various formulations for layout problems to solve these problems. However, none of them consider occupational health and safety perspectives in layout problems at marble factory.

CHAPTER TWO
BACKGROUND

2.1 Basic Placement Regulations

2.1.1 The Importance of Facility Placement

In manufacturing environment, each pieces follow a unique sequence of operations. In order to transform the raw material into a product, it has to undergo a series of aforementioned operations. Each part of the assembly is subjected to one or more processes that are realized either alone or in part. The quality and quantity of parts to be produced depends on the customer demand. The facilities are the places where these processes are carried out and a facility can be a workbench, a business center, a workshop, etc. Furthermore, transportation (material transfer) costs that are based on the transportation amounts can be calculated in the facility. These amounts generally depend on the product mix (how many pieces are produced), rods and batch sizes. Transportation costs can be calculated according to daily, weekly, monthly or annual periods. These costs depend on the distance between the facilities (İşlier, 2000).

The main aim of the facility placement is to minimize the amount of movement for all living and non-living assets in the manufacturing activities involved in the processes. The ineffectiveness of the layout increases material handling and fixed transportation costs. Also, ineffective placement causes energy loss, turmoil, high discard rate, latency, control and management difficulties. The inefficient placement scheme reduces the utilization rate of the factory.

There are many purposes for facility layout arrangement. Generally, it is aimed to minimization of costs of material handling and transportation. From literature, it can be obtained that 20% to 50% of the total operating costs in manufacturing are the material handling costs, and an effective layout can reduce these costs by at least 10% - 30% (Tompkins et al., 1996). Also, it is aimed to effectively use of unused space with respect to parts shape.

Plant layout (production) is implemented when significant changes occur or when a new production system is installed or when new resources (robots, automated guided vehicles, etc.) are added to the production system on flow volumes and/or routes (Dolgui & Proth, 2010). Sometimes it is very costly and even impossible to make changes to existing facilities (cement, petroleum refinery, paper, sugar, etc.). In such industries, the establishment of the plant must be carefully planned before plant installation. Especially in the mass manufacturing industries that produce various products. In addition, there may be various changes in the arrangement of the firstly established facility layout. The reasons can be the necessity of re-organization over time due to capacity increase and the addition of new products.

2.1.2 Purpose of Facility Placement

The most basic aim of the facility layout is to develop a product or service system that meets the foreseen capacity and quality requirements in the most economical way. In this sense, the facility layout problem aims to minimize the amount of movement of living and non-living assets related to placement, activities for the production of goods or services (Erkut & Baskak, 2003).

According to Panneerselvam (2006), the purposes of in-house placement are listed as follows:

- To facilitate production processes,
- To reduce transportation and material cost,
- To reduce hardware investment,
- To reduce the entire production time,
- To provide flexibility in operations and regulations,
- To facilitate organizational structure,
- To use existing areas more efficiently.

In addition to above-mentioned purposes, Kumar and Suresh (2009) stated that:

- To arrange the material flow within the plant,
- To ensure high-volume circulation of inventory in the process,
- To efficient use of workers, equipment and space,
- To make the use of cubic areas efficient,
- To satisfy the flexibility of production processes and regulations.

It is difficult to actualize all these aims at the same time in a real production line. The efficient use of production inputs such as the plant's areas, equipment, materials, labor etc., restricts production flexibility. Therefore, it is important to achieve an optimum solution in which efficiently balance goals. In the product process, in order to minimize the transportation costs, some priority can be given to the production line in the arrangement of the product according to the process.

Facility layout problem cover the following scopes:

- Necessary facilities for health, nutrition and education,
- Adequate areas for maintenance and repair for all working equipment,
- Materials and storage areas in the production system,
- Arrangement of layout also provides areas for moving the products, materials, tools and workers,
- In addition, the placement of the machines and equipment in the correct areas are also within the scope of layout problem.

According to Quarterman et al. (1997), facility planning provides the physical capacity to add value to facilities (land, buildings, equipment, furniture, etc.). A properly designed facility gives following competitive advantages to the company:

- Low cost operation,
- Fast delivery,
- Adapting easily to new products,
- Producing large variety of products,
- Availability of producing high or less products amount,

- Producing the highest quality product,
- Providing unique service or feature.

Organization can renew itself by looking following areas of facility:

- Product-focused workstation,
- Plant-oriented factories within the plant,
- Reduced inventory and distribution areas,
- Kanban stocking points (centers),
- Direct distribution of raw materials,
- Integrated support areas.

2.1.3 Factors of Facility Placement

There are number of factors that affect the organization of a facility or workplace. These factors can be gathered in eight separate groups (Erkut &Baskak, 2003):

Material: Design, change, quantity, required operations and their order,
Machine: Production tools and their use,
Human: Surveillance, inspection and service,
Movement: Intradepartmental and interdepartmental movements, different operations, storage and examinations,
Standby: Continuous and temporary storage and delays,
Service: Maintenance, inspection services etc.,
Building: Interior and exterior features, usage of characteristics and equipment of the building,
Change: Expansion, flexibility.

2.1.4 Necessary Data of Facility Placement

A good facility layout requires some following data information to calculate this cost while reducing the cost of material and human movement (Heragu, 2006):

- Material flows between departments or frequency of movements,
- Shapes and spaces knowledge of departments,
- Knowledge of space requirements for departments,
- Restrictions on placement within departments,
- Proximity requirements between departmental peers.

Generally, not all of these aforementioned data are necessary. However, the interdepartmental material and the frequency of human movement, the knowledge of the shapes and areas of the departments are necessary to prepare the initial layout. The movement frequency between departments is used to determine the interdepartmental relationship. If there is no information about this frequency, the facility designer has to make an estimation about the flows and movements between the departments. However, designer should know the size and space requirements of each department. It is noted that, if the facility is a machine or a workstation, the space requirement can be calculated by adding the required areas for the worker to work, and the corridor area where the material is to be moved.

2.1.5 Principles of Facility Placement

There exist following principles for facility placement:

Merge/integration principle: This principle provides an integrated use of workers, materials, machinery and support services to achieve an efficient layout, optimal use of resources and maximum efficiency.

Minimum distance principle: This principle concerns the minimum movement of materials and workers. It prefers that material movements and workers' movements are as close and linear as possible.

The usage of cubic areas principle: An effective layout provides the use of both horizontal and vertical areas. Only optimal usage of the ground area is not sufficient, the height must also be used efficiently.

Flow principle: An effective layout provides the movement of materials towards to the completion phase of process. It is noted that, these movements include no backward movement.

Maximum flexibility principle: An effective layout scheme should take consider changes of factors such as time and cost while designing the current placement.

Security, privacy and satisfaction principle: An effective layout satisfy the workers', plant' and machineries' safety against such situations as fire, theft.

Minimum transport principle: An effective layout reduces material handling to a minimum.

2.1.6 General Flow Models

The first step in designing a production facility is to determine materials, parts, and stocks in the business process. Flow models include the entire flow process from start to product, that is from raw to semi-finished or from semi-finished to final product (Heragu, 1997).

It would be more accurate to describe flow models separately as "flow within workstations", "flow within sections", and "flow between parts" (Tompkins et al., 1996).

2.1.6.1 Flow in Workstations

In this flow, there exists two things that need attention. These are the movements and ergonomics of the workers. The flow in the workstations should be symmetrical, synchronous, natural, rhythmic and familiar.

2.1.6.2 Flow in Sections

The flow in the sections depends on the types of section. In a production department, the workflow can be created based on the product flow. The product flow is typically one of the models shown in Figure 2.1.

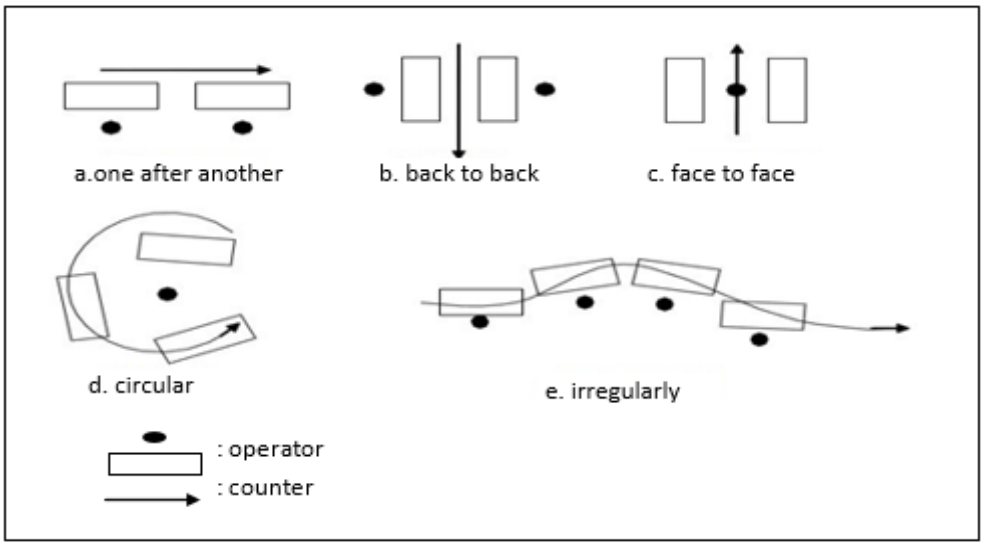

Figure 2.1 Product flow models

In the process section, the flow between the workstations should be small. Flow typically occurs between workstations and corridors. The flow models are based on the directions of the workstations relative to the corridors. In Figure 2.2, three flow models are showed based on workstation-corridor layout. The decision of selection from workstation-corridor layout will depend on the relationship between workstation floor space, available space, and the amount or size of the item being moved.

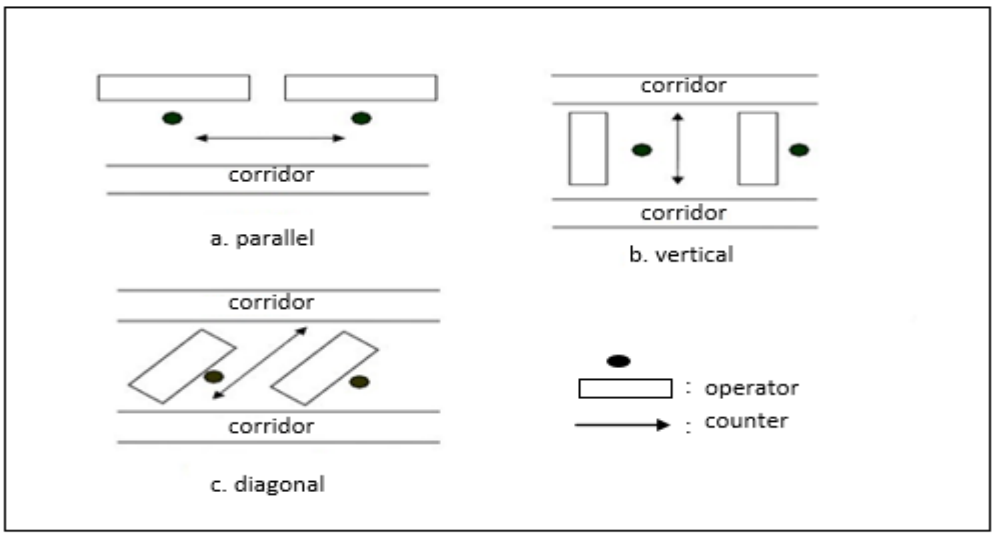

Figure 2.2 Flow charts by workstation-corridor layout

2.1.6.3 Flow Between Parts

The flow between parts is a measure that is often used to evaluate the entire flow in a process. The flow generally consists of a combination of the four types of flow models shown in Figure 2.3. Flow models differentiate due to the position of entry and exit points that shown in the Figure 2.3. As a result of the drawing scheme or building structure, the inlet and outlet locations are usually fixed.

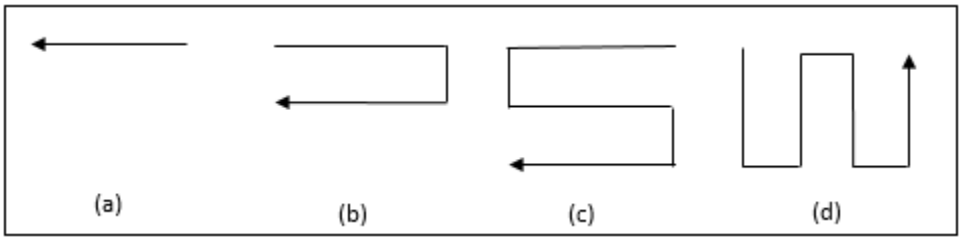

Figure 2.3 General flow models: (a) I type flow, (b) U type flow, (c) S type flow, (d) W type flow

2.1.7 Workflow Types

Erkut and Baskak (2003) stated that after the machine and human power required for the production of a particular product or group of products, this machine and the working group must be assembled together. The main purpose of this regulation is to create a workflow that carry the goods with minimum weight, distance and cost from duration of entry of raw material to delivery of the finished product to the customer. The flow of materials in operation is one of the important factors that determine the facility layout. One of the aims to be achieved in the workplace regulation is not make constant the place of machines, but to provide the best flow of material in the factory.

An effective flow of material depends on the material transfer costs, the amount of semi-finished products, the principal goods and the space connected to semi-finished products, the length of the total production time. Each of these items is sufficient for the examination of the flow systems. Thus, it is necessary to provide the smallest movement by making an efficient flow of the facility. The workflow system also affects the inspection and control mechanism. Lean workflow lines are ideal for

control purposes, and in this case, surveillance can be done with the eye. A complex workflow system usually results in a complex control system.

After the basic information about the product and process been collected, the next step is to analyze the layout design, materials, tools, equipment and the material flows. The reason is that facility layout actually facilitates the flow of the product from the raw material state to the finished product state.

2.1.7.1 Items Affecting the Workflow System

The features of the workflow models are considered in detail, whether they are tailored to the process or the product. The main factors influencing the workflow can be listed as follows (Erkut & Baskak, 2003):

1. External transport facilities,
2. The number of pieces in the work,
3. The number of operations in each part,
4. The parts,
5. The number of sub mounts,
6. The number of products to be produced,
7. The flow between workstations,
8. The volume and form of the available area,
9. Effect of processes,
10. Flow types,
11. Facility arrangement according to product and process,
12. The locations of service departments,
13. The locations of the production departments,
14. Particular requirements of departments,
15. Material storage,
16. The desired flexibility,
17. Buildings.

2.1.7.2 Workflow Models

Workflow models can be divided into following two categories according to their specifications (Erkut & Baskak, 2003):

1. Workflow models in terms of production line:

   a. Linear (straight),
   b. U- shaped,
   c. S- shaped,
   d. Spirited (helical).

2. Workflow models in terms of assembly line:

   a. Comb-shaped,
   b. Tree-shaped,
   c. Branch,
   d. Overhead.

All these workflow models are as shown in Figure 2.4.

The linear flow type model requires a building as narrow or as wide as the production line. The U-shaped production line allows delivery of materials or products in the same building, which allows consolidation of operation and control points.

In the assembly line model, the main assembly line is fed from the same direction, while in the tree model the sub-assembly lines are fed from both sides. For the same number of sub-assembly lines coming from the main assembly, the assembly process in the tree-type assembly line can be completed in a shorter time compared to the comb-type model. The comb-type assembly line is most suitable for a facility that has a long wall or corridor type installation. Whereas, the tree-type assembly line is used when the main assembly line located at the center of the production area and supplied

with from sub-assembly lines that exist in the side. Furthermore, in the branch-type model, while sub-assembly lines travel along the production line, they merge with other sub-assembly lines and eventually form the main assembly line. In this way, as approaching the final assembly line, the number of sub-assembly lines is reduced and the main assembly line is established. In the overhead workflow, the assembly line goes down from the upper space and the lower space is completed. In the assembly line workflow type, it is tried to make the processes that should follow each other among subgroups as closely as possible. Thus, the transportation time is kept to a minimum and the time spent for product production is reduced. In terms of efficiency and cost in the total production system, assembly lines are arranged in such a way to provide the greatest possible benefit from the existing area.

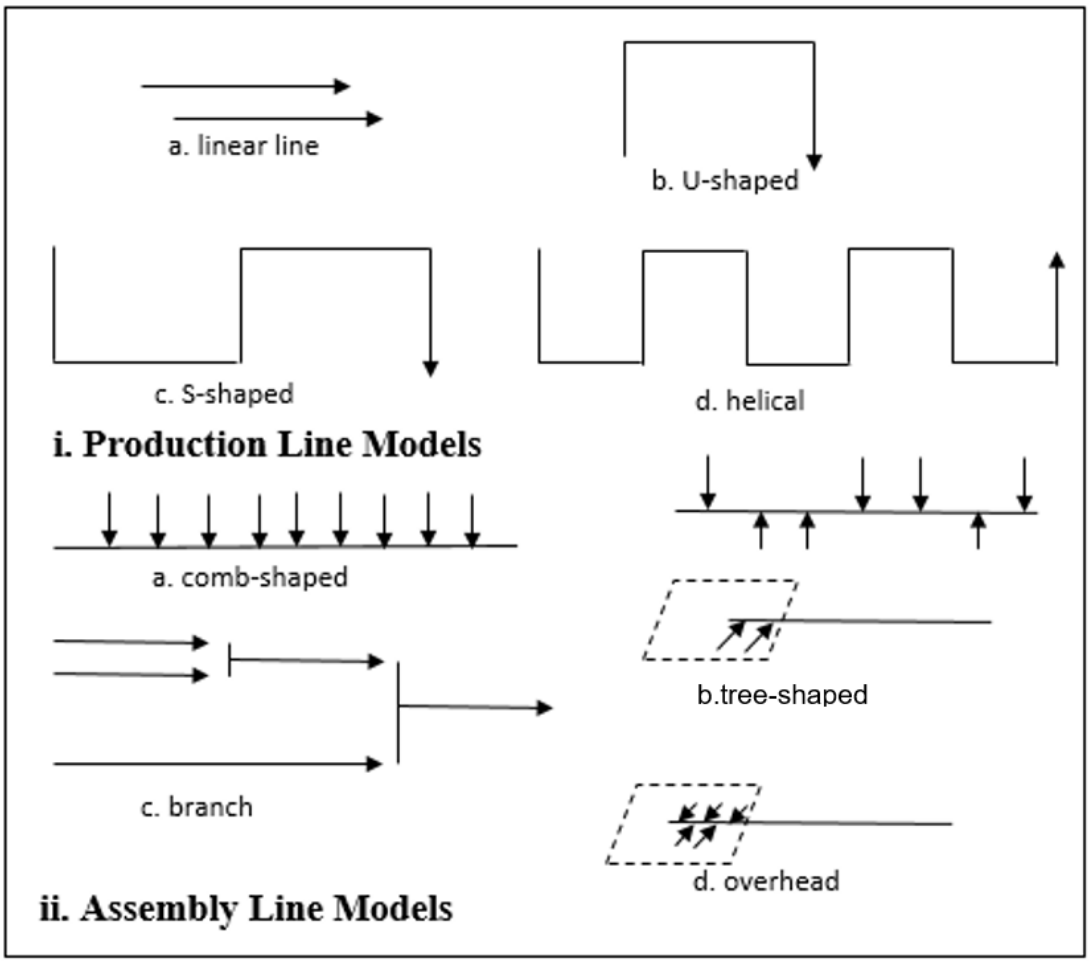

Figure 2.4 Workflow models

According to different aspects, workflow systems are divided into two section (Erkut &Baskak, 2003):

1) Horizontal workflow lines:

a. Linear or I flow line,
b. L flow line,
c. U flow line,
d. Circular or O flow line,
e. Snake or S flow line.

2) Vertical workflow lines:

a. Upstream or downward process flow system,
b. Central or decentralized lifting system,
c. One-way or return flow,
d. Vertical or inclined flow,
e. Single or multiple flows,
f. Flow between buildings.

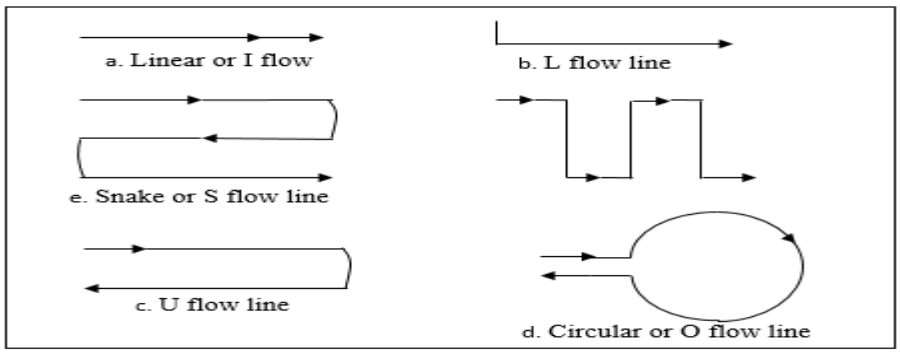

Figure 2.5 Horizontal workflow lines

Horizontal workflow lines are shown in Figure 2.5.

Linear or I-flow lines from horizontal workflow lines are the simplest flow type. However, it is necessary to create separate segments for sending and receiving. The L-

shaped flow is used when the linear flow cannot be applied or when it requires high costs. Management of U-shaped flow is simple and mostly preferred due to the usage of same segment for sending and receiving items. Circular flow finds application area if it is desired to form the end point very close to the starting point. Furthermore, snake flow is used when the zigzag is to be formed in the production area due to the fact that the production line is very long.

2.1.8 Facility Placements

The locations of the plants, departments and machines are determined after the types of workflows to be used in production are decided. This is usually done by a trial and error method. There may be many possible solutions, but the problem is to find the optimal placement method for the purposes according to their characteristics. Depending on the goals and constraints assessed, it is possible to make some choices based on various calculation methods. Kumar and Suresh (2009) mentioned following five different placements:

1. Placement according to process,
2. Placement by product,
3. Placement by fixed position product,
4. Cellular placement,
5. Unified placement.

Placement according to process; Process placement is recommended for mass production. According to the process placement, all the machines grouped together in the placement that actualize similar operations. For instance, operation such as turning, milling, etc. are classified in similar groups. The material flow line changes from one process area to the next to the other. Usually the line is long and backward flow is possible. The process placement is normally used when the amount of production is not sufficient for product placement. Often workshops use process placement. Because of the diversity of products produced and low production quantities. There exist following benefits and drawbacks.

Benefits:

- The machines are better used and fewer machines are needed,
- Labor and equipment flexibility is possible,
- Less machine investment is required,
- The use of production facilities increases,
- A high degree of flexibility is ensured in the distribution of jobs of the machines and workers,
- The diversity and variety of tasks make the job interesting,
- Administrators are very knowledgeable about jobs in their departments.

Drawbacks:

- In this case, there may be backward flowing and long-distance movements in the material handling process and the cost of transportation of these material s will increase,
- Material handling cannot mechanize,
- It may increase the amount of inventory of both processed and unprocessed materials and cycle time of production,
- Depending on the number of installations, productivity may decrease,
- The output time (the time interval between the input and output) become longer.
- Gain and necessary area are highly dependent on the semi-finished product.

Placement by product; In this placement, the machines and the auxiliary services are arranged according to the order of processing of the product. If the production amount of one or more product is higher, facilities may be arranged to reduce the unit cost and streamline the material flow. Special machines are used to perform the required fast and reliable work. Placement of product is used when a production quantity of a product requires a separate production line for process. Machines cannot be shared for different products in this layout placement. For this reason, the amount of production should be sufficient to ensure efficient use of equipment. There exist following benefits and drawbacks.

Benefits:

- The flow of production should be smooth and logical,
- Semi-finished stock is small,
- Total production time is short,
- Material handling cost is minimized,
- It is possible to simplify production, planning and control systems,
- With temporary storage and job transitions, less space is occupied,
- Smooth flow and mechanical transport systems reduce material handling costs,
- Good line balancing removes idle capacity and bottlenecks,
- The production cycle is short due to the uninterrupted flow of materials,
- Unprocessed product stock is low,
- Non-qualified workers can learn the job.

Drawbacks:

- Failure of a machine in the production line may cause subsequent machines to stop in the flow line,
- A change in product design may require major changes in the layout,
- The machine in the bottleneck determines the speed of production,
- Higher investment is required for equipment,
- It is not flexible,
- A change in the business requires a reorganization of the installation.

Placement by fixed position product; This type of layout is also called a project type layout. In this placement, vehicles, machinery, workers and other materials are transported to this area while the material or basic elements are stationary. This type of layout is suitable if one or heavier products are produced and the assembly involves heavy parts with high transport costs. The biggest advantages of this type of placement are:

- It helps spread the business and increase the skills of the workers,
- Workers define themselves with a product they are interested in doing business with,
- This type of layout is very large,
- Capital investment is less than others for placement.

Cellular placement; Group Technology (GT) analyzes and compares parts and divides them into similar family groups. GT can only develop a mixture of placement and process placement. This technique is very useful. Because it has the economical advantages of the flow line, which is suitable for the production of various products in small batches for the enterprises. GT implementation involves two basic steps; the first step is to specify the part families or groups, and the second step is to edit the hardware area that used in the process of a specific component family. It appears in small complex facilities. The GT reduces production planning time, work and installation time. Thus, according to the cellular production, the placement (group placement) is combination of product and process placement. This placement provides the advantages of both placements. The main purpose in cellular production is to minimize the total transport and equipment costs. For this reason, it is called a multipurpose placement scheme.

Placement by cellular production satisfies followings:

- Standardization and rationalization,
- The reliability of estimates,
- Effective machine operation and productivity,
- Customer service.

It can enhance the following things:

- Paperwork and overall production time,
- Non-progressive work and business movements,
- Overall cost it can be reduced.

Unified placement; Placement with consolidation of process involves the advantages of both types. It is possible to produce a part in different types and sizes in a combined layout. The machines are arranged according to the process as in situ, but the process is grouped in order to produce products of different types and sizes. It should be noted that the process order remains the same in various products and sizes.

2.1.9 Classification of Facility Arrangement Problems

Facility layout problems can occur in such situation as change the factory design, process or quantities. Also, it can be seen in case of a new machine-equipment purchasing or a new facility construction. For overcoming the solution of problems that accumulate over a long period of time, it can be needed that the facility layout needs to be revisited. Some situations such as high material transfer times relative to total production time, crowded work environments, inadequate operations, bottlenecks in machines, unexplained delays and idle times, and poor working environment can be counted as some example reasons of facility layout problem.

Regardless of the causes, mainly facility layout problems can be classified as follows (Erkut & Baskak, 2003):

- Minor changes to existing arrangements,
- Reconsideration of the existing arrangement,
- Moving to existing facilities,
- Establishment of a new business / factory.

2.2 Solution Approaches for Facility Layout Problem

Objective of the facility layout problem is to find a placement plan that provides an optimal layout based on flow matrices between departments (Bhowmik, 2008). There exist mainly two kind of solution approaches. These are exact methods and heuristic methods.

2.2.1 Traditional Approaches

In literature, solution approaches are categorized based on two major methods, namely algorithmic and procedural. That is, the problem of facility layout covers both design and optimization problem. In algorithmic approaches, the solutions can be obtained based on some achieving objective function values under constraints. The majority of current literature mostly use algorithmic approaches. Design of facility layout requires time and effort with the purpose of structure and information requirement. Numerous researches have been carried out in order to meet these requirements. The main objective of algorithmic approaches is to try to minimize flow distances that minimize material handling costs. The procedural approaches are based on the experience of experts (Heragu, 1997).

The algorithm consists of a very precise set of commands that allows a solution of particular problem by applying number of predetermined steps. In general, the following features of the algorithms are addressed (Nabiyev, 2003):

- Generality,
- Precise orderliness,
- Sequence control structure,
- Contingency and consequence.

Since, the facility layout problem is an optimization problem, optimization problem can briefly stated as follows: Optimization is the best search process under the current conditions. In a more technical sense, it is a mathematical discipline interested in finding maxima or minima of a function under certain constraints (if any). Optimization models are defined as mathematical expressions of the relations of the system in order to optimize a system output.

Talbi (2009) grouped the classical optimization methods as shown in Figure 2.6.

In order to solve the optimization problems, there are many algorithms that are suitable only for certain types of problems.

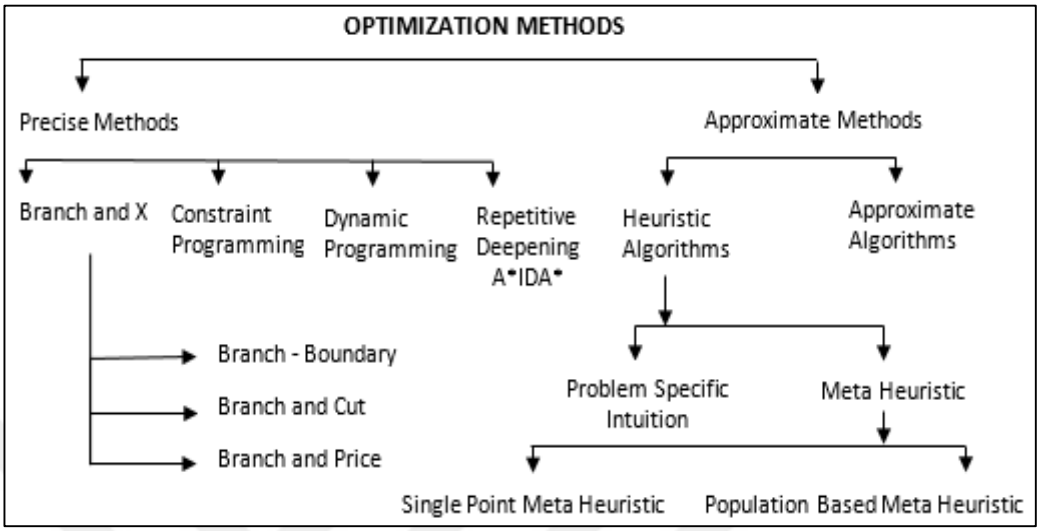

Figure 2.6 Classical optimization methods

Exact methods always obtain optimal solutions and guarantee this optimality. Exact methods calculate all the candidate solutions by searching in the whole solution space and find the best result. Exact methods have a definite conclusion and they spend a lot of time finding the solution as the problem size grows. Exact methods can be effectively used in small-sized examples of difficult problems.

The main approaches dealing with the layout of the facility as an optimization and design problems are discussed in the subheading.

2.2.1.1 Design Problems

The design problem deals with the problem of facility layout arrangement as a systematic facility layout planning (SLP) and an engineering design problem. These are:

i) Systematic layout planning: SLP technique basically consists of 4 steps (Heragu, 2006):

Step 1: Arrangement of Departments' Place: This step includes the identification of places for departments. For instance, this area can take part in north or west side of the building or in another building adjacent to the old building.

Step 2: Establishment of General Placement: In this phase, the flow between the sections, the proximity conditions, the space requirements for each section are determined. Also, constraints such as the space availability, budget and the type of placement is decided. The plans are generated on the basis of cost and non-cost factors and a layout is selected from the generated plan.

Step 3: Creating Detailed Layout Plans: Step 2, addresses the placement issue of departments. Step 3, addresses placement and placement details within each department.

Step 4: Establishment of the Selected Placement: Administrative staff and/or managers select the appropriate placement scheme after approval. These plans should be showed with all the details. Because, they are used in the transportation or installation of new plants.

The most important steps in the above steps are Steps 2 and 3. The input data required for SLP can be summed up in five classes:

Product (P): Product types to be produced,
Quantity (Q): Production volume of each piece type,
Routing (R): Sequence for each track type,
Services (S): Support services, cabinets, inspection station, etc.,
Timing (T): When the part types are to be produced and which machines are to be used during production.

With the P-Q-R data, a material flow matrix is created. This matrix shows the flow density between each pair of machines. Similarly, with the P-Q-S data relationship diagram is generated. Then, the field-relationship is constructed by using the flow matrix and the relationship diagram. The next step is to determine field requirements and competencies. Using these two, knowledge and relationship diagrams, field-relationship diagrams are created. Also, other factors (material handling methods,

warehouse equipment, etc.) and constraints (cost, existing structures, personnel and equipment safety, energy efficiency) are taken into account. Then, the field-relationship diagram is used to create alternative layout plans. In this phase, usually two or three alternative layout plans are created. After, each option is evaluated based on the placement constraints, cost, and other non-physical factors. Finally, the most appropriate layout is selected.

ii) Engineering design problem: It consists of the following six steps (Tompkins & White, 1984):

1. Define the problem: In both a production facility and a service operation, the product to be produced or the service to be provided must be quantitatively stated. Levels of volumes or activities should be defined if possible.

2. Analyze the problem: Define main and support activities when the objective is being achieved. The main and supporting activities carried out and the requirements such as operations, hardware, personnel and material flows must be met. Both quantitative and qualitative relations must be defined. Also, within the facility boundaries, it should be determined how events affect or support each other. Furthermore, space requirements for all activities must be examined.

3. Create option designs: Options include facility designs, alternative residential designs, structural designs and material handling systems.

4. Rate options: For each candidate facility plan, identify the subjective factors and assess how much they affect and do not affect the facilities and operations.

5. Choose your favorite design: Choose which candidate plan best meets your facility goals and objectives.

6. Create the selected design: Once the plan is selected, the next step is to realize it. As is known, employees generally show resistance. If a new plant layout is established, it must first be approved and supported by employees (Heragu, 1997). Systematic facility layout procedure is shown in Figure 2.7.

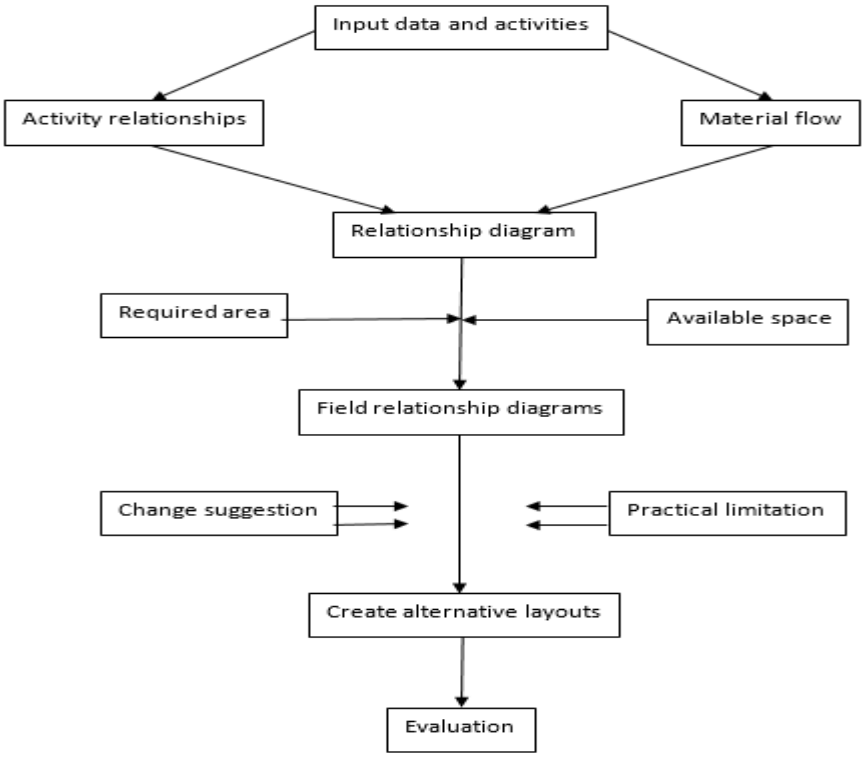

Figure 2.7 Systematic facility layout procedure

Some of the facility layout and installation problems include the placement of a single new site in the existing facility layout or the design of the facility for a single section. It is a very difficult task to consider qualitative items as well as quantitative items in solving facility layout and placement problems. For this reason, it is difficult to integrate quantitative and qualitative items into a quantitative form so that alternative solutions can be evaluated. It is often observed that some facility layout and placement problems are solved using quantitative goals, and then the resolution is based on qualitative studies. Under normal circumstances, this process is quite adequate and more than a non-qualitative approach (Erkut & Baskak, 2003).

2.2.2 Heuristic Approaches

The operation of exact algorithms may not be efficient. In this case, we can find an ideal solution without using exact algorithms. In practice, heuristic algorithms and definite algorithms are preferred (Aytekin & Kalaycı, 2010). In many applications, heuristic algorithms produce a reasonable, but not optimal solution to a problem. The

solution may be optimal, but it cannot be mathematically propagated. Heuristic algorithms are used when the optimal of the problem is not known or when the solution time is not economical. Heuristic methods find good results in large size samples. They allow to achieve acceptable performance at an acceptable cost over a wide range of problems. Heuristic algorithms do not guarantee the best solution. The most commonly used heuristic methods are the constructive methods, the limited enumeration methods and the improvement methods.

2.2.3 Meta Heuristic Approaches

Meta-heuristic methods are based on making deep searches of the most favorable areas of a solution domain. The quality of solutions produced by a meta-heuristic methods are higher than those obtained with classical heuristic. We can divide meta heuristic algorithms into three main group with respect to their solution approaches. These groups are local based search algorithms (e.g. simulated annealing, deterministic annealing, tabu search and etc.), population based search algorithms (e.g. adaptive memory methods, genetic search) and learning mechanisms (artificial networks, ant colony systems).

In the literature, the solution methods in the meta heuristic algorithm class are given as follows (Tezer, 2009):

- Tabu search (Glover et al., 1993),
- Simulated Annealing and tabu search (Osman, 1993),
- Taburoute (Gendreau et al., 1994),
- Adaptive memory (Rochat & Taillard, 1995),
- Combined tabu search (Cordeau et al., 2001),
- Adaptive memory (Tarantilis & Kiranoudis, 2002),
- Granular taboo search (Toth & Vigo, 2003),
- Ant system optimization (Reinmann et al., 2004).

CHAPTER THREE
OCCUPATIONAL HEALTH AND SAFETY

3.1 Occupational Health and Safety

Nowadays, the man is the most important factor of production and has being faced various problems in the workplace in parallel with technological developments. These problems have been posed threats to human health and then to all kinds of goods belonging to management. The increasing of activity areas, the complexity of the transactions, and as a result of these, the increase of the hazards, the introduction of new certain rules and laws have been required. Because of all these reasons, scientific studies started related to this subject and the concept of occupational safety has emerged as a common field of study of medicine, technique and other sciences.

Occupational safety covers the necessary work to be done in order to determine the control measures for the identification of the hazards that may exist in the working place or that may arise from the outside, the grading of the risks, and the factors and hazards that cause these risks to turn into risk by analyzing. According to the rules and laws of occupational health and safety legislation, it is necessary to carry out the risk analysis to identify the sources or dangerous situations that may or may create hazards in the working place. By evaluating the risks of working place, the planning of the activities for preventing the working places risks and the monitoring of the applications need to be done. In addition, these activities should be supported by printed materials. Otherwise, the inappropriate conditions of working place can cause loss of product and material, damaging of work equipment, and most importantly qualified employees who are most important capital of the companies, can be injured or organ loss or death. However, the psychological atmosphere caused by job accidents can affect productivity of work and in the meantime causes loss of prestige in the working place. Improving the level of occupational health and safety that is one of the indicators of social and economic development has great importance in the creation of safety culture in society. As in the European Union countries, there is a need related to total safety

culture in our country from the kindergarten to the retirement age through lifelong learning.

Occupational health and safety studies have being aimed to ensure that the employees work in a comfortable, safe and peaceful environment by protecting them from the negative effects of the working place and from the work-borne diseases.

The establishing of occupational health and safety is closely related to various institutions and organizations because of it effects social system. Employers and workers in the workplace, drivers and pedestrians in the traffic, and all family members in the household are involved in interaction with occupational health and safety. The occupational health and safety should be taken into account by employers because of their material and spiritual interests; by the workers as directly affected people, and by the governments because of their responsibility to establish happy life and health of the citizens. For creating a productive working system, the employer should spent money for organization and technique preventive measures; the workers have to keep working system according to the rules of occupational health and safety; the government must done necessary controls, establish institutions. As a result of the combination of these, a productive and happy working system would be established. There are three elements closely related to occupational health and safety for employees.

- **The protection of workers:** It is main aim of the studies of occupational health and safety. To protect the workers from the negative effects of the working place, to provide comfortable and safety environment for work are the main aims. In other words, the main purpose is to protect the workers against job accidents and occupational diseases for providing spirit and body integrity.
- **To establish the safety of production:** To establish the safety of production in a working place is economically important because of increase of productivity. The protection of the workers will cause the decreasing of labor and workday losses because of the decreasing of job accidents and occupational diseases. For

this reason, the production will keep in high level and the work efficiency will increase related to safe environment in the working place.

- **To establish the safety of management:** By taking the preventive measures in working place, the situations that can create danger like machine malfunctions related to unsafety working conditions and job accidents, explosion and fire will be eliminated.

3.2 The Approach of Occupational Health and Safety

To provide occupational safety is both a humanistic and legal obligation. To prevent job accidents by providing occupational safety, is easy and more humanistic approach than to pay losses. Nowadays, it is possible to protect future of workers' family by protecting worker until their time of retirement. This can be done by decreasing the intensity of job accidents and providing safety-working environment.

To decrease the losses of managements caused by job accidents, to keep the productivity uncut, to decrease the worker's circulation, to help the development of the country by increasing the labor productivity and total productivity are the benefits of the population.

Nowadays, the usage of possibilities coming from scientific and technological developments for the activities to provide occupational safety, the job accidents can be decreased importantly. The positive developments in the world, especially in the developed countries, show the decreasing the job accidents are possible. To provide this and to decrease material and spiritual losses caused by job accidents, it is compulsory to give the necessary precautions for occupational safety studies. It should remember that to reach the occupational safety aims, safety measurements developed by the light of scientific and planned studies (Dağ, 2011).

It is possible to establish occupational safety by removing the unsafe situations that are constituent of the job accidents. The basic principle of occupational safety is to take necessary measures for preventing the occurrence of job accidents in spite of

careless and insecure behavior of the workers. Because of the human's nature and the effect of different factors, the workers can do unsafe behavior. This requires the identification of the hazards related to working place, the production process, management and supervisor disturbances, and needs detailed analysis. The scientific studies related to occupational safety show the identification of the reasons of disruptions are very important for understanding the unsafe situations and unsafe behaviors in the production process. After determining the hazards, which cause job accidents and analyzing them, it is necessary to determine the occupational safety precautions (TMMOB Makine Mühendisleri Odası, 2012).

3.2.1 Identification of Hazards

The first step in work safety studies is the identification of hazards arising from the production process and the environment of working place. In order to identify the hazardous situations causing job accidents, the working place, production technology, production equipment, raw and auxiliary materials used in the work, source of energy, the origin, quality and structure of hand tools should be examined carefully. The dangerous situations arising from the production process and the nature of the work should be identified and listed according to their importance and priority. Previous job accident statistics should be examined to understand where, why and how job accidents happened.

After every single accident, the insecure conditions and actions should be identified, assessed and the results recorded. The aim of accident analysis is to get the most accurate and valid information about the causes and the way of accident. A correct and accurate analysis is of great importance in terms of protection from other or similar accidents. Thus, it is possible to clarify unforeseen hazards. An analysis of all accidents leading to large, small, damaged and injured should be made. Because, from every 601 accidents result 1 death or permanent incapacity, 100 injuries resulting in temporary incapacity and 500 without injuries. The accident statistics should be used to foreseen hazards. Every minor injury, casualty-related accident is the news of

dangerous accidents that may occur later. For this reason, it is necessary to record all the accidents to the statistics (TMMOB Makine Mühendisleri Odası, 2012).

3.2.2 The Analysis of the Hazards

In the studies carried out for identification of the hazards, the investigation of the job accidents in the working place should be done for preventing the possible accidents. The kinds and causes of dangerous situations and behaviors that cause job accidents should be determined. The causes of occupational accidents must be analyzed by accident investigations. The causes and types of dangerous situations must be resolved and ordered by examining the production process; the kind of the work done and the production tools used using accident investigations and statistics (TMMOB Makine Mühendisleri Odası, 2012).

3.2.3 The Development of Safety Measures

According to identified and analyzed threats, the security measures should be determined. The new security measures should be developed by considering working conditions and production methods to prevent the emergency of new hazards. The types of protection should be determined in accordance with the kind of the work done and the functioning in the means of production in order to avoid dangerous situations, to correct unsafe behaviors and to prevent accidents that may occur. Then the most effective ones should be selected. The training of employees should be done by an effective plan. Lighting, ventilation, heat, placement of equipment, humidity and noise levels floor condition, machine protectors, personal protective equipment, work machines in the working place should be designed for protecting health and safety (TMMOB Makine Mühendisleri Odası, 2012).

3.2.4 The Application of Safety Measures

The safety measures developed for eliminating the threats should be projected and put into the practice. The developed safety measures and protectors should avoid the

hazards completely. They must be easy to use and do not make the work difficult. The applied safety measures should be checked regularly, if any hitch was detected, the measures must be reorganized. The production process has flexibility and can change continuously. The safety measures that are planning to apply must be suitable for this situation. After the safety measures applied, no dangerous situations can occur by time. For this reason, the control must continue without any hitch. A system should be established in the working place for the control and supervision of the work, and it should be ensured that the persons selected from different occupational groups, including the lower and middle level managers, are included in this system (TMMOB Makine Mühendisleri Odası, 2012).

3.3 The Management System of Occupational Health and Safety

The aim of occupational health and safety studies is to prevent employees from being harmed due to job accidents and occupational diseases, to protect them and to work in a healthy environment. However, there are two important issues that should not be ignored in the health and safety aims. The first one is to increase productivity by ensuring production safety and the second one is to ensure operational safety. The ILO (International Labor Organization) and the WHO's (Word Healthy Organization) Joint Commission on occupational health and work safety set out the following principles of worker's health:

- To maximize the health of the worker's physical, mental and socio-economic life in all business lines and to keep it in same level,
- To prevent the deterioration of worker's health due to the working conditions and hazardous materials,
- To run the workers in a work according to their physical and mental situations.

The management system of occupational health and safety has a responsibility to prevent job accidents and job related diseases. For this, the management has three important missions:

- To identify the hazards,
- To predict and detect the size of each risk,
- To decide the risk is acceptable and to control the risk.

In order to prevent such events affecting the working life, productivity and the profitability of the enterprises that depend on them, it is necessary to first analyze the existing situation and determine the risks, to create and implement programs integrated with the legal regulations, legislation and laws to eliminate these risks. A series of management systems are implemented in which these activities are monitored and audited, which are documented and announced to interested parties. These systems has been called as "Occupational Health and Safety Management Systems".

Some organizations preparing standards, documents and laws related to management system of occupational health and safety in the world are listed in below:

- American Petroleum Institute (API),
- National Fire Protection Association (NFPA),
- American Society of Mechanical Engineers (ASME),
- Standards New Zealand (SNZ),
- British Standards Institute (BSI),
- Occupational Safety and Health NZ Chemical Industry Council,
- Standards Australia,
- International Organization for Standardization (ISO).

Some other standards that are in progress:

- QS 9000,
- BS 8800(Guide To Occupational Health and Safety Management Systems),
- ILO Business Health and Safety Management System Guide: 2001,
- ISA 2000,
- NPR 5001,
- OSHA AS/NSZ 4360,

- OSHA AS/NSZ 4804,
- OHSAS (Occupational Health and Safety Assessment Series) 18001,
- OHSAS 18002 Application Guide Administration (OHSA).

3.3.1 The General Principles of Management Systems of Occupational Health and Safety

Occupational health and safety standards provide a consolidated framework consisting of criteria, practices and principles for better application of the occupational health and safety management system. They provide practical advices on how to implement the risk management process to manage occupational health and safety risks. Occupational health and safety risks cover the risks occurring by giving little importance of occupational health and safety, the risks of the illness, injury or death of the persons, risks of financial liability to the company and individuals, the risks of loss of part or whole of the process of the organization or the equipment in operation. The important point is to make a definition of risk management processes to prevent diseases and accidents. However, the risk management process can also be applied to the management of the organization's financial and other risks.

The general principles of the management of occupational health and safety are follows:

1. Preventing dangerous movements and dangerous situations is essential.
2. The job accidents are caused by dangerous movements (88%), dangerous situations (10%) and unavoidable and unknown reasons (2%).
3. The size of damage as a results of accident cannot be predicted, this completely depends on the coincidences.
4. On the basis of each accident resulting severe injury or death, there are the events that cause 29 organ losses and 300 injuries (1-29-300 ratio).
5. The reasons of dangerous movements are:

- The personal defects (carelessness, unceremoniousity, indifference)
- The deficiency in the knowledge and expertise

- The physical deficiency of the worker
- Unappropriated mechanical conditions and physical environment

6. The methods for protection are:

- The engineering and revision
- The persuasion and encouragement
- Benefit from ergonomics
- The discipline rules

7. The methods of protection from accidents and production, cost and quality control methods are similar and parallel.
8. Senior managers should be involved and accountable for the rules and measures to be taken in the occupational safety studies.
9. Foreman and other first level managers having similar responsibility are most prominent personnel in the protection from job accidents.
10. In addition to human emotions guiding the studies of job safety, there are two financial factors that play a role in ensuring job safety:

- In a safe working place, the production increases, and cost decreases.
- The cost that needs to spent after job accident will be five times higher than the cost that need to spent for preventing job accidents.

3.3.2 The General Principles of Risk Management System of Occupational Health and Safety

Organizational factors, misinformation and other issues affect the health and safety consequences of workers and the ultimate profitability of the company. Processes resulting from illness and disability are developed by time and intervention possibilities can be provided. But the best time to intervene is the beginning of this process. Energy and other types of stresses have been resulted with illness and disability, and create high costs for the person in charge and the people and organizations in the community. The value judgments about the acceptability of occupational health and safety risks are based on perception. Communication and advise are two important factors to make sense of different perceptions of interest groups. The most effective control of occupational health and safety risks is to provide

a safe working place rather than to change the people. Occupational health and safety management covers the identification of the risks, the analysis, the definition, the monitoring, and the provision of communication and advising throughout this process. The risk management process provides a technique for treating the unpredictable nature of occupational health and safety risks.

3.3.3 The Benefits of Management System of Occupational Health and Safety

Occupational health and safety risk management provides a structured systematic approach to managers who will make decisions about these issues. Occupational health and safety risk management activities provide an organization with a good understanding of the hazards associated with its operations and the ability to respond effectively to changes in internal and external situations. Occupational health and safety risk management is a guide to direct benefits to an organization. The benefits of occupational health and safety risk management program are:

- It reduces sickness and disability, improves employee and community,
- It provides added value and money saving with efficient allocation of resources,
- It improves management's ability to make decisions by improving the quality of already available information,
- It provides concordance with occupational health and safety legislation,
- It is developed the company's image and reputation.

The benefits of an effective occupational health and safety risk management program are:

- It increases the understanding and knowledge of exposure to significant risks and effective strategic planning,
- Low labor compensation due to the ability to anticipate undesirable occupational health and safety consequences,
- Positive occupational health and safety results and good preparation for this,
- Development of control process,

- Good results in terms of the suitability, efficiency and effectiveness of occupational health and safety programs,
- Advanced communication between groups within and outside the organization.

3.4 The Structure of Occupational Health and Safety Risk Management

Implementation of risk management throughout an organization requires the establishment of programs to manage risks at all levels. This way should be taken into account, where the health and safety risks and other risks interact and are managed within the organization. In general, the following elements are required for compliance with the occupational health and safety management system. Occupational health and safety policy, planning, implementation and operation, controls and imperative actions, management oversight and continuous improvement. For example; AS/NZS 4804; the occupational health and safety management staff are defined in 2001 as:

- Policy and commitment,
- Planning,
- Applications,
- Quantification and consideration,
- Observation and inspection.

Methods are needed for the application and communication of politics and programs.

3.5 Modality

The risk management method is the application of management policies, procedures and practices to the institutional tasks of risk identification, analysis, evaluation, treatment, monitoring and communication (AS/NZS 4360). The basic risk management method is shown in Figure 3.1. The method can be repeated many times with an added or modified risk assessment criterion, leading to a continuous improvement method. Each step of the risk management system should be

documented, including results, data sources, methods and assumptions, to ensure traceability (Özkılıç, 2007).

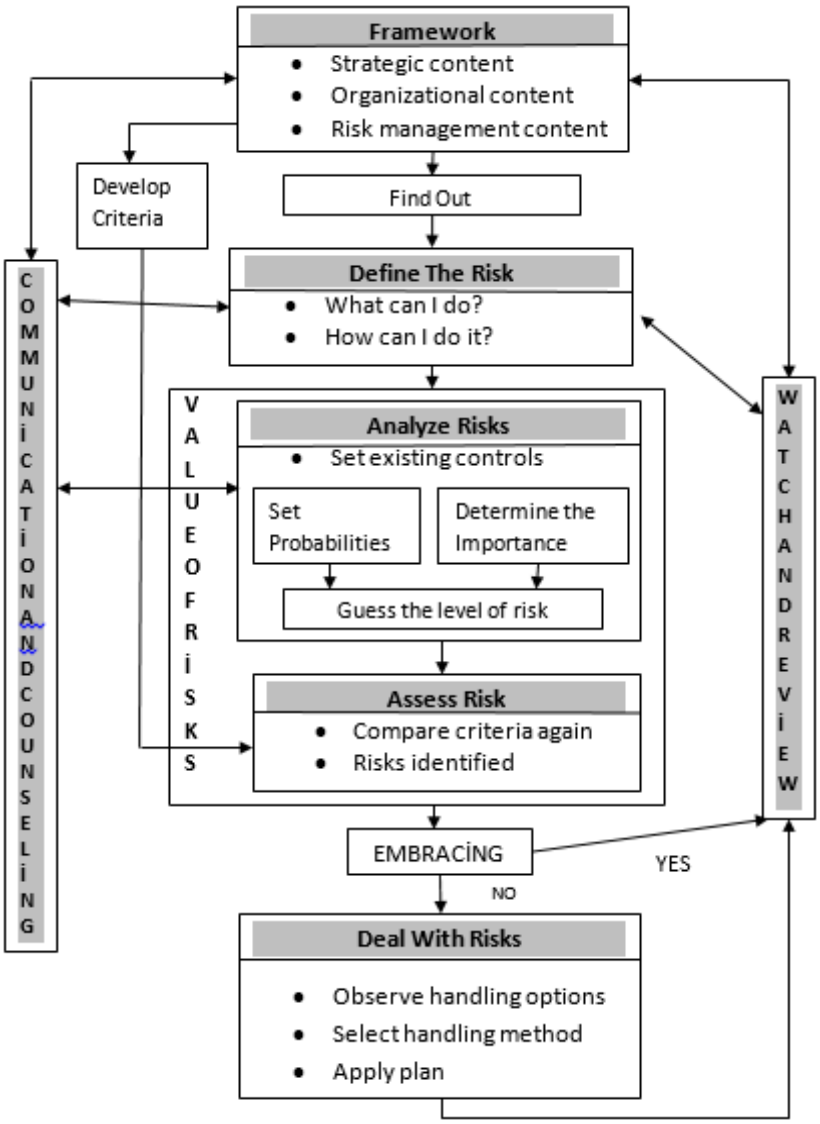

Figure 3.1 Risk management system (Özkılıç, 2007)

(a) Communication and Information

The conventional methods establishing the frame; identifying, analyzing, evaluating, treating, and monitoring the risks should be systematic and should include consultation of employees, sub-employers (with certain conditions) and other interest groups. Thus, everybody trusts the results. Regarding occupational health and safety risk management, communication and consultation are generally mandated by law.

Effective and bilateral communication, timely reporting is important for occupational health and safety management. These are the most important parts of each step in the risk management process. An organization should have the procedures to prove that relevant occupational health and safety is shared by all those in need. Some regulations are needed to determine the needs and to prove that they meet these needs. At this stage, the concept of consultation arise, consultants and other interested parties are directly involved in these matters. The benefits of consultant to workers and others are:

- Sharing the information about health and safety with employees, contractors and visitors health,
- Giving the opportunity to workers for expressing their contributions and opinions in the subjects of resolution of occupational health and safety risks,
- Evaluating the opinions of the interested parties and using these opinions.

Counseling to employees should be in the following situations:

- When something changed in the materials used in the working place, work method or system,
- When evaluating the health and safety risks,
- When deciding the decisions related to measures that are eliminating or decreasing the risks,
- When something changed or renewed in the procedures that are following risks,
- When deciding the decisions related to facility for worker's welfare,
- When deciding the decision about consultation procedures,
- When new information arises.

The consultation mechanism establishes by:

- The occupational health and safety committee,
- The occupational health and safety representatives,
- The occupational health and safety representatives of workers.

(b) Establishing the frame

This step arranges the conditions of the way of risk management, taking into account the overall strategic position of the organization. It defines a strategic point of view why an organization accepts risk management. It follows the risks by the frame of culture, values and work needs and includes infrastructure occupational health and safety within the working place. Stakeholder groups are defined; communication and consultation policies are identified. The occupational health and safety risks of the workers are one of the risks that the organization should be managed. The determination of the connections between occupational health and safety risks and other risk areas is needed. In this preliminary step, the information is defined and occupational health and safety risk management program is established.

The first step in the risk management is to collect information about all organization and make the decisions. This information is deal with strategic, organizational and risk management issues. The framework is formed by defining the strengths and weaknesses of the organization and the work, the identification of the dangers, opportunities and threats, and the relationship between the organization and the environment.

(c) Defining the risks

The defining the occupational health and safety risks require the defining everything that are potentially cause lost and damage. The recognition of the source of the damage (occupational health and safety hazards) requires the recognition of the reasons that cause disease and disability.

(d) Analyzing the risks

The risks are analyzed in terms of probability and results within the frame of existing controls. The grade of “Frame Facility” may include uncontrolled planned assessment of the risk. A number of results can be considered, and probability and

outcome estimates for producing the estimation of risk level. There are many methodologies for analyzing risks; the most suitable one is selected among them. Risk analysis is carried out through the use of quantitative or semi-qualitative methodologies.

3.6 Application of Risk Management

The risk management can be applied in all levels of the organization. The application is done in strategic and operational level.

(a) In Strategic Level

Occupational health and safety management includes, in the strategic level, how occupational health and safety risks affect an organization, its mission and its objectives. When the application of occupational health and safety risk management in strategic level, the followings are ensured:

- Creating or updating the occupational health and safety management system and politics of the organization,
- With a risk-based approach, strategic planning for the organization is undertaken,
- Determination of the risk assessment method within the concept of risk management,
- Arranging the criteria for occupational health and safety risk acceptance,
- Affordability of community expectations.

(b) In Operational Level

Operational risk management includes the combination of decisions based on continuity of an organization and the incorporation of day-to-day activities of the organization. When the application of occupational health and safety risk management in operational level, the following information are provided:

- A preliminary examination of the occupational health and safety risks identifying the areas of the organization's primary areas of concern or the general areas of occupational health and safety risks,
- The management of certain risks by the participation of workers,
- The management of occupational health and safety risks within a specific project or area,
- The selection amongst different methods and equipment on the basis of occupational health and safety,
- It is necessary to plan new projects by minimizing risks of occupational health and safety in order to achieve the objectives,
- Providing urgent plans for possible reflection of an unwanted accident,
- Determination of conformity with the norms or organizational risk acceptance criteria or standards,
- Helping in reporting occupational health and safety.

3.7 Method

The first step in providing and maintaining a healthy and safe working environment is the creation of a new approach to health and safety policy. According to the new approach to risk evaluation, employers are obliged to conduct a risk assessment for health and safety, including the situation of employees who may be affected by specific risks in their workplaces. The employer decides on the protective measures to be taken and the protective equipment to be used according to the result of the risk analysis. The risk evaluation practices are prepared by expert engineers certified by the ministry. The risk evaluation is document quality and it is a teamwork that should be done by the experts of the subject according to the nature of the work performed. The most important element of the new approach is the concept of risk assessment (risk analysis). Risk is a combination of the probability of an event coming from a danger and the degree of damage done. The risk evaluation is to estimate the magnitude of the risk in all processes and to decide whether to tolerate the risk. It is the whole of the studies carried out by using appropriate qualitative or quantitative methods to systematically identify hazards, identify risks and control risks.

3.7.1 The Risk Management and Evaluation

3.7.1.1 The Risk Perception

It is necessary to know what the danger and risk concepts mean before the risk assessment is done. Definitions are given in below:

- **Danger:** The source, condition, or process that could cause injury to persons, impaired health, or cause them to.
- **Breakdown of Health:** It can be determined that a business activity or work related condition has caused and / or worsened, negative physical or mental condition
- **Event:** Events related to work that have injury, health impairment, or potential to cause or cause death. The events that occur without causing injury, deterioration of health or death are called " almost happen".
- **Accident:** The event that cause of injury, impaired health or cause death.
- **Risk:** The combination of the severity of a hazardous event or exposure to the likelihood of injury and the severity of the injury or health impairment that the event or exposure could cause.
- **Risk Assessment:** The process used to estimate the magnitude of the risk arising from hazards and to determine whether it is acceptable to take into account the adequacy of existing controls.
- **Acceptable Risk:** The risk that the organization can tolerate, according to its legal obligations and its own occupational health and safety policy.
- **Safety:** The ability to carry out the work and the risks or risks that occur during the execution is out of the acceptable range during a defined time interval.

Risk exposure and conclusions contain a great deal of uncertainty. Indeed, the definition of risk is inherently uncertain. In many cases, although the risk is very well understood statistically, it can become unclear when the events are handled one by one. Symbolically, we can draw a circle around any material, process, building or organization and apply risk management measures to identify hazards, assess risks,

and select appropriate control measures. We face danger in every moment of our lives. There is always danger in the air we breathe, in the foods we eat, in the places we live, in very dangerous sports, in the professions or positions we can think of. In order to survive, we need to apply a certain method to recognize the danger, to evaluate the risk, to control the risk and to retain. Every company should allocate some of its time and resources to issues related to risk management for its own safety. Common objectives of risk analysis is to determine the most economical method for the business without sacrificing security, to determine whether the measures have been achieved, to determine whether the purpose has been achieved, to prevent the risk from causing another risk while avoiding a risk.

3.7.1.2 The Methods for Risk Evaluation

Today, more than 150 risk assessment methods are mentioned in the world. The following methods are usually used to determine the hazards in the system to be risk analyzed:

- Qualitative risk assessment methods,
- Quantitative risk assessment methods,
- Mixed risk assessment methods.

Some of these risk assessment methods are given in below (Özkılıç, 2005):

- Risk Matrices,
- Check List,
- Fine – Kinney,
- Failure Mode and Effect Analysis (FMEA),
- Fault Tree Analysis (FTA),
- Hazard and Workability Analysis (HAZOP),
- Event Tree Analysis (ETA),
- Cause-Effect Analysis,
- What Happens (What If),

- Preliminary Hazard Analysis (PHA),
- Job Security Analysis (JSA).

3.7.1.2.1 Risk Matrices. Risk matrices are mostly used approach during hazard identification and risk assessment processes (Cook 2008). They are used to: determine the level of risk by taking consideration of an identified hazard; to rank risks and therefore propose actions; to justify a proposal or action; and to re-assess risk to show the effectiveness of a control (residual risk) (Cook 2008; Cox 2008; Smith et al., 2008). Risk matrices maintain a construct for people needing to demonstrate the two variable relationship between likelihood and consequence that are considered to be the elements of risk (Standards Australia 2004).

3.7.1.2.2 Check-List. It detects whether all the equipment and tools of a plant or process are complete or operating properly. It is performed in two steps; specific questions in the control lists identify the deficiencies of the plant being analyzed. The corrective actions need to be taken are recommended by a catalog of measures. The most efficient results are drawn from lists prepared by experienced experts based on the long experience of the manufacturer company (for example: the check lists that are used by pilots in the airplane) (Seber, 2012).

3.7.1.2.3 Fine-Kinley Method. The results of possible risks are graded by this method. If the hazard occurs, the severity of damage or damage to human, working place and environment will be assessed. It is easy to use and uses widely. It allows the use of working place statistics. The urgency of the measures to be taken and the order of importance is determined according to the risk level (Seber, 2012).

3.7.1.2.4 Failure Mode and Effect Analysis (FMEA). It is one of the widely used methods. In this method, all or parts of any system are considered; how the parts and the whole system can be affected and the possible outcomes are analyzed from the faults which may occur in the parts, tools and components (Seber, 2012).

3.7.1.2.5 Fault Tree Analysis (FTA). As a quantitative technique, it examines the error by dividing it into subcomponents. It's aim is to identify the mechanisms of errors; mechanical, physical, chemical or human errors. it schematizes these possible sub-events with a logical diagram; reliability and probability theorems. Then, root causes that are detected, are discussed in the FMEA table (Seber, 2012).

3.7.1.2.6 Event Tree Analysis (ETA). An event tree analysis method is selected to see where an accident will go because of operator errors and system failures. It is a quantitative analysis system. The logic calculation system is used. As it shows pre-accident and post-accident situations, it is the main technique used in the result analysis. The left side of the diagram is connected with the start event, the right side is connected with the damage status of the operation, and the system is defined at the top. If the system is successful, it goes up, if it fails, it goes down (Seber, 2012).

3.7.1.2.7 Hazard and Operability Analysis (HAZOP). It is applied in the processes in chemical sector and critical systems. It has been developed by the chemical industry by taking into account the specific potential hazard of this industry. A multidisciplinary team is deployed to identify, analyze, and remove accident foci. A systematic brainstorming exercise using specific guided words. Participants are asked to ask questions in a particular structure and what consequences will arise if these events are not or do not occur (Seber, 2012).

3.7.1.2.8 Cause-Effect Analysis. This technique was created in RISO laboratories in Denmark for use in risk analysis of nuclear power plants. It can also be adapted to determine the security level of other industrial systems. Cause-effect analysis is a combination of error tree analysis and event tree analysis. The purpose of the cause-effect analysis is to determine what the undesirable consequences have come about when defining the chain of events. A detailed cause-effect diagram is in the form of a fishbone, so it is also called a fishbone diagram. The reasons for drawing the diagram are generated using simple control charts pre-prepared by the brain storm or team members (Seber, 2012).

3.7.1.2.9 What Happens. This method is useful during factory visits and oversight of procedures. It increases the detection rate of the inevitable potential hazards that are present. This method can be applied at any stage of the process and can be carried out by less experienced risk analysts. It starts with the general question "What if happens?" and is based on the answers given to the questions. The probable outcomes of the failures are identified and the recommendations for each case are defined by the responsible persons. The disadvantage of the system is that the risk analyst focuses only on one point, or the analyst does not allow the experience to see the danger at that point (Seber, 2012).

3.7.1.2.10 Preliminary Hazard Analysis (PHA). The aim is to identify potentially hazardous parts of the system or process and to determine the probability of accidents for each potential hazard identified. An analyst conducting preliminary hazard analysis makes this analysis by trusting on checklists showing dangerous particles and conditions. These lists arrange according to the technology and needs. The hazards identified in these lists are then evaluated in the risk evaluation form. This method is not designed for providing comprehensive details. Preliminary hazard analysis is a qualitative risk assessment analysis that can be used as a model for the final design stage of the installation or for more detailed work. This can be prepared quickly. It is formulated with possible remedies and preventive measures for each objectionable event or hazard. The outcome of this analysis determines which types of hazards occur frequently and which analysis methods need to be applied (Seber, 2012).

3.7.1.2.11 Job Security Analysis (JSA). It focuses on job tasks performed by persons or groups. If the works and tasks well defined in a factory or management, this method is suitable. Analysis examines the nature of the hazards arising from job (Seber, 2012).

CHAPTER FOUR
RISK ASSESSMENT OF MARBLE COMPANY

4.1 Factory Introduction

Considered marble firm have successfully completed over 6,000,000 m2 of natural stone installation work, which is the biggest natural stone design and installation contracting companies in the industry. This firm is a special natural stone contracting company operating in all aspects of natural stone works in over 40 countries.

Considered marble firm works with well-known construction companies on prestigious projects and has a long list of successfully completed projects, where the company's high working standards are evident.

4.2 Marble Factory Workflow

Workflow of considered marble company is shown in Figure 4.1. The block coming from the mine is lowered with the help of winches to the factory block area. From here, it put on ST or gang saw using a crane according to the production program. The blocks put into the ST cut as upholstery, tile or kitchen countertops. The marble products coming from cutting area carry by the workers to head-cutting area. From here, the products carry to processing area by the workers by forklift or other mechanical carrier. The marble products for upholstery (stripers) straighten in head-cutting area and can sell in the market directly or after they were dimensioned. For private and small spaces, it is more appropriate to give the straplines to the flooring. However, in such a case, it is necessary to take the side calibrations in order to standardize the dimensions of the striations that are trimmed at the end of the cut and the dimensions of the cut. If ST products are to be used for making tiles, then cuts are given according to the thickness of the strips after head-cutting.

The blocks put into the gang saw cut usually 1.5, 2 or 3 cm. But, these dimensions can change if there is a special order. The plates can be presented directly to the market,

as well as by taking the edges off in the bridge-cutting and presents after the polishing process. Nevertheless, the plates for gang saw can be used to make kitchen countertops. But, these plates cannot suitable to be used in complete dimension, usually ST products is preferred for making kitchen countertops. Gang saw plates are used to make table, stand, fireplace and for decoration.

Marble tiles are placed into the strafor or cardboard boxes after the production. Strips and plates present to sell after boxing. In the short distance product transportation, the shipment can done without boxing in to the tracks or other vehicles. However, the boxing should be done for tile transportation. The marbles are shipped using forklift or crane. In the transportation within the factory, wheelbarrow that are simple but special for carrying marble has been use (Özfırat, 2007).

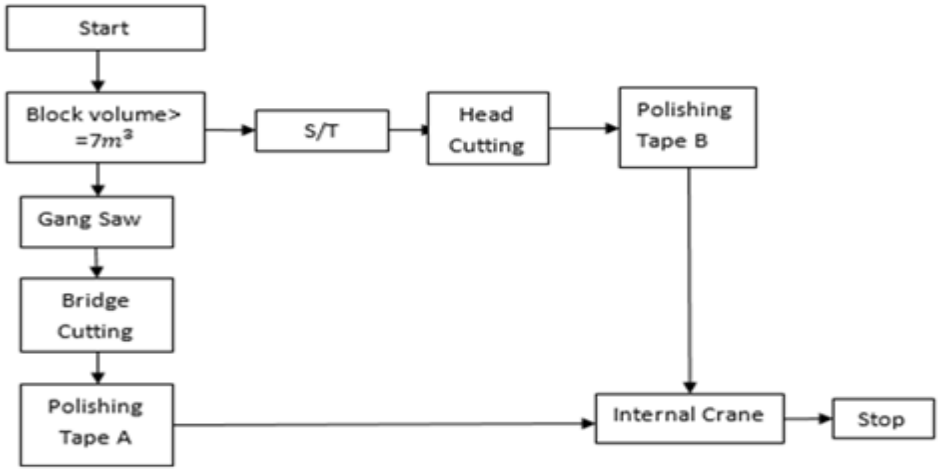

Figure 4.1 Factory workflow diagram

4.3 Marble Factory Layout

Factory layout of the considered marble company is shown in Figure 4.2. Facility placement are designed according to process. Basic components in the plant; External crane, Block car, ST, Gang saw, Head cutting, Tile line, Bridge cutting, Broad band polish line and Internal crane. Blocks coming from the quarry are stacked in the factory, then taken with external crane and given to the floor or set line in the factory according to their dimensions. The blocks cut here is passed to the polish line through

the head cutting or bridge cutting line. The products from the polish line are stored in the factory area to be presented to the market with the inner crane.

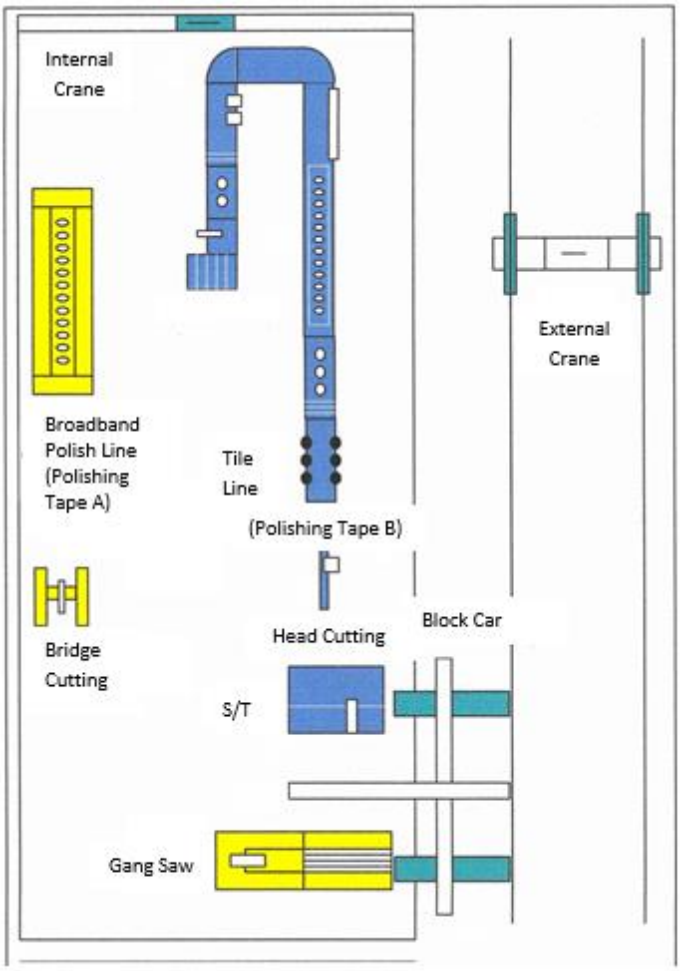

Figure 4.2 Layout of the factory

4.4 Risk Hazards

Mining industry involves many hazards due to the nature of operations. Therefore, work safety rules and regulations must be strictly applied in the mining industry. Literature is abound with studies about physical workload, noise, vibration, high temperature, humidity and exposure to dust and gas-phase hazardous substances. However, studies integrating quantitative risk analysis methods are limited. In this study, a detailed risk analysis is made in marble mining industry by taking into consideration of marble factory layout design. Therefore, the study fills an important gap in terms of hierarchical application of quantitative risk analysis methods.

4.4.1 Definition of Potential Hazards

This study was carried out in a marble plant. The activities of a marble processing factory consist of block cutting, block dimensioning, surface abrasive machines, polishing machines and chemicals operations, sandblasting machines, resin filling, restoring machines and transportation of machines. Therefore, hazards are present in all phases due to working with heavy machinery equipment and heavy natural stones for mining operations in the manufacturing process. Hazards are listed based on occurred accidents, field engineers' and authors' views. Hazard sources are grouped as follows:

- Stockyard and piling up the blocks,
- Dimensioning of blocks,
- Carrying the blocks into the plant with cranes,
- Sockets popping out while working with ST block cutter and gang saw, and dimensioning,
- Surface grinding-blasting,
- Sanding with the horizontal splitting machine,
- Work conducted in a corrosion chamber and possible hazards due to chemical contaminants.

Figure 4.3 View of the cutting machines in the marble factory

Block cutting process is one of the important operations for the final product and these cutting machines are given in Figure 4.3.

These hazards include bursting of the socket in the circular saw when the cutting speed on the sawing disc (SD) cutter machine is not adjusted according to the type of the natural stone. Another hazard may be bursting of balance wheel on the gang saw machine. In addition, there is the risk of crushing in horizontal splitting machines if the plates fall down. In grinding and polishing, there are possible risks during changing grinds and cleaning plane pieces. In sandblasting there is risk of steel ball bursting. If a wearing plate falls or crashes, the operator's hand may be squeezed. Also, tumbling machines cause high vibration and noise, which may lead to occupational illness. Chemicals may cause allergies, skin burns, and respiratory diseases. In addition, cement and dust in filling may cause work diseases (lung function damage and mesothelioma). In the stocking area, improper stacking of blocks may lead to accidents.

4.4.2 Definition of Major Hazards

Risk matrix is used to determine major hazards. Risk matrix methods can be classified as L matrix (3 X 3), L matrix (5 X 5) and X matrix. L matrix (5 X 5) is a simple method with a useful scale. L matrix (5 X 5) is a quantitative risk analysis method that leads to in-depth risk analysis. It identifies all potential hazards and events that may lead to an accident, ranks the identified accidental events according to their severity, and identifies the necessary hazard controls and countermeasures (Özfırat et al., 2017). For example, it can be used to find out which risks require a detailed analysis, need to be controlled immediately and be brought to the attention of management. In addition, matrix can also be used to find out ‘‘negligible’’ risks. Finally, the matrix can be used to find acceptable/tolerable and unacceptable/intolerable risks (Özfırat et al., 2017). These hazards are separately analyzed and classified. Steps in L matrix is given in Figure 4.4.

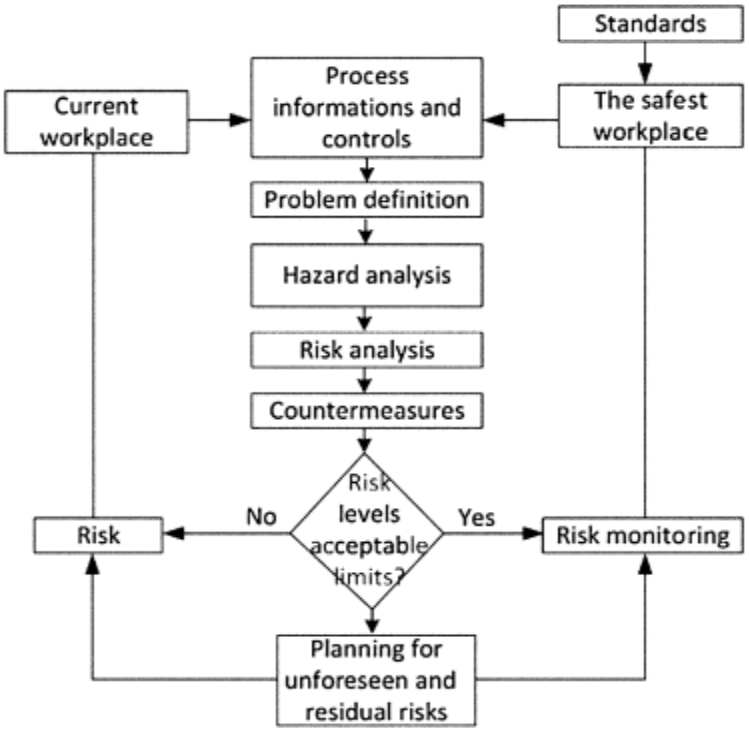

Figure 4.4 Steps in L-matrix analysis

Risk scores are obtained by multiplying risk severity by probability (Eq. 4.1).

$$\text{Risk score} = \text{Probability X Severity} \tag{4.1}$$

The risk scores in Table 4.1 are determined using the probability and severity values. Table 4.1 classifies risks by using a score matrix (Bevilacqua, 2008; Özkılıç, 2014; Özfırat, 2012). After calculating the risk scores, risk mitigation and measures are given in Table 4.2. In this level, the work under ‘‘not tolerated’’ (25) and ‘‘high-risk’’ (15–20) category should not be started until the risk is reduced. If a factory has an ongoing activity, it must be immediately stopped. After preventive measures are taken, work can be continued. In moderate-level risks (8–12), risk mitigation measures should be applied before work can be continued. In ‘‘foldable risks’’ (2–6), the risks are low and further risk reducing measures are not required. However, existing controls should be continued. For insignificant risk (1), existing controls should be continued. Risk evaluation of the marble company layout is given in Table 4.3. It is noted that, in this thesis, circumstances that are exist in the current company are taken into account when actualized evaluation.

Table 4.1 Risk score and classification

			Severity				
Probability	Description of probability	1 time every x. years	(1) Negligible	(2) Marginal	(3) Critical	(4) Serious	(5) Catastrophic
(1) Very rare	Virtually impossible	>20	1	2	3	4	5
(2) Rare	Unlikely	3–20	2	4	6	8	10
(3) Occasional	May happen a few times, at least once	1–3	3	6	9	12	15
(4) Probable	May happen several times	Once every 6 months	4	8	12	16	20
(5) Frequent	May happen often	>Once every 6 months	5	10	15	20	25

Risk classification: Low (1–6), Moderate (8–12), High (15–20), Not tolerated (25).

Table 4.2 Risk score and management

Result	Preventive action
Cannot be tolerated (25)	Work should not be started until the risk is reduced. Any ongoing activity must be immediately stopped. If risk is not reduced, activity must be immediately stopped
Important risks (15–20)	Work should not be started until the risk is reduced. Any ongoing activity must be immediately stopped. After preventive measures are applied, work can be continued
Moderate-level risks (8–12)	Risk mitigation measures should be applied. Work can be continued
Foldable risks (2–6)	The risk is low, and further risk reducing measures are not required. However, existing controls should be continued
Insignificant risk (1)	Existing controls should be continued

Table 4.3 Risk analysis table

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Factory	Emergency exit	No emergency signs showing doors and escape routes	Injury, Dead	4	5	20	Emergency routing plates must be attached to places that can be easily seen.	2	5	10	Warning and Education
Factory	Emergency exit	Outward not opening emergency exit door	Injury, Dead	4	5	20	Emergency exit doors must be opened to the outside.	2	5	10	Warning and Education
Factory	Emergency exit	Emergency exit door locked	Injury, Dead	5	5	25	No entry and exit gates will be locked or connected within the working hours of the premises.	3	5	15	Warning and Education
Factory	Emergency exit	Obstruction in front of emergency exit door	Injury, Dead	5	5	25	The exit doors will be hinged and unlocked. The exit doors will be clearly visible. There will be no obstacles to make it difficult to see the exit in front of and around these doors.	3	5	15	Warning and Education
Factory	Emergency exit	Emergency exit doors and roads not illuminated in case of power failure	Injury, Dead	4	5	20	Emergency exit routes and doors must be provided with an emergency lighting system connected to a separate source of energy to provide adequate illumination in the event of a power failure.	3	5	15	Warning and Education
Factory	Emergency exit	Not to do fire and emergency operation	Injury, Dead	4	5	20	Fire and emergency operations must be done. Employees should be trained. Emergency teams must be set up and emergency plan must be prepared. Lastly, all these activities should be documented.	3	5	15	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Factory	Emergency exit	Emergency phone numbers are not hung in visible places.	Fire, injury, smoke poisoning, death.	4	5	20	Phone numbers should be displayed where they will be seen. Employees should be informed.	3	5	15	Warning and Education
Factory	Emergency exit	No workplace layout plan	Panic, chaos	4	4	16	Workplace layout plan should be prepared and visible on all floors.	2	4	8	Warning and Education
Factory	Emergency exit	No emergency collection point	Panic, chaos	4	4	16	Emergency locations should be identified and warning signs should be placed in hazardous areas around the building.	3	4	12	Warning and Education
Factory	Fire	No fire extinguisher	Fire	3	4	12	Sufficient number of fire extinguisher devices will be taken in suitable places.	2	4	8	Emergency Response
Factory	Fire	Placing anything in front of and near fire extinguishers that will make it difficult to access	Fire	3	4	12	Nothing will be put around the fire extinguishers.	2	4	8	Emergency Response
Factory	Fire	No periodic checks	Fire	3	4	12	Certified organizations will be made periodically.	2	4	8	Emergency Response
Factory	Fire	Selection of not suitable fire tubes	Fire	3	4	12	Appropriate fire extinguisher will be selected according to work area.	2	4	8	Routine control
Factory	Fire	The location of the fire extinguisher is not clear	Fire	3	4	12	Where the fire extinguishers are located, warning signs will be hanged.	2	4	8	Routine control
Factory	Fire	No training on the use of fire equipment	Fire	3	4	12	Training will be given and practice will be held once a year.	2	4	8	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Factory	General Factory	No general warning signs inside the factory	Work accident	3	4	12	Hazardous sources shall be identified and appropriate warning signs shall be affixed within the premises.	2	4	8	Routine control
Factory	General Factory	General warning signs inside the factory are closed	Work accident	3	3	9	Check the warning signs in the factory area and replace the old ones and they will be prevented from putting materials in front of them.	2	3	6	Routine control
Factory	General Factory	The nonuse of personal protective equipment specified in the factory area.	Occupational Accident, Occupational Disease	4	4	16	It is should be checked whether Employees' use personal protective equipment.	2	4	8	Warning and Education
Factory	General Factory	Slippery and wet ground	Work accident, Injury	3	3	9	Warning signs for slippery and wet ground will be placed.	2	3	6	Warning and Education
Factory	General Factory	Not organizing heavy and dangerous work health report	Job loss	3	4	12	A health report will be issued for heavy and dangerous jobs.	2	4	8	Routine control
Factory	General Factory	Not having first aid trained personnel	Cannot Emergency Response	4	4	16	In very dangerous workplaces, 1 out of 10 people must have first-aid certificate.	2	4	8	Emergency Response
Factory	General Factory	Employee should be tetanus when employee's hand is cut.	Dead	3	5	15	Employees will be vaccinated against tetanus.	3	5	15	First aid
Factory	General Factory	Use of loose clothing and similar accessories during work	Injury, limb loss	3	3	9	Use of accessories in work areas will be prevented. Employees will be trained.	2	3	6	Routine control

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Factory	General Factory	No first aid cabinets and absence of first-aid materials in the cabinet	No first intervention	3	3	9	First aid kit will be placed in convenient places and the necessary first aid materials will be put into.	2	3	6	First aid
Factory	General Factory	Stuck between marble stands	Work accident, Injury, Dead	3	5	15	It is necessary to widen the angle of the marble stand and train employees.	2	5	10	Warning and Education
Factory	General Factory	Short distance between machines	Work Accident, Injury	3	4	12	The distance between the machines must also be a distance that is not dangerous for the workers.	2	4	8	Warning and Education
Factory	General Factory	Stacking areas are narrow for cutted marble blocks	Work Accident, Injury	3	4	12	Properly stacking is necessary to prevent overturning of the marble blocks.	2	4	8	Warning and Education
Factory	General Factory	Irregular stacking of marble blocks inside and outside of the facility	Work Accident, Injury	3	4	12	Properly stacking is necessary to prevent overturning of the marble blocks.	2	4	8	Warning and Education
Factory	General Factory	On rough floors, transportation of materials and carried out work	Work Accident, Injury	3	4	12	Failure to work and carry on the damaged floor and to repair the damaged floors are necessary.	2	4	8	Warning and Education
Factory	Electrical Installation	Panel cover is open	Electric shock, Injury, Dead	3	5	15	The panel covers will be closed and warning plates will be hung.	2	5	10	Routine control
Factory	Electrical Installation	No insulating mats in front of panel covers	Electric shock, Injury, Dead	4	5	20	It is necessary to put an insulating mat in front of the panels.	2	5	10	Periodic check-up
Factory	Electrical Installation	Unauthorized persons make maintenance and repair operation	Electric shock, Injury, Dead	4	5	20	Intervention by persons other than authorized maintenance repairmen will be prohibited.	2	5	10	Periodic check-up

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Factory	Electrical Installation	No electrical and mechanical grounding	Electric shock, Injury, Dead	5	5	25	Electricity and machinery grounding will be done once a year by authorized persons.	2	5	10	Periodic check-up
Factory	Electrical Installation	Floppy and irregular cables	Electric shock, Injury, Dead	3	5	15	Electrical wiring shall be enclosed in a protective enclosure.	2	5	10	Routine control
Factory	Electrical Installation	No grounding plug, no socket	Electric shock, Injury, Dead	3	5	15	Grounded plug and socket shall be used according to the voltage value.	2	5	10	Periodic check-up
Factory	Electrical Installation	No periodic grounding control.	Injury, Dead	4	5	20	Periodic grounding checks must be carried out by authorized persons.	2	5	10	Warning and Education
Factory	Electrical Installation	Tearing and peeling of electrical cables	Electric shock, Injury, Dead	3	5	15	Damaged cables must be replaced immediately by authorized persons. The cables must be visually checked by the employees. All cables must be protected against mechanical crushing.	2	5	10	Warning, Education and Routine control
Factory	Electrical Installation	No warning signs on power panels and fuses.	Injury, Dead	4	5	20	Voltage warning, dangerous, forbidden signs must be hung on electric panels.	2	5	10	Warning and Education
Factory	Electrical Installation	No leakage current relay.	Injury, Dead	5	5	25	The leakage current relay must be provided, annual periodic grounding measurements are required.	3	5	15	Warning and Education
Factory	Cranes	Cranes have not voice and light warning systems.	Work accident	3	3	9	It will be checked periodically before being used by the operator.	2	3	6	Routine control

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Factory	Cranes	Failure of safety hook of crane hook.	Work accident	4	3	12	Non-safety hooks will not be used.	2	3	6	Routine control
Factory	Cranes	No periodic checks of crane ropes.	Work accident, Dead	5	5	25	Check in at the beginning of the shift. Technical checks will be carried out every 3 months.	2	5	10	Routine control
Factory	Cranes	Working under the cranes in motion.	Work accident, Dead	3	5	15	Notice boards will hang. If audible and illuminated system is working, there will be no personnel in the transportation area.	2	5	10	Warning and Education
Factory	Cranes	Marble blocks are stacked in a dangerous and irregular way.	Work accident	4	4	16	It shall be arranged securely and procedurally by means of a crane in accordance with the instructions.	2	4	8	Warning and Routine control
Factory	Cranes	Use of cranes by non-competent operators.	Work accident, Dead	4	5	20	Driver's license will be given to the crane operators. Non-licensees will not be allowed to use it.	2	5	10	Warning and Education
Factory	Forklifts	Not being used at the right speed.	Work accident	3	4	12	Warning sheets about speed limit will hang. Training will be given.	2	4	8	Warning and Education
Factory	Forklifts	Usage by unqualified persons.	Work accident	4	4	16	Use of non-competent persons will be prevented. Warnings and inspections will be increased.	2	4	8	Warning and Education
Factory	Forklifts	Not to work voice and light warning systems.	Work accident	3	4	12	The warning lights will operate absolutely while moving.	2	4	8	Periodic check-up
Factory	Forklifts	Passenger transport on the vehicle.	Work accident	3	4	12	Warning signs will hang, operators will be trained on this issue.	2	4	8	Warning and Education
Factory	Forklifts	Overloading in excessive amount.	Work accident	3	4	12	The carrying capacities of the forklifts will be determined. Warning signs will hang.	2	4	8	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Factory	Forklifts	Inability to transport or stack	Work accident, Dead	4	5	20	Operators will constantly be alerted to this. Responsible staff will follow.	2	5	10	Routine control
Factory	Forklifts	Unspecified forklift routes within the enterprise	Work accident	3	4	12	Usage areas of forklifts will be evident in the operation.	2	4	8	Warning
Factory	Forklifts	No fire extinguisher	Work accident, Fire	3	4	12	Fire extinguisher will be found on the forklift continuously.	2	4	8	Periodic check-up
Production	Gang Saw Machine	Removing the protective equipment of the machine.	Work accident, Dead	3	5	15	Protective equipment of the machine should not be removed.	2	5	10	Periodic check-up
Production	Gang Saw Machine	To be opened machine control panel.	Electric shock, Injury, Dead	4	5	20	Control panels of the machines should be closed all the time.	2	5	10	Warning and Education
Production	Gang Saw Machine	Not using insulator materials in front of the control panels.	Electric shock, Injury, Dead	3	5	15	There should be an insulator materials in front of the control panels.	2	5	10	Periodic check-up
Production	Gang Saw Machine	To operate employee without training.	Work Accident, Property Damage	4	4	16	Employees should be trained about machines with respect to machine instructions.	2	4	8	Warning and Education
Production	Gang Saw Machine	High amount of water is collected in the machine's working area that may results slipping.	Work accident, Injury	3	3	9	Work clothes and steel non-slip shoes should be provided for employees.	2	3	6	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Gang Saw Machine	The volume level of the working environment is higher than legal limits.	Occupational Accident, Occupational Disease	4	4	16	Employees must use headphones in the working environment.	2	4	8	Warning and Education Periodic check-up
Production	Gang Saw Machine	Lack of ground line connection of electrical installation.	Work accident, Dead	5	5	25	The electrical connections of the machines should be connected to the ground line.	2	5	10	Routine control
Production	Gang Saw Machine	Strips that are coming from machine can be misaligned to the pallets or stacked.	Work Accident, Property Damage	4	3	12	The produced strips should be arranged on to pallets with respect to the instructions.	2	3	6	Warning and Training Routine Control
Production	Gang Saw Machine	Not being worked in accordance with instructions.	Work Accident, Property Damage	4	3	12	Instructions of machine usage should be hung in wall and the instructions must be followed.	2	3	6	Warning and Education
Production	Gang Saw Machine	While the gang saw machine is working, some employees climbing onto the marble block.	Work accident	4	4	16	While the gang saw machine is working, it should not allowed climbing onto the marble block to employee and it should be protected.	2	4	8	Warning and Education
Production	Gang Saw Machine	Spattering, plate throwing during cutting	Work Accident, Property Damage	3	3	9	Blocks' tie bar should be attached and the blocks' wedge should be fixed.	2	3	6	Periodic check-up
Production	Gang Saw Machine	No elimination of aqueous media during cutting and it exist no curtains.	Work Accident, Property Damage	4	3	12	The water curtains on the gang saw machine should be open all the time and non-slip shoes should be wear.	2	3	6	Periodic check-up
Production	Gang Saw Machine	There is insufficient plaster between wedge which is under the blocks and cutting blocks.	Work Accident, Property Damage	3	3	9	Before the block is producing, it should be plastered according to instructions.	2	3	6	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Gang Saw Machine	Failure of crane operators to have crane drivers' license	Work Accident, Property Damage	4	4	16	It is obligatory that the operators of the gang saw machine have their own crane licenses.	2	4	8	Warning and Education
Production	ST Machine	Removing the protective equipment of the machine.	Work accident, Dead	3	5	15	Protective equipment of the machine should not be removed.	2	5	10	Periodic check-up
Production	ST Machine	To be opened machine control panel.	Electric shock, Injury, Dead	3	5	15	Control panels of the machines should be closed all the time.	2	5	10	Warning and Education
Production	ST Machine	Not using insulator materials in front of the control panels.	Electric shock, Injury, Dead	3	5	15	There should be an insulator materials in front of the control panels.	2	5	10	Periodic check-up
Production	ST Machine	To operate employee without training.	Work Accident, Property Damage	4	4	16	Employees should be trained about machines with respect to machine instructions.	2	4	8	Warning and Education
Production	ST Machine	High amount of water is collected in the machine's working area that may results slipping.	Work accident, Injury	3	3	9	Work clothes and steel non-slip shoes should be provided for employees.	2	3	6	Warning and Education
Production	ST Machine	The volume level of the working environment is higher than legal limits.	Occupational Accident, Occupational Disease	4	4	16	Employees must use headphones in the working environment.	2	4	8	Warning and Education Periodic check-up
Production	ST Machine	Lack of ground line connection of electrical installation.	Work accident, Dead	5	5	25	The electrical connections of the machines should be connected to the ground line.	2	5	10	Routine control

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	ST Machine	Strips that are coming from machine can be misaligned to the pallets or stacked.	Work Accident, Property Damage	4	3	12	The produced strips should be arranged on to pallets with respect to the instructions.	2	3	6	Warning and Training Routine Control
Production	ST Machine	Not being worked in accordance with instructions.	Work Accident, Property Damage	4	3	12	Instructions of machine usage should be hung in wall and the instructions must be followed.	2	3	6	Warning and Education
Production	ST Machine	Strips which are cut from ST machine are conveyed by hand and as a result they can be falled onto the foot.	Work Accident, Property Damage	4	4	16	Vacuum robots will be used to hold the plates.	2	4	8	Periodic check-up
Production	ST Machine	Contact with the saw during cutting.	Work accident, Injury	3	4	12	When the machine is in operation, the saw will not be touched.	2	4	8	Warning and Education
Production	ST Machine	Socket ejection during cutting	Work accident, Injury	3	4	12	Protection should be done at the back of the machine and it should be provided that employee not to stand at the back side of the machine.	2	4	8	Warning and Education
Production	ST Machine	Burr is thrown away during cutting.	Work accident, Injury	4	4	16	There will be protection brushes on the machine. Operators will be required to wear protective goggles.	2	4	8	Periodic check-up
Production	Tile lines	Removing the protective equipment of the machine.	Work accident, Dead	4	5	20	Protective equipment of the machine should not be removed.	2	5	10	Periodic check-up
Production	Tile lines	To be opened machine control panel.	Electric shock, Injury, Dead	3	5	15	Control panels of the machines should be closed all the time.	2	5	10	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Tile lines	Not using insulator materials in front of the control panels.	Electric shock, Injury, Dead	3	5	15	There should be an insulator materials in front of the control panels.	2	5	10	Periodic check-up
Production	Tile lines	To operate employee without training.	Work Accident, Property Damage	4	4	16	Employees should be trained about machines with respect to machine instructions.	2	4	8	Warning and Education
Production	Tile lines	High amount of water is collected in the machine's working area that may results slipping.	Work accident, Injury	3	3	9	Work clothes and steel non-slip shoes should be provided for employees.	2	3	6	Warning and Education
Production	Tile lines	The volume level of the working environment is higher than legal limits.	Occupational Accident, Occupational Disease	4	4	16	Employees must use headphones in the working environment.	2	4	8	Warning and Education Periodic check-up
Production	Tile lines	Lack of ground line connection of electrical installation.	Work accident, Dead	5	5	25	The electrical connections of the machines should be connected to the ground line.	2	5	10	Routine control
Production	Tile lines	The dust level of the working environment is higher than the legal limits.	Occupational Accident, Occupational Disease	4	4	16	Employees must use dust masks in the working environment.	2	4	8	Warning and Education
Production	Tile lines	Strips that are coming from machine can be misaligned to the pallets or stacked.	Work Accident, Property Damage	4	3	12	The produced strips should be arranged on to pallets with respect to the instructions.	2	3	6	Warning and Training Routine Control
Production	Tile lines	Not being worked in accordance with instructions.	Work Accident, Property Damage	4	3	12	Instructions of machine usage should be hung in wall and the instructions must be followed.	2	3	6	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Tile lines	Inappropriate usage of chemicals in the machine.	Occupational Accident, Occupational Disease	4	4	16	Usage instructions of chemical should hang on to machine and necessary training should be given.	2	4	8	Warning and Education
Production	Tile lines	Chemicals that used in the machine can contact with employees' hand, body and eye.	Occupational Disease, Toxicity	3	4	12	Material safety data sheets related to the chemicals used in filling machines should be hung to the machines.	2	4	8	Warning and Education
Production	Tile lines	Usage of chemicals in the machine for long time period.	Occupational Disease, Toxicity	4	5	20	Protective equipment should be provided to employees in accordance with instructions.	2	5	10	Warning and Education
Production	Plate filling line	Removing the protective equipment of the machine.	Work accident, Dead	4	5	20	Protective equipment of the machine should not be removed.	2	5	10	Periodic check-up
Production	Plate filling line	To be opened machine control panel.	Electric shock, Injury, Dead	3	5	15	Control panels of the machines should be closed all the time.	2	5	10	Warning and Education
Production	Plate filling line	Not using insulator materials in front of the control panels.	Electric shock, Injury, Dead	3	5	15	There should be an insulator materials in front of the control panels.	2	5	10	Periodic check-up
Production	Plate filling line	To operate employee without training.	Work Accident, Property Damage	4	4	16	Employees should be trained about machines with respect to machine instructions.	2	4	8	Warning and Education
Production	Plate filling line	High amount of water is collected in the machine's working area that may results slipping.	Work accident, Injury	3	3	9	Work clothes and steel non-slip shoes should be provided for employees.	2	3	6	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Plate filling line	The volume level of the working environment is higher than legal limits.	Occupational Accident, Occupational Disease	4	4	16	Employees must use headphones in the working environment.	2	4	8	Warning and Training Routine Control
Production	Plate filling line	Lack of ground line connection of electrical installation.	Work accident, Dead	5	5	25	The electrical connections of the machines should be connected to the ground line.	2	5	10	Routine control
Production	Plate filling line	Strips that are coming from machine can be misaligned to the pallets or stacked.	Work Accident, Property Damage	4	3	12	The produced strips should be arranged on to pallets with respect to the instructions.	2	3	6	Warning and Training Routine Control
Production	Plate filling line	Not being worked in accordance with instructions.	Work Accident, Property Damage	4	3	12	Instructions of machine usage should be hung in wall and the instructions must be followed.	2	3	6	Warning and Education
Production	Plate filling line	Inappropriate usage of chemicals in the machine.	Occupational Accident, Occupational Disease	4	4	16	Usage instructions of chemical should hang on to machine and necessary training should be given.	2	4	8	Warning and Education
Production	Plate filling line	Chemicals that used in the machine can contact with employees' hand, body and eye.	Occupational Disease, Toxicity	3	4	12	Material safety data sheets related to the chemicals used in filling machines should be hung to the machines.	2	4	8	Warning and Education
Production	Plate filling line	Usage of chemicals in the machine for long time period.	Occupational Disease, Toxicity	4	4	16	Protective equipment should be provided to employees in accordance with instructions.	2	4	8	Warning and Education
Production	Plate filling line	Working in non-ventilated environment	Occupational Disease, Toxicity	4	4	16	There should be adequate ventilation in the working environment.	2	4	8	Warning and Training

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Plate filling line	Exhaust gas from the epoxy outlets	Work accident, Injury, explosion	4	4	16	The inside and the digger parts of the epoxy furnaces will be cleaned frequently, and material will not be stored in the places above and next to the ovens.	2	4	8	Warning and Training Routine Control
Production	Plate filling line	Plates which are conveyed to the filling line by hand and as a result they can be falled onto the foot.	Work accident, Injury	4	3	12	Vacuum robots should be used to hold the plates.	2	3	6	Warning and Education
Production	Plate Filling Line	Removing the protective equipment of the machine.	Work accident, Dead	4	5	20	Protective equipment of the machine should not be removed.	2	5	10	Periodic check-up
Production	Plate Filling Line	To be opened machine control panel.	Electric shock, Injury, Dead	3	5	15	Control panels of the machines should be closed all the time.	2	5	10	Warning and Education
Production	Plate Filling Line	Not using insulator materials in front of the control panels.	Electric shock, Injury, Dead	3	5	15	There should be an insulator materials in front of the control panels.	2	5	10	Periodic check-up
Production	Plate Filling Line	To operate employee without training.	Work Accident, Property Damage	3	3	9	Employees should be trained about machines with respect to machine instructions.	2	3	6	Warning and Education
Production	Plate Filling Line	High amount of water is collected in the machine's working area that may results slipping.	Work accident, Injury	3	3	9	Work clothes and steel non-slip shoes should be provided for employees.	2	3	6	Warning and Education
Production	Plate Filling Line	The volume level of the working environment is higher than legal limits.	Work Accident, Occupational Disease	4	4	16	Employees must use headphones in the working environment.	2	4	8	Warning and Training Routine Control

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Plate Filling Line	Lack of ground line connection of electrical installation.	Work accident, Dead	5	5	25	The electrical connections of the machines should be connected to the ground line.	2	5	10	Routine control
Production	Plate Filling Line	Strips that are coming from machine can be misaligned to the pallets or stacked.	Work Accident, Property Damage	4	3	12	The produced strips should be arranged on to pallets with respect to the instructions.	2	3	6	Warning and Training Routine Control
Production	Plate Filling Line	Not being worked in accordance with instructions.	Work Accident, Property Damage	4	3	12	Instructions of machine usage should be hung in wall and the instructions must be followed.	2	3	6	Warning and Education
Production	Plate Filling Line	Inappropriate usage of chemicals in the machine.	Occupational Accident, Occupational Disease	4	4	16	Usage instructions of chemical should hang on to machine and necessary training should be given.	2	4	8	Warning and Education
Production	Plate Filling Line	Chemicals that used in the machine can contact with employees' hand, body and eye.	Occupational Disease, Toxicity	3	4	12	Material safety data sheets related to the chemicals used in filling machines should be hung to the machines.	2	4	8	Warning and Education
Production	Plate Filling Line	Usage of chemicals in the machine for long time period.	Occupational Disease, Toxicity	4	5	20	Protective equipment should be provided to employees in accordance with instructions.	2	5	10	Warning and Education
Production	Plate Filling Line	In the plate filling machine burner shields are soluble.	Work accident, Fire	4	4	16	The burner shields should be controlled routinely and soluble burner shields should change immediately.	2	4	8	Warning and Training Routine Control
Production	Plate Polishing Line	Removing the protective equipment of the machine.	Work accident, Dead	4	5	20	Protective equipment of the machine should not be removed.	2	5	10	Periodic check-up
Production	Plate Polishing Line	To be opened machine control panel.	Electric shock, Injury, Dead	3	5	15	Control panels of the machines should be closed all the time.	2	5	10	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Plate Polishing Line	Not using insulator materials in front of the control panels.	Electric shock, Injury, Dead	3	5	15	There should be an insulator materials in front of the control panels.	2	5	10	Periodic check-up
Production	Plate Polishing Line	To operate employee without training.	Work Accident, Property Damage	3	3	9	Employees should be trained about machines with respect to machine instructions.	2	3	6	Warning and Education
Production	Plate Polishing Line	High amount of water is collected in the machine's working area that may results slipping.	Work accident, Injury	3	3	9	Work clothes and steel non-slip shoes should be provided for employees.	2	3	6	Warning and Education
Production	Plate Polishing Line	Lack of ground line connection of electrical installation.	Work accident, Dead	5	5	25	The electrical connections of the machines should be connected to the ground line.	2	5	10	Routine control
Production	Plate Polishing Line	The volume level of the working environment is higher than legal limits.	Work Accident, Occupational Disease	4	4	16	Employees must use headphones in the working environment.	2	4	8	Warning and Training Routine Control
Production	Plate Polishing Line	Strips that are coming from machine can be misaligned to the pallets or stacked.	Work Accident, Property Damage	4	3	12	The produced strips should be arranged on to pallets with respect to the instructions.	2	3	6	Warning and Training Routine Control
Production	Plate Polishing Line	Not being worked in accordance with instructions.	Work Accident, Property Damage	4	3	12	Instructions of machine usage should be hung in wall and the instructions must be followed.	2	3	6	Warning and Education
Production	Plate Polishing Line	Inappropriate usage of chemicals in the machine.	Occupational Accident, Occupational Disease	4	4	16	Usage instructions of chemical should hang on to machine and necessary training should be given.	2	4	8	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Plate Polishing Line	Chemicals that used in the machine can contact with employees' hand, body and eye.	Occupational Disease, Toxicity	3	4	12	Material safety data sheets related to the chemicals used in filling machines should be hung to the machines.	2	4	8	Warning and Education
Production	Plate Polishing Line	Usage of chemicals in the machine for long time period.	Occupational Disease, Toxicity	4	5	20	Protective equipment should be provided to employees in accordance with instructions.	2	5	10	Warning and Education
Production	Bridge Cutting	Removing the protective equipment of the machine.	Work accident, Dead	3	5	15	Protective equipment of the machine should not be removed.	2	5	10	Periodic check-up
Production	Bridge Cutting	To be opened machine control panel.	Electric shock, Injury, Dead	3	5	15	Control panels of the machines should be closed all the time.	2	5	10	Warning and Education
Production	Bridge Cutting	Not using insulator materials in front of the control panels.	Electric shock, Injury, Dead	3	5	15	There should be an insulator materials in front of the control panels.	2	5	10	Periodic check-up
Production	Bridge Cutting	To operate employee without training.	Work Accident, Property Damage	4	4	16	Employees should be trained about machines with respect to machine instructions.	2	4	8	Warning and Education
Production	Bridge Cutting	High amount of water is collected in the machine's working area that may results slipping.	Work accident, Injury	3	3	9	Work clothes and steel non-slip shoes should be provided for employees.	2	3	6	Warning and Education
Production	Bridge Cutting	The volume level of the working environment is higher than legal limits.	Work Accident, Occupational Disease	4	4	16	Employees must use headphones in the working environment.	2	4	8	Warning and Training Routine Control

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Bridge Cutting	Lack of ground line connection of electrical installation.	Work accident, Dead	5	5	25	The electrical connections of the machines should be connected to the ground line.	2	5	10	Routine control
Production	Bridge Cutting	Strips that are coming from machine can be misaligned to the pallets or stacked.	Work Accident, Property Damage	4	3	12	The produced strips should be arranged on to pallets with respect to the instructions.	2	3	6	Warning and Training Routine Control
Production	Bridge Cutting	Not being worked in accordance with instructions.	Work Accident, Property Damage	4	3	12	Instructions of machine usage should be hung in wall and the instructions must be followed.	2	3	6	Warning and Education
Production	Sizing Machines	Removing the protective equipment of the machine.	Work Accident, Dead	4	5	20	Protective equipment of the machine should not be removed.	3	5	15	Warning and Education
Production	Sizing Machines	To be opened machine control panel.	Electric shock, Injury, Dead	4	5	20	Control panels of the machines should be closed all the time.	2	5	10	Warning and Education
Production	Sizing Machines	Not using insulator materials in front of the control panels.	Electric shock, Injury, Dead	3	5	15	There should be an insulator materials in front of the control panels.	2	5	10	Periodic control
Production	Sizing Machines	To operate employee without training.	Work Accident, Property Damage	4	4	16	Employees should be trained about machines with respect to machine instructions.	2	4	8	Warning and Education
Production	Sizing Machines	High amount of water is collected in the machine's working area that may results slipping.	Work Accident, Injury	3	4	12	Work clothes and steel non-slip shoes should be provided for employees.	2	4	8	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Production	Sizing Machines	The volume level of the working environment is higher than legal limits.	Work Accident, Occupational Disease	4	4	16	Employees must use headphones in the working environment.	2	4	8	Warning, Education and Periodic control
Production	Sizing Machines	Lack of ground line connection of electrical installation.	Work accident, Dead	5	5	25	The electrical connections of the machines should be connected to the ground line.	2	5	10	Routine control
Production	Sizing Machines	Strips that are coming from machine can be misaligned to the pallets or stacked.	Work Accident, Property Damage	4	3	12	The produced strips should be arranged on to pallets with respect to the instructions.	2	3	6	Warning, Education and Routine control
Production	Sizing Machines	Not being worked in accordance with instructions.	Work Accident, Property Damage	4	3	12	Instructions of machine usage should be hung in wall and the instructions must be followed.	2	3	6	Warning and Education
Production	Sizing Machines	Manual hand-over	Work Accident, Belt Hearing, Hurt	3	4	12	In machines, it is necessary to use moving vacuum and pallet for long and heavy stripes.	2	4	8	Warning and Education
Factory	Chemical matter	Influence from chemical substances	Occupational Disease, Toxicity	4	4	16	Employees will be trained according to material safety forms.	2	4	8	Warning and Education
Factory	Chemical matter	Contact with chemical substances	Occupational Disease, Toxicity	4	4	16	Personal protective equipment shall be used according to material safety data sheets.	2	4	8	Warning and Education
Factory	Chemical matter	Misuse of chemical substances	Occupational Disease, Toxicity	4	3	12	Instructions for use of chemical substances shall be prepared and security measures shall be taken.	2	3	6	Warning and Education

Table 4.3 continues

Activity Area	The Cause of the Danger	Danger	Risk	Risk Level			Control Measures	Remaining Risk Level			Precautions to be Taken in Possible Situations
				Possi-bility	Violence	Result		Possi-bility	Violence	Result	
Factory	Chemical matter	Excessive stockpiling of chemical substances in the production floor	Work Accident, Property Damage	4	4	16	Instructions for use of chemical substances shall be prepared and security measures shall be taken.	2	4	8	Periodic check-up
Factory	Chemical matter	Chemical spillage	Work Accident, Property Damage	3	3	9	Spilled chemical materials must be absorbed with absorbent materials such as sawdust, sand, clay and taken to the solid waste area.	2	3	6	Warning and Education
Factory	Chemical matter	Prolonged chemical inhalation during production	Occupational Disease	3	3	9	Instructions for the use of chemical substances shall be prepared and adequate ventilation shall be provided.	2	3	6	Periodic check-up
Factory	Chemical matter	To dispose chemical packaging wastes in a improper way.	Occupational Disease, Toxicity	3	4	12	The chemical substance will be stored in the waste area and given to a licensed firm and disposed of appropriately.	2	4	8	Periodic check-up
Factory	Chemical matter	Exposure to chemicals	Work Accident, Loss of Vision	4	4	16	Training will be given on the chemical substances used and appropriate glasses will be used.	2	4	8	Emergency Response
Factory	Chemical matter	Manual contact of chemical substances	Work Accident, Skin Irritation	4	4	16	Training will be given on the chemical substances used and appropriate glasses will be used.	2	4	8	Warning and Education
Factory	Chemical matter	Chemical materials are transmitted to work clothes.	Skin Irritation, Property Damage	3	3	9	Work clothes will be used, daily cleaning will be done at the end of work.	2	3	6	Warning and Education
Factory	Chemical matter	Education program is not given to employees in chemical substances.	Work Accident, Skin Irritation	4	4	16	Employees will be educated about chemistry and trainings will be repeated every 6 months.	2	4	8	Warning and Education

4.5 Factory Layout Arrangements According to Evaluation of Marble Company's Layout

After making risk evaluation, some regulations are observed with respect to the occupational health and safety laws in the considered company. Thanks to the proposed regulations, besides satisfaction of law’s necessities it is also forecasted that number of work accident will be decreased. Mentioned regulations are as follows:

- It should be not close front of fire extinguishers.
- It should be put warning signs in slippery ground areas and it should supplied non-slip footwear to the employees. Furthermore, it should checked whether they obey or not this rule.
- All electric panels in the factory area should be closed and these panels can be used by only authorized personnel.
- Grounding should be control regularly and conformity of occupational health and safety laws must be satisfied.
- When water is used in cutting operation of marble blocks in the gang saw or ST machine, in this working areas no electrical cable should be located.
- In factory areas, cranes and forklifts should regularly be controlled. Also, these vehicles should used only authorized personnel and warning lights with sound should be used which shows cranes and forklifts are used.
- In factory areas, cranes and forklifts should be used with respect to their capacity limits.
- When machines are worked in factory areas, all the protective equipment should be activated.
- When cutting machines are working, employees should not enter into the marble areas.
- All chemicals' material safety information which is used in the factory areas should be hang on to visible areas.
- Employees are exposed to risk of compression between marble blocks. Therefore, to prevent these risks it should be used wider marble plate stands. Example of these marble plate stands are given in Figure 4.5.

Figure 4.5 Marble plate stand examples (Personal archive, 2017)

- It is necessary that the distance between the machines has sufficient space. So that, it does not hinder the employees.
- Block stacking areas must be rearranged due to prevent danger for employees.
- On rough floors, materials should not be transported and carried out work. Furthermore, these areas need to be arranged as soon as possible.
- The water should be discharged quickly that coming from the machine and be put warning signs in visible areas.
- Employees who do not make the job professionally, have no job orientation training and not receive health and safety education will not be employed.

In addition to aforementioned a few precautionary measures, all the control measures are given in a detailed way in the risk assessments (Table 4.3). Both these measures are necessary to ensure occupational health and safety within the factory.

CHAPTER FIVE
CONCLUSION

Occupational health and safety management depends upon the scope of the industry as it varies according to the functions and scale. The essential for the proper implementation of occupational health and safety management system in any of the industry is based on risk identification process in relation to the overall system. Risk assessment has been carried out for marble factory layout within the scope of the study. In parallel with the risk assessments, the evaluations have been actualized in layout placement. The purpose of this study is to determine the necessary precautions to keep the risks at acceptable levels by analyzing the dangers and risks in marble factories. In marble factory layout risk assessment, taken measurement factor are very important. As a result of this, measurement factors such as physical, chemical, ergonomic and working environment risks are evaluated. The results of risk assessment are evaluated and also some suggestions are given to reduce the work accidents.

To conclude, the layout of marble factory consists of all types of risks. Working environment risks are more important than others and the awareness for them is much more significant. In order to provide appropriate working environment for the employees, all risks must be taken into consideration and the precautions must be taken by considering all elements in the marble factory layout. These can be provided easily by establishing occupational health and safety program. In here the most important thing is that all workers must be included in the application of the occupational health and safety program.

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