# CHAPTER I

# INTRODUCTION

Marble are rock formations formed by nature. These are formed naturally by enormous pressure under the earth. Marbles are used in decorating and sculpturing from the moment civilization was born. These are time tested for their natural beauty. Ancient buildings and monuments made of natural stones during early civilization still stand erect narrating the beauty and durability of natural stones. Modern people want to make their home stand out of the rest and they used natural stones for their floors and walls to bring about eternal beauty[1].

When natural stones were widely used in constructing monuments and temples, it was the Greek empire that brought marble to personal use. References to baths and pools lined with marble can be seen in ancient literature[1].

Building constructions using marble was popular in India too and the Taj Mahal one of the seven Wonders of the World was constructed using pure white marble stones. This uniqueness of natural stones has made people want for more use of natural stones. In the ancient periods, marble and granite were used for lining and decoration. The natural stone flooring was used in the various rooms of the house except for in Bathrooms[1].

## 1.1. Scenario of Marble Industry

### 1.1.1. Worldwide

The world total production of marble and granite reaches over 100 million tons and total consumption is valued about $40 billion per year. In 2010, the world export value of marble and granite was $62 billion. Since 1999, world marble production grew at a high rate of 8.7 per cent and the industry is expected to grow over 8 per cent till 2025 (Mehdi, 2006).

Marble and granite are produced in more than 40 countries in the world. Italy, Turkey, Spain, India and China are the top five dominant countries

in terms of marble production. These countries control over one-half of the world market. Italy alone produces over 17 per cent of the world marble. A major part of production is consumed locally by producing countries, and only a small percentage of total production is exported (Rassin, 2012).

### 1.1.2. India

India, one among the top most five marble producing countries possesses a wide spectrum of mines of granite, marble, sandstone, limestone, slate, and quartzite. It is amongst the largest producer of raw stone material. Among these stones, marble is the most demanded one used for commercial as well as residential areas[2].

The Indian marble is available in a wide range of shades and colors, the marble, granite and other stones are also exported and have gained popularity in the international markets. This is mainly due to the quality of marble cut, quality of marble surface finish and crack free pieces. Marble deposits are widespread in India across different states like Rajasthan, Gujarat, Madhya Pradesh, Haryana, and Andhra Pradesh. Gujarat produces very fine marble followed by Madhya Pradesh. Rajasthan is the main depository of marble which accounts for over 90 per cent of total marble production in India (1100 m tons). Newer varieties of marble are being developed in Bihar, Jammu & Kashmir, Maharashtra, Sikkim, Uttar Pradesh and Bengal[2].

#### 1.1.2.1. Rajasthan

At the time of independence, Makrana was the sole producer of marble in the state of Rajasthan. A tremendous change has been occurred in the marble scenario of Rajasthan. A number of new marble deposits have been located, explored and exploited in various parts of the State. It is being produced in 20 out of 32 districts. Green marble which was unexplored upto seventh decade, gained an important place among other varieties of marbles world over. Besides, more new varieties such as wood marble (English Teak Wood) of Phalodi, Yellow marble of Jaisalmer, Red / Chocolate marble of Mandaldeh etc. came into the market[3].

The marble industry in Rajasthan has flourished after 1980's as indicated by continuous increase in production, number of leases and revenue. The marble production which was only 17620 tones in 1950 has been increased to 4278.630 thousand tonnes (243 times) and revenue from Rs. 1,17,880/- to Rs. 5,55,177.551 thousand (470 times) in 1999-2000. At present (2019), a total of 3243 leases and 840 quarry licenses are in existence [3].

#### 1.1.2.1.1. Kishangarh Marble

Kishangarh is a tehsil of Ajmer district in Rajasthan. It is biggest marble mandi of Asia. The Kishangarh marble area is developed by Kishangarh marble association. In 2019, more than 9000 marble selling units are situated in the market with an investment of Rs. 5000 crore (approx). There are 32 Granite enterprises having capital investment of Rs 16 crore & 385 persons have been employed. Other main enterprises are of marble cutting with an investment of Rs. 15.30 crore & also around 1995 persons have been employed in marble edge cutting units by the year 2019[4].

## 1.2. Marble production process

The production of marble passes through several stages. The first stage of production is exploration and identification of a quarry location, followed by extraction of marble from the quarries, thereafter lifting and transportation, inventory management and finally cutting the stone into slabs and tiles. The leftover slabs of marble are further utilized depending on the size of slab. Some of the slabs are made into tiles, some of them are cut into small pieces for making the decorative items used in residences and commercial purposes. Polishing of the slabs takes place after cutting, and finally, they are distributed to end users.

## 1.3. Workers in Marble Cutting

A drastic change in marble scenario during half century of independence has generated job opportunities manifold. A large number of persons are engaged in marble mining and marble based industries. This has uplifted

the socio-economic status of the people working in marble mines associated with marble industries The marble production sector has employed near about fifty thousand direct & indirect labours[3] When a certain order is placed, the raw stone block is transported to the factory to be cut as demanded either into tiles or slabs of various thickness (usually 2 cm or 4 cm). Stone-cutting is a lengthy process that can take more than a continuous 12-16 hours of operation, depending on the model of the cutting machine as well as the status of its diamond wire or diamond blades (Kandil and Selim, 2013).

Despite of the technological development for lifting bulky marbles and cutting them, the role of a human being cannot be denied. The findings of the pilot study conducted by the researcher at Kishangarh tehsil, Ajmer district, Rajasthan found that the laborer is required at every step of marble production maintaining different postures and standing for long period of time. The marble cutting machine on which the small slabs are cut into the required shape for making tiles requires the worker to adjust the marble on the machine and hold it till the blade cuts the marble through. The marble cutting activities are performed by the worker throughout his shift of 8 hours including a rest break for 1 hour. The marble pieces that are cut for residential areas are carried manually by the worker from the marble cutting machine to the store house. Sometimes these slabs weigh from 25 kg to 75 kg. The investigator was interested to find out whether such practices have an impact on MSD and on Posture, thus this study was framed.

## 1.4. Muscles and Musculoskeletal Pain

Muscles are made up of body cells that have the ability to contract along a single direction. Microelements of a muscle include the tiny filaments called actin and myosin, which slide along each other during contractions and extensions. Collections of those elements make up myofibrils (Lehto,2006).

Excessively stretching a muscle can lead to a strain. A strain is an injury to a tendon or muscle resulting in swelling and pain. When a group of fibers get torn apart, a more serious injury occurs. Obstruction of blood or nerve supply to the muscle can lead to complete deterioration of the muscle, if the obstruction occurs over an extended period of time (Bush, 2012).

Musculoskeletal pain refers to pain in the muscles, bones, ligaments, tendons, and nerves may be in one area of the body or throughout the body if it is widespread condition like fibromyalgia (Bush, 2012). The pain can range from mild to severe enough to interfere with your day-to-day life. It may start suddenly and be short-lived, which is called **acute pain**. Pain that lasts for more than 3 to 6 months is called **chronic pain**. Lower back pain is the most common type of musculoskeletal pain. Other types include muscle pain (myalgia) from an injury, infection, cramp or spasm, loss of blood flow to the muscle, or tumor. (Watson, 2019).

Musculoskeletal disorders (MSDs) and pain are the major causes for workers' inability, expense raise, and efficiency reduction in industrialized and developed countries. The prevalence of musculoskeletal problems were found among construction workers, goldsmiths, porcelain workers and stone cutting workers. (Silvian, et. al., 2011, Nag et. al., 2010, Talwar et. al., 2009, Shaou et al, 2010, Ghosh et.al., 2010, Punnett et al., and Gangopadhyay et. al., 2010).

## 1.5. Posture

Posture is a static state - 'A position of the body' or an arrested movement' the bones hold the body, the joints link the bones, the muscles move the bones around the joints and the nerves facilitate control of the whole. The key to good posture is correct joint alignment, but muscle activity, balance and nerves should also be considered[6].

Steidl and Bratton, 1967 quoted

> "A Good Posture is important to reduce both dynamic and static loads on muscles. The posture of work is the posture of movement If maximum efficiency of the body in movement is to be achieved, then movement must be performed within the framework of those laws which control stability. The alignment of body weight without strain on muscles and ligaments is the basis of good posture. Ease and freedom of the movement of the body, its parts during work are important for fatigue reduction by an easy balance upon the base of support".

Poor posture at work is a major cause of back pain, workplace stress, repetitive strain injury, resulting in lost time, reduced productivity, poor employee health, low morale, and higher costs. The loss to companies is not only the employees who do take time off because of back pain or posture-related repetitive strain injuries, the loss to organizations is also the reduced efficiency, morale and attitude of those who suffer posture-related discomfort or stress. Mal-aligned joints and ligaments makes the person feel uncomfortable, it aches, or hurts. Shear forces (that is, across rather than along) the spine affects the discs, putting pressure on the nerves that fan out from the spine. Due to poor posture, muscles suffer through lack of circulation, which manifest itself as discomfort, ache or pain as well as lack of performance, getting tired quickly. The body's healing process is impeded when blood-flow is restricted [5,6].

### 1.5.1. Postural Discomfort

Pain may arise when nerves are stretched or inflamed by mal-alignment in poor posture. The range of symptoms varies from discomfort, through tingling, pins and needles, hot or cold feeling or numbness to pain. A characteristic of nerve damage is that sometimes the symptom is not in the place where the damage is being caused. For instance, a nerve being damaged in the lower back may cause tingling in the thigh or pain around the ankle[6].

The posture analysis in various studies revealed that stone cutters, gold smiths, construction workers worked continuously in awkward

postures. Consequently, they suffered from discomfort in different parts of their body, specifically in the lower back, knees and shoulders. Due to this feeling of discomfort workers were affected when continuing their work. This study also showed that stonecutters felt maximum discomfort during sleep at night and a large proportion also felt discomfort throughout the day (Gangopadhyay et. al., 2010, Dhar et.al.,2007 and Ghosh et. al., 2010).

## 1.6. Environment of the Workplace

The environment of the worker includes noise, illumination, humidity, temperature and vibration which affects the workers' performance and health.

Improving workers' productivity, occupational health and safety are major concerns of industry, especially in developing countries. However, these industries are featured with improper workplace design, ill-structured jobs, mismatch between workers' abilities and job demands, adverse environment, poor human-machine system design and inappropriate management programs (Shikdar and Sawaqed, 2003).

Improper working conditions could lead to workplace hazards, poor worker health, disabilities, and affect the productivity of workers and quality of products. Work injuries create significant economic and humanitarian consequences to our society (Kirsh and McKee, 2003).

Shikdar and Sawaqed (2003) pointed out that there was high correlation between performance indicators and health, facilities, and environmental attributes. In other words, companies with higher health, facilities, and environmental problems could face more performance related problems such as low productivity, and high absenteeism. Employees with complaints of discomfort and dissatisfaction at work could have their productivity affected, result of their inability to perform their work properly (Leaman, 1995). Laboratory and field studies showed that the physical and chemical factors in the work environment could have a notable impact on the health and performance of the occupants, and consequently on the productivity. Workplace environmental conditions,

such as lighting, indoor air quality, and acoustics have significant relationships with workers' satisfaction and performance (Tarcan, et. al., 2004; Marshall et. al., 2002; Fisk, 2000).

### 1.6.1. Noise

Noise is one of the physical environmental factors affecting the health in today's world. Noise is generally defined as the unpleasant sounds which disturb the human being physically and physiologically and cause environmental pollution by destroying environmental properties (Atmaca and Altin, 2005). The marble industry has a number of equipment's which are used for processing marble. The machines produce noise and thus the marble cutting workers are exposed to noise. Noise control possibilities on-site are limited.

It has been reported that noise impairs performance and output. A decline in performance may be attributed to certain kinds of jobs requiring skill and dexterity. Many studies have shown that a level of noise above 90 db, discontinuous or unexpected can impair mental performance. Noise has negative effects on jobs requiring skill, learning dexterity and high levels to impair mental performance (Khan, 2010).

Exposure to noise has its effect on mental concentration, thought and reflection. Many physiological studies have also shown that exposure to noise produces raised blood pressure, accelerated heart rate, contracted blood vessels of the skin, increased metabolism, slowed digestion and increased muscular tension. The irritating effects of noise on the autonomic nervous system are not confined to working hours but extend into the hours of rest and sleep, and it is likely to upset the balance between stress and recovery (Kromer and Grandjean,2009).

### 1.6.2. Temperature and Humidity

Thermal comfort describes a person's state of mind in terms of whether they feel too hot or too cold. It is defined as 'that condition of mind which expresses satisfaction with the thermal environment[7].

Thermal environment may contribute to the overall health and well-being of the employee and the well-being of the organization. Poorly managed thermal environment may cause absenteeism, turnover of staff and complaints. If an employee is thermally comfortable, it can increase employee motivation, productivity and quality of output[8].

Even with workplace climate control, high temperatures may have health effects because they are experienced outside the working day. The high temperatures are associated with increased absenteeism if occasional absences are not penalized by the wage contract. For daily wage workers, where the cost of every absence is high, there are no such practices observed (Sudarshan et.al., 2015).

Understanding the impact of high temperatures on human behavior and economic performance is especially important for poor and middle-income countries where populations are less protected.

### 1.6.3. Light and its effect on work

Lighting can do so much more than illuminate. It can enhance form and function, improve safety and security and create flexible spaces that adapt to the task at hand. Good lighting in the workplace with well-lit task areas is essential for optimizing visual performance, visual comfort and ambience, especially with an ageing workforce. Over the last two decades medical science has consistently shown that light has a positive influence on health and wellbeing. With better lighting performance can be improved by speeding up tasks and reducing failure rates and when added to the energy saving aspects (Králiková et.al. 2015).

A study by Nemecek and Grandjean (1971) in open plan offices showed that a very high level of illumination is often unsuitable in

practice. Levels above 1000 lx increase the risk of troublesome reflections, deep shadows and excessive contrasts (Kroemer and Grandjean, 2009).

Talwar et.al. (2009) found that there was a gradual increase in visual complaints as the number of hours spent for working on computers daily increased. Visual problems were less in persons using antiglare screen on the computers. Ghosh et. al. (2010) while analyzing the working environment of goldsmiths found that the workstations were poorly illuminated in respect to the precision work. Poorly illuminated workstations may increase the error of the worker as well as add to the risk of working on the marble cutting workstations as the workstation has rotating blades.

### 1.6.4. Vibration

Vibration is the mechanical oscillations of an object about an equilibrium point. The oscillations may be regular such as the motion of a pendulum or random such as the movement of a tire on a gravel road. The study of health effects of vibration require measures of the overall "pressure waves" (vibration energy) generated by the vibrating equipment or structure[9].

Vibration enters the body from the part of the body or organ in contact with vibrating equipment. When a worker operates hand-held equipment such as a chain saw or jackhammer, vibration affects hands and arms. Such an exposure is called hand-arm vibration exposure. When a worker sits or stands on a vibrating floor or seat, the vibration exposure affects almost the entire body and is called whole-body vibration exposure[9].

The risk of vibration induced injury depends on the average daily exposure. An evaluation of the risk takes into account the intensity and frequency of the vibration, the duration (years) of exposure and the part of the body which receives the vibration energy.

Vibration affects visual perception and psychomotor performance of the worker. Simultaneously it also has derogatory effects on musculator, with circulatory, respiratory and nervous systems on the worker (Kroemer and Grandjean, 2009). Workers who operate on vibrating hand tools develop peripheral nerve disorder and white fingers. Exposure to large amounts of vibration in a localized area, such as the user's hand over a prolonged period of time might increase the risk of chronic disorders of the muscles, nerves, and tendons (Khan, 2010). Dasgupta and Harrison (1996) found that the clinical examination of vibration on the hand-arm system of miners in Orissa had soft tissue wasting in the hands, ulnar nerve impairment, median nerve impairment and Dupuytren's contracture.

The marble cutting workers have to place their hands till the marble slab is cut through on the marble cutting workstation thus the researcher was inquisitive to measure the amount of vibration produced by the marble tile cutting workstation.

## 1.7. Role of Physiological cost of work

The analysis of physiological cost of work plays a pivotal role in the process of carrying out ergonomic evaluations of any job. The objective of applying ergonomic principles in work analysis is to maintain a balance between the work and the physical capacity of the worker. If the physiological cost of the work is less the worker is underutilized and there is a productivity loss hence the balance between the two is needed. (Singh, 2013). Determining the physiological cost of work of the marble cutting workers would assist in utilizing their work productivity efficiently. Thus, a need was felt to find out the physiological cost of work of the marble cutting workers.

The pulse rate for the healthy persons varies with age, body, positions, time of day, emotions and physical activity. The resting pulse rate tends to be slower for the physically fit on changing from the reclining position to standing. During exercise, the pulse rate increases linearly with the amount of oxygen consumed. The more severe the exercise and the less

physically fit the individual; the greater the length of time that is taken for the pulse rate to be normal (Kroemer and Grandejan, 1997).

Work with high metabolic demand can lead to physical and mental fatigue, increase in work injuries and decrease in work performance, higher risk for cardiovascular diseases and early retirement (Karpansalo et.al., 2002; Krause et al., 2007; Wigaeus Tornqvist, 2011; Wultsch et.al., 2012 and Krause et. al., 2014).

## 1.8. Fatigue and its effects on Workers

> "Fatigue is a state of feeling very tired, exhausted, weary, or sleepy. Fatigue results from a lack of sleep and can be heightened from prolonged mental activity or long periods of stress or anxiety. Boring or repetitive tasks can also intensify feelings of fatigue[10]."

Fatigue can be acute or chronic. Fatigue is a non-specific symptom but one of the most common ones reported in several studies (Evans & Lambert, 2007; Jason et.al., 2010). It is defined as one's state of overwhelming, debilitating, sustained exhaustion and decreased ability to perform daily activities, and that cannot be relieved by rest (Fukuda et.al., 1994). Fatigue is a work place hazard and can be associated with safety and health of the worker. It affects the health and safety of both the employee and his/her colleagues (Gander et.al. 2007).

Fatigue increases the risk of injuries or other accidents. Fatigue also has significant consequences for society. Several studies have showed that fatigue sustained for a long time can predict future morbidity and mortality (Jason et.al., 2006). Fatigue also can result in declines in worker productivity due to the debilitating nature of fatigue (Kant, et.al. 2003). It is estimated that annually $ 8,554 are lost in household earnings in Georgia (Lin et.al., 2011) and in the whole United States the cost of declines in household/labor productivity amounts to $ 9.1 billion per year (Reynolds et.al. 2004). It may also impair individuals' quality of life. Therefore, fatigue is a grave public health issue that requires the development and implementation of effective interventions and more studies to be conducted to understand fatigue and its risk factors. Among males, the

incidence of fatigue ranged from 1.2 per cent to 34.8 per cent (Wong et.al., 2010; Van et.al., 2010; Reeves et.al., 2007). Peng et.al. (2012) even reported rates of fatigue of up to 81.8 per cent among male workers in China. The wide variations in fatigue prevalence in those studies may be related to the definition of fatigue used (less or more restrictive standardization; different in duration), the assessment methods (conducted by physician or based on self-reporting), the measurement instruments, racial differences, and so on. Nonetheless, it is indisputable that fatigue is a widely experienced symptom in the general population (Lin et.al. 2015).

## Justification of the study

Marble industry in Kishangarh comprises of more than 500 marble industries. The area has employed a large number of direct and indirect labourers. It has more than thousand persons employed in marble cutting units. The marble industry is emerging as an important industry for the construction agencies. The marble cutting in tiles is done on marble cutting workstation. The marble cutting machine on which the small slabs are cut making tiles requires the worker to adjust the marble on the machine and hold it till the blade cuts the marble through. In order to improve the performance and maintain the health of the marble cutting worker, the environment of the workplace need to be adequate. Health of the worker is important because it affects the efficiency and the production of the industry worker but at the same time affects the total production of the industry. The loss of human resource is the loss to the economy of the nation.

While performing the marble cutting activity, body segments are manipulated in the space available resulting in changes to posture. The industrial working environment, the environmental factors like illumination, noise, humidity, temperature affect the productivity of the worker.

Stone quarrying, cutting and masonry is one of the many industries which involve moderate to heavy manual work. Due to the nature of manual work and use of tools, stonecutting job may potentially cause work-related upper limb musculoskeletal disorders.

The review of literature highlighted that work-related musculoskeletal disorders/ occupational disorders have been investigated and reported for workers from various sectors in India. These include computer operators / keyboard users, goldsmiths, stone carvers and workers from sand core making, mining and weaving industry (Gangopadhyay et.al., 2010, Dasgupta and Harrison, 1996, Ghosh et. al., 2010, Nag et. al., 2010, Silvian et. al., 2011, Talwar et. al., 2009 and Dhar, 2007). There are very few studies been conducted on marble cutting workers within and outside India (Gangopadhyay, et. al., 2010 Mukhopadhyay and Srivastava, 2010, Bovenzi, 1994, Harger and Barbosa, 2005). Not a single study was found to be carried at the locale selected for the present study.

The review of literature further revealed that the postural analysis of stone cutters was conducted by Gangopadhyay et. al. (2010) in West Bengal. The environmental factors were studied by Singh et.al. (2009), Talwar et. al. (2009), Ghosh et. al. (2010) on forging industry, computer professionals and goldsmiths respectively.

The anthropometric data of the marble cutting workers working in marble industry, their working environment, physiological cost of work, their posture analysis and occupational related disorders experienced by them is yet to be explored. Thus, the present study is conceptualized. The findings of the study will be helpful in making the owners of the marble industries aware about the existing working environment of their industry. The findings will also be helpful for the marble cutting workers in the industry as it will help them review their postures and adopt the improved ones to reduce musculoskeletal pain. This has a direct relationship on the increased productivity and output of the marble industry.

**Statement of Problem**

The present research aims to assess the musculoskeletal pain and postural discomfort experienced by the marble cutting workers in the marble industry.

## Objectives of the Study

1. To gather the information on demographic profile, perceived Health Status and the anthropometric data of the marble cutting workers in the marble industry and their workstation dimensions.
2. To identify the musculoskeletal pain as perceived by the respondents working in the marble industry.
3. To analyze the postural discomfort experienced by the respondents while carrying out their work in the marble industry.
4. To assess the environment of the workplace of the respondents working in the marble industry.
5. To determine the physiological cost of the work carried out by the respondents and fatigue as perceived by them during their work in the marble industry.
6. To organize an ergonomic intervention programme by providing guidelines for the selected owners and marble cutting workers of the marble industry for their

    a) protection during work and,

    b) maintaining appropriate posture while lifting marble tiles.

## Hypotheses for the Study

1. The Perceived Musculoskeletal Pain experienced by the respondents will vary with their Personal Variables (Age in years and Perceived Health Status), Situational Variables (Years of Working Experience and Environment of the Workplace (Noise Level and Presence of Light).
2. The Physiological Cost of Work of the respondents will vary with their Personal Variables (Age in years and Perceived Health Status), Situational Variables (Years of Working Experience and Environment of the Workplace (Noise Level and Presence of Light).
3. The Perceived Fatigue experienced by the respondents will vary with their Personal Variables (Age in years and Perceived Health Status), Situational Variables (Years of Working Experience and Environment of the Workplace (Noise Level and Presence of Light).

4. There is an association between Physiological Cost of Work and Perceived Fatigue experienced by the respondents.
5. There is an association between Physiological Cost of Work and Perceived Musculoskeletal Pain.
6. There exists a relationship between Perceived Fatigue and Perceived Musculoskeletal Pain.

**Delimitations of the Study**

1. The present research was limited to the marble cutting workers involved in cutting of marble slabs into marble tiles at the marble cutting workstation.
2. The present study was limited to the respondents having a minimum work experience of 2 years in cutting marble.
3. The present research was limited to the healthy marble cutting workers those who were not suffering from any chronic or acute disease.
4. The present study was limited to the marble cutting workers who were regular to work.