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# MARBLE
# IN INDIA

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# Preface

Marble has received lavish patronage of mankind throughout the historical past. Because of its unique aesthetic qualities and easy workability, it has been used to perpetuate the memory of individuals, to immortalise their noble achievements, and to glorify the deities. Even in present day architecture it has been artistically deployed to enhance the beauty of buildings and to lend them an aura of dignity and prestige.

This bulletin has been brought out to cover the many facets of the marble mining & polishing industry and trade considering its extensive use as a building and decorative stone in India and abroad. This, together with the bulletin on 'Granite in India' being simultaneously brought out, covers the major portion of the gamut of the dimension stone industry in the country.

This bulletin presents the available information regarding commercial definitions, specifications, uses, marketability, geological and geographical distribution, methods of mining and processing, and the indigenously manufactured processing machinery.

A concise account of the relative merits of the different mining practices and salient features of the modern processing machinery have also been presented. Attempts have been made to identify the problems and to indicate the prospects of the marble industry in the country.

The information presented in this bulletin is based on published literature and information collected from producers and users and field visits to the major marble producing and processing units in the country. To assess the prospects and problems of the marble industry in the country, personal discussions were also held with the important producers and processors of marble, representatives of the industrial organisations, and the officials of the various State Governments.

The co-operation received from the producers, processors of marble, manufacturers of processing machinery, the various departments of State Governments and the concerned agencies in readily making the information available to us, both through correspondence and personal visits, is thankfully acknowledged. We are also thankful to all those who have supplied us the various drawings, photographs, and blocks, and have also given us the permission to reproduce them in the bulletin.

The officers mainly associated with the preparation of this bulletin are Shri S.Balagopal, Controller of Mines, Shri H.Anantha Ramaiah, Suptdg. Mining Geologist, Shri H.N.Wanare, Regional Controller of Mines, Shri Y.G.Joshi, Junior Mining Geologist and Shri K.S.Parameswaraiah, Junior Mining Geologist.

N A G P U R :
15 Feb. 1983

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# 1. Introduction

## *1.1 General*

The term marble is derived from the latin word "marmor" which itself comes from the Greek root "marmaros" meaning thereby a shining stone. In ancient times, any stone capable of taking polish, without any regard to its chemical composition, was designated as marble. Even the serpentines, alabaster, and granites were categorised as marble - if they could take polish[1]. However, in course of time, earth sciences developed a more sophisticated and accurate classification which can categorise rocks on the basis of their birth-history.

## *1.2 Definitions*

In the earth sciences, stones are first classified on the basis of their origin and sub-classified on the basis of their mineralogical and chemical composition and diagnostic physical characteristics. The classification based on these petrological properties is too detailed for commercial practice. Commercial classification adopted by the stone industry is mainly based on the general properties and uses of the stone. It is quite broad compared to the strictly scientific classification but it caters to the commercial needs of the industry. Definitions of some of the important terms and rock types as they are understood in the stone industry are given below :

Stone :- Stone is natural rock material quarried or mined for constructional or industrial use in its natural chemical state, and its physical character altered only by shaping or sizing[2].

Rock :- Rock is a stone still in place either as a formational component of the earth's crust or a part of a large mass or ledge that cannot be moved without sub-division. To a geologist, rock is any mass of naturally formed coherent mineral matter[2].

Dimension Stone :- The term "dimension stone" is applied to natural rock material quarried for the purpose of obtaining

blocks or slabs that meet the specifications of size and shape[3].

Marble :- Petrologically marble is recrystallized (metamorphosed) limestone. But in commercial perlance the term marble has a much wider application. Commercial marble is any crystalline rock composed predominantly of calcite, dolomite or serpentine that is capable of taking polish[4].

The American Society for Testing Material (ASTM) has given the following definitions related to marble[5].

Commercial Marble :- A crystalline rock composed predominantly of one or more of the following minerals : calcite, dolomite, or serpentine, and capable of taking polish.

Calcite Marble :- A crystalline variety of limestone, containing not more than 5 per cent magnesium carbonate.

Dolomite Marble :- A crystalline variety of limestone containing in excess of 40 per cent magnesium carbonate as the dolomite molecule.

Magnesium (dolomitic) Marble :- A crystalline variety of limestone containing not less than 5 nor more than 40 per cent magnesium carbonate as the dolomite molecule.

Onyx Marble :- A dense crystalline form of lime carbonate deposited usually from cold water solutions. It is generally translucent and shows a characteristic layering due to mode of accumulation.

Serpentine Marble :- A marble characterized by a prominent amount of mineral serpentine.

Travertine Marble :- A variety of limestone regarded as a product of chemical precipitation from hot springs. Travertine is cellular with the cells usually concentrated in thin layers that display a stalactitic structure. Some that take good polish are sold as marble and may be classified as

travertine marble under the class of commercial marble.

Verd Antique :- A marble composed chiefly of massive serpentine and capable of being polished. It is commonly crossed by veinlets of other minerals, chiefly carbonates of calcium and magnesium.

## *1.3 Chemical and Physical Properties*

Marbles have a broad range of physical and chemical properties. Suitability of the marble for any purpose is decided by its properties to meet the specifications established for the purpose. Marbles are mostly used because of their pleasing appearance and physical strength, and the chemical properties are of lesser importance as compared to the physical properties. But the chemical composition determines many physical properties of marble, particularly its suitability with reference to weathering. Marbles are more susceptible to acidic conditions, in the form of rain, smoke, fumes and ground water. Thus a variety of tests are carried out to study the chemical and physical properties of marble.

Chemical Composition :- The chemical composition of some of the world famous commercial marbles[6] are given in Table 1.1.

*Table 1.1*

*Chemical Composition of World Famous Marbles*

| Chemical analysis percent | LOCALITY | | | |
|---|---|---|---|---|
| | Makrana Specimen | Makrana marble used for building Victoria Memorial, Calcutta (India) | Carrara (Italy) | Pentelinkon (Greece) |
| Insoluble residue | 0.46 | 0.89 | Trace | Trace |
| $Fe_2O_3$ | - | 0.28 | 0.11 | 0.05 |
| $Fe_2O_3/Al_2O_3$ | 0.04 | - | - | - |
| CaO | 56.08 | - | - | - |
| $CaCO_3$ | - | 97.74 | 99.35 | 99.85 |
| MgO | 0.90 | - | - | - |
| $MgCO_3$ | - | 1.22 | 0.87 | 0.33 |
| Phosphoric acid | - | 0.04 | Trace | Trace |
| L.O.I. | 43.28 | - | - | - |

Chemical composition of some marbles from Rajasthan[6,7] are given in Table 1.2.

*Table 1.2*

*Chemical Composition of Marbles from Rajasthan*

| Chemical analysis percent | LOCALITY | | | |
|---|---|---|---|---|
| | Piloti | Choratankari | Perwa | Sarangwa |
| Insolubles | 3.96 | 16.16 | 8.52 | 7.80 |
| $Fe_2O_3$, $Al_2O_3$ | 0.67 | 0.74 | 0.54 | 0.02 |
| CaO | 49.55 | 47.89 | 51.49 | 52.98 |
| MgO | 3.47 | 0.70 | 0.90 | 0.11 |
| L.O.I. | 42.34 | 34.82 | 39.36 | 39.72 |

*1.3.1 Chemical and Mineralogical Impurities* :- Chemically, the impurities may be in the form of silica ($SiO_2$), as free quartz or silicates, iron oxides as hematite ($Fe_2O_3$), limonite ($2\ Fe_2O_3 \cdot 3\ H_2O$), manganese-oxide ($MnO_2$), alumina ($Al_2O_3$) in the form of aluminium silicates, and sulphur usually as pyrite ($FeS_2$). Minor quantities of organic material in the form of graphite are also present in some marbles. The presence of impurities often produces decorative patterns and colours in the marble. The impurities are generally present as minerals and the most common minerals are quartz, chert, flint, hematite, limonite, graphite, mica, chlorite, tremolite, actinolite, wollastonite, diopside, hornblende, epidote, tourmaline and pyrites.

Iron sulphides in the form of pyrites may form bands and clusters. Decomposition of iron sulphides often imparts undesirable discolorations to the marble.

Bands of silica may be present in marble as its original constituent or it may be introduced through fractures by the action of percolating waters. The silica so introduced through fractures causes unsoundness in the marble blocks. But silica present as flinty masses often gives decorative markings to the stone. However, because of its

higher hardness silica usually creates problems for channelling, drilling and processing.

Silicate impurites in the form of mica and chlorite are generally scattered as dark patches and bands through the rock mass. These bands and patches may impart a pleasing pattern, or they may also weaken the rock and thus reduce its value. Bands of dolomite and calcite are often present as alternating bands in marble. Lenses of dolomites are also common. The presence of dolomite gives an uneven surface to marble and may cause some difficulties in processing of the marble.

*1.3.2 Physical Properties* :- The desirable physical properties of marble may vary with its intended use. Generally, strength, durability and appearance are the most important physical properties, though a number of other properties may influence the utility and value of marble.

Hardness :- Hardness is a measure of the resistance the surface of a substance offers to abrasion. In this respect the hardness of marble is more than that of most of the limestones, and it depends on its chemical composition of the marble. The presence of flint or silicate minerals increases the hardness of marble. Hardness often impedes the workability of marble, while the cost of quarrying hard marbles is certainly more than that of soft ones. However, hardness is a desirable quality if the marble is to be exposed to abrasion during its end-use as sills, floors, steps, etc.

Abrasive Resistance :- Abrasive resistance is determined by the composition and texture of marble. A tight texture will resist abrasion best. The index of abrasive hardness (Ha) ranges from 8 to 42 for marble.

Specific Gravity :- The specific gravity of marble depends on its chemical composition. Dolomitic marbles are heavier than pure calcitic marbles. The specific gravity of calcite marble is around 2.7. The average specific gravities of some of the marbles from Rajasthan are given below[6,7].

| Locality | Sp.Gr. |
|---|---|
| Piloti | 2.74 |
| Ghoratankari | 2.96 |
| Perwa | 2.72 |
| Sarangwa | 2.74 |
| Makrana | 2.702 to 2.747 |

Solubility :- The solubility of marble intended for exterior use is a very crucial factor. Marble exposed to atmospheric agencies dissolves and disintegrates, though very slowly, with the passage of time. The rate of dissolution varies with its chemical composition, texture and porosity. A permeable marble dissolves more rapidly than an impervious one.

Porosity and Absorption :- These properties have a direct influence on the strength and weathering of marble. Porosity is the volume of pore space in a stone and absorption is the amount of liquid a stone will absorb on immersion. If pore spaces are of sub-capillary size absorption is low. But if the pores are of capillary size or more, absorption is increased with resulting frost action and weathering. The porosity of high grade marble ranges from 0.0002 to 0.5 per cent[8]. Marbles for external use should have a low porosity.

Colour :- Colour is perhaps the most important physical property that is governed by the chemical constituents of marble. Generally calcitic and dolomitic marbles are of pure white colour. Variations from the whiteness of pure marble are due to the admixture of foreign substances. Such impurities which are present in the form of bands or streaks give a clouded or non-uniform colour; when distributed uniformly they give a uniform coloration. Black and grayish shades are due to graphite; pink, red, or reddish brown are mainly due to the presence of manganese oxides or hematite; and yellow-brown, yellow, or cream are caused by minute grains of limonite.

Texture :- Texture of a marble depends on the form, size, uniformity and arrangement of its grains and on the nature and size of grains of accessory minerals. Depending on the grain size of the constituent minerals, marble is described as fine, medium or coarse. Fine-grained equigranular marble is generally preferred for statues while coarse-grained equigranular marble is used for external purposes.

Rift and Grain :- Rift and grain indicate the direction of easiest splitting in marble. This is generally parallel to bedding. Quarrymen always take advantage of this property while splitting or separating the block of marble.

Strength :- The strength of marble is the measure of its capacity to resist stresses and it depends on the rift, hardness of grains, state of aggregation, degree of cohesion, interlocking of grains, etc. Marble is generally stronger across the bedding plane than parallel to it. Crushing strength is the ability of a stone to sustain load without failure. Generally the crushing strength and transverse strength of building stone is measured to determine its suitability. The crushing strength of marble varies between 8,000 and 27,000 psi[9]. These values are much more compared to loads imposed on ordinary white marbles during their conventional use. However some of the veined and brecciated marble may lack the required crushing strength. Transverse strength or flexural strength is an important index of the durability of marble because it is often subjected to unequal pressures or bending stresses. Under uneven loads, a marble may fail because of the pressure difference. The transverse strength of most of the marbles has a ranges between 600 and 4000 psi[9].

Translucence :- Translucence is the capacity of marble for transmitting light. Fine-grained ranslucent varieties of marble are used for ornamental purposes. The waxy look of some of the statuary marbles is because of the translucence.

# 2.0 Uses, Specifications and Marketability

## *2.1 Uses*

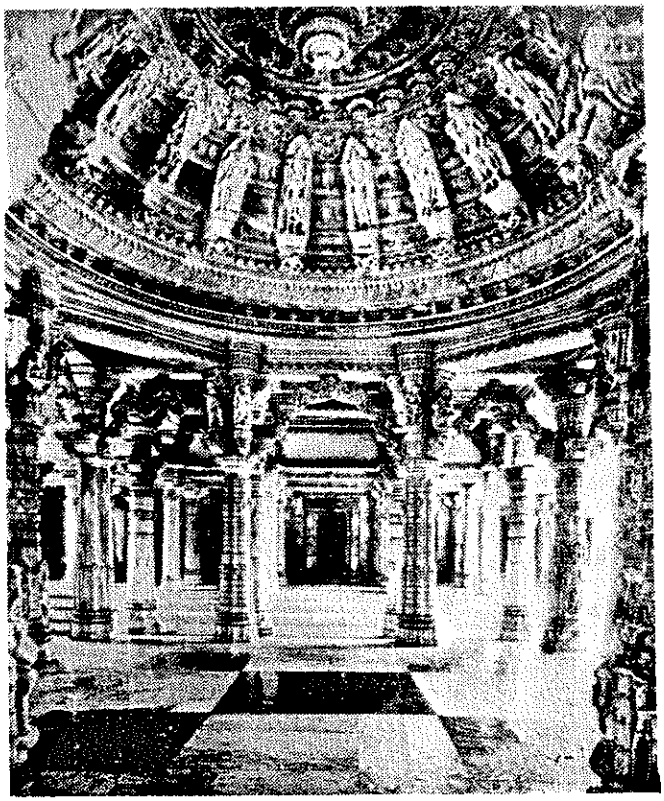
From the historical period marble has been used to perpetuate the memory of individuals, to immortalise their noble achievements, and to glorify the deities. A number of temples, palaces, mosques and monuments have been built in the past under the lavish patronage of kings and noblemen (Plates I and II). For these purposes marble has been much preferred because of its easy workability, pleasing colours, attractive patterns and resistance to failure under abrasive traffic; the use of marble not only enhances the aesthetic beauty of a building but also imparts a feeling of dignity to the structure.

Strong, non-absorptive, uniform grained marbles free from impurities that may stain or corrode the surface are selected for external purposes. The colour of the marble to be used for exteriors is often decided by individual preferences. Earlier, it was a style to have marble of uniform colour throughout a building, but of late many architects have come to prefer a more unconventional blend of colour[2].

Building Exterior :- Marble is used in the form of veneers or thin slabs backed with concrete or some similar cementing material. Veneers are non-load bearing and as such they are made in the form of very thin slabs. Generally, the thickness of a veneer ranges from 2.5 to 10 cm depending on the strength of marble, its cost and the capacity of the saw to make a thin slice. The dimension of the veneers ranges from the size of a tile up to as large as 1.82 x 3.03 m (6 x 10 ft.). Attractive patterns are created by using veneers of different colours in various geometric patterns. In some palaces in Rajasthan, translucent thin slabs of onyx or some suitable marble, about 2.2 cm in thickness, are used in place of windows to admit light.

Building Interiors :- Thin slabs or veneer are most widely used for aristocratic interior decoration. The variety of colours and patterns or figures available through the juxtaposition of different slabs of marble is limited only by the artistic ingenuity of the designer or architect. Marbles are very artistically used for columns, wall panels, steps, baseboards, ceilings, fire places, bath rooms and for many

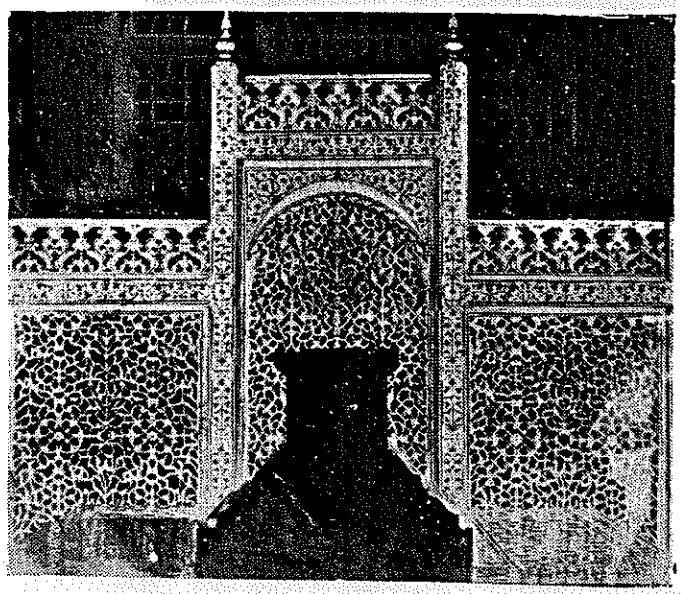
## Plate I



The great hall of the Jain Temple at Dilwara
MT. ABU Rajasthan

*( Courtesy – Shri Y. G. Joshi )*

## Plate II



The beautiful marble screen that frames
the tomb of Taj Mahal, Agra

(*Photograph by Y. G. Joshi*)

such purposes inside buildings. Verde antique, onyx marble, breccia marble, and travertines are selected for the rich and distinctive feeling they add to the interior, apart from their capacity to lend an aura of luxury, distinction, dignity, strength, and affluence to a building[2].

Often, an attractive design is developed through the skilful matching of marble slabs with some pattern. Two of the most popular ways of slab matching are "book matching" and "diamond or quarter matching" (Plate III(a) and III(b)). In book matching, two adjoining slabs are matched along one edge and in diamond or quarter matching four slabs are matched with each other along two edges in a diamond or similar design.

Statuary Marble :- Pure white, fine-grained, equigranular marble, with some translucence and utmost adaptability for carving is selected for statuary purposes. The marble for statuary purposes should withstand artist's chisel without chipping or splitting.

Novelties :- Marbles of ornamental varieties are used as novelties in the form of lamp bases, clock cases, paper weights and various other gift novelties.

In India, marbles have been very tastefully used in the construction of famous structures like Dilwara (Plate I) and Ranakpur temples, Taj Mahal (Plate II), the Victoria Memorial of Calcutta, to quote a few examples. There are a number of monumental buildings, mosques, palaces, and thrones built in the historical past to stand testimony not only to the superior architectural skills of Indian artisans but also to glorify their love for beautiful marbles. Even in the latest architectural practices beauty, taste and individuality have been very skilfully blended with the natural strength of the marble.

## 2.2 *Specifications*

Specifications and standards are required to adjudge the suitability of a stone for the end use. Unlike man-made articles, marbles with particular properties or qualities cannot be manufactured. Moreover because of the natural variability of stones it is very difficult to get at a representative sample for various tests. For marbles or any other dimension stone the requisite quality can be controlled only by selection Generally, the selection of a particular type of marble is done on the basis of individual

choices of colour and texture of the marble, assuming that it is strong enough and durable for the purpose. But many a time, the reputation of individual sellers stands as a guarantee for the appropriateness and strength of the marble. However, efforts have been made to quantify the properties which decide the strength and durability[10].

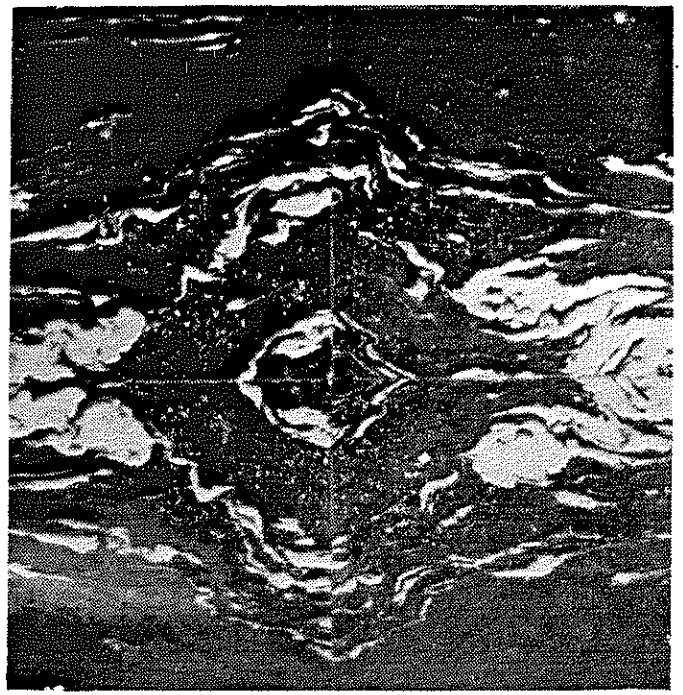
The Indian Standards Institution has evolved a number of standards to test the engineering properties of natural building stones, including marble. A list of some of the important Indian Standards & ASTM Standards is given in Annexures I and II.

## 2.3 *Marketability*

Marketability of marble is mostly governed by its aesthetic properties which cannot be subjected to quantitative measurements. The aesthetic properties include colour, pattern, surface appearance, texture, and workmanship. Marbles with rare colours and designs are high priced and hence have a limited market. But marbles with an acceptable tone, texture and finish, and which are easily available, gets a fair price and have a wide market.

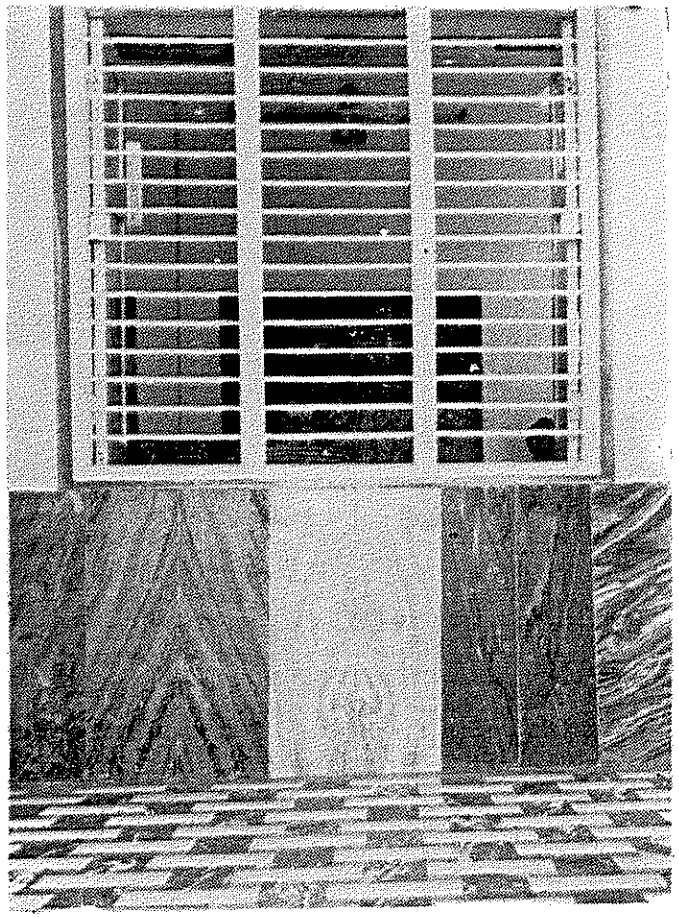
Besides several other practical aspects of mining, transportation of blocks and processing, the location of the mine, the processing plant and the consuming centres, have a bearing on marketability and cost of product. The deposits being located where they are in remote and inaccessible places require a good approach road for not only movement of the mining equipment to the site but also, and more important than anything else, for transport of mined blocks. Unlike any other mining, the mining of marble has to be done to recover large blocks of desired size and such blocks require special care in handling and transport. The necessity of good roads is very important to minimise damage to mined blocks during transportation. The bulk itself poses difficulty in handling. Therefore, absence of good approach roads may necessitate mining and transport of smaller blocks, the value for which gets drastically reduced. Therefore, it is necessary that not only the quarry should be as near the factory as possible but also it should be connected by good roads to transport heavy blocks. The larger the blocks, the lower is the unit cost of transportation, the greater is the profits on the sawed and processed marble.

Plate III(a)



A diamond matching arrangement of polished slabs

Plate III(b)



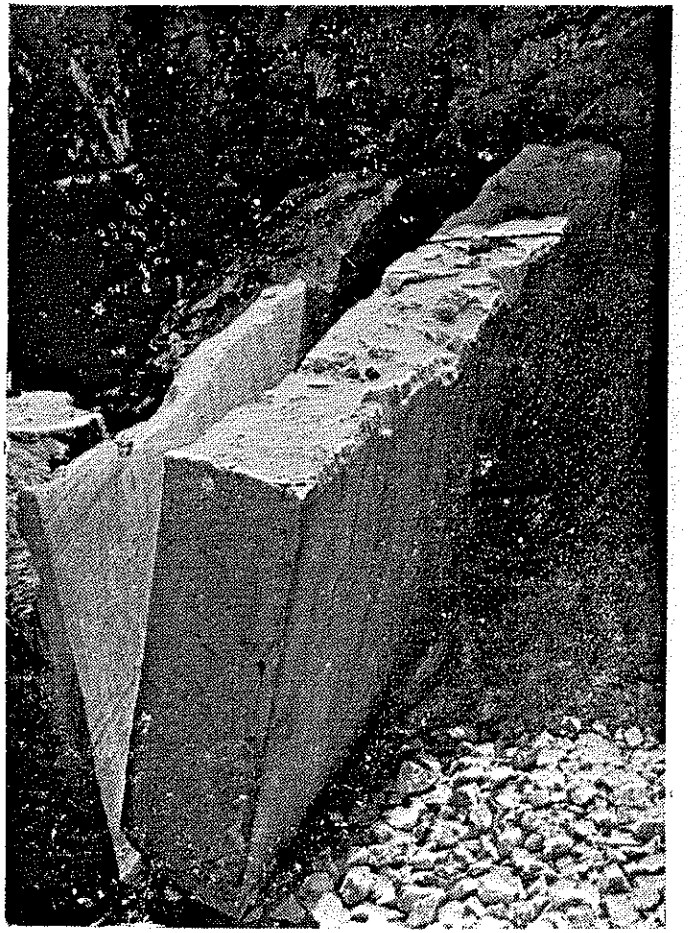
Application of marble in building : the wall panels have book matching arrangement and the flooring has veneer arrangement

*(Courtesy – M/s. Mineral Orientals, Falna)*

Plate IV (a)

Mining of block by wire cutting

Plate IV (b)



A marble block mined by wire saws

*(Courtesy - Shri D. K. Trivedi, Ambaji)*

On the other hand, the processed marbles coming out of the factories also require careful handling and packing so that they reach the destination without any damage. Any slight damage in the processed marble would amount to a vital loss. Therefore, irrespective of the distance the processed marble has to travel to reach the place of consumption, the handling and packing assume great importance.

Besides, to avoid loss in transportation, either by rail or by road to the consuming centres, at least in respect of major consuming centres such as a monument to be built out of marble, it would be desirable to have the processing activity as near to the site of construction as possible. This would not only help in reduced risk in transportation of finished marble but could also avoid huge loss due to such breakages. The above criteria are more applicable in the case of the rare or special types of marble which are highly priced than the ordinary ones.

It is often difficult to make adequate tests for the engineering specification concerning strength and durability of marble. Hence, the reputation of a stone producer is generally a deciding factor in choosing a stone. Properties like strength, colour fastness, porosity and resistance to weathering are best judged through continuous use over a number of years.

Marble from a long established quarry has a distinct advantage as its qualities are well known. No trials are required to prove its merits. Generally customers prefer to purchase their marble requirements only from those quarries whose marble has stood the test of time and usage over a number of years[2].

# 3. Origin, Geological and Geographical Distribution

## *3.1 Origin of Marble*

Marble is a metamorphic rock formed by recrystallisation of limestone. It has the same chemical composition as limestone or dolomite, but the chief characteristics of marble are its granularity and formation by recrystallisation due to metamorphic processes. It has an interlocking or mosaic texture composed of crystalline grains of calcite, dolomite, or both. Igneous intrusions in limestone also give rise to recrystallisation. Fossiliferous limestone subjected to a lesser degree of metamorphism gives rise to fossiliferous marble and in many cases the original fossils remain intact and give rise to beautiful patterns and designs[8].

Onyx marbles are not formed by the metamorphism of pre-existing limestone. These are dense crystalline carbonate deposits formed by precipitation from cold water solutions. Cave onyx is formed by the precipitation in limestone caves and occurs in the form of stalactites and stalagmites. Varying amounts of the oxides of iron and manganese present in successive layers give rise to the characteristic banding. Banded onyx from Mexico is famous for its beautiful banding and translucence and is known as Mexican onyx[8].

Travertine is formed by precipitation from hot or warm ground and surface waters. It is a banded cellular stone with a number of irregular cavities. The cavities are along the bands and lined by microstalactites. This results in very unusual and attractive patterns. Travertine takes a rather dull polish and thus is often sold as travertine marble[2].

Verde antique or serpentine marble is in no way comparable to marble either in origin or composition but it is called marble because of its ability to take a good polish, and the presence of marble-like veins in them. It comprises green to black serpentine criss-crossed by veinlets of calcite, dolomite, or other lighter minerals. Serpentine (hydrous magnesium silicate) is generally derived from the alteration of basic igneous rocks like peridotites or from magnesium silicate rocks formed by the metamorphism of impure dolomitic limestone[8].

*3.2 Geological Distribution*

Marble deposits of India are mostly located in the Dharwar, Cuddapah and Vindhyan group of rocks. Occurrences of lesser importance are also found in the Jurassic and Cretaceous Systems. A brief account of the important occurrences of marble in India is given below[11,12,13].

*3.2.1 Dharwar System :-* Marbles of the Dharwar System are mostly distributed in Aravalli Series and Raialo Series of Rajasthan, Champaner Series of Gujarat, Sakoli and Chilpi Series of Madhya Pradesh and Maharashtra, Salkala Series of Kashmir, and Jutog Series of Simla area.

Rajasthan :- In Rajasthan, the Aravalli Series is unconformably overlain by the Raialo Series which has the unique distinction of containing crystalline limestone of medium to fine texture and in pleasing colours. The famous Makrana marbles used in the Taj Mahal, Delwara Temples and other famous buildings of North India are the products out of Raialo Series. The important marble deposits of Rajasthan are located in Jodhpur, Ajmer, Chittorgarh, Jaipur, Sirohi and Alwar districts.

Gujarat :- A green serpentinous marble mottled with rose and pink is found in Champaner Series, exposed in the vicinity of Champaner. Important marble deposits are located in Banaskantha, Baroda and Broach districts.

Maharashtra and Madhya Pradesh :- Dolomitic marble of Chilpi Series is exposed at Bheraghat in Jabalpur district and Balaghat district of Madhya Pradesh, as well as in Nagpur district of Maharashtra. Dolomitic marbles of Sausar Series are exposed in Nagpur and Bhandara districts of Maharashtra and Chindwara district of Madhya Pradesh.

*3.2.2 Cuddapah and Delhi Systems:-* Important marble deposits of Cuddapah System are located in the Papagni Series (Vempalli Stage) in Andhra Pradesh, Bijawar Series of Madhya Pradesh and Kaladgi Series of Karnataka.

Important marble deposits belonging to Delhi System are located in Alwar Series and Ajabgarh Series of Rajasthan. Marbles of Ajabgarh Series are exposed around Jaipur, Bharatpur, Kishengarh, Ajmer, Mewar, Udaipur and Sirohi

areas of Rajasthan; Danta and Palanpur area of Gujarat; and Narnaul area of Haryana.

*3.2.3 Vindhyan System* :-

Madhya Pradesh :- Flaggy limestones of Lower Bhander Stage are exposed near Sabalgarh and Bijaipur in Morena district of Madhya Pradesh. They are used for building purposes. There is a thin band of concretionary or pisolitic marble outcropping impersistently in the neighbourhood of Garhi area.

Andhra Pradesh :- The Jammalamadugu Series of Kurnool System, which is equivalent to the Lower Vindhyan is well developed in Guntur and Kurnool districts of Andhra Pradesh. The Narji limestone forming the lower beds of Jammalamadugu Series consists of limestones of various colours, especially blue, grey, buff, and fawn. Outcrops of Kurnool rocks developed in Palnad area are called Palnad Series. The Palnad limestones are similar to the Narji limestone, and are used for building purposes.

Karnataka :- Limestones of Bhima Series are developed in Bijapur and Gulburga districts of Karnataka. They are of creamy, grey, bluish and buff in colours and are capable of taking a good polish.

*3.2.4 Jurassic System* :- Rajasthan - Fossiliferous limestones of Jurassic System occurring in Jaisalmer and Bikaner districts of Rajasthan take very good polish. They belong to 'Jaisalmer limestone' and 'Abur beds' of the Jurassic System. They are mostly buff, grey, light-brown, and yellow in colour. Jaisalmer limestone contains fossils of Trigonis costata, Pholodomya, Pecten, Nucula and some ammonites. Abur beds contain mostly the fossils of ammonites.

*3.2.5 Cretaceous System-Madhya Pradesh* :- Coralline limestones belonging to Bagh beds of Upper Cretaceous Age furnish a very handsome marble capable of taking a good polish. Important limestone quarries are located at Kherwan, Chirakhan, and Bowarle in Dhar district.

Table 3.1 lists the various geological formations associated with the important marble deposits of India.

*Table 3.1*

*Geological Formations Associated with Important Marble Deposits in India*

| System | Andhra Pradesh | Gujarat | Haryana | Karnataka | Madhya Pradesh | Maharashtra | Rajasthan | Himachal Pradesh | Kashmir |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Cretaceous | | | | | | **Bagh Beds*** .Kherva .Chirakhan .Bowarla | | | |
| Jurassic | | | | | | | **Abur Beds*** .Abur **Jaisalmer Limestone** .Jaisalmer .Bikaner | | |
| Vindhyan | **Kurnool System** i) **Jammalamadugu Series** .Guntur dist. .Kurnool dist. ii) **Palnad Series** .Palnad **Papaghni Series** Vempalli Stage | | **Alabgarh Series** .Mohindergarh dist. | **Bhima Series** .Bijapur dist. .Gulburga dist. **Kaladgi Series** .Kaladgi | **Bhander Stage** .Bijaipur .Sabalgarh **Bijawar Series** .Bijawar dist. | | **Delhi System** **Alabgarh Series** .Jaipur dist. .Bharatpur dist. .Kishangarh dist. .Ajmer dist. .Udaipur dist. .Sirohi dist. (Ghorathakari) **Alwar Series** .Alwar .Dadikar .Jaipur **Raialo Series** .Jodhpur dist. .Nagaur dist. (Makrana) .Pali dist. (Sarangua) .Ajmer dist. (Ddas, Shivpura and Kayampur) .Chittor dist. (Bhaguanpura) .Jaipur dist. (Bhaisalna) .Alwar dist. .Udaipur dist. (Rajnagar Kankrauli, Nathdwara, Lawa, Kosithal) .Banswar | | |
| Dharwar | | **Champaner Series** .Champaner Motipura | | | **Chilpi Series** .Jabalpur dist. (Bheraghat) .Balaghat dist. **Sausar Series** .Chindwara dist. | **Chilpi Series** .Nagpur dist. **Sausar Series** .Nagpur dist. .Bhandara dist. | **Aravalli Series** .Ajmer dist. .Chittor dist. .Alwar dist. (Rajnagar) .Sirohi dist. (Serwa, Perwa, Piloti). | **Jutog Series** | **Salkala Series** |

* Fossiliferous Limestone

NOTE : The above table has been compiled on the basis of information available[11,12,13]

## 3.3 Geographical Distribution

Marble occurrences are widely distributed throughout India. But the occurrences of economic importance are limited to a very few States. Important deposits of marble are located in Rajasthan, Gujarat, Haryana and Andhra Pradesh. However, marble deposits of lesser importance occur in Madhya Pradesh, Bihar, Utter Pradesh and West Bengal. Rajasthan is the leading producer of marble in India and it also has the largest reserves of good quality marble. A brief description of the geographical distribution of marble and the associated mining activities is given below :

### 3.3.1 Andhra Pradesh :-

In Andhra Pradesh, the occurrences of workable deposits of marble are limited to only two districts, viz. Guntur and Khammam. Deposits of minor importance are seen in other districts.

Guntur District :- Marble deposits are located at a number of places such as Uddalur, Komenki, Dachepalli, Kosanapalle, Goli, Sitarampuram, Rentachintala, and Piduguralla. The marble is of various colours ranging from white, chocolate, pink, sea green, grey to black[14,15]. Presently, marble is being mined at Goli village. These marble deposits belong to Kurnool group of rocks.

Khammam District :- In Khammam district, marble bands are found at Panditog, Yellandu, Nizampet, Jastaipalle, Bethumpudi, Chimalpahad, Kottur, Mallmallipadu, Pubali, Dondagandal, Takalagudem, Polampalli, Kommuguda, and Pallaipalle areas[14,15]. These marbles are mostly of white colour. The marbles of Panditog area are white, grey, yellow and black in colour. But some bands are tremolitic in nature and hence lack strength and ability to take polish.

The other areas of minor importance are Borra area in Visakhapatnam district.

Other than the marble, Andhra Pradesh possesses extensive deposits of what are widely called as 'Cuddapah Slabs' This is a flaggy argillaceous limestone of Jammalamadugu Stage of Kurnool formation, and noticed in Cuddapah, Kurnool, Anantapur and Guntur districts. An other type of slabs called "Napha" Slabs" occurs in parts of Guntur and Kurnool districts. These

Napha slabs represent semimetamorphosed limestone, layered in nature and in various colours. They occur at a number of places almost continuously; as bands from Guntur to Macherla.

*3.3.2 Bihar* :- In Palamau district, crystalline limestone and marble bands occur within granitic rock. Outcrops of marble and crystalline limestone are located in a belt extending from the western end of the Bokaro Coal Field to the south-west of Daltonganj. Occasionally, patches of these rocks are suitable for ornamental work or even for statuary work[16].

*3.3.3 Gujarat* :- Gujarat is one of the potential suppliers of marble having vast resources in Banaskantha, Broach, Baroda, Kutch and Panchmahals districts.

Banaskantha District :- Large reserves of high grade marble are available near Ambaji. White marble from this area was used for the construction of the famous Delwara Temples. At places the white marble has been serpentinised, giving beautiful shades of white, green, brown, dark brown, black and yellowish brown.

Prominent deposits of marble are located at Ambaji, Jarivav, Kumbharia, Koteswar, Bharoj, Khokharibil, Khikla, Ramdurg, and Mahude[17]. Marbles of this area belong to Ajabgarh Series. The Directorate of Geology and Mining, Gujarat has carried out investigations for marble in Kumbharia, Jarivav, Koteswar, Geratankari and Khokharibil villages of Danta taluka and proved reserves of 45 million tonnes of marble in these areas. Presently, there are about 41 mining leases and during 1980, 11,747 tonnes of undressed marble blocks and 2,753 tonnes of dressed marble blocks were produced from this district.

Baroda District :- Baroda district with good deposits of marble comes next to Banaskantha. Good deposits of marble occur at Bhulavara, Chunchupura and Sadel villages in Shankeda taluka of Baroda district[17]. In these places, marbles occur in various shades of green, white, pink and cream[18]. Among these, the green marble belonging to Champaner Series and known as "Baroda green", is more famous than any other coloured marble. Presently, there are four working mines in Baroda district. The Directorate of Geology and Mining, Gujarat has carried out exploration for marble in Gujarat and proved reserves of 1.7 million tonnes in these areas[17].

Broach District[14] :-

Marbles varying in colour from black to green and white occur in Bagh beds, in layers varying in thickness from 5 to 8 cm to several meters. The black varieties take a good polish. Marble bands are exposed in Gora, Zutta Amda, Vanaji, Mokhadi and Todakhai villages.

Kutch District[14] :-

A red or yellow coloured thin bedded calcareous rock known as "Dokawana Marble" occurs in Patcham Island. It is mostly composed of broken sheets and takes a very good polish.

Panchmahals District[14]:-

Crystalline limestone (marble) extending for about 11 km from Jhais to Deohati is capable of taking a good polish.

Other Areas[14] :- A white coloured hard and compact mottled marble, mostly consisting of a mixture of aragonite and calcite occurs at Khirasra and Sajriala in Madhya Saurashtra. This marble takes a good polish. Production of Marble in Gujarat during the period 1976 to 1980 is shown below (tonnes):

| | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|
| Dressed | 1669 | 1704 | 1970 | 2705 | 2758 |
| Undressed | 2683 | 2980 | 3754 | 6943 | 11822 |

### *3.3.4 Haryana* :-

Mohindergarh District[14,18,19,20] :-

The marble deposits of Haryana are confined to Mohindergarh district. These marbles are of variegated colours including white and belong to the Ajabgarh Series of Delhi System. Excellent quality banded marbles occur in good quantity at Ante-Biharipur. White marbles occur in Rasulpura, Khaira-Gohora, Gunguntana, Dhan-Khoro and Musnota. Black and white marbles have been worked at Mandi and Dalta hills. The marbles of this area have enjoyed reputation as "Patiala Marble". Occurrences of marble have also been reported from Islampur, Nangal, Durgh, Dhanota, Dhancholi, Chapra, Bibipur, Makandapur and Jalanwali.

Presently, Haryana Minerals Limited (HML), a State Government Undertaking, is mining the Ante-Biharipur marble deposit in Narnaul area. It has its own factory at Narnaul for cutting and polishing of marble. During

1980-81, HML mined 162 cubic meters (5721 cft.) of blocks and 3724 tonnes of lumps.

*3.3.5 Karnataka :-* Some crystalline limestone called marble occurs around Channur, Andola, Mundargi and Kolkur villages in the Gulburga district[21]. Some outcrops are also found in Kaladgi district.

*3.3.6 Madhya Pradesh :-* Madhya Pradesh is one of the states in which marble occurs in a number of districts, although some of the marble deposits are not useful as dimension stone. The important occurrences are in Jabalpur, Morena and Dhar districts. Minor occurrences are noticed in Betul, Chindwara and Narasinhapur districts[18].

Betul District :- Occurrences of small outcrops of dolomitic white marble have been reported near Manadikhund, Terum and Chikalar Mathni, Phandka and Bhopal villages.

Chindwara District :- Marble suitable for flooring is available near Majhgaven.

Dhar District :- The finest variety of building stones occur at Bowarla, Kharwar and Chirakhan villages in this district. These marbles are actually coralline limestones of Upper Cretaceous Age and they provide handsome blocks capable of taking high polish. These marbles have been utilised locally for the construction of temples[18].

Jabalpur District :- Some 14.5 km south-west of Jabalpur is a gorge known as Marble Rocks. Narmada river cuts a deep channel through the mass of this rock exposing sheer vertical face of limestone up to 36 m high at places. The marble rocks in this gorge are of great scenic beauty in the natural setting in contrast to its beauty in monuments built of marble. The gorge is 1.5 km long and boating in the gorge incidentally provides much pleasure.

Except locally in some of the temples, the rocks have not been used commercially for building purposes. They are much jointed and are traversed by a number of dykes. Some marble blocks of statuary quality are obtained from this area[18].

Morena District :- The flaggy Lower Bhander limestone in the Sabalgarh and Bijaipur tehsils of Morena district is used for building purposes. There is a thin band of concretionary pisolitic marble in the neighbourhood of Garhi. It is locally known as Sabalgarh marble. The rock is a beautiful assemblage of green and red pellets in a ground mass of light buff granular dolomite[18].

Narsinghpur District :- A band of pink dolomitic marble has been reported at Bachai and Sehora.

Sidhi District :- Bands of crystalline marble occur associated with the Bijawars at a number of localities. The marble is compact, massive and saccharoidal in texture varying in colour from white to greenish or light pink. The chief localities of its occurrence are Byrich, Nambbah-Gurjeire, Darmor and Parsuli. A number of marble beds are also recorded in the Singrauli coal fields area, the chief localities falling east of Koelkut and south-west of Manadha[18,22].

*3.3.7 Rajasthan* :- Rajasthan is the richest State in India with regard to marble deposits, both in quality and quantity. The important marble deposits are situated at Makrana in Nagaur district; Amet-Lava, Sardargarh, Babermal, Rajanagar and Kelwa areas of Udaipur district; Parwa-Serwa and Selwara areas of Sirohi district; Bhaisalana and Raialo areas of Jaipur district; Bar deposit of Pali district; Tripura-Sundari deposit of Banswara district; yellow marble deposit of Jaisalmer district; Jhiri-Rajgarh deposit of Alwar district; Kishengarh deposit of Ajmer district; Umar deposit of Bundi district and Moonda deposit of Sikar district[23].

Nagaur District :-

Makrana deposit :- Makrana area in Nagaur district has one of the world's famous marble deposits, representing the typical outcrops of crystalline limestones of Raialo Series[6]. The marble deposits occur in the form of a series of ridges in an area extending for 16 to 18 km in length and 1.6 km in width. The strike of these marble ridges is roughly NNE-SSW, with dips varying from 60 to 75° towards ESE. There are about five parallel ridges of marble in this area with their widths ranging from 40 to 150 m and are called Chosira, Dungri, Pink, Kumari and Borawar ridges. In the individual marble ridges, there are 6 to 7 marble bands having width ranging from 2 to 10 m. The marble bands are sparingly jointed with more or

less quadrangular jointing, which enables the quarrying of large size blocks.

The marble is medium to coarse grained in nature and has varying shades of pure white to pink and grey. The following varieties of marble are generally quarried from this area[18]:

1. Immaculate white
2. Bluish white
3. Bluish white with grey or brownish veins
4. White marble with black, streaks
5. Makrana black zebra
6. Pink
7. Grey

The Makrana marble is harder than the imported varieties and is consequently more resistant to abrasion and yet it is very easy to work with. The details[23] of marble available from these ridges and the mining activities associated with them are given in Table 3.2.

*Table 3.2*

*Details of Marble Bands in Makrana*

| Sl. No. | Notable features | Chosira Ridge | Dungri Ridge | Pink Ridge | Kumari Ridge | Boraved Ridge |
|---|---|---|---|---|---|---|
| 1. | Location (extension) | Mataji ka temple (east to Kalidungi west) | Makrana to Kalidungi | - | - | Makrana to Boraved |
| 2. | Strike length | 8 to 10 km | 4 km | 1½ km | 1 km | 2.5 to 3 km |
| 3. | Width | 100 to 150 m | 60 to 80 m | 60 to 80 m | 30 to 40 m | 40 m |
| 4. | Strike | NNE-SSW N-S | NNE-SSW | NNE-SSW | NNE-SSW | NNE-SSW |
| 5. | Dip | 60 to 80° E | 60 to 70° E | 50 to 80° E | 60 to 80° E | 60 to 75° E |
| 6. | Colour | White | Bluish | Pink | Greyish with black lines | Greyish black |
| 7. | Granularity | fine to medium | fine to medium | fine to medium | fine to medium | medium to coarse |
| 8. | Calcium content | above 35% | around 35% | 32 to 35% | 32 to 35% | 32 to 35% |
| 9. | No. of mines working | around 500 | 40 to 50 | 40 | 30 | 60 to 65 |
| 10. | Average size of pits | 30.5 x 30.5 m (100'x100') | 30.5 x 30.5 m (100'x100') | 30.5 x 30.5 m (100'x100') | 30.5 x 30.5 m (100' x 100') | 30.5 x 30.5 m (100'x100') |
| | | 30.5 x 18.3 m (100'x60') | 18.3 x 18.3 m ( 60' x 60') | | | 30.5 x 18.3 m (100'x60' ) |
| 11. | Block sizes | 3.66x1.83x 1.22 m (12'x6'x4') (Max) | 3.66x1.83x 1.22 m (12'x6'x4') (Max) | 3.66x1.83x 1.22 m (12'x6'x4') (Max) | 3.66x1.83 x1.22 m (12'x6'x4') (Max) | 3.66x1.83x 1.22 m (12'x6'x4') (Max) |
| 12. | Shape | Any shape for art work (massive) and rectangular for slabs. | Any shape for art work (massive) and rectangular for slabs. | Any shape for art work (massive) and rectangular for slabs. | Rectangular for slabs. | Rectangular for slabs. |
| 13. | Usability of marble | Art work statuary and slabs. | Rarely for art work mainly for slabs. | Rarely for art work mainly for slabs. | Only for slabs. | Only for slabs. |

During 1980, around 1.25 lakh tonnes of marble blocks were produced from 650 quarries located on these five bands. About 269 small scale marble industries are located at Makrana, Gunawati and Sorawad villages in which about 800 sawing, cutting and polishing machines are deployed. The State Directorate of Geology and Mining carried out investigations for proving concealed deposits of marble and so far a total strike length of 4.40 km of marble bands has been proved and a total of 3 million tonnes of marble reserves established. A total of 3500 m of drilling in 80 boreholes was completed by the department. The thickness of the marble bands varies from 10 to 50 m with an overburden of 15-20 m.[23]

Udaipur District:-

Agria-Amet-Lava, Sardargarh Marble Deposit :- The deposit is about 70 km from Udaipur towards NE. The Agria marble belt runs from Amet up to Sardargarh with a strike length of 20 km. The width varies from 200 m to 1.5 km. There are 3 or 4 bands of dolomitic marble with regular jointing and cracks. Some 94 quarries are in operation in this area at present.

Rajnagar Marble Deposit :- Marble is exposed over a wide area in the neighbourhood of Nathdwara, Rajnagar Kankroli (Rajsamund) and Kelwa. Although slightly coarse grained for statuary work, the marble of this area is used for other purposes as it takes a very good polish. Rajsamund area is the main centre of mining activity with about 135 mining leases existing in this area. During 1981, about 35,000 tonnes of marble was produced from this area. Presently, there are two sawing and polishing factories at Rajsamund. The other occurrences are at Lawa and Kosithal.

Babarmal-Devimata-Kewra Marble Deposit :- These deposits are located at about 25 km SE of Udaipur. Pink coloured marble of Raialo Series is exposed for a strike length 8 km having a width of 1.5 km. The marble is highly siliceous and cherty and hence hard for sawing[23]. In 1981, Bobermal belt produced about 6880 tonnes of marble which is mainly of pink colour.

Green Marble (Serpentine) deposit near Rikhabdev :- Green marble deposit is in fact a serpentinised rock having asbestos mineralisation. The deposit is about 90 km south of Udaipur. The serpentine rock is exposed in a large area around Rikhabdev. The marble is highly fractured and soft and hence is unsuitable for producing larger blocks and as such is mainly used

for making chips. There are 69 mining leases in this area and during 1981 a production of 5681 tonnes of marble was reported from this area.

In Udaipur district, there are about 250 mining leases for marble. The total number of marble processing units around Udaipur and Rajnagar are 14 and 13 respectively.

Sirohi District :-

Selwara Marble Deposit :- The Selwara marble deposit is located 4 km north east of Reodhar town. The Selwara hill locally known as 'Hara Magra' consists of marble and calc-silicate rocks. The marble bearing area extends for a strike length of 2.5 km with the width varying from 50 to 300 m. The marble is white, fine to medium grained, crystalline, and well jointed[23].

Idar Marble Deposit :- The deposit is located about 4 km east of Deri Base Metal deposit. Abu Road is the nearest railway station which is 20 km from the deposit. The marble occurs as lenses with a strike length of 50 to 100 m. It is white, light green to grey in colour and fine to medium grained[23]. The white marble occurring at Ghoratankri takes a good polish[18].

Perwa-Serwa deposit[7] :- White saccharoidal marble is quarried as building stone near Perwa-Serwa and Piloti areas. The presence of hair cracks and veins of calcite creates problem for block quarrying in this area. Presently there are four mining leases in this area. Nine processing units are located around Abu Road.

Jaipur District :- Bhaisalana marble deposit is located on Jaipur-Delhi national highway and is 96 km from Jaipur. The occurrence of marble is in Ajabgarh Series of rocks. The deposit extends over a length of 2.5 km varying in width from 50 to 300 m. The marble bands have a dip of 30 to 70$^{0}$ due west. The marble is of black colour and is used for statuary purpose[23].

Pali District:-

Bar-Sendra Deposit :- In Pali district, the marble deposit is situated near Bar and Sendra. In this area marble is pink coloured with various shades and stripes[23].

Sarangwa Deposit :- One of the most important marble deposits occurs at Sarangwa. This is a massive white marble, somewhat coarser in texture than the marble of Makrana area. White marble also occurs at other places like Sewari, Muthano-Ana, Kundal, etc., and it is being used for building purposes. A fine variegated marble of Ajabgarh Series occurs at Bhairo-ka-Baria[6,23].

In 1979 there were four mining leases in Pali district which represent a total production of 756 tonnes.

Jaisalmer District:-

Yellow Marble Deposit of Jaisalmer District :- The marble in Jaisalmer area is actually a yellow shaly fossiliferous or ferruginous limestone of Jurassic Age. Owing to its yellow colour and the good polish it takes, this limestone has been recognised as yellow marble. These deposits occur near Moolasagar, Amarsagar, and Abur around Jaisalmer. Typical out-crops of this stone are located at Abur. Hence this marble is known as "Abur Stone" throughout northern India[13]. Presently, there are 15 quarries working in this area. A total production of 1406 tonnes of blocks and 6105 tonnes of Khandas was repor-ted during 1980.

Banswara District:-

Tripura Sundari Talwara Marble (limestone) Deposit :- The deposit is situated near famous Tripura Sundari Temple, 12 km from Banswara. The deposit is 3 km away from Banswara-Dungarpur tarred road. The marble (limestone) is white and fine grained. It is high in magnesia and low in silica. It is used in both block making and chips preparation. This marble takes a good polish[23]. Presently, there are 16 quarries in this area. During 1980, they produced 2368 and 3910 tonnes of marble and chips, respectively.

Alwar District:-

Jhiri-Rajgarh Marble Deposit :- Marble of Jhiri and Dhadikir have been famous for their crystalline texture suitable for

building purposes. Pink coloured marble occurs at Kho and Baldeogarh. Black marble occurs at the Motidongri ridge near Alwar. Marble of white colour occurs around Rajgarh and Badampur areas. There are three mining centres in Alwar district, viz. Jhiri, Rajgarh and Badampur, which are extensions of Makrana area.

Ajmer District:-

Kishengarh Marble Deposit :- Kishengarh marble bands are exposed in Sursura, Narwar, Kalidungri, Torka, Ladpura, Akheri, Untra, Rupnagar, Raghunathpura, Rajpura, Sardhana, and Kayampura areas in Ajmer district[14,23]. In these areas, various types of marbles, i.e. white, pink, black, green, and spotted varieties, occur. Among the above the most important deposit is the Kayampura deposit. The marble here is black and the deposit has got a strike length of 2 km with a width of 500 m. In this area, marble is exposed in the form of small ridges ranging from 45.75 to 76.25 m (150 to 250 ft) in height. The marble bands strike N-S and dip 60 to 80° due west. The marble is medium grained and black in colour. The marble is traversed by both vertical and horizontal joints. There are folded ferruginous bands in this marble and they yield attractive figurative blocks when sawn in appropriate direction.

Sikar District :- White crystalline dolomite marble bands are exposed at Keladungri near Maonde. The marble of the bands is utilised for preparing chips and powder[23].

Bundi District :- The marble deposit is located 42 km north of Bundi near village Umar. The marble is grey with bands and shades of pink, green and dark green. Marble outcrops are exposed over an area of 4 sq km. The fine-grained green coloured marble is known as "Bundi Green". Marble occurrences are also located around Basoli area in the same district[23]. Presently, there are 23 marble quarries in this district.

Bhilwara District:-

Jhajpur Limestone (Marble) Deposit :- The Jhajpur siliceous limestone which is mined as marble, extends from Pagara in Bundi district to Jhajpur and further west in Bhilwara district[23].

Reserves of marble in Rajasthan are shown in Annexure-III. District-wise production of marble in Rajasthan for the year 1979 and 1980 is given below (as furnished by DMG, Rajasthan).

| | District | Production in tonnes | |
|---|---|---|---|
| | | 1979 | 1980 |
| 1. | Udaipur | | |
| | a) Baharmal | 9615 | 3446 |
| | b) Rajasamand | | 10754 |
| 2. | Banswara | 2844 | 6278 |
| 3. | Ajmer | 5571 | 1907 |
| 4. | Nagaur | 1,22,641 | 1,25,702 |
| 5. | Jaipur | 8820 | 14,734 |
| 6. | Alwar | 76,223 | 66,263 |
| 7. | Jaisalmer | 10,770 | 7511 |
| 8. | Sirohi | 1570 | 2746 |
| 9. | Pali | 756 | 3120 |
| 10. | Bundi | 3808 | 4010 |
| 11. | Sikar | 71 | - |

*3.3.8 Uttar Pradesh* :- Marble in Uttar Pradesh occurs mainly in two districts, namely Pithorgarh and Mirzapur.

Pithorgarh District:-

Near Bhakunda, 3 to 18 cm thick impersistent bands of white marble occur in massive limestones[24].

Mirzapur District[14,23] :-

Statuary marble occurs extensively at Ningha. Marble suitable for building material also occurs at Caria. Both the deposits are in Robertganj tehsil. Marble at Ningha runs as a vertical band about 60 m in width and it has been traced for a length of 1.6 km. The vertical depth can be roughly placed at over 100 m. It is learnt that no other marble deposit in the country is so massive as that of this deposit. There are only a few cracks which

do not appear to run very deep and the size of the block it can yield is only limited by the requirements. The marble is quite suitable for statues, pedestals and solid pillars. Half of the reserves are presumed to be suitable for statues. Fine "Verde antique" marble occurs near the mouth of Bichi stream, a tributary of Rer River. The rock is a white crystalline dolomite interbedded with rich green serpentine and layers of tremolitic hornblende. Slabs of 0.91 x 1.83 m (3 ft x 6 ft) can be produced.

*3.3.9 West Bengal*[25] :- Marble deposits in West Bengal are reported from Jalpaiguri and Purulia districts.

Jalpaiguri District :- Dolomites and dolomitic marble occur in Buxa-Dhar area of Jalpaiguri district. Occasional patches of pure marble might be found within these occurrences and could be used for ornamental work or even for statuary purposes.

Purulia District :- In the north western part of the Purulia district, a few kilometers north of Jhalder, a thick marble belt of Archaean Age is exposed. The bands are arranged in en echelon pattern running east-west and dipping $60^0$-$75^0$ towards north and are surrounded by granitic rock. Colour varies from milk-white to greenish white. Megascopically, these marbles may be grouped into two classes, viz. fine-grained cryptocrystalline hard and compact marble, and coarse grained saccharoidal type. Colour banding is sometimes very conspicuous and is due to alternating layers of white calcite grain and green silicate minerals. The marble consists chiefly of calcite and is not dolomitic. The other occurrences are near Jhalda and Panchet hill where crystalline limestone and marble occur in the form of lenses and bands.

Bankura District :- Lenses and bands of crystalline limestone and marble are found near Guniada hillock and Harirampur villages[18].

A statement showing the number of leases with area granted for marble mining in India is given in Annexure-IV.

# 4. Leasing Methods

## *4.1 Mineral Concessions For Marble in India*

The grant of mineral concessions for marble in India is governed by the Minor Mineral Concession Rules of the respective State Governments. Most of the State Governments have enacted the Minor Mineral Concession Rules applicable in the respective States, considering the need for taking into account the local circumstances and their requirements. This has resulted in some similarities and dissimilarities between the Minor Mineral Rules prevailing in the different States. Persons interested in quarrying marble in any State should refer to these. The important provisions of minor mineral concession rules prevailing in the States of Rajasthan, Gujarat Andhra Pradesh and Bihar are discussed in the following paragraphs[26].

*4.1.1 Andhra Pradesh* :- According to Andhra Pradesh Minor Mineral Concession Rules, 1966, two types of concessions are in vogue : 'quarry lease' and 'permit'. A quarry lease may be granted on application or by calling for tenders or by holding public auction. Quarry lease may be granted by the Collector for a period of five years in respect of the minerals such as marble and limestone, 'Shahabad slabs', 'Napha slabs', bentonite, fuller's earth, etc. which require investment and equipment to develop the quarry. Prior approval of the Government is necessary if the period exceeds the above limits. If the Government is satisfied that for a proper and systematic development of the quarry, a period longer than five years is necessary and that the applicant or lessee is capable financially and technically of developing the quarry on a large scale, a quarry lease may be granted for a longer period but not exceeding double the fixed period.

A permit in no case will be for more than six months. There is a fixed rent payable when the quarry lease is granted. The Rules prescribe that the lessee shall pay annually the land assessment, if any, of the area under lease or permit.

When quarry lease or permit is granted on application, either the seignierage fee or a fixed rent for the specific period, whichever is higher, is payable, in quarterly instalments on the dates fixed therefor. On the other hand, when the quarry lease is granted by calling for

tenders or by auction, the lessee is required to pay the bid amount and not the seigniorage fee. The royalty/seigniorage charged for marble is 5% of the sale value.

*4.1.2 Bihar :-* According to Bihar Minor Mineral Concession Rules, 1972, there are two types of concessions in vogue : viz. (i) mining lease and (ii) quarrying permit. The mining lease is for a period of time and is similar to the mining lease granted under Mineral Concession Rules, 1960. The period for which a 'mining lease' may be granted or renewed shall not ordinarily be more than five years but if the Collector considers that a longer period of lease is necessary for proper development and mechanisation of the mines and working on a larger scale, he may grant or renew the lease for a period not exceeding ten years with the prior sanction of the State Government. The maximum area that a person could acquire is 101hect. (250 acres) unless the State Government permits areas in excess of the aforesaid maximum.

Quarrying permits are granted by the above mentioned officer for shorter periods. The permit may be refused for reasons to be recorded in writing.

The dead rent payable for all types of minor minerals as prescribed in Schedule-I is Rs.125/- per hectare. In case of quarrying stone from the hillside, such rent as far as practicable, may be fixed by the Collector on a footage basis by horizontal measurement. Surface rent is charged at the rates specified by the Collector from time to time. Royalty is charged at scheduled rates. In case of mining leases, it is to be paid in four equal instalments on the dates indicated in the lease dead. In case of quarrying permits, the royalty is required to be paid in advance. Royalty for marble is Rs.4.50 per cubic metre.

*4.1.3 Gujarat :-* According to Gujarat Minor Mineral Rules, 1966, there are two types of concessions in vogue : viz. (i) quarry lease and (ii) quarrying permit. A 'quarry lease' is similar in nature to the mining lease granted under Mineral Concession Rules, 1960 whereas, a 'quarrying permit' is a permit to extract and remove any specified quantity of a minor mineral. The period for which a 'quarry lease' may be granted shall not generally exceed ten years. No quarry lease may be generally granted for an area exceeding 20 hectares in the case of specified minerals (marble, limestone, limeshell, bentonite and fuller's earth) and 60 hectares in the case of other minor minerals except with the prior approval of the Government. The maximum area that a person, by himself or jointly with any person, can hold in aggregate under lease for one or more minerals within the State is 7.5 sq km.

No quarrying permit can be granted in respect of specified minerals, viz. marble and limestone.

No quarry lease shall be granted in respect of lands notified by the Government as reserved for the use of the Government, local authorities or for any other public purposes. The holder of a quarry lease is required to pay for every year of the lease the yearly dead rent specified in Schedule-II of the Rules. In case of a "quarry lease", royalty is payable on minor minerals quarried from the lease area at the rates prescribed in Schedule-I.

The rates of royalty currently in force for marble are given below :

| | |
|---|---|
| a) Dressed, carved rough and slabs | Rs.35.00 per tonne |
| b) Chips, powder and ballast | Rs. 5.00 per tonne |

*4.1.4 Rajasthan :-* According to Rajasthan Minor Mineral Concession Rules, 1959, three types of concessions, viz. (i) mining lease, (ii) rent-cum-royalty lease, and (iii) short term permit, are available. The 'mining lease' is similar in nature to the mining lease granted under Mineral Concession Rules, 1960 except that in specified cases it could be granted by auction or tender. The 'rent-cum-royalty lease' means a lease granted for certain specified areas and the lessee undertakes to pay a fixed annual rent and royalty. A 'short term permit' means a permit to extract a certain quantity of minor mineral within the period specified in the permit. The period for which a mining lease may be granted is five years at the first instance unless the Government allows a longer period not exceeding ten years. A mining lease may be renewed for a period equivalent to the period of the original lease. If the State Government is satisfied that the mines have been improved by the lessee and that substantial investments in machinery and equipment have been made by him, it may further grant second, third and fourth renewals, each for a period equal to the period of the original lease.

The maximum area that a person could hold is thirty square miles. The State Government is authorised to grant lease over an area in excess of the maximum in special case in the interest of mineral development. No application for mining lease will be entertained for an area less than 50 x 50 m. The Government may refuse to grant a lease for less than 25.90 sq km (10.0 sq miles) for any minor mineral in any notified area. A rent-cum-royalty lease may be granted for a period of five years unless the applicant desires for a

shorter period. It may be renewed for a further period not exceeding five years. The dimensions of each area for the purpose of grant of rent-cum-royalty lease are to be fixed by the Director of Mines and Geology, provided, the maximum dimensions of the area shall not exceed 61 x 61 m (200' x 200') except in case of marble where the dimension shall be 400 x 200 m. There is no maximum or minimum period or area prescribed in respect of short term permit.

An application for the grant of mining lease should be made to the Mining Engineer/Assistant Mining Engineer in their respective jurisdictions accompanied by a non-refundable fee of Rs.50/-.

A minor mineral deposit may be leased out by public auction or by inviting tenders.

Every application for the grant of rent-cum-royalty lease must be made to the Mining Engineer or Assistant Mining Engineer having jurisdiction on the area applied for. Every application for grant or renewal should be accompanied by a non-refundable court fee of Rs.5/-.

Short term permits are granted by the Mining Engineer or Assistant Mining Engineer on a payment of Rs.5/- per permit. There is no provision for payment of dead rent in case of rent-cum-royalty lease and short-term permits. In case of mining lease, the lessee is required to pay for every year such yearly dead rent within the limits specified in the Second Schedule to the Rules. The rent for a rent-cum-royalty lease shall be between Rs.12 and Rs.1600 per annum. There is no provision for the payment of surface rent either in case of a rent-cum-royalty lease or short term permit. The holder of a mining lease is, however, required to pay surface rent equal to land revenue for the surface area used by him for purposes of mining operations. Royalty is chargeable in respect of minerals removed from the leased area at the rates prescribed in the First Schedule. In case of a mining lease, the royalty is required to be paid in four equal quarterly instalments. For rent-cum-royalty leases, the royalty is to be paid to the Government or any royalty collection Contractor. Royalty for marble used as blocks and/or sawn, polished and with a curved surface is Rs.27.50 per tonne and for marble used for chips it is Rs.5.00 per tonne.

# 5. Geological Appraisal of Marble Deposit

Intimate knowledge of a deposit is necessary to ensure reasonable return on investment required for the development of a marble quarry. Detailed geological examination, economic evaluation, and exploratory work by way of drilling, pitting etc. can alone decide the ultimate worth of a deposit. The study of a marble deposit requires a distinct approach and method because, unlike most mineral deposits, the rock masses to be quarried are quite large and bulky. Moreover, compared to the chemical composition, the physical properties of the marble blocks play a more important role in their marketability.

The effective evaluation of a marble deposit consists of the study of marketability, its soundness, size and shape, nature of overburden, distance to market, transportation facilities, availability of labour, power and other utilities, etc.[4].

The basic information regarding the general geology of the area is usually available through the publications of the Geological Survey of India, the State Directorates of Geology and Mining, and any other exploration agency working in a given area. A study of the relevant publications brought out by these exploration agencies gives an idea of the likely presence or absence of marble in an area. Surface examination of the outcrops reveals many properties of marble bands. A fresh surface of marble will reveal the degree of hardness, colour, texture, nature and intensity of joints, faults, veins, bedding planes, and the presence or absence of rift or grain. Topography, nature and thickness of overburden and drainage are also studied during preliminary examination. If surface examination indicates the possibility of locating a favourable deposit, topographic surveying, geological mapping and exploration by core drilling is undertaken.

A competent geologist can undertake detailed study of the structural, lithological and textural features of a marble deposit and estimate the reserves. Currier[3] gave a very detailed account of the points that must be covered in a report on prospecting and exploration of a building stone deposit. The basic principles of mineral exploration are explained in detail in the publications, 'Elements of Mineral Exploration' published by the Indian Bureau of Mines in 1980.

A schedule for the examination of building stone deposits as given by Currier is as follows[3]:

A. General features

1. Location of deposit or quarry, name of owner, name of district
2. Size of quarry (if any)
3. Formation name, trade name (if any)
4. History of past operations

B. Geological features

1. Distribution of formation
2. Stratigraphic position
3. Thickness of formation and workable portion
4. Lithological classification and description, notable variations
5. Petrographic description and classification
6. Mode of origin and occurrence, and form
7. Major structural elements and attitudes, folds, etc.
8. Contact relations to other formations
9. Texture and fabric : variation and relation to other features
10. Fractures and fracture system
    a. Joints : attitude, distribution and spacing
    b. Faults : attitude, displacement width of shattered or gaugy zones
11. Rock cleavage : natural planes of parting, relation to other features
12. Inclusions and segregations: distribution, nature
13. Overburden : nature, thickness
14. Weathering : depth, nature and relation to other features
15. Surface water : amount and direction of drainage

C. Industrial features

1. Classification : points of similarity or difference with other commercial stones of its class

2. Use of stone, specific structures as example

3. Topography

4. Accessibility

5. Working facility, structural elements

6. Workability of the stone, production and milling into finished blocks or other architectural and monumental units

7. Colour, texture and finish

8. Reserves, proven and inferred areas available for development by potential competitors

A systematic appraisal on the above lines is very essential and it takes care of not only the immediate prospects but also a long term outlook of the deposit. However, very few areas have adopted such systematic approach. The common practice is to start developing an outcrop if its suitability and utility from the point of location is considered favourable.

# 6. Mining Methods

## 6.1 *General*

Marble is obtained by working out the marble bearing deposit by opencast methods of mining. Unlike in other countries, the winning of marble is done by quarrying only and there is no underground mine of marble in India.

The method of mining adopted in India for quarrying marble is mostly manual. However, the method practised for mining of marble differs substantially from the method of mining adopted for other minerals and ores like iron, manganese, limestone, etc. The difference is because of the fact that in case of marble mining, the aim is to obtain the marble block of the required measure (i.e. dimensions). This factor is so important that it puts limitation on the use of conventional mining machineries for digging, excavation and loading. The whole mining operations are oriented to obtain the marble block of particular regular geometrical size intact, i.e. without any cracks; and the machineries to cut the stone are designed accordingly. In order that the marble blocks mined should not be damaged during transportation, great care has to be taken in handling, loading and hauling of these mined out blocks.

There are three important centres of mining for marble in India located in the States of Rajasthan, Haryana and Gujarat.

### (i) *Mining of Marble in Makrana Area in Rajasthan* :-

Makrana has the unique distinction of supplying marble to some of the most beautiful buildings of India like the Taj Mahal and Victoria Memorial, etc. Marble was being mined in this area for more than 350 years.

#### Quarrying

There are more than 650 marble quarries in Makrana and most of them are being worked on a Rent-cum-Royalty Lease basis (R.C.R.L). The sizes of individual quarries generally vary from 60 x 60 to 100 x 200 m.

Mining is done mostly by manual methods. Stripping or the removal of overburden is done by spades and scrapers. The waste material is dumped on sides of the quarry. After the marble is exposed, it is carefully examined for the colour, uniformity, joint pattern, rift, etc. Joints and slip planes are taken advantage of for primary separation.

Quarrying of marble is started at the outcrop of marble over its full width and progressively followed along the dip. In many quarries, no benches have been made. A number of quarries have reached depths of 60 to 65 m.

Quarrying starts by cutting two trenches, about 0.5 m wide. One trench is made along the strike and the other across the strike. The trench along the footwall or hangingwall is known as 'Galli' and the other one across the strike is known as 'Toda'. Thus, two free surfaces are created. The depth of 'Galli' and 'Toda' depends on the thickness of the block required.

The size of the block to be mined is marked on the exposed surface of marble and two sets of channels are made by chisels and hammers along the periphery of the marked block. Then, two rows of closely spaced holes (15 cm apart) of 1.25 cm diameter are drilled by steel rods or 'Sarias' through these channels up to the required thickness of the block or up to the slip plane if it occurs earlier. Round wedges of appropriate sizes are then driven through these holes till a fracture is formed along the periphery of the block. If a slip plane is present, the block is separated from the main mass by levering it with crow bars. If a slip plane is not present, a set of holes is drilled along the bottom of the block and the block separated by wedging.

Channels or holes are generally made along the direction of easiest split, i.e. along the joint plane, rift or bedding.

Preparing Blocks and Splittings

The block thus obtained is then dressed into a regular shape. The first operation of obtaining the

block of regular shape and size is done by wedging out along the rift. Splitting a big block into two when necessary is done by fracturing the block at right angles to the rift by driving holes of 1.25 cm diameter at intervals of 20 to 25 cm to about half the thickness of the block and then knocking the space between two holes with a wedge.

Hoisting

Blocks of marble are then hoisted from the pit to the surface by manually operated cranes which are locally fabricated. The ropes are directly tied to the block and lifted. The blocks are then further chisel dressed on the surface before being sent to the factories for cutting into slabs and polishing.

*(ii) Antri-Beharipur Marble Mine in Haryana*

Haryana Minerals Limited, Narnaul, a State Government Undertaking, is quarrying marble at Antri-Beharipur. There are four pits and the size of the main pit is 70 x 15 m. The depth of the pits varies from 3 to 8 m. In this mine, marble beds strike NE-SW with a dip of 60 to 75° towards NW. Four different varieties of marble are being worked in this mine. These four varieties occur in parallel bands having a thickness of 10, 3, 2 and 3 m, respectively. There are parallel sets of dip joints and strike joints which are utilised with advantage, while channeling or trenching for primary separation. A set of horizontal joints helps in obtaining the rectangular blocks.

Stripping to remove the overburden and to expose the workable marble bands, both along the strike and dip, is carried out manually. The position of joint planes is searched for making channels or trenches. Shallow jack hammer holes are drilled in a row or line at intervals of 15 cm both along the dip and the strike. The spacing between two adjacent rows made across the strike depends upon the width of the block required. The depth of the drill holes is kept slightly less than the thickness of the block to be removed. Wedges are hammered in these holes to develop a smooth fracture plane. If a slip plane is available at an appropriate depth, the overlying block is moved by the levering action of crow bars. If a slip plane is not available a series of shallow holes is drilled in a plane, from down dip side to up dip side, and then wedges

are successively hammered through them to separate the block from the in situ mass, along a smooth plane. If wedging is not possible, mild charge of gun powder is loaded into the holes and blasted.

*(iii) Zarivav Marble Mine , Ambaji, Gujarat*

Although the mining method practised at Zarivav Marble Mine of D.K. Trivedi in Ambaji area is same as that at Narnaul & Makrana, mining of blocks is done by wire cutting method. This is the only mine in India using this method. This method is explained briefly below (Plates IV(a), IV(b), V(a) and V(b).

After cleaning and removal of the overburden, space is made to fix the wire cutting unit on both sides of the block to be cut, either by making trenches or channels across the length of block; and the depth of the channel depends upon the thickness of the block required. After the space is ready for the wire cutting unit, two poles having two pulleys, each with a helicoidal cutting-wire are fixed one on each side of the block to be cut. The cutting wire is made of high carbon steel. This wire moves from pulleys on the marble at a uniform speed and in the process cuts marble. Water and sand are used as cutting media. The wire cuts through the marble and after cutting it moves nearly 250 to 300 m in air before it is wound in the winder. This process helps the wire to cool down and gain tension. Moreover, because water and sand are used as cutting media, water also cools the wire and suppresses the dust. This wire cutting machine, with a wire length of around 1,000 to 1,200 m, can cut around 10 to 12 m a day excluding waste. After a block of particular length is cut for a given depth vertically, the wire cutting unit is arranged to make a horizontal cut to release the block from the bottom of the block. Once a block is cut to the specific size, the dislodged block is tied in chains and pulled out by winders. Cranes are deployed to load the blocks in the trucks. Generally, 2.44 x 1.22 x 1.22 m size blocks are cut but depending on order, some bigger sizes of blocks can also be cut. The wire cutting unit has a capacity to cut blocks of 18.3 m length, 6.1 m width and 1.22 m thickness. But due to geological limitations like fracture, differences in grain size, colour, and problems in transport of big blocks, generally small blocks are preferred.

Prevention and Utilisation of Waste

Mining of marble generates a lot of rejects and the ultimate recovery of stone is often less than 50

per cent. Perhaps in no high bulk mineral industry there exists such a low ratio of useful stone to waste.

The chief causes of waste generation are natural imperfections like joints, strain breaks, impurities, lack of attractive colours and patterns, and crude methods of mining.

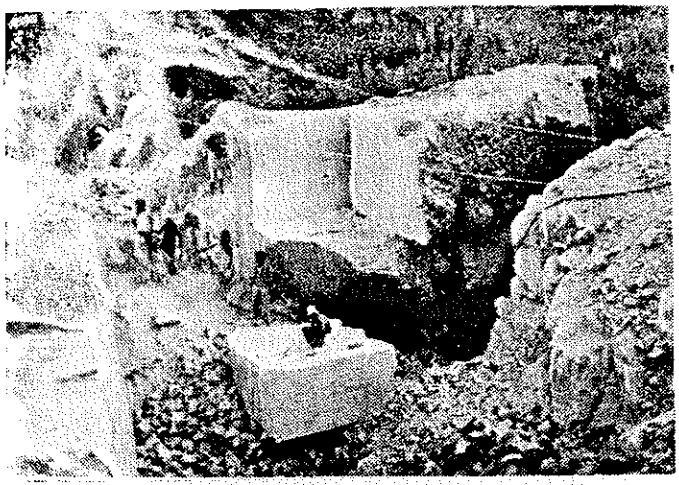
Remedial Measures

(i) Adequate systematic prospecting may help in selecting proper method of development which may help in minimising or reducing waste generation. Joint systems may be closely studied to decide the method of development. In order to keep the generation of waste to a minimum, quarry walls are to be made parallel to the main direction of joint system. In steeply dipping beds, it is useful to separate the blocks parallel to the bedding. This not only reduces the waste but also helps in maintaining the quality of blocks.

(ii) In situ marble bodies are under severe compressive strain. Any opening made in the marble relieves the strain and consequent expansion gives rise to fracturing of the rock at places. This fracturing may give rise to blocks of very odd shapes which are unsuitable for building purposes. To avoid losses caused by strain relief, efforts have to be made to afford relief of as large a mass as possible at one time. For this purpose, a line of close spaced drill holes is made along each side of the quarry parallel to the direction of compression, and a similar line of closely spaced drill holes is made at right angles to the first line. Thus, as the natural strain is relieved, the rock expands and crushes the webs between the holes[2]. The strain is thus relieved initially and the subsequent operation may progress without any problem of strain till a lower level of strain accumulation is reached. However, a foolproof method of strain relief has not yet been devised.

(iii) Major impurities in the form of silica, mica, and pyrite occur in definite zones or beds in marble. These unwanted zones or beds can

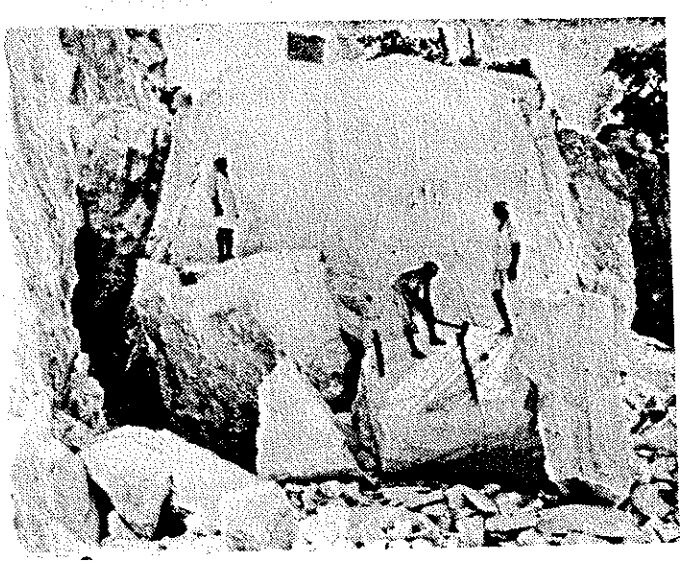
Plate V (a)



A quarry showing the dismantled block cut by wire saw

*(Courtesy – Shri. D. K. Trivedi, Ambaji)*

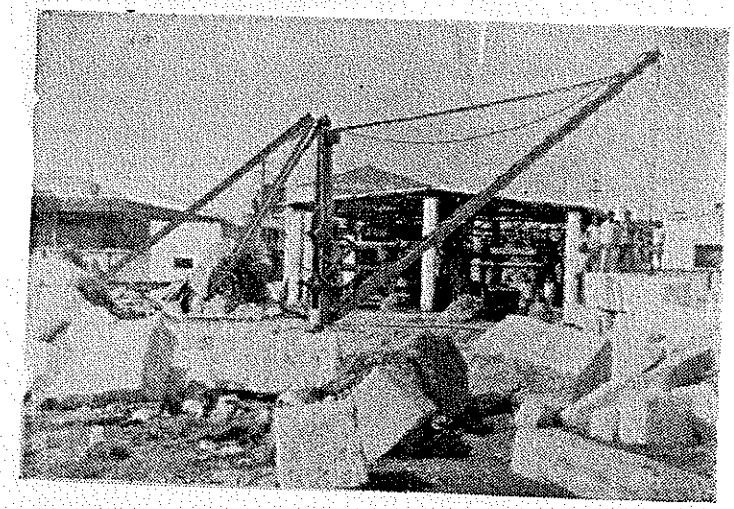
Plate V (b)



A wedging operation to reduce the size of mined blocks

*(Courtesy – Shri. D. K. Trivedi, Ambaji)*

Plate VI



A marble processing factory

*(Courtesy - Naresh Stone Industries, Udaipur)*

be separated and rejected by making cuts parallel to the bedding. Bands or streaks of waste material passing diagonally through a block give rise to a lot of waste material.

(iv) Deployment of proper machinery and systematic mining practices may also help in reducing waste.

Utilisation of Waste

Waste material in the form of blocks and chips of marble can be utilised for terrazzo chips, ashlar in buildings, lime-burning, crushed stones, reconstituted stones or resin bound "conglomerate-marble"; and the marble flour can be utilised as whiting and as constituent of stock feed and fertilisers.

The sale of these by-products of marble-mining may not only help in conservation of marble but also earn some revenue and partly set off the losses, if any, caused during mining.

*6.2 Mining Methods*

It is observed that the marble quarries worked in India have not by and large been planned and worked on scientific lines. It is felt that there is great scope for improving both the planning and mining of marble in the country. The various stages and considerations involved in proper quarrying of marble are described below :

Location of the Quarry : The deposit nearest to the consuming centre needs to be selected for developing into a quarry. The grade and quality of the marble available in the deposit should meet the commercial specifications of the nearest consuming centre.

Plan of Quarry : The plan of working a quarry may be prepared based upon the information collected through geological studies, surface and sub-surface exploration, production requirements, and other techno-economic consi-

derations. The quarry plan is mainly influenced by the orientation and thickness of the marble band, its dimensions, dip, internal structural features and the disposition of the individual block to be quarried from the deposit.

The direction of the quarry and the location of the first opening or entry is often decided by "rift" (i.e. the easiest direction of the split) and "grain", orientation of joints, fractures, cleavage planes, or other lineaments along which natural breakage takes place.

The waste material dump may be located at a place which is easily accessible, and without any valuable mineral or rock underneath. The quarry plan may be made with due consideration to maintain ecological balance, and special care is taken to avoid environmental pollution of any sort[2,8].

Open pits are of two types, 'shelf' quarry and 'pit' quarry. A ledge of marble forming a hill is worked by the shelf method. A shelf quarry is worked on the hillside but it's floor may be lower than the surrounding area. Pit quarries are sunk below the ground level, and stairs, ladders and mechanical hoists are used for handling materials. The quarried blocks are carried from the pits with the help of inclined tracks, trucks, derricks, or cableways. In India, most of the marble is worked by open pit methods. In USA and Italy, underground methods are also used for the exploitation of marble[2,8].

Stripping, primary separation and secondary separation with trimming are the various stages of operations involved in open pit mining.

### *6.2.1 Stripping*

Marble bands of marketable type are often overlain by soil, clay, gravel, unsuitable stone and any other

debris. The process of removing the overburden is called stripping. Often the upper portion of an otherwise good marble deposit has been rendered useless due to weathering and it has to be removed by quarrying to exploit the underlying portions of good marble. Depending on the nature of the overburden, distance to be moved, topography and attitude of the beds, a suitable method of stripping may be decided. In case of an earthy and friable overburden, hydraulic stripping is generally adopted subject to the plentiful availability of water and scope for suitable drainage. Hydraulic monitors are used for this purpose. For the removal of hard rock, blasting is often resorted to, taking care to avoid the shattering of underlying good rock. Earth moving machinery like bulldozers, dragline scrapers, clamshell buckets, and power shovels, etc. are also used to remove the overburden[2].

### 6.2.2 *Primary separation*

After the careful stripping of overburden material, primary breaks or cuts, are made on the in situ mass of rock to separate a block of stone. A scheme of primary separation is decided on the basis of the attitude of marble beds, orientation of joint planes, rift, and other natural planes of separation.

Primary cuts in marble are generally made by channelling machines, wire or diamond saws and by drilling and broaching.

*6.2.2.1 Channelling :* This is done by channelling machines. Different types of channelling machines, which can be operated by steam, diesel or electricity are in vogue at present. The machine operates with a chopping action similar to that of a reciprocating drill. Cutting is achieved by a number of chisel-edge steel bars welded together. The machine travels on steel tracks and the chopping mechanism cuts a channel 5 to 8 centimeters wide and several metres deep. The depth of the channel is regulated on the basis of the desired height of the block to be removed. The important factors to be considered for channelling are the dip of the beds, soundness and rift of the deposit. Flat beds without any decided rift are ideal for channelling as laying of tracks on a level surface is quite easy. Inclined beds are quarried separately and the removal of right angled blocks from successive inclined beds gives rise to a saw-toothed quarry floor.

In the case of dipping beds, the channelling machine track is placed on an inclined rock surface in the direction of the dip. A balancing weight is provided to overcome the force of gravity. In case of a parallel system of joints, cuts are usually made perpendicular to the joint planes to derive the best advantage of the joint system. Channelling is not suitable for steeply dipping beds.

*6.2.2.2 Drilling and Broaching Method :* In this method, closely spaced drill holes are made in a line with the help of a reciprocating drill mounted on a bar. A continuous channel is then made by removing the intermediate webs with the help of a broaching tool. This method is comparatively cheaper than the channelling method. For floor cuts, horizontal holes are made and the block is separated by wedging.

In order to take the best advantage of the ease of splitting in the beds, drilling is done in the direction of rift or grains of the rock, wherever possible. Drill holes are made in a regular pattern to give uniform blocks of rectangular or square shape. The depth of each hole is decided by the size of the block to be removed and it is marked on the block to select the proper size of wedge[8].

## *6.3 Mining Machinery*

The different types of machines have been successfully employed for cutting the marble blocks of desired size. The description of the machines generally employed for marble cutting is given below :

### *6 3.1 Wire Saw*

Wire saw has been very successfully used in many marble quarries of the U.S.A. and Italy. It consists of a single strand or 3 strand wire forming a closed loop which is loaded for tension to augment the cutting action. Specially made helicoidal wires are commonly used for the saw. The wire of the saw passes over and through the marble block and cuts a narrow channel of about 7 mm in width. Sand, aluminium oxide, silicon carbide or any other cutting agent is carried in a stream of water to facilitate a smooth and uniform cut. Besides carrying the cutting media, water acts as an agent for cooling and flushing. Cutting can be done

in flat or inclined beds. The wire saw is presently used in India by D.K. Trivedi &Sons in the marble quarry at Zarivav village in Gujarat. Hindustan Marble Company will be soon installing a wire saw in its marble mines.

The wire saw unit comprises a driving unit, tension carriage and cutting wires (Plate XII).

The driving unit is made of a 10 to 15 HP motor with a worm-gear reduction in oil. The tension carriage consists of a suspended platform to which a weight of 362 to 908 kg is loaded to give the necessary tension to the wire. The tension carriage is placed on a track which can travel back and forth to adjust the length of the wire as the cut progresses.

The cutting wires are made of high carbon steel. Guide pulleys are mounted on standards or steel rods of 4-5 m length. Each standard is fixed with two sheaves at the top and one sheave at the bottom. The upper sheaves are meant to receive and conduct the wire to a lower sheave which travels down as the cutting goes on.

The standards are placed 30 to 40 m apart, and fixed in 3-4 m deep holes wide enough to accommodate the lower sheaves. By lowering the guide pulleys, the wire is brought into contact with the marble. Sand and water are fed along the cut for providing abrasive action.

The upward curvature of cutting strands is prevented by the heavy tension maintained for the purpose.

### *6.3.2 Madrigali Machine*[27]

This is basically a diamond impregnated chain saw machine which has revolutionised sawing of marble in the Italian quarries. The Madrigali machine known after its inventor Luigi Madrigali, cuts into the marble rock face with a 20 m long steel cable which is fitted with diamond cutting elements. One end of the cable is first inserted into the holes drilled vertically and horizontally into the marble, then the two ends are joined on the spot and the cable mounted on to the Madrigali machine which pulls it through the marble. A cable speed of 24 m per second is

employed when cutting marble, the cable simultaneously being rotated axially through 360° every two meters. As the diamond electroplated beads also rotate around themselves an excessive wear in one side of the bead is avoided. It is estimated that the 20 m diamond/steel cable cuts 500 sq m of marble on an average in 150 to 250 working hours. The same job would have taken much more time if done with steel helicoidal wire. The resultant saving are estimated to be of the order of 60 per cent.

Presently, there are more than 100 Madrigali machines working in the Carrara marble quarries, Italy. Each machine with its closed-loop wire replaces some 1500 kg of old helicoidal steel wire.

Luigi Madrigali is now working on a Mark II model with the power unit incorporated in the frame. Madrigali Mark II machine will also be able to make oblique cuts.

### *6.3.3 Circular Diamond Saw*

Blocks of limited size are at times removed during primary separation with the help of circuler diamond saws. However, the use of a circular diamond saw for primary separation is not a common practice.

## *6.4 Undercutting, Bed Lifting & Floor-breaking*

This refers to separation of blocks attached to the base, and free on all the remaining five sides. For this purpose any of the above methods can be used. But the plug and feather technique is most commonly used. Feathers are two half rounds of iron, flat on one side and curved on another. The curved sides of the feathers fit the wall of the drill-hole and the flat surface are in contact with each other. A steel plug is driven between these two flat surfaces. Plugs are driven lightly in succession till a continuous fracture is formed. In order to maintain even strain on the rock, the driving of plug is started from one end of the line and is continued in the successive holes till a fracture appears[2].

## *6.5 Secondary Separation with Trimming*

In this phase of work, larger blocks of marble separated from quarry floor are sub-divided into smaller

blocks of desired shape and size. They are reduced into convenient sizes, which are easy to transport out of the quarry. In splitting the blocks to the required size and shape, advantage of the natural direction of splitting is taken. Major fractures are made in the direction of prominent rift. A series of shallow drill holes (10 cm deep) are made with hammer drills using compressed air. The final break is made by "plug and feather" method. Trimming of blocks to the true rectangular form is known as "scabbling". The scabbling process can be omitted in quarries if the processing mill is close to the quarry. In some quarries wire saws and circular diamond saws are also utilised for scabbling.

## 6.6 *Lifting of Blocks and Yard Services*

Generally, hoist derricks with a swinging boom or crane are utilised for the lifting of blocks. In some quarries, portable crawl-type-tread or tire mounted cranes have replaced the derrick because of the ease of movement under their own power.

From the above description of the various factors and stages involved in planning of the marble quarry and the various machines that can be used for cutting of the blocks, it is felt that there is great scope for modernising marble mining in India keeping in view the increasing demand for it.

# 7. Processing of Marble

Processing of marble consists of three main activities, namely, sawing, polishing and edge cutting.

## *7.1 Sawing*

Big blocks of marble received from the quarry are first sawed into smaller and thinner slabs or rectangular blocks of usable size. Generally, mechanical sawing is carried out by gang saws or frame saws, wire saws, and circular saws. Sawing can also be made by manual methods but mechanical sawing is much superior and it can saw quite thin slabs without any consideration of the rift or grain of the marble. Moreover, mechanical sawing also conserves rock by reducing waste.

### *7.1.1 Gang Saws*

This is the most common sawing machine used in the marble processing industry. Also known as frame saw, it consists of a series of straight iron or steel blades set parallel in a frame that moves in a backward and forward sawing motion[2]. Blocks of any width or slabs of any thickness may be obtained by merely adjusting the spaces between the blades. Generally, the blades are fed with silica sand and water, as an abrasive. In some mills, steel shots, aluminium oxide or other granular abrasives along with water are utilised. Individual gang saws may consist of upto 40 or 60 blades ranging in thickness from 3.17 to 0.31 cm (1.25 to one-eighth of an inch). A 0.31 cm (one-eighth inch) thick blade can give 0.48 cm (a three-sixteenths of an inch) thick smooth walled cut. Generally, sawing is done parallel to the rift or grain, but sometimes cross-sawing is also done to obtain distinct or attractive patterns[8]. The rate of sawing varies greatly depending upon the hardness of the marble, cutting medium and the speed of movement of the saw. The gang saw can make a 5 cm deep cut in an eight-hour shift. A system of gang cars and transfer cars is employed to place and remove the stone from beneath the saw. Utmost care is taken to hold the marble blocks perfectly stationary during sawing operation. Any jerk or movement of the marble block not only disturbs the sawing operation but also spoils the sawing blades which are often quite costly.

Dressed blocks are placed on the trolley or gang car with the help of cranes. Depending on the capacity

of the trolley, a number of blocks may be placed on it. For the efficient sawing of blocks, they are cemented together with plaster of paris mix. The mix is prepared by mixing together 15 kg gypsum and 2 kg wood wool in 20 litres of water. The mix so prepared is sufficient for cementing marble blocks on two trolleys. After cementing the blocks, the trolley is brought below the sawing machine.

The trolley is then fixed and tightened to a firm stationary support of steel and wood so as to avoid any jerks or vibrations during sawing action.

### *7.1.2 Diamond Blade Saw*[28]

Thin slabs of marble (of about 2 cm thickness) are very commonly used for cladding of building walls, floors and steps, both internally and externally. For this purpose, frame saws are becoming quite popular because of their speed of sawing and the smooth finish they impart to the sawn surface. As regards the output and quality of sawn face, the diamond frame saw surpasses anything obtained with the earlier swing saw and shot combination. The diamond blade saws work on the principle of perfect linear reciprocating movement.

The diamond frame saw consists of four corner pillars in brazed steel or cast iron, and further strengthened by setting in concrete. Generally, there are 40 to 60 blades each with a tension of about 7.1 to 10.16 tonnes (7 to 10 tons). The frame is made exceptionally strong as it has to stand to a tension of about 406 to 610 tonnes (400 to 600 tons).

As the blades are subjected to high and variable bending stresses, they are made of steel capable of high yield strength and resistance to fatigue. They are generally 3.6 m long, 178 mm high and 3.15 mm thick. However, depending on the length of blade or the hardness of stone, appropriate height or thickness of blades can be used. Normally, a diamond concentration of 1.32 carats per $cm^3$ is used. The diamond teeth are brazed to the underside of the blade. Bond hardness is varied to suit the stone being cut. Diamonds may get shattered because of the high vibrations set up in the blade. This can be avoided by using blades either with a harder bond or by varied spacing of diamond segments. The blades are given appropriate tension to avoid any deflection in the cut. Tension is given by driving a wedge behind the

frame sash while the blade positioning is made by machined spacers. The wedge system is quite common but is rather inadequate. Most modern machines use a hydraulic tensioner where the tension of each blade can be checked in a manometer[28].

The quality of cutting and the useful life of blade depends on the care and precision observed in positioning or setting of blades. Perfect verticality and parallelism form the key to the proper positioning of blades for obtaining optimum sawing rates. Not only the individual blades but their downward movement through the cut, too must be perfectly vertical. The verticality of the set is checked on the horizontal component of the frame with a spirit level while the downward movement of the set of several blades is checked against a comparator. Any error of verticality not only ruins the slab dimensions but also wears down the costly diamond segments. The parallelism of the plane of blade with the cutting movement is also checked by moving the frame slowly against a comparator. Inaccurate parallelism is often caused by faulty spacers.

In order to obtain the best results from a diamond frame saw, the block of marble should be carefully selected to have the best dimensions to fit into the machine. Ideally, the length of the block should perfectly match with the machine. This avoids unequal wearing of diamond teeth over the blade. The marble block should be properly fixed to the base or the trolley during cutting. This is achieved by placing the block on a sound bed made of two soft timber joists of (100 x 50 mm cross section) extending along the full length of the block and having an extra length of about 150 mm from each edge of the block. The joists are liberally plastered and secured to the base of the trolley. A loosely fixed block may increase the blade wear by about three times compared to a properly fixed block. The block placed below the blades should have regular shapes. This not only ensures the easy loading of equipment but also gives maximum utilisation of the blade surface. In case of irregularly shaped blocks, all the blades do not remain always in full contact with the blocks and thus may give rise to vibrations resulting in wearing of the diamond and reduction in downward speed. Reduction in downward speed results in loss of productivity. Cutting of long blocks after a series of short blocks will accelerate wear of segments which were not used in the first cutting.

Copious supply of cool soft water sprayed evenly along the entire cutting area ensures maximum blade life and

even wear. In the initial stages of cutting, a water supply of 4.5 litres per minute per blade is considered satisfactory, but as the full speed is reached the water supply should be raised to 6.8 litres per minute per blade. Often chemical additives which lower water tension are used for the purpose with advantage.

The diamond frame saw can achieve a cutting rate of about 15-20 cm per hour in hard marbles and about 20 to 30 cm per hour in travertine and coarse crystalline marble[28].

### *7.1.3 Wire Saws*

Wire saws are used to a limited extent for sawing the marble blocks during processing. These can simultaneously saw a number of marble blocks lined up together[8]. Sawing is done by single or multiple wires using silicon carbide or aluminium oxide as abrasives[2]. The abrasive is carried in a water flow and is fed to the cutting wire. The cutting tool is a three strand or single strand wire running as a belt or closed loop, under tension. Compared to the ordinary gang saws, the cost of sawing by wire saws is slightly more but the advantage of the latter is that the cut made by the wire is so narrow (about 0.64 cm or one-quarter of an inch) that it conserves the stock. the wire leaves such a smooth surface that it results in a considerable saving of time and cost in the further processing. Wire saws with diamond beads are also used at places for secondary sawing of marble.

### *7.1.4 Circular Saws*

Though various types of circular saws are used for sawing of marble, the diamond impregnated circular saws are preferred because of their great speed and accuracy in sawing, besides yielding a smooth and uniform surface. The size of the circular diamond saw blade restricts the size of the block that can be cut. The diamond saw is widely used for sub-dividing slabs and in trimming, shaping and jointing.

The diameter of diamond circular saw varies from 203 mm (13 in) to 3.7 m (12 ft)[28]. The maximum depth of cut is generally equal to one-third of the diameter of the saw. Circular saws can be used singly or mounted

in gange and at various angles. The effect of rotational speed on the overall efficiency of circular saw has not yet been fully studied. It is known, however, that a relation exists between the rotational speed and the amplitude of vibrations of the machine. These amplitudes affect bond wear. However, the manufacturers support the idea of using high rotational speed for soft stones. The recommended surface speed for the diamond circular saws varies between 35 m per second for hard marbles and 40 m per second for medium limestone and marble. The forward feed rate is decided on the rate of bond wear and horse power of the machine. A feed rate capable of giving free cutting characteristics is selected. Presently the trend is towards high cutting rates and a speed of about 645 sq. per minute is an accepted cutting rate for marble and hard limestone[28].

Clamping devices are used to ensure perfect stability of blocks during cutting. This eliminates blade damage and reduces blade wear. Sawing by diamond circular saws requires carefully controlled supply of a maximum quantity of cooling water which should reach the cut at a very high velocity indeed.

The size of the diamond grit used in the circular saw is generally 1.5 times the size of the rock grain. A grit size of 30 to 40 U.S. mesh is generally used for marble[28].

## *7.2 Grinding and Polishing*

A sawed piece or a neatly quarried stone is given a smooth finish to enhance attractiveness. Rubbing, gritting, buffing, and polishing are generally done with the help of various machines and abrasives available for the purpose. Polishing is done in 3 or 4 stages and the size of the grinding medium is reduced in every successive stage, viz., 40, 80, 120, to 140 mesh size are deployed in successive finer stages of polishing. Even manual polishing is done by rubbing the sawed surface against a cast iron plate, using a suspension of carborundum powder or emery powder as a polishing medium. However, manual polishing has its own limitations, besides being very laboricus and time consuming, though it is in vogue at places. Mechanical polishing includes the following stages[8].

Rubbing :- Horizontal circular beds of cast iron revolving at moderate speed around a vertical axis form the rubbing

bed. Generally, the beds are driven from above by countershaft and gears, but beds driven from below are also not uncommon. Marble slabs or blocks are held against the revolving disc and sand and water are fed on the disc till the slabs acquire the desired smoothness. Carborundum beds are also used instead of cast iron discsfor rubbing small pieces of marble.

Circular grinding and polishing machine is a crude polishing method practised at some places in India. In this method, a set of marble slabs to be polished is fixed on the base and another set fixed on a circular moving frame rub against them in a circular motion. Thus, both the sets get polished. This machine is also used for Kotah slabs, Napha slabs, and Cuddapah stones. Water and sand are used as grinding media (see Plate XI).

Gritting :- Gritting is a process which gives a smooth surface than rubbing. For this purpose, emery powder or abrasive bricks are used. Bricks of silicon carbide or aluminium oxide are used to give the desired finish.

Buffing :- Buffer head of felt or other soft materials are used to give the final polish or buffing to marble. The mechanically rotated buffer head is guided over the wetted surface of the marble. A mixture of tin oxide and oxalic acid or only tin oxide is used as abrasive. Buffing is achieved in stages by employing buffer-heads of successively smoother types and by using abrasives of finer sizes.

Radial armed grinding polishing machine requires an operator to move the spindle over the stone surface. But continuous mechanical polishing devices like automatic gantry-type slab grinding are also finding wide use on account of their high speed.

## 7.3 *Edge Cutting*

This is a process of trueing the edges with the face and squaring the ends and sides to finish the working dimensions without chipped corners. Manually, edge cutting is done with the help of chisel and hammer. This is quite a laborious job and even a slight mistake may spoil the finished panel. In the mechanical methods, edge cutting is done by cutting the edges with emery wheels, carborundum wheels or diamond impregnated wheels. Water is used as coolant. Various

types of edge cutting wheels, including the diamond wheels, are manufactured in India. Some processing units manufacture their own emery or carborundum wheels. The edge cutting wheels are fixed to rotating discs, which in turn are attached to the main motor. The rotating disc moves on the marble slab and cuts it in the process of moving.

In one of the units the emery wheel is prepared by mixing 400 gm of carborundum powder of 10 to 15 mesh size with 600 gm of powdered sulphur. The mixture is heated till the sulphur liquefies. The liquid mix is applied to the periphery of 33 cm(13 inch)diameter wheel with groved periphery. It dries in about 15 to 20 minutes. The wheel, when dried,is attached to the motor. One wheel so prepared can cut about 5.58 sq m (60 sq ft). Oxalic acid is applied to the cut slabs to clean them. Finally, wax polishing is done before the slabs are packed for despatch.

## *7.4 Cutting of Columns*

Columns of marble are often prepared for architectural purposes. The columns can be prepared either in a drum column cutter or in a lathe. A drum column cutter is a circular steel drum revolving around a vertical axis[8]. It may have diamond teeth on its lower surface or the cutting may be done by sand or steel shot. Lathe is used for handling monolithic columns. The marble is roughed by manual methods to 1.27 cm (one-half inch) of the finished diameter before being placed on the lathe. The column is rotated around a horizontal axis and the shaping is accomplished with a cutting tool similar to that used in ordinary lathes for turning metal shafts. The cutting tool travels slowly back and forth with the help of a worm gear or a similar device. The column is given a final finish by rubbing and polishing. Fluted columns are made by turning a block into a column by a lathe[2]. Then the column is kept stationary in the lathe and flutes made with the cutting tool which cuts a groove over the entire surface of the column. The process is repeated by rotating the column till the required number of flutes are made.

## *7.5 Cost of Processing*

The cost of marble processing mainly depends on its chemical composition, hardness and the percentage of recovery after processing. The efficiency of a particular type of machinery used for processing also determines the cost.

Coloured varieties of marble are generally harder because of their siliceous and ferruginous contents and thus they require more abrasives, power and time for processing; moreover, the rate of recovery is much less in the case of coloured marbles. These factors naturally result in a higher cost of processing of coloured varieties compared to the soft and white marble. Similarly, the speed of processing with the diamond impregnated tools is much more as compared to the conventional ones. Also, the fine sawing achieved by the diamond impregnated tools results in lowering the cost of processing.

Cost of Processing in Rajasthan :- The cost of processing of marble in Rajasthan varies from unit to unit depending on the machinery deployed and nature of the marble processed. A brief idea of the cost of sawing, polishing and edge cutting is given below :

Sawing :- The cost of sawing by conventional frame saw varies between Rs.43.0 and 161 per sq meter (Rs.4.0 to Rs.15.0 per square foot) in five processing units with an average of Rs.75.0 per sq meter (Rs.7.0 per square foot). Cost of sawing per cubic meter varies between Rs.890.0 and Rs.2850.0 (i.e. Rs.25.0 and Rs.80.0 per cubic foot) in ten processing units deploying the conventional saws and between Rs.1250.0 and Rs.2500.0 (Rs.35.0 and Rs.70.0 per cubic foot) in five units deploying the diamond frame saws. One processing unit using a diamond impregnated circular saw reported that its cost of sawing is Rs.107.0 to Rs.161.0 per square meter (i.e. Rs.10.0 to Rs.15.0 per square foot).

Polishing :- Cost of polishing varies between Rs.5.30 and Rs.10.75 per square meter (i.e. 50 paise and Re.1.0 per square foot) in nineteen processing units and the polishing cost in only one unit is Rs.21.50 per square meter (Rs.2.0 per square foot).

Edge Cutting :- The cost of edge cutting varies between Rs.1.30 and Rs.3.20 per running meter (i.e. 40 paise to Re.1.0 per running foot) and it was Rs.5.0 per running meter (Rs.1.5 per running foot) only in one unit.

# 8. Important Processing Centres

Important marble processing centres are mostly concentrated in Rajasthan and Gujarat. However, some centres are also located in Haryana, Andhra Pradesh, Madhya Pradesh, Maharashtra, Tamil Nadu and Uttar Pradesh.

Information regarding the number of processing units and the equipments available with them was collected by sending questionnaires to processing units and by discussions with the officials of the Departments of Industry, Departments of Mines & Geology and the representatives of the associations of marble producers. A brief account of the important processing centres in different States is given below. A list of important marble processing units in India and the details of the processing done is given in Annexure-V.

## *8.1 Gujarat*

In Gujarat, there are three important processing centres, viz., Ahmedabad, Ambaji and Baroda.

Ahmedabad :- Ahmedabad has 11 factories dealing with the processing of marble . Most of the units draw their marble for processing from their own captive mines located in Ambaji and Koteshwar areas. Besides, they also purchase marble from Rajasthan. Presently, there are 10 frame saws, (conventional type), 19 polishing machines and 16 edge cutting machines in Ahmedabad area.

Ambaji :- Ambaji in Danta taluka of Banaskantha district has six processing units with a total of 10 frame saws of conventional type, six polishing machines and four edge cutting machines. Here also most of the units draw their marble from their mines at Ambaji, Zarivav and Koteshwar area. They also purchase marble from Kankrouli, Abu Road and Rajanagar areas. The Ambaji marble itself is as white as Makrana marble and is used for temples and buildings.

Baroda :- In Baroda, there are two units. These units mainly use green marble from Chunchunapura area.

In addition to the above, there are some more units at places like Surat, Anand Godhva and Kalol.

## *8.2 Rajasthan*

Rajasthan is the most important centre of marble processing in India with about 95% of the total processing units. The important processing centres are located at Makrana, Gunawati and Borawad in Nagaur district, Udaipur, Nathdwara, Kankrauli and Rajasmund in Udaipur district; Falna in Pali district; Abu Road in Sirohi district; Jodhpur in Jodhpur district and Kishengarh in Ajmer district. A number of processing centres are located at Chittorgarh, Alwar, Bundi, Deoli, Jaipur and Banswara.

Nagaur District :- Makrana is one of the most important processing centres in India. Nearly 990 ordinary frame saws, 14 diamond saws including 7 imported and one diamond circular saw are working at present in this area. These units are spread over Makrana, Gunawati, and Borawad villages. These units saw, polish and edge cut the marble from almost all the places from Rajasthan, Gujarat and even from Narnaul in Haryana. However, the main supply of stone comes from Makrana, Gunawati and Borawad areas. The details of the 14 diamond sawing units as supplied by the Assistant Mining Engineer, Makrana, Directorate of Mines & Geology, Rajasthan, are given in Table 8.1.

## *Table-8.1*

## *Diamond Sawing Units in Makrana Area*

| Sl. No. | Name of firm | Brand name | Country from which imported | Capacity in (HP) | Cutting rate/hr |
|---|---|---|---|---|---|
| 1. | M/s Universal Marble Supply Corpn.Ltd. | Carl Mayer | West Germany | 165 | 25.40 to 30.5 cm (10 to 12") |
| 2. | M/s Sangamermer India Pvt. Ltd. | Sultan Machine Tools | Indigenous | 125 | 20.32 to 25.40 cm (8 to 10") |
| 3. | M/s Pahadia Marbles | B.R.A. | Italy | 100 | 20.32 to 25.40cm (8 to 10") |
| 4. | M/s Rajasthan Mining and Allied Industries | B.R.A. | Italy | 125 | 20.32 to 25.40cm (8 to 10") |
| 5. | M/s Marwar Mines | B.R.A. | Italy | 100 (Circular Saw) | - |
| 6. | M/s Rathod Marble Co. | N.A. | Indigenous | 90 | 15.24 to 20.32cm (6 to 8") |
| 7. | M/s Rajasthan Marble Udyog | Rajas-than Super-20 | Indigenous | 100 | 15.24 to 20.32cm (6 to 8") |
| 8. | M/s Jain Marble | B.R.A. | Italy | 115 | 20.32 to 45.40cm (8 to 10") |
| 9. | M/s Agarwal Marble Stone Co. | Rajas-than Clycor-60 | Indigenous | 150 | - |
| 10. | M/s Fine Marble and Mineral Pvt.Ltd. | Carl Mayer | West Germany | 130 | 25.40 to 30.5 cm (10 to 12") |
| 11. | M/s Manjushree Marble | Venvor-den | Belgium | 125 | 15.24 to 20.32cm (6 to 8") |
| 12. | M/s Mahaveer Marble | B.R.A. | Italy | - | 20.32 to 25.40 cm (8 to 10") |
| 13. | M/s Amrit Shila | Rajas-than Clycor-60 | Indigenous | 150 | 20.32 to 30.5 cm (8 to 12") |
| 14. | M/s Granite and Marble Industries | Shah Granite (P) Ltd. | Indigenous | 140 | 7.44 sq meter/hr (80 sq. ft./hr) |

It is learnt that M/s Manjushree Marbles, M/s Fine Marbles and Minerals, M/s ESS Enterprises, M/s Nainwa Properties and M/s Oswal Marble Works, will also be adding diamond saws shortly.

In addition to the sawing machines, several number of polishing and edge cutting machines are working at Makrana. All the edge cutting and polishing machines at Makrana are indigenous, either locally made or supplied by Indian manufacturers.

Chittorgarh District :- These units draw their marble for cutting from Rajnagar, Nathdwara, Kankrauli and other areas. The white variety comes from Amet, Rajnagar, Talaiah and Kelwa areas pink from Babermal, green from Kesariyaji, yellow stone from Jaisalmer and chacolate marble from Mangaldeo in Chittorgarh district. There are 56 sawing machines (conventional type) at Chittorgarh in operation. Two circular diamond saws are also working in Chittorgarh area. In this area, the polishing is also done by conventional wheel polishing machines.

Udaipur District :- Udaipur district has two important marble processing centres, viz., (a) Mewar Industrial Area in Udaipur city and (b) Nathdwara, Kankrauli and Rajasmund area.

Mewar Industrial Area, Udaipur :- There are altogether 33 units in operation. These also include units dealing with marble chips. Most of the sawing units have conventional saws. Some firms have got only polishing and edge cutting units. Most of the marble blocks come from the surrounding areas, i.e. Kankrauli, Rajanagar, Banswara, Keshriyaji, Bundi and Jaisamand areas (see Plate VI).

Nathdwara-Kankrauli and Rajasmund Area :- In this area there are 14 processing units at present and most of them have their captive mines for the supply of marble. There are nearly 20 frame saws in operation, besides polishing and edge cutting machines. Most of the units have frame saws supplied by M/s Rajasthan Industries. M/s Associated Stone Industries (Kotah) Limited recently started a factory at Pasoond with two imported diamond saws of Carl Mayer make, Germany.

Pali District - Falna :- In Falna, there are four processing units at present. In all eight frame saws are in operation

in this area. M/s Mineral Orientals has five frame saws, two polishing machines and two edge cutting machines. This unit draws white marble from its own mines from Rajnagar area and green marble from Rishabdes region of Udaipur district, black marble from Abu Road and Selwada area of Sirohi district. The other firm M/s Balia Marbles gets their multi coloured marble from Dujana and Khandra mines in Pali district. The other two units possess only wheel type polishing machines and some edge cutting machines.

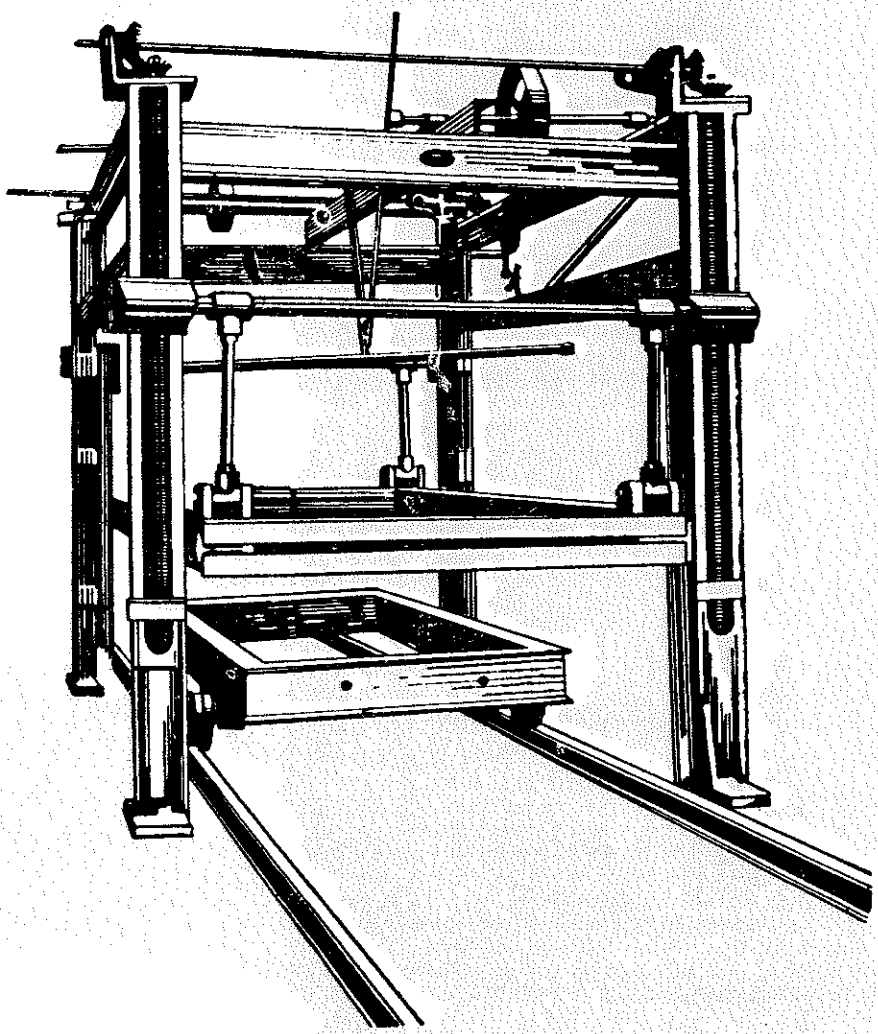
Sirohi District - Abu Road :- There are 9 marble processing units at Abu Road. But, presently, only three units are working with 10 frame saws. These units draw their marble supplied from their own mines situated in Abu Road and adjacent areas in Sirohi district and from Ambaji area of Banaskantha district of Gujarat.

Jaipur District - Jaipur :- Jaipur is one of the important centres although the number of operating units is very limited. It is learnt that three units were working in the past but at present only one is working. Three units used to get the marble from different areas of Rajasthan but mainly from Bhaisalana area in Kotputli taluka of Jaipur district. The important unit, viz. M/s Rajasthan Marble and Minerals, has four conventional saws, one polishing machine and one edge cutting machine.

Jodhpur District :- There are six processing units at Jodhpur out of which the unit belonging to M/s Rajasthan State Granite and Marble Limited, a State Government undertaking is an important one. This unit has 2 imported diamond frame saws, one automatic polishing machine and one edge cutting machine. All the machines have been supplied and erected by M/s Gregori of Italy. The RSGML is doing marble processing on contract basis. Other units have only polishing and edge cutting machines.

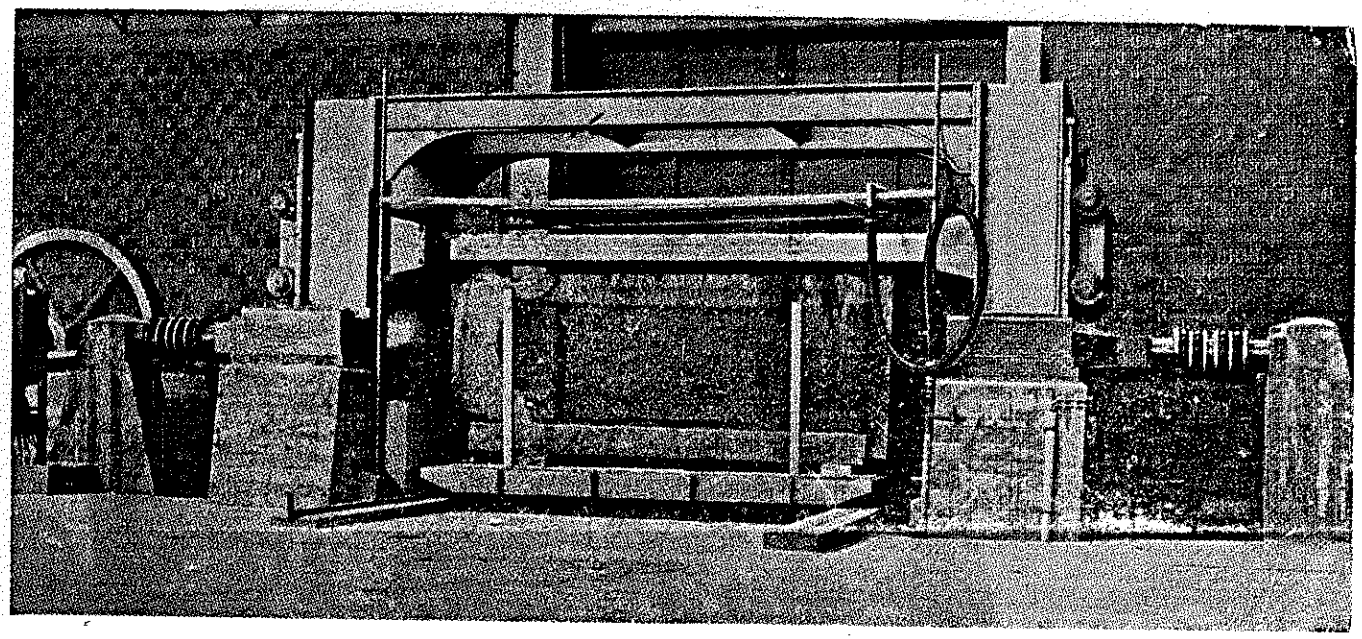
Ajmer District - Kishengarh :- It is learnt that in the past, two units had frame saws for sawing marble but at present there is no sawing. Fifteen edge cutting units are working at Kishengarh at present. These units purchase lumps of marble sized 0.30 x 0.30 x 0.30 m (1 ft x 1 ft x 1 ft)or above from all areas and size them to tiles of different sizes. Depending upon the size of the tiles, they are sold at different rates on per piece basis.

## Plate VII



**Sketch of a conventional frame saw**

*(Courtesy – M/s. Rajasthan Udyog, Jodhpur)*



A 20 blade diamond gang saw

*(Courtesy – M/s. Rajasthan Udyog, Jodhpur)*
*"Rajasthan Super 20"*

Banswara District :- There are two marble processing units at Banswara, both of conventional type. These units draw marble from Tripura Sundari and Talwara deposit.

Bhilwara District :- There is one unit each at Deoli and Bhilwara in Bhilwara district for cutting and sawing blocks. Other than these, many units are working in the preparation of chips and pouder.

## 8.3. *Haryana*

Narnaul :- Narnaul is the only marble processing centre in Haryana. The marble processing unit owned by M/s Haryana Minerals Limited has three frame sawing machines of conventional type, one polishing machine and one edge cutting machine. It gets marble from their captive mines at Antibeharipur Marble mines, 27 km from Narnaul. It also produces fancy articles from marble like ash trays, name-plates, flower vases, etc., on a commercial basis.

# 9. Manufacture of Processing Machinery in India

Today, India is almost self-sufficient in the manufacture of various types of processing machines used in the marble industry. The manufacture of both the conventional and diamond-based sophisticated processing equipment has given a strong fillip to the progress of the stone industry in the country. A number of manufacturers of processing equipment are trying hard to improve the efficiency of their equipment by incorporating the superior know-how available abroad. Serious efforts are also being made to manufacture the latest equipment indigenously by entering into technical collaboration with foreign manufacturers.

Information regarding the technical details of the various processing equipment presently being manufactured in India, as supplied by the respective manufacturers is given below:

## *9.1 Saws*

Presently, all types of saws, viz., ordinary frame saws, diamond frame saws, circular saws and wire saws are manufactured in India.

### *9.1.1 Ordinary Frame Saws*

Presently, three sizes of ordinary frame saws are available in the Indian market. A typical frame saw is shown in Plate VII. General specifications of ordinary frame saws manufactured in India are given in Table 9.1.

*Table-9.1*

*Specifications of Ordinary Frame Saws*

| Specifications | S I Z E | | |
|---|---|---|---|
| | Size I | Size II | Size III |
| 1. Size of stone | 3.05x1.52x 1.52 m (10'x5'x5') | 2.44x1.22x1.22m (8'x4'x4') | 1.83x0.91x0.91m (6'x3'x3') |
| 2. Width of cut | 165 cm (65") | 137 cm (54") | 107 cm (42") |
| 3. Height of cut | 165 cm (65") | 137 cm (54") | 107 cm (42") |
| 4. Length of cut | 320 cm (126") | 259 cm (102") | 198 cm (78") |
| 5. Max. number of Blades | 63 | 52 | 40 |
| 6. Blade carrier frame movement | 25.4 cm (10") | 27.94 cm (11") | 30.48 cm (12") |
| 7. Rapid rise of blade carrier frame | 5.08 cm or 2"/5 min | 6.35 cm or 2.5"/min | 10 cm or 4"/5 min |
| 8. Lowering control of blade carrier frame | 5.08 cm or 2"/5 min | 6.35 cm or 2.5"/5 min | 10 cm or 4"/5 min |
| 9. Main Motor Power | 20 HP | 15 HP | 10 HP |
| 10. Overall dimensions | | | |
| a) Length of Machine | 12.2 m (40') | 10.68 m (35') | 9.76 m (32') |
| b) Width of machine | 4.27 m (14') | 3.66 m (12') | 3.05 m (10') |
| c) Height of machine | 4.27 m (14') | 3.66 m (12') | 3.05 m (10') |
| 11. Net approximate weight of Machine (in kg) | 12,000 | 10,000 | 75,000 |
| 12. Net approximate weight of fly-wheel (in kg) | 1,500 | 1,200 | 900 |
| 13. Blade strokes per foot | 75 | 80 | 90 |
| 14. Minimum slab thickness | 2.22 cm (7/8") | 2.22 cm (7/8") | 2.22 cm (7/8") |
| 15. Approximate cost | Rs.85,000/- | Rs.75,000/- | Rs.65,000/- |

The specifications shown in Table 9.1 may vary slightly from manufacturer to manufacturer. In an eight hour shift the ordinary saws make a cut of about 5 to 6.34 cm (2 to 2.5 inch) depth in soft white marble or a cut of 6 to 20 mm (0.25 to 0.75 in) depth in hard marbles like black marbles of Oujana.

The following are the important producers of ordinary frame saws in India:

i) M/s Rajasthan Industries,
Behind Old Power House,
Jodhpur - 342 001

ii) M/s Arunodaya Foundries,
Guttan Bhavan, Behind Khetan Bhavan,
M.I. Road, Jaipur - 302 001

iii) M/s Vishwakarma Engineering Works,
Makrana - 341 505

iv) M/s Choudhary Engineering Works,
Makrana - 341 505

v) M/s Sree Bala Engineering Works,
Salapose Cross Road,
Near Employment Exchange Office,
Ahmedabad - 380 001

vi) M/s Krishna Industrial Corporation,
Block No.9, New Chhotalal Compounds,
Shahpur Gate, Near Gandhi Bridge,
Ahmedabad - 380 001

### 9.1.2 *Diamond Frame Saws*

The diamond frame saws are in great demand now a days because of their high speed and the capacity to produce a very smooth and even surface. Thus, though the initial cost of diamond frame saws is rather high, they are preferred for their superior efficiency. Presently, the diamond frame saws are manufactured by the following two manufacturers in Rajasthan:

i) M/s Rajasthan Udyog,
13, Heavy Industrial Area,
Jodhpur - 342 003

ii) M/s Arunodaya Foundries,
Guttan Bhavan, Behind Khetan Bhavan,
M.I.Road, Jaipur - 302 001

M/s Rajasthan Udyog, Jodhpur has developed two models of diamond frame saws namely "Rajasthan Clycor-60" and "Rajasthan Super-20". The "Rajasthan Clycor-60" has 60 diamond-impregnated saw blades whereas the Rajasthan Super- has 20 diamond-impregnated saw blades.(see Plates VIII and Ix). The diamond frame saw manufactured by M/s Arunodaya Foundries is suitable to operate with 50 such blades(see Plates VIII and IX). The specifications of these three saws are given in Table 9.2.

*9.1.3 Circular Saws*

Diamond impregnated circular saws are manufactured in India by the following manufacturers:

i) M/s Rajasthan Udyog,
13, Heavy Industrial Area,
Jodhpur - 342 003

ii) M/s Shah Granites,
Karamchand Mansion,
Barrack Road, Behind Metro Cinema,
Bombay - 440 020

The circular saws have an advantage over frame or wire saw as the slabs obtained by using the circular saw are in level within an accuracy of 1 to 15 mm over a slab of 3 m x 90 cm and the sawn surface is exceptionally smooth and flat and thus requiring very little polish in the subsequent processing. It is possible to saw slabs of varying thickness ranging from 12 mm to 200 mm with this machine.

The circular saw SLM-II manufactured by M/s Shah Granites weighs about 20 tonnes and covers an area of 6 x 6 m with a total power requirement of 110 HP. The size of the cutting blade is 137.0 cm (54 in). The blocks are sawn not vertically but horizontally. One half of the block is sawn from one side and the other half from the opposite side. Thus, this system enables the use of smaller circular saws for sawing comparatively large blocks.

*Table-9.2*

*Technical Specifications of Diamond Frame Saws*

| Sl. No. | Specifications | M O D E L | | |
|---|---|---|---|---|
| | | Rajasthan Super-20 | Rajasthan Clycor-60 | Arunodaya Foundries |
| 1 | 2 | 3 | 4 | 5 |
| 1. | Description | Type 160 T/270 | - | - |
| 2. | Max. tension of blades | 160 tons | 480 tons | 400 tons |
| 3. | Max. No. of blades | 20 blades | 60 blades | 50 blades |
| 4. | Max. block length | 2.7 m | 3000 mm (3.0m) | 2.4 m |
| 5. | Max. block height | 1.7 m | 1.8 m | 1.2 m |
| | width | unlimited | 1.65 m | 1.2 m |
| 6. | Dimension of saw car | 2.60 x 1.90 m (length of rail 5.5 m) | 3.0 x 1.75 m (length of rail 6 m) | 2.7 x 1.4 m |
| 7. | Span | 850 mm | - | - |
| 8. | Stroke length (Number of strokes per minute) | 32 cm (80/min) | 54 cm (100/min) | Approx. 100/min |
| 9. | Minimum slab thickness with machine in standard execution | 20 mm | 20 mm | 20 mm |
| 10. | Weight of machine | about 12500 kg | 25000 kg | 25000 kg |
| 11. | Main motor | 40 HP | 110 kw (150 HP) | 100 HP |
| 12. | Motor rise and fall | 5.5 kw (7.5 HP) | 7.5 kw(10 HP) | - |
| 13. | Number of buffers | 4 | - | - |
| 14. | Normal tension of buffers | atmospheres | - | - |
| 15. | Water consumption | 7 litres/ blade/min | 7 litres/blade/ min | 400 litres/ 2.5 cm |

ii) M/s Arunodaya Foundries,
Guttan Bhavan, Behind Khetan Bhavan,
M.I.Road, Jaipur - 302 001

M/s Rajasthan Udyog, Jodhpur has developed two models of diamond frame saws namely "Rajasthan Clycor-60" and "Rajasthan Super-20". The "Rajasthan Clycor-60" has 60 diamond-impregnated saw blades whereas the Rajasthan Super-has 20 diamond-impregnated saw blades.(see Plates VIII and IX). The diamond frame saw manufactured by M/s Arunodaya Foundries is suitable to operate with 50 such blades(see Plates VIII and IX). The specifications of these three saws are given in Table 9.2.

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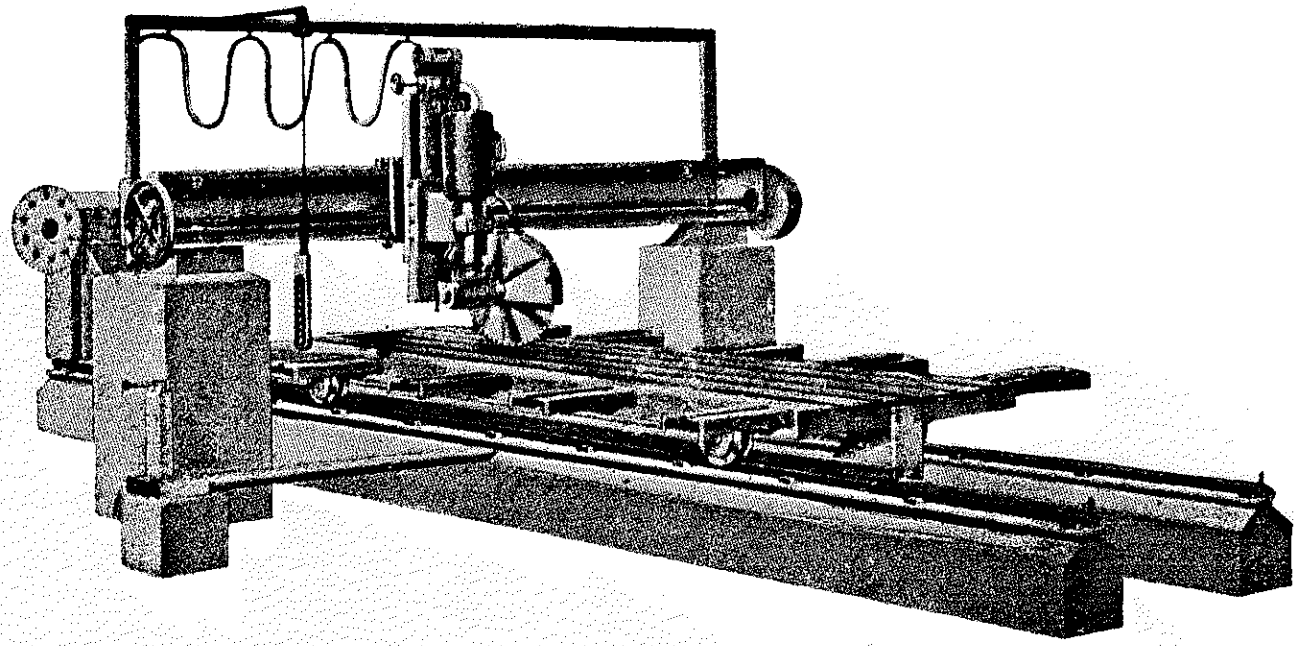
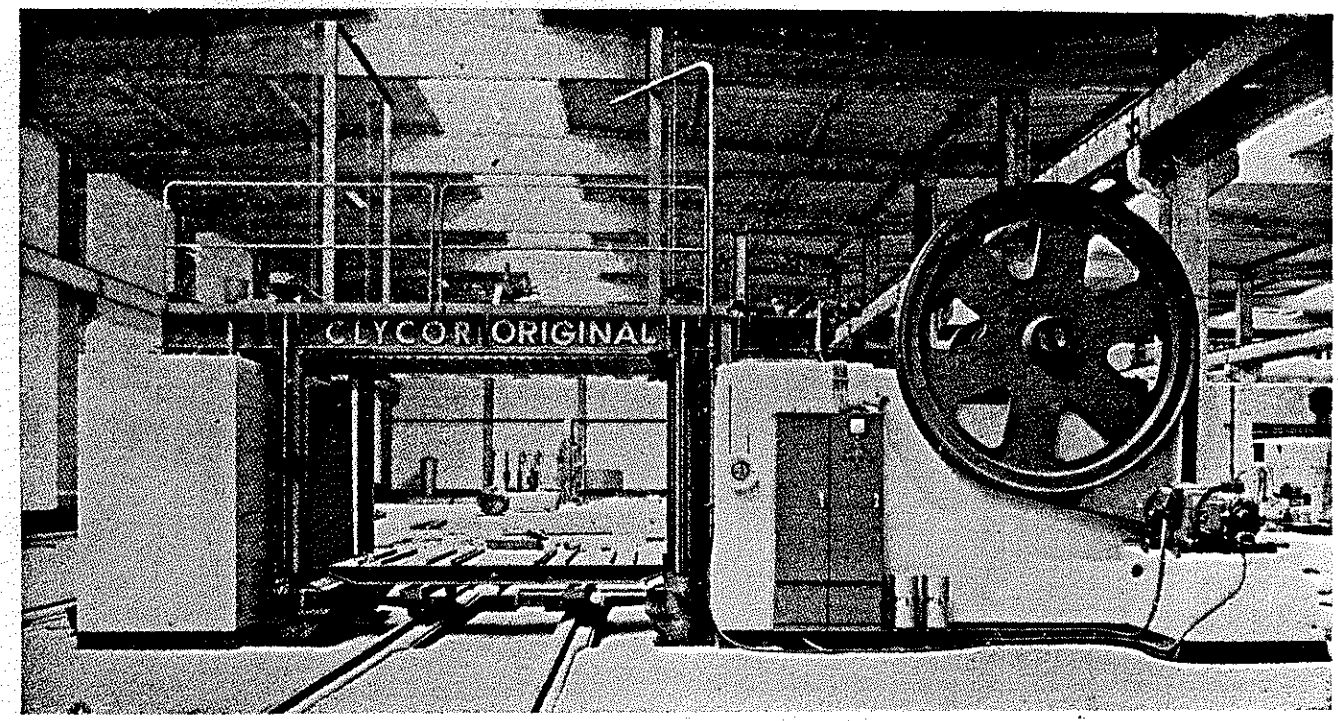
The circular saw SLM-II manufactured by M/s Shah Granites weighs about 20 tonnes and covers an area of 6 x 6 m with a total power requirement of 110 HP. The size of the cutting blade is 137.0 cm (54 in). The blocks are sawn not vertically but horizontally. One half of the block is sawn from one side and the other half from the opposite side. Thus, this system enables the use of smaller circular saws for sawing comparatively large blocks.



Circular sawing and sizing machine

*(Courtesy – M/s. Rajasthan Udyog, Jodhpur)*
*"Rajasthan Portick-1"*




A 60 blade diamond gang saw

*(Courtesy – M/s. Rajasthan Udyog, Jodhpur)*
*"Rajasthan Clycor–60"*

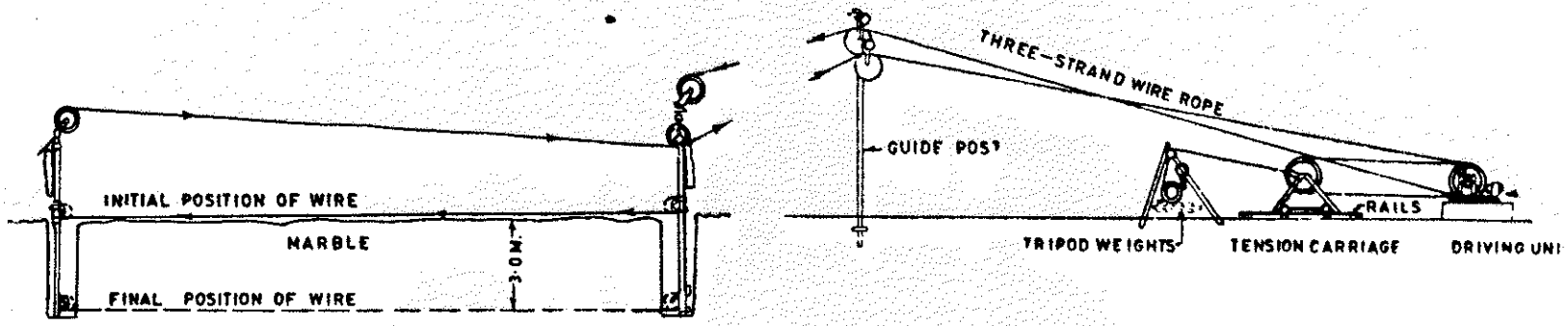
Plate IX

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 31. | Total cost of machine | Rs.8,20,000/- | Rs.17,00,000/- | Rs.8,50,000/- (includes a set extra saw car) |
| 32. | Cost of Diamond Segmented blades | 20 blades set<br>a. (suitable for 2.7 m block) Rs. 1,42,000 /-<br>b. (Suitable for 3.2 m block length) Rs. 1,50,000 /- | One set of 60 blade suitable for 3 m block Rs 4,50,000 /- | 50 blades sets Rs. 2,50,000 /- |
| 33. | Saw car (extra set) | a. Suitable for a block length of 2.70 m : Rs. 22,000/-<br>b. Suitable for a block length of 3.20 m : Rs.25,000/- | Rs.40,000/- | - |

NOTE : The information is compiled from the published catalogues of the respective manufacturers.

....

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 16. | Machine measurement | L : 11485 mm<br>H : 3200 mm<br>W : 4000 m (only machine width) | L : 11055 mm<br>H : 5525 mm (Full)<br>W : 4600 mm (Full width) | L : 2700 mm<br>W : 1400 mm<br>H : 1400 mm |
| 17. | Useful cutting width | - | 1.60 mm (platform girder) | - |
| 18. | Sawing speed | - | 5-70 cm/hr | - |
| 19. | Stroke length | 320 mm | 540 mm | - |
| 20. | Rotation speed of shaft | - | Approx.100/min | - |
| 21. | Maximum distance between girder | - | 1.75 m | - |
| 22. | Water pump HP | - | - | 5 HP |
| 23. | Run of blades | - | - | Approx. 500/min. |
| 24. | Lubrication | - | - | Centralised |
| 25. | Space requirement | 11.5x6.3x3.2 m | 11.5x4.6x5.6 m | 13.5x4.5x 6.0 m |
| 26. | Electric motor for up and down movement | - | - | 10 HP |
| 27. | Spacers | 1 set for slab thickness 2 cm | 1 set for slab thickness of 2 cm | 50 sets for slab thickness of 20mm |
| 28. | Vertical cut rate of each machine/hr | 20.32 to 25.4 cm or 8" to 10"/hr | 25.4 to 30.50 cm or 10" to 12"/hr | 15.24 cm or 6"/hr |
| 29. | Tensioning device | Hydraulic | Hydraulic | Mechanical system |
| 30. | Electrification | 380 V 50 cycle/ sec | 380 V-50 cycle/ sec | |




A wire saw set up for cutting marble

## Plate XI

A circular grinding and polishing machine

*(Courtesy – M/s. Umamaheswara Slab Polishing Industries, Macherla, A.P.)*

*Table 9.3*

*Specifications/Details of Polishing Machines*

| Sl. No. | Specifications and other details | M/s Rajasthan Industries, Jodhpur | M/s Krishna Industrial Corporation, Ahmedabad | M/s Shree Bala Engineering Works, Ahmedabad | M/s Vishwa Karma Engineering Works, Makrana | M/s New National Engineering Works, Bombay |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1. | Model | Wall mounted polishing machine | Krishna heavy duty marble and stone polishing machine | 'Bala' Marble Granite Polishing Machine | 'Vishwakarma Model' | Marble Polishing Machine |
| 2. | Area that can be ground | 1.25 x 2.5 m | 2.4 x 1.2m (8' x 4') | 2.4 x 1.2m (8' x 4') | 2.4 x 1.2m (8' x 4') | 2.13 x 1.2m (7' x 4') |
| 3. | Spindle Speed | 700 RPM | 600 RPM | 450 RPM | - | 600 RPM |
| 4. | Approx. capacity in 8 hrs | 10 to 15 sq m | 9.3 to 11.63 sq. m (100 to 125 sq ft) | - | 9.3 sq m (100 sq ft) | |
| 5. | Weight of machine | 750 kg | - | - | - | - |
| 6. | Space required | - | 4m x 3m (120 sq ft) | - | This model is same as that of M/s Rajasthan Industries, Jodhpur. | - |
| 7. | Horse Power required | 5 HP (440 volts 3 Phase A.C.) | 3 HP | 3 HP (1440 RPM 50 c/s Motor) | | 4 to 5 HP |
| 8. | No.of polishing heads | - | 4 | - | - | - |

It is stated that the production capacity of this machine is 7.45 sq meter (80 sq ft) per hour and the blades have a life of 307.0 sq meters (33,000 sq ft). The cost of the whole unit is about ten lakh rupees.

The circular saw machine manufactured by M/s Rajasthan Udyog is known as "Rajasthan Portick-1". It works with a 20 HP motor and with a maximum saw diameter of 72.5 cm. The sawing depth, length and width are 27.2 cm, 3.50 m, and 2.10 m, respectively. The saw head is rotatable at 90° and hand operated, for sawing in the longitudinal and transverse directions. The rise and fall also works in mitre position so that the mitre (angular cutting) of harder material in steps is also possible (see Plate X).

### *9.1.4 Wire Saw*

M/s Sultan Machine Tools, Delhi manufactures wire saw machine. High-carbon helicoidal wire is used for cutting. The wire saw can cut 60 cm/hr.

## *9.2 Polishing Machines*

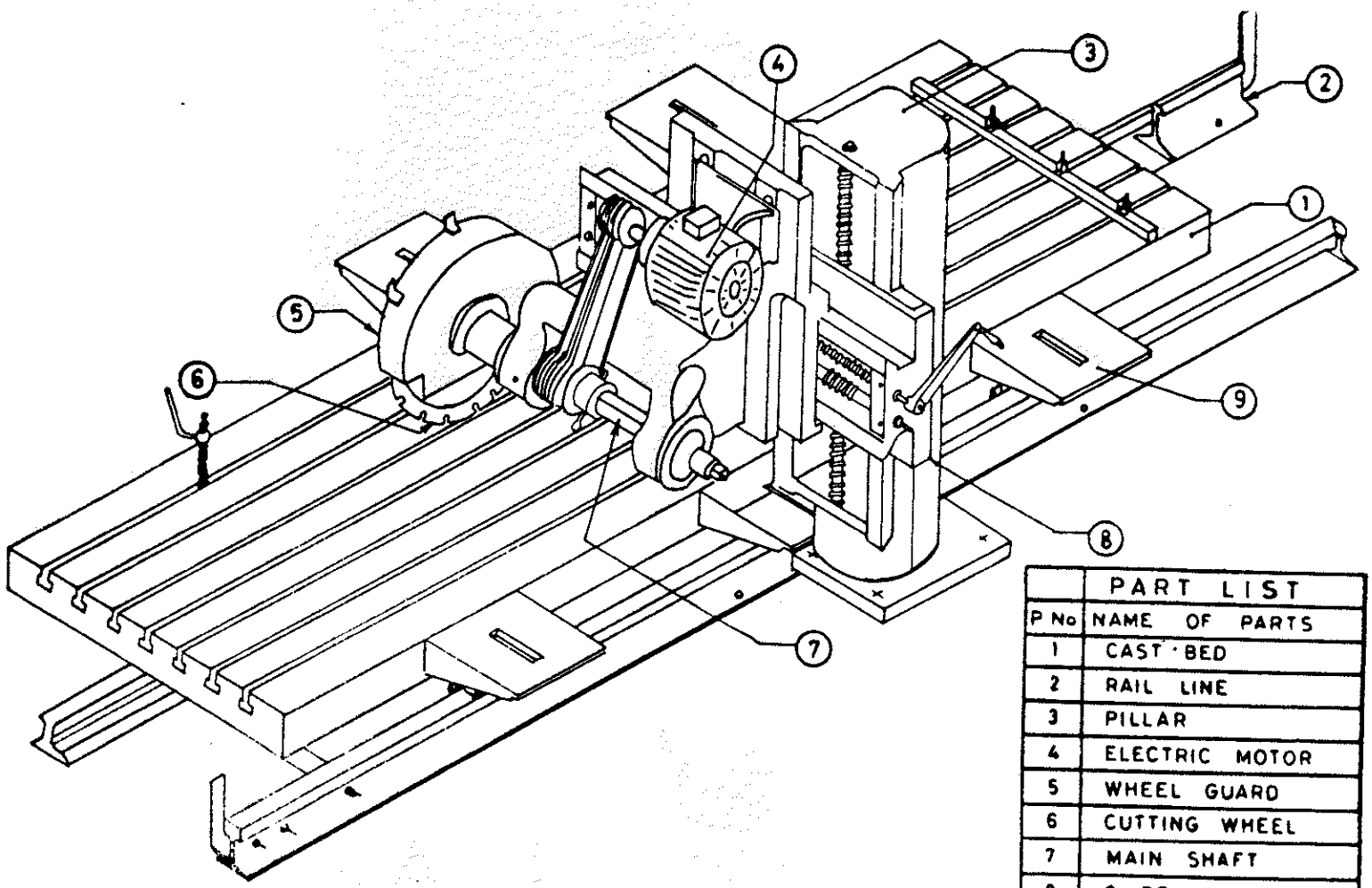
Two types of polishing machines are manufactured in India, namely, hand polishing machines and automatic polishing machines.

### *9.2.1 Hand Polishing Machines*

These are pillar mounted machines with two swivel arms having a screw arrangement to take stones of different thicknesses. The swivel arms run on heavy roller and thrust bearings housed in accurately bored seatings to ensure that the axes are absolutely parallel which is essential for smooth swivel movement while in operation (see Plate XIII). These machines are generally designed to polish 2.44 x 1.22 m (8 ft x 4 ft) slabs and they work on a 3 to 5 HP motor. Some important manufacturers are :-

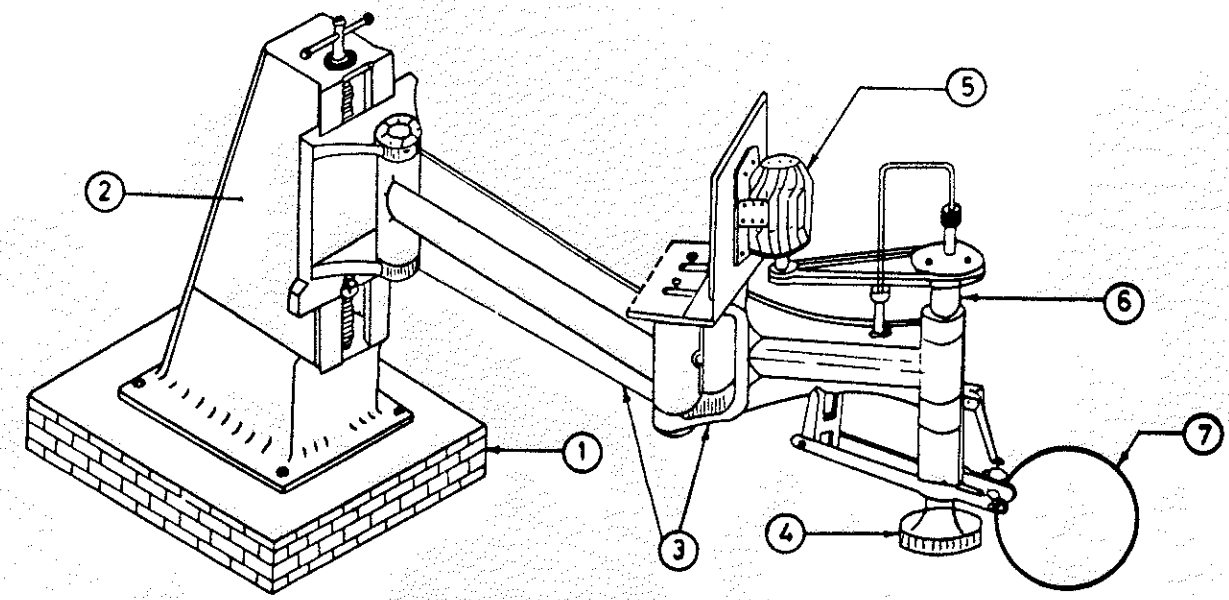
i) M/s Rajasthan Industries, Jodhpur.
ii) M/s Krishna Industrial Corporation, Ahmedabad.
iii) M/s Shree Bala Engineering Works, Ahmedabad.
iv) M/s Vishwa Karma Engineering Works, Makrana.
v) M/s Arunodaya Foundries, Jaipur.
vi) M/s Choudhary Engineering Works, Makrana.
vii) M/s AbdulHakim Hussain Bux, Makrana.

The technical details and specifications of some of the polishing machines are given in Table 9.3.




| | PART LIST |
|---|---|
| P No | NAME OF PARTS |
| 1 | CAST BED |
| 2 | RAIL LINE |
| 3 | PILLAR |
| 4 | ELECTRIC MOTOR |
| 5 | WHEEL GUARD |
| 6 | CUTTING WHEEL |
| 7 | MAIN SHAFT |
| 8 | SLIDE |
| 9 | BRACKET |

An edge cutting machine




| | PART LIST |
|---|---|
| P No | NAME OF PARTS |
| 1 | FOUNDATION |
| 2 | STAND |
| 3 | SWIVELLING-ARMS |
| 4 | GRINDING WHEEL |
| 5 | ELECTRIC MOTOR |
| 6 | SPINDLE |
| 7 | HANDLE |

A table polishing machine

### *9.2.2 Automatic Polishing Machine*

M/s Rajasthan Udyog, Jodhpur manufactures an automatic polishing machine known as "Rajasthan Uranus". This is a completely automatic and programmable machine for grinding and polishing for the slabs of following dimensions:

Thickness : Minimum 15 mm
Length : Maximum 3.80 m
Width : Minimum 2.00 m

Presently, M/s Rajasthan Udyog manufactures this machine in three different models. Model SM-1K-200-1T is useful for marble, model SG-1K-200-1T for granite and model SMG-1K-200-1T for marble and granite. The salient features of these three models are given in Table 9.4.

## *9.3 Edge Cutting Machines*

Conventional type edge cutting machines and automatic edge cutting machines are manufactured in India.

### *9.3.1 Conventional Edge Cutting Machines*

The conventional type edge cutting machines are manufactured in India by the following firms :

i) M/s Rajasthan Industries, Jodhpur
ii) M/s Sree Krishna Industrial Corporation, Ahmedabad
iii) M/s Shree Bala Engineering Works, Ahmedabad
iv) M/s New National Engineering Industries, Bombay
v) M/s Vishwakarma Engineering Works, Makrana
vi) M/s Chowdhary Engineering Works, Makrana
vii) M/s Abul Hakim Hussain Bux, Makrana
viii) M/s Arunodaya Foundries, Jaipur
ix) M/s B.M. Gandhi & Co., Ahmedabad

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 9. | Size of polishing heads | - | 300 mm (dia) | 250 mm (dia) | - | - |
| 10. | Length of adjusting swivel arm | - | 970 mm | 1100 mm | - | 81.28 cm (2' 8") |
| 11. | Polishing arm | - | 750 mm | 1000 mm | - | 81.28 cm (2' 8") |
| 12. | Vertical slide adjustment | - | 150 mm | - | - | 15.24 cm (6") |
| 13. | Length of vertical slide | - | 600 mm | 750 mm | - | 60.96 cm (2') |
| 14. | Diameter of polishing wheel | 40.64 cm (16") dia | - | - | - | - |
| 15. | Cost of the machine | Rs.15,000/- | Rs.12,980/- | Rs.10,500/- | Rs.8,000/- | Rs.7,000/- |

NOTE : Information compiled from the published catalogues of respective manufacturers.

A typical edge cutting machine is shown in Plate XIV. The technical specifications and other details of some of the edge cutting machines are given in Table 9.5.

### 9.3.2 *Automatic Edge Cutting Machines*

Presently automatic edge cutting machines are manufactured in India by the following two firms.

i) M/s Rajasthan Udyog, Jodhpur

ii) M/s Shah Granites Pvt. Ltd., Bombay

The details of "Rajasthan Portick-I" a circular saw, which is also used for edge cutting have been given in para 9.1.4 (Plate X).

M/s Shah Granites Pvt. Ltd., Bombay manufactures two models of automatic edge cutting machines, namely ECM-I and ECM-II.

ECM-I with a slab carrying capacity of 2.4 m x 1.2 m x 25 cm consists of two platforms which can be independently and automatically raised or lowered to any desired height. The main cutter is mounted on a saddle which in turn slides on a beam by means of a D.C. motor and electromagnetic clutches to give a smooth stepless speed variation. The beam itself, alongwith the cutter can again be transported on rails. This machine is extremely useful for accurate edge cutting of slabs up to 2.4 m x 1.2 m and up to 25 cm thick. The platforms supporting the slabs can be adjusted to cut slabs at either $30^{0}$, $45^{0}$, or $60^{0}$ angles as desired. The cutting head can be adjusted for mitre cutting of the edges from zero to $90^{0}$. The machine is provided with all necessary electrical equipment on a well designed electric panel to provide easy and ready accessibility to the operator. The production capacity of this machine is about 40 to 50 sq. meters of granite slabs (of 20 mm thickness) in a shift of 8 hrs. The production capacity may vary depending on the sizes of the slabs to be edge cut and the hardness of stone. The main spindle of the machine, made of heat treated nickel chrome steel is driven by a 10 HP motor. Longitudinal and transverse motions are given by 2 HP D.C. motors and the raising and lowering motions of platform are effected by two 2 HP A.C. motors.

*Table 9.4*

*Salient Features of "Rajasthan Uranus" Automatic Grinding/Polishing Machine*

| Details | MODEL | | |
|---|---|---|---|
| | 1.SM-1K-200-1T for marble | 2.SG-1K-200-1T for granite | 3.SMG-1K-200-1T for marble+granite |
| Main motor | 15 KW (20HP) | 18 KW (25 HP) | 18/11/ KW (25/15HP) |
| Number of revolutions (main spindle) | 550 r.p.m. | 360 r.p.m. | 420/275 r.p.m. |
| Plates | 7 plates | Planetary head with 6 sets of plates dia. 13 cm and 1 plate dia. 35 cm for felt. | Planetary head and plates of both executions, for marble and granite. |
| Workable width | Max. 2.00 m | | |
| Workable length | 3.50 m | | |
| Bridge rails length | 5.00 m | | |
| Polishing movements | Both the bridge and the support are moved electro-mechanically by means of short circuited motors of 0.75 and 1.5 KW respectively with a speed of 6 m/min. | | |
| Rise and fall | The main spindle has a rise and fall of 30 cm by means of a short circuited motor 0.55 KW with which also the regulable pressure on the plate is exerted. | | |
| Polishing Table | Concrete table 3.50 x 1.20 m (to be cast by buyer) | | |
| Electrification | The machine is wired completely and has three automatic programmes and one semi-automatic control. All electro-mechanic movements are secured by means of end-switches.<br><br>The machine is supplied with electric motors, starters and suitable control panel. | | |

| Models | Price |
|---|---|
| 1. SM - 1 K - 200 - 1T - Type 3 SB 1-1 | Rs.2,50,000/- |
| 2. SG - 1 K - 200 - 1T - Type 2 SB 1-4 | Rs.2,75,000/- |
| 3. SMG- 1 K - 200 - 1T - Type 3 SB 1-7 | Rs.3,00,000/- |

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 11. | Maximum size of the marble cut | 1.25 x 2.5 m | - | 2400 x 1200 m (8' x 4') | 2.13 x 1.52 m (7' x 5') |
| 12. | Approx. capacity in 8 hr. | 10 to 15 | - | - | - |
| 13. | Weight of machine | 750 kg | - | - | - |
| 14. | Diameter of Carbon steel cutter | - | 35.56 cm or 14" (diamond wheel) | 35.56 cm or 14" (carbon steel) | 0 to 30.48 cm (0-12") (carborandum) |
| 15. | Length of Rails | - | - | - | 4.27 m (14'-0 ) |
| 16. | Cost of the machine | Rs.30,000/- | Rs.21,500/- | Rs.15,500/- | Rs.13,500/- |
| 17. | Cost of diamond wheel | - | Rs. 3,200/- | - | - |

Note :Information compiled from published catalogues of respective manufacturers.

*Table 9.5*

*Technical Specifications of Edge Cutting Machines*

| Sl. No. | Specifications | M/s Rajasthan Industries, Jodhpur | M/s Krishna Industrial Corporation, Ahmedabad | M/s Shree Bala Engineering Works, Ahmedabad | New National Engineering Works, Bombay |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1. | Length of vertical slide | - | 600 mm | - | 61 cm or 2" |
| 2. | Adjustment of vertical slide | - | 200 mm | 540 mm | 0 to 25.4 cm or 0-10" |
| 3. | Length of horizontal slide | - | 750 mm | 30 mm | 5.4 to 20.32 cm or 2" - 8" |
| 4. | Adjustment of horizontal slide | - | 250 mm either side | 30 mm either side | 2.5 to 10.0cm or 1" - 4" |
| 5. | Angular adjustment of swivel bracket | - | $45^{\circ}$ side | $45^{\circ}$ side | |
| 6. | Size of Trolley | - | 2400 x 750 mm (8' x 2½') | 2100 x 900 mm (7' x 3') | 234 x 66 cm (7'-8" x 2' -2") |
| 7. | Horse power required | 5 HP | 7.5 to 10 Hp | 7.5 HP | 7.5 HP |
| 8. | RPM of blade | 700 RPM | 1500 to 2400 | 2800 or 1400 RPM | 2000 RPM |
| 9. | RPM of Motor | - | 1440 | 1440 | 1440 |
| 10. | Space required for machine | - | 6 x 3 m (200 sq ft) | - | - |

# 10. Marble Industry-Problems and Prospects

The Indian marble industry has not yet reached the optimum rate of growth as it is beset with a number of problems. Some problems as put forward by the representatives of marble industry are given below.

## *10.1 Problems*

Inherent Problems of Marble Occurrence :- The nature of the marble band decides its suitability for end use and hence its ultimate value[8]. The quality of a marble band is not uniform and often changes in adjacent bands or from layer to layer. Thus,it becomes very difficult for a mineowner to plan for systematic production of marble of a particular quality. In places like Dujana, Khandra and Pali, marble bands having beautiful colours and decorative patterns are often infected with cracks, fissures, quartz grains, or rust markings. In Makrana mines, it is common experience to have a white fine-grained statuary marble band of 2 m width adjacent to a coarse grained low quality band of equal thickness.

Many a times, the marble contains flaws which are not apparent until it has been installed and exposed to weather. Physical deterioration in the form of loss of strength or discoloration occurs causing damage to the reputation of the producer and all the expenditure incurred in mining, processing and installation of such marble sometimes goes to waste.

Forest Areas :- Many deposits of good marble are located in forest areas. According to the Forest Conservation and Development Act, 1981, a forest cannot be utilised for any purpose except for its development. Powers to grant permission for utilising forest areas for other purposes vest with the Central Government from which the State Government has to obtain permission before releasing any forest land for marble mining. Thus, marble deposits located in forest areas can be worked only after obtaining permission from all the concerned authorities.

Transport and Accessibility :- Deposits of good quality marble are often located in remote places. The development of such deposits and their marketability necessitates proper accessibility. Availability of link roads is a prerequisite for the

ECM-II edge cutting machine is a lighter machine compared to ECM-I. In this machine the beam is stationary and the slide has a simple longitudinal motion imparted by means of a 2 HP D.C. motor for variable speed control. The slab can be cut on all the four sides by cutting one edge at a time and shifting of the slab by $90^{\circ}$ before cutting the other edge until all the four edges are cut. It is basically a simple machine meant for the light cutting of strips and slabs of granite and marble of thickness of 20 mm. However, by means of raising and lowering the slide a thickness of up to 100 mm can be cut. The main spindle, made of alloy steel, is driven by a 7.5 HP motor. The machine weighing about two tonnes has a capacity to cut about 10 $m^2$ of granite of the thickness of 20 mm per shift of 8 hrs.

Diamond Wheels :- M/s Veenedyt, Bombay manufactures various types of diamond-impregnated wheels used in special profiling machines.

are not readily available. Some of the processing units have started manufacturing their own grinding wheels but it is a very cumbersome and time-consuming process.

Power :- Power supply is a very critical problem facing the marble industry. The marble industry requires a continuous supply of power without any voltage fluctuations. Voltage fluctuation results in uneven sawing and processing. Repeated power cuts in addition obstruct the proper development of the marble industry.

Competition from other sources of building material like glass, stainless steel, porcelain - enamelled steel and reconstituted stones also affect the growth of the marble industry.

Environmental Problems :- Environmental problems facing the industry are mainly in the form of general unsightliness, contamination of local streams and rivers and high noise levels. Unsightliness can be hidden or kept away from the general public by the skillful use of artificial or natural screens. Contamination of water courses can be avoided by the use of efficient methods of mining and processing and by taking care to avoid the mixing of dump or waste material with the nearby water courses. Noise levels too can be reduced by using efficient mining methods and equipment. De Beers Industrial Diamond Research Laboratory, Johannesburg, has developed a new circular diamond saw which has the noise level falling in the acceptable limits for human beings[29].

## *10.2 Prospects*

The US Bureau of Mines forecast for the dimension stone industry during the period 1976-2000 envisages that, by 2000 A.D., the demand for dimension stone in the rest of the world would fall in the range 1.0 to 1.3 billion tonnes[30]. Marble being one of the most attractive stones, has a very bright role to play in the dimension stone industry and the Indian marble industry can certainly have a good share in it for its products. Modern production techniques based on diamond tooling have greatly increased the production and correspondingly reduced the cost. Diamond tools provide faster cutting rates, eliminate costly post-cutting operations and enable the stone mason to achieve levels of accuracy never imagined before.

establishment of marble industry. Unlike other mineral industries, the marble industry is faced with special problems of transport because of the heavy blocks of marble requiring to be carried over for long distances. Moreover, in most of the cases, the centres of production are far away from the centres of utilisation.

Shortage of Skilled Workers :- Despite mechanisation that is gradually entering the marble industry, much human effort and care goes into quarrying, shaping and transport of marble blocks. This requires skilled workers to attend to the various activities of production and processing. Any small mistake in handling the delicate raw or finished block may result in the loss of many man hours of skilled labour. Presently the marble industry is facing a great shortage of skilled workers.

Problems of Overburden and Waste Dumping :- Most of the quarries in Rajasthan are limited in extent being mostly of 60 x 100 to 200 x 100 m size. Thus, they have no spare area for dumping waste and overburden. Because of the limited extent the lessees often find it difficult if not impossible to develop their properties systematically.

Problems of Processing Units :- Problems of processing units are mostly related to the non-availability of marble of good and consistent quality, machinery, polishing bricks and power.

On account of poor quality a lot of marble goes waste after processing. The presence of joints, flaws and impurities reduces the percentage of overall recovery to a very low level. Moreover, the cost of processing hard marbles of low quality is quite high.

In India, mostly the conventional machines in the form of frame saws and table polishing machines are used. These machines are very slow in operation compared to the diamond tooled machines. The conventional machine cannot give a superior finish which can be easily obtained by deploying diamond based machines. However, the cost of diamond tooled machines is often beyond the financial resources of many small lease holders.

Shortage of Polishing Disc :- Many polishing units find it difficult to procure the polishing bricks and discs as they

of waste utilisation should be identified to derive the maximum benefit of the available resources and also improve simultaneously the profitability of the industry itself. The generation of waste material should be minimised by resorting to efficient mining practices and proper equipment. One such use of mining waste in the form of left out blocks and chips is as crushed stones in Terrazzo tiles.

Substitute raw materials in the form of synthetic rocks are being developed to compete with natural marble. These compete with natural marble in the aesthetic quality, dignity and performance. The manufacture of reconstituted marble in the form of conglomerate marble is the latest effort towards the conservation and substitution of natural marble blocks. Reconstituted marbles are made abroad from marble chip obtained from Carrara, Alps, Germany etc. A reconstituted marble known as "Quil Albelia" is being manufactured by A. Quil Gotti & Co. Cheshire, U.K.[32]. Experiments have shown that reconstituted marble has many advantages over the Terrazzo tile, which has an unavoidable minimum thickness of around 2.5 or 4.0 cm. The new material can be sliced on a diamond bladed saw into much thinner tiles. Moreover, in its resin bonded form the new material is much resistant to the attack of atmospheric pollution and to the effects of climatic changes. It has been proved that reconstituted marble has less porosity and greater crack resistance than the solid marble.

Indian marble industry would do well to initiate work in producing reconstituted marble which will conserve natural marble and also provide an outlet for the waste generated in the marble processing industry.

Role of Government Agencies in India :- Systematic prospecting and exploration of a marble deposit can certainly provide a very detailed picture of the marble available for exploitation. This can avoid a lot of unnecessary expenditure caused by insufficient information about the deposit. Services of competent geologists are now available through a number of State Government agencies for this purpose. Many State Government agencies like the Directorate of Mines & Geology, Government of Rajasthan and also the Government of Gujarat have embarked on detailed exploration programmes for the evaluation of their marble deposits.

Other Facilities :- The Gujarat Industrial Investment Corporation, a Public Sector Undertaking of Government of Gujarat, has established marble estate for helping the marble industry. The Gujarat Industrial Development Corporation is financing the entrepreneurs for the development of small scale industries based on marble. Plots of land are offered at moderate interest rates and under an easy hire purchase scheme. The GIDC has developed the infrastructural facilities in the form of housing, godown, canteen, communications, stamp duty exemptions, lease deed on 25 per cent down payment etc. For the marble industry of Ambaji area, cash subsidy equivalent to 15 per cent of fixed assets or 25 lakhs whichever is less is available[31]. Sales Tax exemption is also offered on the articles produced.

In Rajasthan, the Government has a programme of building the approach roads. It also gives the mining equipment on nominal rent. There are schemes to provide loan facilities to weaker sections. The State Directorate of Mines & Geology also undertakes prospecting work at nominal charges.

## *10.3 Challenges for the Marble Industry*

Though much is being done by the Government for the development of the marble industry, a lot of challenges will have to be met by the marble industry itself. Some of the points which may help in solving the problems of the marble industry and which can also broaden its avenues are briefly dealt with below:

Substitution and Conservation :- Much marble is wasted during mining and processing. Though sufficient resources of marble are known to be available in the country, the wastage of this national asset has to be stopped. Alternative sources

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ANNEXURE-I (Contd.)

6) IS : 1126 - 1974

Method of test for determination of durability of natural building stones (First Revision)

Lays down procedure for testing the durability (soundness) of natural building stones by using sodium sulphate decahydrate.

7) IS : 1127 - 1970

Recommendations for dimensions and workmanship of natural building stones for masonary work (First Revision)

Lays down recommendations for dimensions and the minimum requirements of workmanship for natural building stones used for masonry work.

8) IS : 1128 - 1974

Limestone (Slab and Tiles) (First Revision)

Lays down requirements for dimensions, moisture, absorption, transverse strength, crushing strength and durability, and the minimum requirements of workmanship for limestone slabs for use in flooring and facing work.

9) IS : 1129 - 1974

Specification for Dressing of natural building stone

Lays down recommendations for requirement of various types of hand dressing of natural building stones.

10) IS : 1130 - 1969

Lays down requirements for dimensions and physical properties (water absorption, specific gravity and hardness) and workmanship for marble (blocks, slabs and tiles) used for flooring, facing, etc.

11) IS : 1706 - 1972

Method for determination of resistance to wear by abrasion of natural building stones (First Revision)

ANNEXURE-I

## Indian Standard Specifications of Building Stones

1) IS : 1121

Methods of test for determination of strength properties of natural building stones.

IS : 1121 (Part-I) 1974

Compressive strength (First Revision)

IS : 1121 (Part-III) - 1974

Transverse strength (First Revision)

IS : 1121 (Part-III) 1974

Tensile strength (First Revision)

IS : 1121 (Part-IV) - 1974

Shear strength (First Revision)

2) IS : 1122 - 1974

Methods of test for determination of true specific gravity of natural building stones (First Revision)

3) IS : 1123 - 1975

Methods of identification of natural building stones (First Revision)

4) IS : 1124 - 1974

Methods of test for determination of water absorption, apparent specific gravities and porosity of natural building stones (First Revision)

5) IS : 1125 - 1974

Methods of test for determination of weathering of natural building stones. Lays down procedure for testing natural building stones for effects of weather. Suitable apparatus for conducting these tests duly illustrated by a figure has been described.

ANNEXURE-II

## ASTM Specifications of Building Stones

| | |
|---|---|
| ASTM C 119-50, 1958 | Standard Definitions of Terms Relating to Natural Building Stones. |
| C 97-47 | Absorption and Bulk Specific Gravity |
| C 99-52 | Modulus of Rupture |
| C 131-55 | Abrasion Resistance |
| C 170-50 | Compressive Strength |
| C 217-58 | Weather (Acid) Resistance of Natural Slate. |
| C 218-48 T | Combined effect of Temp cycles and wash salt solutions on natural building stone. |
| C 241-51 | Abrasion Resistance of stone Subjected to Foot Traffic. |
| C 503-62 (R 64) | Exterior Marbles. |

12) IS : 1805 - 1973

Glossary of terms relating to stones : Quarrying and dressing (First Revision)
Describes terms relating to stone (used for construction purposes) quarrying and dressing including the tools used for these.

13) IS : 1401

Code of practice for external facing and veneers

IS : 1401 (Part-I) - 1967

Stone facing

IS : 1401 (Part-II) - 1967

Cement concrete facing

IS : 1401 (Part-III) - 1969

Wall tiling and mossies

14) IS : 4121 (1967)

Method of test for determination of water transmission rate by capillary action through natural building stones.

15) IS : 4122 - 1967

Method of test for surface softening of natural building stones by exposure to acidic atmosphere.

16) IS : 4348 - 1973

Method of test for determination of permeability of natural building stones (First Revision)

17) IS : 5218 - 1969

Method of test for toughness for natural building stones.

**ANNEXURE-III** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 7. | Chittorgarh District, Mandaldeh | Mandaldeh | 19.0 | - | Chocholate colour | Limestone |
| 8. | Dungarpur District Nandhi-Baula Pindawar Belt | Nandhi-Baula, Pindawar | 2.0<br>3.0 | - | - | - |
| 9. | Dungarpur District Daski Ramanwara | Daski-Ramanwara | 2.0 | - | - | - |
| 10. | Jaipur District Kotputali Teh. | Bhaisalana, Jamuwaramgarh | N.A. | Covers an area of 40.40 hectares | Black | Dolomitic marble |
| 11. | Jaisalmer District Jaisalmer | Amarsagar Mool Sagar | N.A. | - | Yellow | Limestone ferruginous and siliceous. |
| 12. | Nagaur District Makrana | Makrana, Borawar, Gunawati | 3 (in concealed area) | 12 km length 1.5 km width 4.4 sq approved | White pink figured and other shades. | Calcitic marble |
| 13. | Pali District Bar-Sendra | Bar-Sendra | N.A. | - | Pink with shades and stripes. | Siliceous marble |
| 14. | Sikar District Maonda | Maonda | N.A. | - | White grey and dark grey. | Dolomitic marble |
| 15. | Sirohi District Abu Road | Parua Serva | 1 | 500 mts length 30-200 m width | White | Calcitic marble |
| | | Deri-Indi | N.A. | 50 to 100 m length | White | Calcitic marble |
| 16. | Sirohi District Selwara | Selwara | 10 | 2.5 km length 50 to 300 m width | White | Calcitic marble |

ANNEXURE-III-(Concld.)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 17. | Udaipur District Ageria-Amet-Lava Sardargarh. | Amet, Jogimagara, Bandla, Ageria Parvatti, Chhatar-pura, Sardargarh | 13.5 | - | White | Dolomitic marble |
| 18. | Udaipur District Babermal-Devimata-Kewra. | Babermal, Devimata & Kewra. | 50 m upto 30 m depths out of which 13 m mineable (blocks, consi-dering reco-very 30%) | 8 km length 1.5 km width | Pink | Siliceous marble |
| 19. | Udaipur District Rikhabdev. | Rikhabdev, Odwas, Masara-ki-obri in Bhawana. | 4-5 | - | Green | Serpentine marble |
| 20. | Udaipur District Kelwa Ton Ka Phalla. | Kelwa Ton Ka Phalla. | 22.0 | - | - | - |

SOURCE :

1. Sl. Nos. 1,2,4,5 & 10 to 19 - Directorate of Mines and Geology, Government of Rajasthan

2. Sl. Nos. 3,6,7 to 9 & 20 - Report of the sub-committee on assessment of marble reserves in Udaipur, Chittorgarh, Dungarpur and Banswara district. Installed sawing capacity and future prospects for its further expansion By R.S. Sharma of Directorate of Mines and Geology, Government of Rajasthan and K.P. Lal of M/s Rajasthan Industrial Investment Corporation, Jaipur.

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ANNEXURE-IV

## A Statement Showing Number of leases with Area Granted for Marble Mining in India

(As on 31-12-80)

| State/District | Number of leases | Total area under lease, hectares |
|---|---|---|
| Andhra Pradesh | | |
| Guntur | 3 | 78.66 |
| Bihar | | |
| Palamau | 9 | 74.67 |
| Gujarat | | |
| Baroda | 4 | 9.16 |
| Banaskantha | 41 | 157.25 |
| Rajasthan | | |
| Ajmer | 19 | 8.44 |
| Alwar | 30 | 28.15 |
| Bhilwara | 4 | 1.81 |
| | 2 | N.A. |
| Bundi | 29 | 19.04 |
| Jaipur | 15 | 5.77 |
| Jaisalmer | 13 | 1050 |
| Jhunjhunu | 1 | 0.36 |
| Nagaur | 650* | - |
| Neem ka Thana | 1 | 7.33 |
| | 1 | N.A. |
| Pali | 2 | 5.17 |
| | 1 | N.A. |
| Sirohi | 19 | 10.00 |
| Udaipur | 197 | 118.65 |

SOURCE: INFORMATION SUPPLIED BY THE DIRECTORATE OF MINES AND GEOLOGY OF RESPECTIVE STATES

N.A. - Not available * - Most of the leases are under Rent-cum-Royalty lease scheme.

## List of Important Marble Processing Units in India and Details of the Processing Machinery

**ANNEXURE – V**

| Sl. No. | Name of the Unit | Location | Sawing Machines | Polishing Machine | Edge Cutting Machine | Remarks |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | | | **ANDHRA PRADESH** | | | |
| | | | **Hyderabad District** | | | |
| 1. | M/s Sunder Shila Pvt. Ltd., Hyderabad | Hyderabad | Four Frame Saws | One | One | |
| | | | **Guntur District** | | | |
| 2. | M/s Srinivasa Stone Polishing Industries, Rentachintala | Rentachintala | – | One | – | |
| 3. | M/s Venkateswara Slab, Polishing Co., Rentachintala | –do– | – | One | – | |
| 4. | M/s Aruna Polishing Industries, Rentachintala | –do– | – | One | – | |
| | | | **BIHAR** | | | |
| 1. | M/s Global Marble Industries, Fariyalal Building, Fariyalal Chowk, Ranchi | Ranchi | One Frame Saw | – | – | |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| | | | DELHI (Union Territory) | | | |
| 1. | M/s Sabu Minerals and Polishers, New Delhi | New Delhi | Five Frame Saws | One | One | |
| 2. | M/s Subha Laxmi Exporters, B-211, Chittaranjan Park, New Delhi | New Delhi | - | - | One | |
| 3. | A.T. Knis India Ltd., E-4, Nariana, New Delhi | New Delhi | - | One | One | |
| 4. | M/s Marble Indie, New Delhi - 57 | New Delhi | Three Frame Saws | One | One | |
| | | | GUJARAT | | | |
| | | | Ahmedabad District | | | |
| 1. | M/s Ahmedabad Stone Supplying Co., Khadia - Char - Rasta, Ahmedabad-380 001 | Ahmedabad | - | One | One | |
| 2. | M/s Atco Marble and Stone Industries, Khadia-Char Rasta, Ahmedabad - 380 001 | Ahmedabad | - | One | One | |
| 3. | M/s B.M.Gandhi and, Co.8, Navyug Society, Gita Mandir Road, Ahmedabad-380022 | Ahmedabad | N.A. | N.A. | N.A. | |
| 4. | M/s Jyoti Marbles Factory, Behind Municipal Industrial Estate, Bapunagar, Ahmedabad-380024 | Ahmedabad | - | Two | Two | Own lease at Ambaji |

Annexure – V *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 5. | M/s Shah Marble and Stone Industries, F.P.69, Beyond Chakudia Mahadev, Near Gravity House, Ahmedabad - 380024 | Ahmedabad | - | Three | Three | |
| 6. | M/s Shah Stone Industries, 910/21 O.S. Sarangpur Gate. Ahmedabad | Ahmedabad | - | Three | Two | |
| 7. | M/s Ambica Stone and Polishing Industries, Sarangpur, Lat Bazar, Ahmedabad | Ahmedabad | Three | Six | Two | Own mine in name of M/s Hariom Marble,, Ambaji |
| 8. | M/s Radha Marble Industries, 33, GIDC, Industrial Estate, Naroda - Ahmedabad - 380025 | -do- | Three | One | One | Own mine at Ambaji and other areas |
| 9. | M/s Modern Marbles and Stones, N.13, Municipal Industrial Estate, Bapunagar, Ahmedabad-380023 | -do- | Two | - | One | Own quarry at Ambaji |
| 10. | M/s Shriji Marble Industries, 32/9 GIDC Industrial Estate,Naroda, Ahmedabad-380025 | -do- | Two | One | One | Own quarry at Ambaji |
| 11. | M/s High Grade Marble Co., Mukhi Estate, Near Christian Church, Behrampura, Ahmedabad-380022 | Ahmedabad | - | One | One | |

Annexure – V *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 12. | M/s Oghadlal and Lallubhai Shah, Ahmedabad | Ahmedabad | - | Two | One | Own quarry at Ambaji |
| | | | Banaskantha District | | | |
| 13. | M/s Laxmi Marble Co., Ambaji. | Ambaji | Two | One | One | Own quarry at Ambaji |
| 14. | M/s Hariom Marble , Ambaji | Ambaji | One | - | - | -do- |
| 15. | M/s Green Marble, Ambaji | Ambaji | Three | Two | One | -do- |
| 16. | M/s J.D.Trivedi and Sons, Ambaji | Ambaji | Two | One | One | -do- |
| 17. | Shri Ambaji Marble Corpn., Ambaji | Ambaji | One | - | - | |
| | | | Chhota Udaipur District | | | |
| 18. | M/s Mineral Industries, Chhota Udaipur | Chhota Udaipur | One | - | - | - |
| 19. | M/s Kalpana Dhaslidhe Co., Chhota Udaipur | Chhota Udaipur | One | - | - | |
| 20. | Gujarat Marble Corporation Ltd., Chhota Udaipur | -do- | Two | - | - | |
| | | | Baroda District | | | |
| 21. | M/s Baroda Minerals, Baroda | Baroda | One | - | - | |
| 22. | M/s Indian Natural Marble Co.,C-2, Patel Estate, Pratap Nagar, Baroda | Baroda | - | - | - | Details not available |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 23. | M/s Kalpana Dharti-dhan Corpn., Highway Road, Baroda | Baroda | - | - | - | |
| | | | Bharuch District | | | |
| 24. | M/s Alak Nanda Marbles, 45, Bharuch Industrial Area, Gujarat | Bharuch | Two | - | - | |
| | | | HARYANA | | | |
| 1. | M/s Haryana Minerals Ltd., Nizampur Road, Naranaul, Mohindergarh district, Haryana | Naranaul | Three | One | One | Own Mine at Antribeharipur |
| | | | KARNATAKA | | | |
| 1. | M/s Silpasree Enter-prises Ornamental Stone Polisher, 1209, 2nd Main Road, Vijaynagar, Bangalore-560040 | Bangalore | One | One | One | |
| | | | MAHARASHTRA | | | |
| 1. | M/s Marble Art, Worli, Bombay | Bombay | - | - | One | |
| 2. | M/s Raj Marbles, Kurla, Andheri, Bombay | Bombay | One | - | - | |
| | | | Poona District | | | |
| 3. | Shri Sharda Ram Ashwani, Poona | Poona | One | - | - | |
| | | | UTTAR PRADESH | | | |
| 1. | M/s Ramakrishna Mission, Sevasram, Vivekananda Puri, Lucknow | Lucknow | Three | One | One | |

Annexure – V *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| | | | MADHYA PRADESH | | | |
| | | | Jabalpur District | | | |
| 1. | M/s Jai Amba Marble Works, Uncha, Jabalpur | Uncha | Two | - | One | |
| | | | Gualior District | | | |
| 2. | M/s Gualior Marble Industries, Gualior | Gualior | - | - | One | |
| | | | Balaghat District | | | |
| 3. | M/s Sathi Brothers, Balaghat | Balaghat | - | - | One | |
| | | | Shivpuri District | | | |
| 4. | M/s Shivpuri Stone Polishing Industries, Kamala Ganj, Shivpuri | Shivpuri | - | One | - | |
| | | | Rajanandgao District | | | |
| 5. | M/s Chandrasekhar Mundalia, Rajanandgao | Rajnandgao | - | One | One | |
| | | | Raipur District | | | |
| 6. | Shri Vasudhau Udyog, Raisagar, Para, Raipur (MP) | Raipur | Two | One | One | |
| | | | RAJASTHAN | | | |
| | | | Ajmer District | | | |
| 1. | Rajasthan Udyog Kishen- garh, Ajmer | Kishengarh | - | - | Two | |
| 2. | Anand Marble Works, Kishengarh | -do- | - | - | Two | |

Annexure – V *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 3. | M/s Mahesh Marble Works, Kishengarh | Kishengarh | - | - | One | |
| 4. | M/s R.K.Marble Ltd., Kishengarh | -do- | - | - | Two | |
| 5. | M/s Kamala Marble Ltd., Kishengarh | -do- | - | - | One | |
| 6. | M/s Maheshwari Marble Ltd., Kishengarh | -do- | - | - | One | |
| 7. | M/s Om Marble Works, Kishengarh | -do- | - | - | One | |
| 8. | M/s Sharma Marbles Ltd., Kisnengarh | -do- | - | - | Four | |
| | | | Bundi District | | | |
| 9. | M/s Kalyan Das and Sons, Umar | Umar | Two | - | - | |
| | | | Chittorgarh District | | | |
| 10. | M/s Gupta Marble and Stone Industries, Bapu nagar, Chittorgarh | Chittorgarh | One | | | |
| 11. | M/s Kailash Marble Industries, 6-80, Industrial Area, Chittorgarh | -do- | One | | | |
| 12. | Shree Ram Marble, 6-80, Industrial Area, Chittorgarh | -do- | One | | | |
| 13. | M/s Vilal Marbles, F-75, RIFDC Industrial Area, Chittorgarh | -do- | One | | | |

Annexure – V *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 14. | M/s Satyanarain Industries, Senthi, Chittorgarh | Chittorgarh | Two | | | |
| 15. | M/s Mahalaxmi Marble and Stone Industries, Chittorgarh | -do- | Two | | | |
| 16. | M/s Bodar Marble and Stone Co., Old Industrial Area, Chittorgarh | -do- | One | One Circular One Table type | One | Own mine Chittorgarh and Udaipur dist. |
| 17. | Olympic Marble Industries, F-18, RMIDC Industrial Area, Chittorgarh | -do- | Two | | | |
| 18. | Doshi Industries, Bapunagar, Chittorgarh | -do- | One | | | |
| 19. | Shiv Stones, Chittorgarh | -do- | One | | | |
| 20. | M/s Ashi Marble and Stone Industries, 34-35, New Industrial Area, Old Power House, Chanderia, Chittorgarh | -do- | Four | Circular wheel type | One | |
| 21. | Shri Charbujaji Marble, F-67, and 68, New Industrial Area, Chanderia, Chittorgarh | -do- | One | | | |
| 22. | M/s Brij Marble and Stones Ltd., G-48, 49 & 50 New Industrial Area, Chittorgarh-31200 | -do- | One | One | One | |
| | | | <u>Jaipur District</u> | | | |
| 23. | M/s Shyam Marble Industries, Jaipur Jaipur | | One | | | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 24. | M/s Associated Marble Industries, Jaipur | Jaipur | One | One | | |
| 25. | M/s Shyam Marble Industries, Jaipur | -do- | Four | One | One | |
| 26. | M/s Ashok Marble Industries, Halwai Bazar, Phulera, Jaipur | Phulera | Two | | | |
| | | | <u>Jodhpur District</u> | | | |
| 27. | M/s Bhavan Stones, Jodhpur | Jodhpur | | One | One | |
| 28. | M/s Pink Marbles, Jodhpur | -do- | One | | | |
| 29. | M/s Bharat Marbles, Smashan Road, Vivenchi Gate, Jodhpur | -do- | | One | One | |
| 30. | M/s Ahsan Marbles Stone Polishing Industries, Mesuria Circle, Jodhpur | -do- | | One | One | |
| 31. | M/s Hindustan Marble Work, Choti Bhambi Colony, 5, Chopasani Road, Jodhpur | -do- | | Two | Two | |
| 32. | M/s Rajasthan State Granite and Marble Ltd., E-17-18 Basni, Jodhpur | -do- | Two | Two | One | Own quarry for granite marble |
| | | | <u>Kota District</u> | | | |
| 33. | M/s Associated Stone Industries (Kotah) Ltd., Ramganj Mandi | Ramganj Mandi | Two | One | | |

Annexure – V (Contd.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 34. | M/s J.K.Synthetics Ltd., Jakay Nagar | Jay Kay Nagar | Two | One | One | |
| | | | Pali District | | | |
| 35. | M/s Maharaja Shri Umaid Mills, Pali | Pali | | | One | |
| 36. | M/s Salia Marble R.I. Estate, Falna | Falna | One | - | - | Own mines at Dujana Khandan in Pali District |
| 37. | M/s Mineral Oriental Industries, Industrial Estate, Falna | -do- | Six | One | Two | Own mines in Rajasthan and Gujarat |
| 38. | M/s National Marbles 32, A Industrial Estate, Falna | -do- | Two | | | |
| 39. | M/s National Trading Co., 20-D,Industrial Area, Falna | -do- | | Two | One | |
| 40. | M/s Century Marble and Granite Pvt. Ltd., Plot No.E 32-33, RIICO Industrial Area, Abu Road | Abu Road | Four | One | One | Own mines in Gujarat, Ambaji |
| 41. | M/s D.K. Trivedi and Sons, Gandhinagar, Abu Road | -do- | Four | One | One | Own mine at Ambaji-Zanvar |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| | | | Nagaur District | | | |
| 42. | M/s Sangemarmer India Pvt. Ltd., Makrana | Makrana | One Diamond and Frame Saw<br>One Wire Saw | | | |
| 43. | M/s Pahadia Marble, Makrana | -do- | One | - | | |
| 44. | M/s Rajasthan Mining and Allied Industrial Pvt. Ltd., Makrana | -do- | One | One | One | |
| 45. | M/s Marwar Mines, Makrana | -do- | One | | | |
| 46. | M/s Rathod Marble Co., Makrana | -do- | One | | | |
| 47. | M/s Jain Marble Co., Makrana | -do- | One | | | |
| 48. | M/s Agrawal Marble Stone Co., Makrana | -do- | One | | | |
| 49. | M/s Manjushree Marble, Makrana | -do- | One | | | |
| 50. | M/s Mahaveer Marble, Makrana | -do | One | | | |
| 51. | M/s Amrit Shile and Co., Makrana | -do- | One | | | |
| 52. | M/s Fine Marble and Minerals Ltd., Borawar Road, Makrana-341 504 | -do- | One | | | |
| 53. | M/s Granite and Marble Industries, Borawar Road, Makrana-341 505 | -do- | One | | | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 54. | M/s Rajasthan Marble Udyog Ltd., Borawar Road, Makrana | Makrana | One | | | |
| 55. | M/s Vishwakarma Industries, Borawar Road, Makrana | -do- | Three | Two | One | |
| 56. | M/s Universal Marble Supply Corpn Ltd., Makrana | -do- | One | | | |
| 57. | M/s Shaikh Marble Corpn., Makrana | -do- | One | | | |
| 58. | M/s Krishna Marble Industries, Borawar | Borawar | One | | | |
| 59. | M/s Jai Bharat Industries, Borawar | -do- | One | | | |
| 60. | M/s Jair Marble Factory, Makrana | Makrana | Two. | | | |
| 61. | M/s Makal Marble Factory, Makrana | -do- | One | | | |
| 62. | M/s Kailash Marble Works, Makrana | -do- | Three | | | |
| 63. | M/s Govind Marble Industries, Borawar | Borawar | One | | | |
| 64. | M/s Chand Marble Industries, Borawar | -do- | Two | | | |
| 65. | M/s Agarwal Marble & Stone Industries, Borawar | -do- | Two | | | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 66. | M/s Govind Marble Industries, Borawar | Borawar | Three | | | |
| 67. | M/s Maheshwari Marbles, Makrana | Makrana | One | | | |
| 68. | M/s Chand Marble Industries, Borawar | Borawar | One | | | |
| 69. | M/s Agarwal Marble & Stone Factory, Makrana | Makrana | Five | | | |
| 70. | Shri Maha Laxmi Oil Industries, Borawar | Borawar | One | | | |
| 71. | M/s Madhu Sudan Marble Industries, Borawar | Borawar | Three | | | |
| 72. | M/s Mukesh Marble Industries, Makrana | Makrana | Three | | | |
| 73. | M/s Avant Marble Works, Makrana (Borawar Road) | -do- | Two | | | |
| 74. | M/s Gujarat Marble Trading Co., Makrana | -do- | Three | | | |
| 75. | M/s Srinivas Marble Industries, Makrana Road, Borawar | Borawar | One | | | |
| 76. | M/s Shree Ram Marble Industries, Borawar | Borawar | Three | | | |
| 77. | M/s Gaulani Marble Industries, Borawar | -do- | Five | | | |
| 78. | M/s National Marble & Stone Works, Makrana | Makrana | One | | | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 79. | M/s Maruli Marble Industries, Borawar Road, Makrana | Makrana | Four | | | |
| 80. | Shri Ganesh Marble Factory, Makrana | Makrana | Two | | | |
| 81. | M/s Laxmi Devi, Ganya Mohem Marble, Makrana | -do- | Five | | | |
| 82. | M/s Anil Marble Industries Pvt. Ltd., Borawar | Borawar | Three | | | |
| 83. | M/s New Rajasthan Marble Factory, Borawar | -do- | Three | | | |
| 84. | M/s Agarwal Marble Corpn, Makrana | Makrana | One | | | |
| 85. | M/s Krishna Marble Industries, Borawar | Borawar | Three | | | |
| 86. | M/s Vishnu Marble Industries, Borawar | Borawar | Four | | | |
| 87. | M/s S. Monim Marble Suppliers, Makrana | Makrana | One | | | |
| 88. | M/s Anil Marble Industries, Borawar | Borawar | One | | | |
| 89. | M/s Paradise Marble Industries, Makrana | Makrana | Two | | | |
| 90. | M/s Asarag Ali Panna Mohd., Makrana | Makrana | One | | | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 91. | M/s Mital Marble Industries, Makrana | Makrana | Three | | | |
| 92. | M/s Samrat Marble Industries, Borawar Road, Makrana | -do- | Four | | | |
| 93. | M/s Mahavser Marble Pvt. Ltd., Makrana | -do- | Four | | | |
| 94. | M/s Abdul Aziz Kadar, Box 2,Maszid Chera Rasta, Makrana | -do- | | | One | |
| 95. | M/s Paradise Marble Industries, Makrana | -do- | One | | | |
| 96. | M/s Om Marble Industries, Makrana | -do- | Two | | | |
| 97. | M/s H.N. Gauri Marbles Factory, Borawar | Borawar | Two | | | |
| 98. | Shri Abdullaji s/o Ajmedji, Borawar | Borawar | Two | | | |
| 99. | M/s Jamil Marble Industries Borawar, Makrana | Makrana | Two | | | |
| 100. | M/s Hanuman Marble Co., Makrana | -do- | One | | | |
| 101. | M/s Royal Marbles Supplies, Makrana | -do- | Two | | | |
| 102. | Shri Jagnath Mandhamiya, Makrana | -do- | | | One | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 103. | M/s Manoj Marbles Industries, Borawar | Borawar | Three | | | |
| 104. | M/s Maheshwar Marbles & Tile Co., Makrana | Makrana | Three | | | |
| 105. | M/s Raju Marble Industries, Makrana | -do- | Two | | | |
| 106. | M/s New Tak Marble Industries, Bidiyad Road, Makrana | -do- | Three | | | |
| 107. | M/s Vijay Laxmi Marble Industries, Borawar | Borawar | Four | | | |
| 108. | M/s Santosh Marbles, Makrana | Makrana | Two | | | |
| 109. | M/s Saudiaya Marble Factory, Borawar | Borawar | Two | | | |
| 110. | M/s Ganga Marble Industries, Makrana | Makrana | Four | | | |
| 111. | M/s Shyam Marble Udyog, Borawar | Borawar | Two | | | |
| 112. | M/s Shiv Karan Marbles, Makrana | Makrana | One | | | |
| 113. | M/s Ragava Marbles Industries, Makrana | -do- | Three | | | |
| 114. | M/s Sada Marble Industries, Makrana | -do- | Two | | | |
| 115. | M/s New Gehlot Marble Industries, Makrana | -do- | One | | | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 116. | M/s Bamalwa Marble Industries, By Pass Road, Makrana | Makrana | Three | | | |
| 117. | M/s Ashok Choudhary Marble Industries, Main Road, Borawar | Borawar | Two | | | |
| 118. | M/s Sharma Marble Factory, Gunawati Road, Makrana | Makrana | Two | | | |
| 119. | M/s Sharda Marble Industries, Borawar Road, Makrana | -do- | Two | | | |
| 120. | M/s Jakhtya Marble Industries, Makrana | -do- | Two | | | |
| 121. | M/s Rajasthan Marble & Tiles Industries Pvt. Ltd., Makrana | Makrana | Two | | | |
| 122. | M/s Hydrochem Enterprises, Borawar | Borawar | Two | | | |
| 123. | M/s Suresh Marble Industries, Makrana Road, Borawar | -do- | Two | | | |
| 124. | M/s Pawan Marble Industries, Makrana Road, Borawar | -do- | Two | | | |
| 125. | M/s Charbuja Marble Industries, Borawar | -do- | Two | | | |
| 126. | M/s Fatma Marble Industries, Borawar | -do- | Two | | | |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 127. | M/s Sukh Enterprises Factory, Makrana | Makrana | Two | | | |
| 128. | M/s Mour Sangamermar Udyog, Borawar | Borawar | Two | | | |
| 129. | M/s Sanjay Marble Industries, Borawar | -do- | Two | | | |
| 130. | M/s Shamboo Marble Industries, Makrana Road, Borawar | -do- | Two | | | |
| 131. | M/s Mangalaram Choudhary Marble Works, Makrana | Makrana | Two | | | |
| 132. | M/s Madan Marble Industries, Borawar | Borawar | Two | | | |
| 133. | M/s Chandmal Badrinarayan Marble Works, Borawar | -do- | Two | | | |
| 134. | M/s Bharat Marble Industries, Bidiyad, Makrana | Makrana | Two | | | |
| 135. | M/s Jai Amba Marble Industries, Borawar | Borawar | Two | | | |
| 136. | M/s Singhvi Marble Industries, 39 Incustrial Area, Bidiyad, Makrana | Makrana | Two | | | |
| 137. | M/s Neelkanth Marbles Industries, 122, Industrial Area, Bidiyad, Makrana | -do- | Two | | | |
| 138. | M/s Randheer Sangemermer Udyog, E-34 Industrial Area, Bidiyad, Makrana | -do- | Two | | | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 139. | M/s Pachori Marble , E-15 B, Industrial Area, Bidiyad, Makrana | Makrana | Two | | | |
| 140. | M/s Dholia Sangemarmer Udyog, E-33 Bidiyad, Makrana | Makrana | Two | | | |
| 141. | M/s Uma Enterprises, 6-82, Bidiyad, Makrana | -do- | Two | | | |
| 142. | M/s Gurudeo Marble Industries, Makrana Road, Borawar | Borawar | Two | | | |
| 143. | M/s Gedhar Marble Industries, Makrana Road, Borawar | -do- | Two | | | |
| 144. | M/s Mohamand Marble Industries, Borawar Road, Makrana | Makrana | Two | | | |
| 145. | M/s Mangilal, Makrana Road, Borawar | Borawar | Two | | | |
| 146. | M/s Mohan Marble Industries, Makrana Road, Borawar | -do- | Two | | | |
| 147. | M/s Arun Marble Industries, E-206, Bidiyad, Makrana | Makrana | Two | | | |
| 148. | M/s Mamta Marble Industries, E-208 Industrial Area, Bidiyad | -do- | Two | | | |
| 149. | M/s Asoka Marble Industries, C-93, Bidiyad, Makrana | -do- | Two | | | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 150. | M/s Utam Marble Industries, Makrana Road, Borawar | Borawar | Two | | | |
| 151. | M/s Hanuman Marble Industries, Makrana Road, Borawar | -do- | Two | | | |
| 152. | M/s Kasturi Marbles, F-65 Bidiyad, Makrana | Makrana | Two | | | |
| 153. | M/s G.H.Marbles, F-107 Makrana | -do- | Two | | | |
| 154. | M/s Mangla Marble Industries, By Pass Road, Makrana | -do- | Two | | | |
| 155. | M/s Vinayak Marbles, E-170 Industrial Area Bidiyad, Makrana | - do- | Two | | | |
| 156. | M/s Bandukia Marble Industries, Harijav Badi, Idgah, Borawar | Borawar | Two | | | |
| 157. | M/s Gajendra Marble Industries, Makrana Road, Borawar | -do- | Three | | | |
| 158. | M/s Gelara Marble Industries, Makrana Road, Borawar | -do- | Three | | | |
| 159. | M/s Kohinoor Emporium Marble Industries, Makrana Road, Bidiyad, Borawar | Borawar | Three | | | |
| 160. | M/s Surana Marble Industries, E-40 Industrial Area, Bidiyad, Makrana | Makrana | Two | | | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 161. | M/s A.R.Siwal Marble Factory, E-204, Industrial Area, Bidiyad | Makrana | Two | | | |
| 162. | M/s Champion Industries, E-159 Industrial Area, Bidiyad | -do- | Two | | | |
| 163. | M/s Yogeswar Marble Factory, E-220 Bidiyad, Makrana | -do- | Two | | | |
| 164. | M/s Mangala Marbles, Bidiyad, Makrana | -do- | Two | | | |
| 165. | M/s Vikas Marble Industries, Bidiyad, Makrana | -do- | Two | | | |
| 166. | M/s Shashi Marble Industries, Makrana Road, Borawar | Borawar | Two | | | |
| 167. | M/s Pinkoo Marble Sawing & Polishing, E-124 Bidiyad, Makrana | Makrana | Two | | | |
| 168. | M/s Kasturi Marbles, F-65 Industrial Area, Bidiyad | Makrana | Two | | | |
| 169. | M/s Gohar Marble Industries, Makrana Road, Borawar | Borawar | Three | | | |
| | | | <u>Udaipur District</u> | | | |
| 170. | M/s Udaipur Plastic Industries, E-104, Industrial Area, Udaipur-313 001 | Udaipur | Two Frame Saws conventional | | | |

Annexure – V (Contd.)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 171. | M/s Lucky Marble Stone and Chips Industries, E-72, M.I.Area, Udaipur | Udaipur | | Two | One | |
| 172. | M/s Jaihind Marble Stone Chip Factory, I-108, M.I.Area, Road No.3, Udaipur-310 3001 | Udaipur | Two | | One | Quarry at Jogimagra area |
| 173. | M/s Naresh Stone Industries, F-51, Industrial Area, Road No.3, Udaipur-310 3001 | -do- | Two | | | |
| 174. | M/s V.D. Marble Industries, Rajasmund | Rajasmund | One | | | |
| 175. | M/s Rajasthan Chemical and Marbles Industries, Fatehpura, Udaipur | Udaipur | Two | One | One | |
| 176. | M/s Himalaya Marble Industries, 256 Haran Magi, Udaipur | Udaipur | | One | | |
| 177. | M/s Raiala Marbles, F-322, M.I.Area, Udaipur | -do- | Two | | One | |
| 178. | M/s Somani Galicha Tiles, M.I.Area, Udaipur | -do- | Two | | One | |
| 179. | M/s Swastic Marble, A-192 (A) M-1, Area, Udaipur | Udaipur | One | | | |
| 180. | M/s Himalaya Marble Industries, E-159, Road No.3, M.I.Area, Udaipur-313 001 | -do- | Four | One | One | |

**Annexure – V** *(Contd.)*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 181. | /s Shreeji Marbles, N.H.No.8, Industrial Area, Nathdwara-313 301 | Nathdwara | Two | One | One | Own mines |
| 182. | M/s Mineral Oriental Ltd., Morchana, Via Kelwa 313 326 | Morchana | Two | | | Own mines |
| 183. | M/s Hindustan Marble and Mineral Industries, Industrial Area, Morchana : 313326 Via Kelwa Rajasmund Tal. | Morchana | Three | One | One | Own mines |
| 184. | M/s Janatha Marble Industries, Morchana Rajasmund, Udaipur | Udaipur | One | | | |
| 185. | M/s Associated Stone Industries (Kotah) Ltd., Pasoono Tehsil, Rajasmund | Pasoond | Two | | | Own mines |
| 186. | Shri Charbuja Marble Industries (Oppn. Rameshwar) Mahaduji, Rajasmund-313 326 | Kankrauli | Two | One | One | Own mines |
| 187. | M/s Sangam Marble Factory, Savali Road, National Highway Rajasmund-313 326 | Kankrauli | Two | One | One | Own mines |
| 188. | M/s Raj Marble, M.I.Area, Udaipur | Udaipur | One | | | |
| 189. | M/s Udai Marble, M.I.Area, Udaipur | -do- | One | | | |
| 190. | M/s Hindustan Marble, M.I.Area, Udaipur | -do- | One | | | |

Annexure – V (Concld.)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 191. | M/s Mahaveer Marble Cutting, M.I. Area, Udaipur | Udaipur | One | | | |
| 192. | M/s Minerva Cutting and Polishing Industries, M.I. Area, Udaipur | -do- | One | | | |
| 193. | M/s Bharat Marble Cutting, M.I. Area, Udaipur | -do- | One | | | |
| 194. | M/s Raja Marble Industries, M.I. Area, Udaipur | -do- | One | One | One | |
| 195. | M/s Chabra Marble Industries, M.I. Area, Udaipur | -do- | One | | | |
| 196. | M/s A.J. Marbles, M.I.Area, Udaipur | -do- | One | | | |
| 197. | M/s Vijay Marble, M.I. Area, Udaipur | -do- | One | | | |
| 198. | M/s Mewar Marble Udyog, M.I. Area, Udaipur | -do- | One | | One | |
| 199. | M/s Aravali Sangmervar Udyog, M.I. Area, Udaipur | -do- | One | | One | |

NOTE : The processing units at Sl.No.1 (Karnataka), 22, 48 and 55 of (Rajasthan) have circular diamond saws and units at Sl.No.32, 42 to 47, 49 to 52, 54, 56 and 185 (Rajasthan) have diamond frame saws. Among these, the processing unitsat Sl.No.32, 42 to 45, 47, 49, 50, 52, 56 and 185 are of imported and rest being indigenous which are mostly located in Rajasthan.

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