Scientific Research Publishing

International Journal of Nonferrous Metallurgy, 2025, 12(1), 1-16
https://www.scirp.org/journal/ijnm
ISSN Online: 2168-2062
ISSN Print: 2168-2054

# The Study of Dichinama Marble Waste and Its Utilization in Tigray Ethiopia

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**How to cite this paper:** Zeweli, K.H. and Hailu, M.T. (2025) The Study of Dichinama Marble Waste and Its Utilization in Tigray Ethiopia. *International Journal of Nonferrous Metallurgy*, **12**, 1-16.
https://doi.org/10.4236/ijnm.2025.121001

**Received:** December 16, 2024
**Accepted:** January 24, 2025
**Published:** January 27, 2025



## Abstract

According to the present industrialized methods for marble quarry mining, the extraction, drilling, cutting, polishing, handling, and processing of marble continuously produce a significant amount of waste, both direct and indirect, which causes financial losses for the business and environmental problems. No research has been done on how the mining operations at the Dichinama marble mining site of Saba Dimensional Stone PLC in Tigray, Northern Ethiopia produce distinct kinds of waste. This research study aims to understand the marble mining process better, pinpoint areas where current methods and procedures are hindered, and implement corrective measures such as reusing marble wastes and generating economic benefits parallel with minimizing negative environmental effects. This study suggests a few products that the dimensional stone industries now produce from waste marble. However, more research is necessary to determine whether the producing products would be economically feasible or not. To protect the negative environmental effects, we have discussed and highlighted several marble waste appropriate uses, such as the production of construction material, decorative uses, filler and powder, applications in agriculture and the environment, as an alternative to limestone and creative items.

## Keywords

Mining, Drilling, Cutting, Marble, Environment, Waste

## 1. Introduction

Marble is a metamorphic or metasedimentary rock resulting from regional metamorphism at the time of contact metamorphism of sedimentary carbonate rocks, either limestone or dolostone. In our country, mining sectors play a key role in

economic growth, such as surface mining, *i.e.* quarrying has high priority in developmental activities, such as employing large manpower, paying taxes for the country, and producing decorative stones for different construction purposes. The Dichinama marble quarry is one of the largest marble-producing sites in Ethiopia.

The basic objective of this study is mainly focused on studying the Dichinama marble wastes and its utilization. Marble is a metamorphic rock consisting of carbonate minerals that have recrystallized under the influence of heat and pressure. In Ethiopia, the marble deposits are found within the Precambrian metamorphic terrains. Some of the most interesting deposits are found in the northern part of Ethiopia in Tigray, Tembien (black marble), and west of Sheraro in Dichinama (white, purple, multicolor, and rose green marble). Marble has been used as a decorative building stone since ancient times and is widely appreciated for its beautiful colors, structure, and high gloss on polished surfaces. Most marbles are predominantly composed of the relatively soft mineral calcite, which can be cut with a knife. Thus, marbles are far easier to saw than harder rocks and wire sawing is a frequently applied method in the extraction of building stone from marble deposits.

The first step in the marble mining or quarrying process is extracting the primary block from the solid massif of marble rock. In most marble quarries, the primary blocks should be cubic or rectangular and measure from a few hundred cubic meters to big size. To loosen the block from the rock face, the use of various methods of making primary cuts is recommended as a convectional mining technique. Continuous channels are made by sawing (most common), line (slot) drilling, jet burner, or water jet (less common) can be applied.

Vertical or horizontal, natural fracture cutting can be applied to separate blocks following the weak line to produce marble blocks. In rare cases, wedging is used for primary cuts, especially when the primary blocks are small sized. Specifically for deposits like the Dichinama marble deposit, the most important extraction techniques are described and recommended. These methods can be implemented solely or in combination. To cut marble blocks from *in situ* rock mass, various techniques start from ancient to modern. For the present marble block cutting, the following methods, from ancient to modern, are recommended and it is possible to combine different marble-cutting techniques.

In Dichinama quarry, all cuts can be made by sawing with a combination of other methods. Vertical or horizontal, natural fracture cutting can be applied to separate blocks following the weak line to produce marble blocks. In rare cases, wedging is used for primary cuts, especially when the primary blocks are small sized. Specifically for deposits like the Dichinama marble deposit, the most important extraction techniques are described and recommended. These methods can be implemented solely or in combination. Therefore, the mining method for marble deposits is an open pit quarrying, adopting lateral-advanced and vertically descending multi-bench to extract marble that can be operated by manual, semi-mechanized, and mechanized

techniques.

Nowadays, the processing techniques have changed. Electrical hoists are enabled to handle large blocks safely. Nowadays, technology in quarries has been improved a lot. Different tools like diamond gang saws have replaced the labor work and made things easier.

Nowadays, in quarries, high technology equipment and tools are used. This enables more marble production with less labor work and less waste. All facets of society welcomed the growing marble industry, hoping it would bring prosperity, jobs, market improvement, and industrialization to the sector. The anticipated outcomes were also observed for a few years, but society and intellectuals quickly recognized the issues and disadvantages of the well-liked industry. The problem was the waste produced during mining and processing due to the declining number of mining and processing units, which posed ecological, environmental, sociological, and pollution hazards. Utilizing marble debris as a resource is a crucial part of environmental management strategies for attaining sustainable development.

The dimensional stone marble is sold by size rather than weight (*i.e.* in square meters or square feet rather than tons or kilos), which sets the marble industry apart from other industries. Slabs of the largest size are sought after for processing and mining purposes, as the selling price rises with size.

## 2. Geology of Dichinama Marble Deposit

Marble is a metamorphic rock made up of carbonate minerals that have undergone recrystallization because of pressure and heat. It is usually not foliated (layered), but there are some exceptions and has a crystalline texture. Metamorphism is a mineralogical and textural change that occurs in the rock in the solid state as a response to changes in environmental variables, especially temperature and pressure. Metamorphic rocks are rocks that developed their mineralogical and structural characteristics by metamorphic processes (Metamorphism) [1].

The marble belts of the Dichinama marble deposit are covered with Meta sediments. That is marble bounded by chlorite and phyletic schists. The deposit consists of a topography oriented with a lithological contact in the surrounding rocks dipping to the Northwest at 60˚. The study area is characterized mostly by the basement complex rocks, which are Precambrian metavolcanics (Amphibolites, Chlorite schists, Greenstone, etc.) and Precambrian Meta sediments (Quartzite, Phyllites, slate, marble, etc.). Those rock units were intruded with granitoids. The Precambrian Metavolcanic sediments and granitoids are good sources of dimensional stones besides hosting precious and base metal minerals [1].

The quarry site area is characterized by joints, fractures, cavities, schists, and mega-fold structures. The study area rock units are metamorphic rocks. The marble quarry is surface mining and different drilling methods, cutting techniques, and excavating methods are applied. During the quarry opening, the deposit has a horizontally bedded formation and continuous up to 2 metre depth. After two

meters of depth, the deposit nature was changed by a mega-fold structure. The direction of the spot line is also changed with the fold. The company experts continue the marble block-cutting process in the same fashion. The visible linear or vein-like inspections that appear as a series of small spots or sparks were not visible. If the blocks are not cut following the spot lines, the mined-out blocks will be wasted. Because the mined marble blocks are impossible to make smooth (polish) in the processing plant. Because the spot line direction was changed due to the fold formation. Due to these issues, a huge amount of marble block waste was generated.

## 3. Methods and Materials

The main research methods for this study are field observations and unpublished reports of the company. Corporate policies that were adapted from articles to fit the specific goals of the research and safeguard data privacy used unpublished data. This outlines the technique used for the investigation. Company employees, quality and quarry managers, company supervisors, and the local communities surrounding the quarry and processing plant locations were the main players who helped us gather the data. We have also collected and analyzed data from previous studies, including both published and unpublished works.

## 4. Result and Discussion

### 4.1. Marble Quarrying Process

Marble is a metamorphic rock made of carbonate minerals that have undergone recrystallization because of pressure and heat. There are some exceptions to the rule, but it usually lacks foliation and has a crystalline texture. The main component of marble is calcium carbonate and contains acidic oxide.

The powerful heat wave released by the decomposing substance combines the nearby stones. Stones are forced to the surface by geological processes such as plate tectonics and pressure. Due to its dimensionality, marble requires entirely different mining and processing techniques than other types of stone.

Marble quarrying is not the same as other metal or industrial minerals mining. Big marble chunks are dug out during the quarrying process. While underground mines extract deeper reserves in Italy and certain nations, open-surface quarry miners mostly extract marble stones from Ethiopia's dimensional deposits. Marble was previously extracted manually from the Dichinama quarry site using a jackhammer. However, the mechanization technique has now begun, and the Dichinama and the other dimensional stone quarry mining companies in Ethiopia are producing with modernized technology. Marble mining recovery and output have both grown because of mechanization. Waste production at the quarry site has decreased as a result. Modern sawing excavator machines take the place of Diamond wire-cutting machines.

Furthermore, the entire landscape of contemporary marble mining has altered with the introduction of mobile heavy earth-moving equipment. Additionally,

loading and carrying machines have undergone a radical transformation.

**Slab Processing Line:**

| Raw Block From quarry | Primary Cutting | Calibrating and Polishing | Resizing or Finishing | Packaging For market |
|---|---|---|---|---|

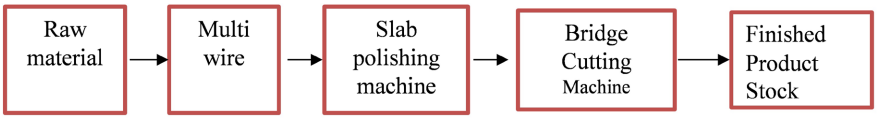


Figure 1. Flow chart of the marble production.

The three products of the marble industry are mining (raw block), processing (cutting, polishing, and resizing), and marketing (packaging the finished product), as illustrated in Figure 1.

Blocks are produced during mining, whereas the cutting, slabbing, sizing, resizing, and polishing activities take place during the processing phase. The final products can be wastes, chips, and polished slabs or tiles, as well as unique monuments. Primary blocks are produced via mining coupled with waste.

Primary blocks are split and sawed into slabs at the Gangsaw machine to the desired thickness. Next, a chain-mounted cutter of the appropriate sizes is used to help meet client demands. Slab polishing can cause the slab to break down, so resizing is done to save waste.

From the quarry to the processing facility, the main marble blocks are transported. The crane is used to unload the blocks into the adjacent stockyard. After that, if necessary, get dressed and fix the multi-wire gangsaw machine. The cutting-edge gang saw with a fixed-height blade-holder frame and lifting block-holding platform that allows for the quick cutting of marble blocks.

It guarantees precise cuts even at the fastest decreasing speeds and offers lengthy and high cutting strokes. This machine is smooth and effective because of the unique "pendulum" technology that enables the blade-holder frame to move without friction. The large dimension of all mechanical parts makes it a machine of very high quality, strength, and reliability thus providing the user maximum performance over time.

There are between 60 and 80 saws in the gangsaw machine. Every saw has many brazed segments known as diamond segments. These sections function as teeth, slicing blocks to the precise thickness needed to meet the needs of each client.

The block splits into various slabs as the saws move side to side. Heat is produced during this process in addition to dust, however, water is needed to cool the heat and prevent the production of dust. A gangsaw uses roughly 46,200 liters of water every hour since each plate uses 10 to 12 liters of water each minute. Improved sawing rates are now possible thanks to advancements in processing technology and segment manufacture modifications.

- **Features of Gang saw segment for marble cutting:**

- Cutting at high speed without chipping.
- Long life span, highly cost-effective, and stable cutting performance.
- Smooth cutting flat surface and even size cutting result.
- A good segment shape is easy for diamond opening.
- Strict product quality inspection processes.

### 4.2. Marble Waste Production

The waste produced by the marble-processing industry is referred to as "offcuts" and is produced in a variety of sizes and types. These offcuts are produced from broken bits that remain after working on or extracting a marble piece, which happen frequently because of the nature of the material. During block or slab cutting, the marble processing industry produces huge amounts of waste in the form of slurry, dust, and irregularly sized stones. Due to the absence of a proper disposal mechanism, these rock fragments are carelessly dumped in open areas around the quarries.

According to the above definition, the waste from marble quarries, even a decrease in primary use, results in a significant loss of revenue since larger blocks and tiles command higher prices than smaller blocks and tiles or any other secondary output. The amount of waste generated by marble varies greatly, ranging from 30% by weight (in mechanized mines where marble blocks are extracted using wire saw cutting techniques) to 65% by weight (in mines where mining is necessary, and the rocks are shattered). Thirty to forty percent of the production is expected to be waste from mechanical quarrying methods (Table 1).

Table 1. Waste generation during the Dichinama marble production from site to processing plant [1].

| S. no | Type of waste | Percentage (%) |
|---|---|---|
| 1 | Drilling waste | 2 |
| 2 | Mining waste | 52 |
| 3 | Handling waste | 10 |
| 4 | Processing waste | 20 |
| 5 | Polishing waste | 12 |
| 6 | Cutting waste | 4 |

Source: Assessment study in Dichinama marble quarry in 2016 and 2017.

From Figure 2, a huge amount of waste is produced during mining work because of the sudden change marble deposit bed nature. It was affected by the mega-fold structure. It is also affected by the naturally formed fractures (Figure 3(a)), cavities (Figure 4(a)), folds, impurities, shists (Figure 4(b)), and joints within the deposit during primary block slicing (when the block falls, it may break down easily), and drilling (Figure 3(b)) and cutting produce a smaller number of wastes.

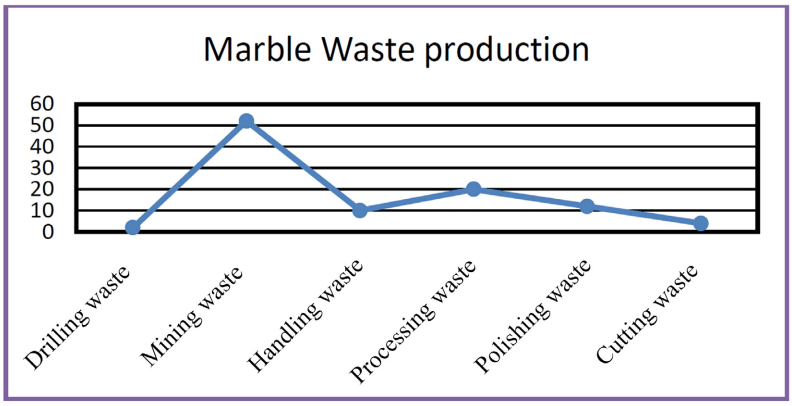


**Figure 2.** Graphical representation of the marble waste production.


**Figure 3.** Marble quarry wastes, due to improper mining and drilling activities respectively.


**Figure 4.** Marble quarry wastes, due to cavities and the presence of shist respectively.

### 4.2.1. Marble Waste Types

This waste encompasses various materials, including coarse marble waste such as defective-fractured marble blocks, and crushed slabs, as well as fine waste materials. We can categorize the marble wastes into two types, quarry and processing wastes.

**1) Quarry waste**

This waste includes blocks of various sizes and shapes, undesirable trimming, and shaping of mined-out blocks before dispatch to the stockyard. There are two types of quarry waste. We can see one by one as follows:

### A) Direct waste

This type of waste is generated *directly from marble extraction in the quarry mining site. It can be caused due to the following different reasons*.

- **Land clearance:** This is the first step in quarry mining, which includes the removal of unwanted materials like plants, weathered rocks, and other materials from the marble deposit (Figure 5(a)). The weathered rocks, plants, and soils are excavated, collected, and ready for loading (Figure 5(b)). The generated waste is stripped and transported to a disposal area to uncover the marble deposit, and the activities are done by the dozer.


Figure 5. Marble quarry wastes, due to land clearance.

- **Removal of topsoil:** An essential step in the quarrying of marble deposits is the removal of topsoil and the staking of the same for subsequent treatment. The topsoil from medium- and large-sized quarries are often disposed of at a different location slightly distant from the quarry. Small quarries, on the other hand, do not have a dumping area and instead dispose of the soil wherever within the quarry that is suitable. The Dichinama marble quarry has cleared the topsoil from the marble deposit and dumped it near the quarry (Figure 6).

Figure 6. Marble quarry wastes, due to the removal of topsoil.

- **Opening of box cut:** A box cut is a small open cut built on a marble deposit to supply a secure and safe entrance as starting access to a slope of the quarry mine. Generally, the box cut is sunk until sufficiently unweathered rock is found to

permit the development of the decline. It is used to deploy the quarry machines for bench development (Figure 7(a) & Figure 7(b)).


Figure 7. Wastes can be generated due to box cut opening.

- **Overburden removal:** One of the main sources of quarry waste is the removal of overburden, which is necessary to expose the deposit. Blasting the rock part usually requires drilling and blasting. Blocks might be made from high-quality rocks. Additional worn pieces of rock, debris, etc., are piled at strategic locations. The Dichinama marble quarry has removed the overburden using a loader and dumped it near the quarry site (Figure 8).

Figure 8. Wastes can be generated due to overburden removal.


Figure 9. Wastes can be generated due to bench development.

- **Bench development:** One of the main prerequisites for marble block extraction is bench development. The procedure entails creating the appropriate approach roads, ramps, benches of the necessary sizes, etc. This process produces a significant amount of waste, but it is surpassed only by overburden. The old

(Figure 9(a) & Figure 9(c)) and new (Figure 9(b)) marble block bench progress is in Figure 9.

- Secondary block splitting, primary block splitting, and other factors could also contribute to direct quarry waste.

**B) Indirect waste**

These *indirect wastes* are from total reserves which were designated to produce much higher revenue but only giving small due to small sizes of product. They were caused due to the following reasons.

- **Traditional tensioning:** When the miners want to drill both vertically and horizontally to cut the "V" shape cutting, they make tensioning using a thin wire to find the horizontal and vertical cutting meeting center point. Since it is very traditional, they did not find the center point easily. This activity generated waste.
- **Primary slicing (Initial cut):** A wire saw makes a "V"-cut for the first cut in the deposit, or a chain saw opens the deposit entirely. After cutting the primary block, they were doing slicing by measuring the gangsaw height intervals which meets the standard block sizes. The original blocks in both situations are smaller than appropriate and do not sell for a good price.
- **The existence of natural fracture patterns:** Once the mining path has been carefully determined by considering all pertinent factors, it cannot be changed often. Any abrupt change in the natural fracture pattern in this situation could result in blocks of a lower size.
- **Geological features:** In addition to fissures, abrupt alterations in geotechnical and geological flaws can produce waste. For example, differences in the size and color of the grains, the presence of veins and specks, segregation, the unfavorable occurrence and orientation of joints, shear zones, folds, faults, etc.
- **Due to traditional quarrying method:** This is the most frequent reason that enormous volumes of indirect waste are produced. Due to their cheap but outdated overburdened technology, many quarry mine operators lack solid financial backgrounds and produce a significant amount of waste by not utilizing mechanization.
- **The quarry wastes can have the following forms:** Both huge and small rejected blocks, dressing chips, and Slurries due to dust generated during cutting, carving, drilling, and slicing.

### 4.2.2. Processing Wastes

The waste generated during the marble processing is of the direct type, meaning it is produced as a byproduct of the process and only has a limited secondary use. The following kinds of waste are produced during marble processing: dressing, cutting, polishing, transportation, and handling.

As explained above, the waste from slabbing, sizing, and polishing processes are referred to as processing waste. A groove that is the width of the cutting tool and the length of the block or slab is transformed into waste (slurry) throughout these procedures. In gang sawing marbles and slabs, standard sizes and thicknesses have

a standard thickness of 2 - 3 cm, but it is always possible to obtain, on request, a thickness of 1.8 cm or greater than 3 cm. The length and width of the produced slabs are 10 × 10, 20 × 20, and 40 × 40 centimeters. This means that grooves are cut over their whole length and width in a single block of 80 (in an 80-blade gang saw).

- **Forms of marble processing waste products:**
  - Slurry (resulting from dust from grinding, polishing, and cutting processes).
  - Rejected chips or fragments that remain after usable tiles or slabs of desired dimensions are cut; these are sometimes referred to as "crazy".
  - Chips and other tiny fragments left over during cutting, etc.

### 4.2.3. Practical Use of Marble Waste

Practical use of marble waste can support resource conservation and sustainability. The useful applications of leftover marble not only lessen their negative effects on the environment but also open new business prospects. Industries can maximize available resources and contribute to a more sustainable future by investigating novel applications. Here are a few methods to use marble waste effectively:

**A) Construction material**

- **Bricks and blocks:** Adding crushed marble dust to the manufacturing of bricks and blocks can increase their strength and durability. Crushed marble waste can be used as an alternative to conventional aggregates in concrete and asphalt. The waste marble aggregates substitute the natural aggregates; the concern is more scientific than economical and environmental. The various concrete mixtures may help to understand the behavior of the recycled aggregates. The appropriate incorporation of marble waste aggregates can lead to interesting characteristics in terms of strength, indeed the use of marble aggregates resulted in a considerable increase in the compressive and tensile strength. The enhancement in resistance is very significant for 25%, 50%, and 75% of substitution. The marble waste can be used as alternative aggregates for concrete and for many other purposes, such as brick manufacturing, road construction, and landfills [2].
- **As a substance to fill in roadways and embankments:** A waste product created during the crushing procedure used to extract stone is called quarry dust. According to several studies on the subject, quarry dust is regarded as a widely recognized and reasonably priced ground improvement for the stabilization of fragile soil deposits. The massive amounts of waste material that are obtained from crusher facilities because of crushing stones is known as quarry dust. The strength of the mixes with soils has been measured using Unconfined Compressive Strength (UCS), and it has been found that adding 30% marble dust increases UCS by 20% [3].
- **Portland cement production:** The primary raw materials for Portland cement production are clay and other correction materials, as well as limestone of cement grade. Marble waste can satisfy also the chemical composition requirements

of limestone suitable for use in cement production. Limestone can be partially replaced by marble debris, or a combination of limestone and lime can be utilized.

- **To produce concrete:** Adding 35% marble dust to sand increases the compressive strength of concrete mixtures by 15%. Additionally, there is an enhancement in the concrete's density [3].
- **Marble slurry:** It is used to make bricks, made of extremely small particles, and is chemically dolomitic. When making bricks, it can be utilized as a fine aggregate with a binder of cement or lime. The physical characteristics of the bricks made using this procedure are superior to those of regular bricks, and the results are quite encouraging.
- **Production of terrazzo:** Terrazzo flooring is made by embedding small pieces of marble, quartz, granite, glass, or other suitable chips in cement or another type of chemical binder. The mixture is poured, cured, and then ground and polished to a smooth surface. Terrazzo is a composite material, poured in place or precast, which is used for floor and wall treatments.

**B) Decorative uses**

- **Landscaping:** Marble chips can be used as beautiful gravel for roads, walkways, building floors, and gardens.
- **Sculptures and art:** Waste marble can be used by artists to make ornamental items or sculptures.
- **Used to make home goods:** Nowadays, the marble processing industry produces different home and recreation center goods like flat and circular tables and kitchen cabinets. Different designers have made a line of straightforward home goods using leftover materials from the mining and cutting of marble. The designer created an experimental ceramic substance by mixing discarded stone powder with clay and twisted it by hand on a wheel to produce the collection.

**C) Filler and powder**

- **Filler material**: Marble powder can be utilized as a filler to improve the qualities of a variety of goods, such as paints, coatings, and plastics.
- **Ceramics:** It can be included in clay mixtures to enhance the quality of ceramic products.

**D) Applications in agriculture**

- **Soil treatment:** Marble dust is a soil amendment that can help raise the pH of the soil and supply calcium, which is good for some crops.
- **Acidic soil treatment:** The marble cutting waste and especially marble quarry waste could be used alternatively to agricultural lime for the neutralization of acid soils. Carbonate resulting from the processing of marble is an effective amendment to neutralize soil acidity. The use of marble quarry waste and marble cutting waste due to their great potential as an acid-neutralizing material may also help reduce the negative effects of these materials as waste disposal on the environment [4].

- **Animal bedding:** In livestock facilities, crushed marble can be used as bedding to provide comfort and lessen odors.

**E) Applications in the environment**

- **Water treatment:** To eliminate contaminants from water, marble waste can be utilized in filtering systems.
- **Carbon capture:** According to certain research, marble may be useful in removing carbon dioxide from the atmosphere.
- **Activated calcium carbonate manufacture:** Precipitated or activated calcium carbonate can be made using limestone or a mixture of leftover marble and marble dust from slurry.

**F) As an alternative to limestone**

In many industrial applications, limestone serves as the primary raw material. Marble waste can be used in place of limestone in various applications, such as the manufacture of lime, artificially agglomerated marble, glass, plastics, diluents, and pesticide carriers. It can also be used as a flux in the refining of metals in iron and steel metallurgy. In the production of magnesium and magnesia, uranium, alumina, nickel, tungsten, and the flotation of gold and silver, among other non-ferrous metals, as a neutralizing agent and filler for paints, rubber, etc. as a curing substance aiding in the efficient curing of water and numerous chemical manufacturing industries. As a mineral filler for putty and chalking compounds based on linseed oil or plastic.

**G) Creative items**

- **Composites:** Recycled marble can be mixed with resins to make composite materials for countertops, furniture, and other uses.
- **3D printing:** Waste marble can be used in additive manufacturing to create more environmentally friendly materials.

### 4.2.4. Advantages of Marble Waste Utilization

Utilizing marble waste has several financial advantages, including increased market competitiveness, employment creation, cost savings, and environmental sustainability. Adopting this strategy can improve company responsibility and profitability. There are various financial advantages of using marble waste in construction:

**A) Cutting expenses**

Reduced material costs: When producing concrete and asphalt, using leftover marble as a substitute for natural aggregates can lower the cost of raw materials.

Savings on waste management: Making use of waste reduces the expenses related to the transportation and processing of marble waste.

**B) Improved performance of the product**

Increased durability: Over time, concrete and other materials built from leftover marble may become stronger and more durable, which could result in cheaper maintenance costs.

Aesthetic appeal: Marble waste's distinctive look can raise the building materials' aesthetic value and possibly raise the value of a property.

**C) Differentiation in the market**

Sustainable branding: Businesses that use marble debris can promote their products as eco-friendly, attracting clients and customers who care about the environment.

Innovative products: By using leftover marble, new, distinctive products that stand out in the market can be created.

**D) Employment creation**

In new industries: Debris management, recycling, and building are among the industries that may benefit from the processing and use of marble debris.

Opportunities for skilled labor: To improve labor skills, workers may need specialized training in the processing and application of marble debris.

**E) Enhanced efficiency of resources**

Circular economy: Using garbage is in line with the circular economy's tenets, which include reusing materials, lowering dependency on virgin resources, and encouraging sustainable activities.

Decreased environmental impact: Government subsidies or tax breaks may result from reducing the carbon footprint linked to the sourcing of traditional materials.

**F) Long-term economic gains**

Decreased lifecycle expenditures: For builders and property owners, the durability and reduced maintenance requirements of materials made from leftover marble can result in lower long-term expenditures.

Innovation investment: Businesses may be eligible for grants, subsidies, or advantageous financing alternatives if they make investments in sustainable materials and procedures.

## 5. Conclusion

Using properly planned and designed quarry mining operations can significantly improve the quality and management of the environment in the marble quarry mining in Dichinama. The dimensional stone quarry mining is very different from the other metal or industrial minerals mining. It is mandatory to follow the necessary steps to lessen harm to the ecology and surrounding mining sites. Improved mining methods and recent technology should be used to minimize waste production during marble quarry mining operations. The marble quarry mining wastes need a proper disposal site, and it would be out of the mineralized zone of the marble deposit. It is also important to have a huge tailing dam near the marble processing facilities for collecting the mud, slurry, water, and other wastes. The water is recycled from the tailing dam and the slurry and mud are removed from the tailing to a properly designed disposal area closer to the marble processing plant. The mud and slurry are suitable for the intended use once they have dried. There is no unwanted concentration of any mineral component in the waste. The Dichinama marble wastes have several appropriate uses, such as the production of terrazzo, roads, railways, concrete, bricks, acidic soil treatment, etc.

## 6. Recommendations

Dimensional stone companies should create a sustainable mining strategy that includes post-mining recovery for impacted areas as well as waste management and reuse plans. Companies must use the appropriate cutting tool for the size and shape of the block, considering the multiwire cutter gangsaw machine in the processing plant, to reduce marble waste during mining. To reduce waste, the quality control representative should make sure the marble block at the quarry site satisfies product standards before it is loaded into the processing facility. For the greatest marble processing outcomes, the company should polish the marble surface using a professional-grade polishing machine. Large holes in marble should normally be filled with color-matched epoxy or another type of special cement to reduce the amount of wasted marble blocks. You might fill the hole with a silicone or vinyl caulk that matches in color if it's tiny and unnoticeable.

## Acknowledgements

We extend our gratitude to all colleagues and friends who critically reviewed this paper study and to those who provided some technical ideas and information. We also extend our sincere thanks to Saba Dimensional Stone PLC for covering full accommodation to study this research at the Dichinama marble quarry site.

## Authors' Contributions

The corresponding author (Kiross Haile Zeweli) prepared a research proposal and developed the design of the research study and review. The authors carried out all the work needed for and presented in this paper. Both authors reviewed and approved the manuscript for submission.

## Funding

No fund.

## Availability of Data

The datasets used or analyzed during the current study are available from the corresponding author upon reasonable request.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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