**CHAPTER ONE**

**INTRODUCTION**

A ceiling board is a horizontal slab covering the upper section of a room or internal space. A ceiling board is generally not structural but is a shell concealing the details of the structure above. However, the ceiling might be holding up building materials such as heat or sound insulation.

In modern buildings, electric lights, smoke detector, security cameras and signage are commonly attached to ceilings.

            This project however, is based on the production of ceiling board from local raw materials. These local raw materials include cement, fibre cellulose, fibre obtained from ground paper, mainly waste paper, water and some other additives.

            There are different types of ceiling boards. These include;

1)      Gypsum ceiling boards;

2)      Acoustical ceiling boards;

3)      Gypsum fibre ceiling boards;

4)      Cement fibre-ceiling boards. Etc

These types of ceiling boards are grouped in accordance to the raw materials used for the production. Gypsum ceiling boards are produced from gypsum, Acoustical ceiling boards are obtained from mineral wool, gypsum and small amount of paper and starch. Gypsum fibre ceiling boards are produced from gypsum and fibre to reinforce the ceiling board.

            This study however will be based mainly on the production of fibre cement ceiling boards. This consist essentially of an inorganic binder usually calcium silicate formed by the chemical reaction of a siliceous material and a calcareous material. This is reinforced by organic fibres(saw dust), fillers and pigment compatible with the fibre-reinforced cement to form a ceiling board.

In the past, ceiling boards were produced using Asbestos a fibre present naturally in rocks. It was used because of its high tensile strength, poor heat conductivity and high fire resistance. However, asbestos causes asbestosis, which leads to cancer. As a result of this problem, manufacturers of ceiling boards went into research to find out substitutes that can be used in the production of ceiling boards.

This substitute includes shredded wood(saw dust), cellulose fibre agricultural waste etc. Rather than industrial products (glass-fibre, iron fillings) and man-made

materials, the fibres best suited to the socio-economic circumstances of developing countries are natural fibres.

This project therefore, is based on how these natural fibres can be used in the production of ceiling boards in order to reduce cost and as well comparing the product with that which has been produced naturally.

PROBLEM STATEMENT

* The problem which is aimed at being tackled is that of cost of production materials with the use of agricultural waste material like sawdust in production.
* Another one is that of health threat of the existing production material, which is asbestos that is known to be cancerous.

**AIMS AND OBJECTIVES OF THE PROJECT**

* To study the possibility of making use of local raw materials for the production of ceiling board.
* To produce a board with good acoustic and thermal insulating properties.
* To produce a board with reduced cost to discourage importation there by saving Nigeria her foreign exchange and booting her economic status.
* To reduce environmental pollution caused by indiscriminate litering of papers and the pollution of the air resulting from burning these waste.

**JUSTIFICATION**

Sawdust concrete-based products can be classified as a light weight concrete building material that exploits organic elements being waste wood like sawdust, chip, and other cuttings with concrete-based material, which are cement and other aggregates. Sawdust concrete has several unique characteristics which make it competitive among other building materials (Sawdust Concrete, 2010): it is made of green, ecologically pure material; it controls interior humidity level; it is frostproof; it has favourable thermal mass and sound-proofing properties; it is fireproof; it is rot resistant; it is not subject to mold and fungi; it is light; it is compatible with cement, different finishes, stains, and varnishes.

**SCOPE OF THE STUDY**

The ceiling board is to be produced with the following dimensions:

* Length and width of 2 by 2 feet
* Thickness of 4mm, having thickness range with upper and lower limits of (4.02mm - 3.98mm)

**CHAPTER TWO**

**HISTORY OF CEILING SHEET**

The U.S. Gypsum Company (USG) invented drywall in 1916. It was originally called "Sackett Board," after the Sackett plaster company, a USG subsidiary. The material was first sold in the form of small, fireproof tiles, but within a few years, it was sold in multi-layer gypsum and paper sheets. In less then a decade, it took on the form we know, consisting of a single layer of compressed gypsum sandwiched between two sheets of heavy paper. While it only took a few years for this board to evolve into the material we know today, it took 25 years for builders to begin using drywall in any substantial quantity.

With all its uses and benefits, why were builders hesitant to use something as simple as drywall? At the time, drywall was thought of as a cheap fix, with none of the fine art associated with making plaster. People didn't want to live in homes that were shoddily constructed, so they stuck with the tradition and expense of plaster.

U.S. Gypsum eventually changed the brand name of the material to "Sheetrock" in an attempt to improve drywall's reputation, but builders and homeowners still paid no attention. It wasn't until the United States became involved in World War II that builders came around to the benefits of using drywall. As the country's labor force became focused on war manufacturing and many soldiers were sent overseas to fight, quick and inexpensive building materials were needed to offset the labor shortage and war costs. Because the labor shortage was too intense for plastering to remain a viable building option, people began to use drywall instead. Houses and factories could be constructed in a fraction of the time and with a fraction of the labor previously required. Cheap and efficient products were seen as patriotic because they allowed citizens to spend more time and money supporting the war effort.

By the time the war ended in 1945, drywall had become the dominant building material for walls and ceilings in the United States. During the post-war building boom, contractors knew they could construct homes and workplaces in one-tenth the time if they abandoned plaster for drywall, leading to higher profits. Over time, the use of plaster gradually faded as people all over the world turned to drywall. With net sales of over $5 billion in 2007, the U.S. Gypsum Company is still one of the world's top producers and innovators of drywall and related products.

**TYPES OF CEILING BOARDS**

* Asbestos cement ceiling board
* Acoustical ceiling board
* Gypsum ceiling board
* Gypsum fibre ceiling board
* Cement fibre ceiling board

**Acoustical ceiling board**

Acoustic ceilings tend to be made from fibrous materials that absorb sound energy, unlike plaster and gypsum ceilings. They do not necessarily reduce the transmission of sound between spaces, rather they reduce the amount that reflects back into the space and so can be used to tailor the acoustic character of a space.

The sound absorption performance of a ceiling material is expressed in terms of its noise reduction coefficient (NRC). An NRC of 0.85 means that a ceiling material absorbs 85% of the sound that reaches it, and reflects 15% back into the room. NRCs for most acoustical ceilings range from 0.5 to 0.9, compared to values below 0.10 for plaster and gypsum ceiling board materials.

Where acoustic privacy is required, heavier ceiling materials such as plaster or gypsum board are more effective.

**Gypsum ceiling board**

Gypsum board is the generic name for a family of panel products that consist of a noncombustible core, composed primarily of gypsum, and a paper surfacing on the face, back and long edges.

Decorative gypsum board has many properties such as light weight, high strength, fire proofing, ksound insulation and high ductility etc. It can be processed in such ways as sawing, planing, nailing, drilling and sticking. It's convenient in application and installation. The right side of decorative gypsum board should not have such defects to weaken its decorative effects as pores, blots, crackles, unfilled corners, disproportion of colors and incomplete patterns etc.

Gypsum board is the most common indoor building material in the United States. In the United States and Canada, gypsum board is manufactured to comply with ASTM Specification C 1396 which was designed to replace several existing ASTM specifications, leaving one reference standard for all gypsum board products. This standard is to be applied whether the core consists of natural ore or [synthetic gypsum](https://www.sciencedirect.com/topics/engineering/synthetic-gypsum).

Advantages of gypsum board include its low cost, ease of installation and finishing, fire resistance, nontoxicity, [sound attenuation](https://www.sciencedirect.com/topics/engineering/sound-attenuation), and availability. Disadvantages include: difficulty in curved-surface application and low durability when subject to damage from impact or abrasion.

**Cement fibre ceiling board**

In fibre cement there is a fibre reinforcement, which contributes to making the fibre-cement material even stronger. Together with a carefully planned production process, fibre cement makes it possible to develop strong and long lasting construction materials. Today fibre cement is considered as a material physically suited for construction products such as cladding and roofing. It is primarily due to its function, performance and commercial value.

Fibre cement is a main component of long-lasting [building materials](https://en.wikipedia.org/wiki/Building_material). The main application areas are roofing and [cladding](https://en.wikipedia.org/wiki/Cladding_%28construction%29). The list below gives some common applications.

**Roofing:**

* [Slates](https://en.wikipedia.org/wiki/Slate)
* Corrugated sheets

Some other applications are external and internal cladding.

**Internal cladding:**

* Wet room applications – [tile](https://en.wikipedia.org/wiki/Tile) [backer boards](https://en.wikipedia.org/wiki/Cement_board)
* [Fire protection](https://en.wikipedia.org/wiki/Fire_protection)
* [Partition walls](https://en.wikipedia.org/wiki/Partition_wall)
* [Window sills](https://en.wikipedia.org/wiki/Window_sill)
* [Ceilings](https://en.wikipedia.org/wiki/Ceiling) and [floors](https://en.wikipedia.org/wiki/Floor)

**External cladding:**

* Flat sheets as base and/or architectural facing
* Flat sheets for e.g. wind shields, wall copings, and soffits
* [Corrugated](https://en.wiktionary.org/wiki/corrugated) sheets
* Slates as architectural full and partial facing
* Underroof
* [Planks](https://en.wikipedia.org/wiki/Plank_%28wood%29)

Fibre-cement products have found a wide usage in various sectors of construction: industrial, agricultural, domestic and residential buildings, mainly in roofing and cladding applications, for new constructions and [refurbishment](https://en.wikipedia.org/wiki/Antiques_restoration) projects.

**RAW MATERIALS USED FOR THE PRODUCTION OF CEILING BOARDS**

* Cement: This is the main binding element of the ceiling board.
* Saw dust: This is the fibre used in the production of the ceiling board, in place of the common asbestos.
* Calcium carbonate: It is a colourless or white inorganic compound occurring as chalk, limestone, marble etc. It helps to strengthen the sheet during and after drying and prevent cracking.
* Kaolin: It is a fine clay rich in kaolinite. When kaolin is mixed with water in the range of 20 to 35 percent, it becomes plastic (i.e., it can be molded under pressure), and the shape is retained after the pressure is removed. With larger percentages of water, the kaolin forms a slurry, or watery suspension. The amount of water required to achieve plasticity and viscosity varies with the size of the kaolinite particles and also with certain chemicals that may be present in the kaolin. Kaolin helps the sheet to exhibit the properties of plasticity and shrinkage.

**OVERVIEW OF THERMAL PROPERTIES OF CEILING BOARDS**

Ceiling materials being overhead interior surfaces that can cover the upper limits of the room, are not generally considered as structural element but finished surfaces concealing the underside of room structure or the floor of store above.

In some places, zinc-made roofs without ceilings are very common, thus there is intense heat transfer to the internal environment, which may cause thermal discomfort to the inhabitants. One way to reduce the thermal discomfort is by the use of radiant barrier (i.e. ceilingboard) which reduce the heat flux. However, the knowledge of thermal properties of different materials is very importaknt in the choice of the types of materials to be used as a radiant barrier since the heat flow through any building depends on the thermal properties of the materials used in the building. The study of the thermal properties of materials will help one to know whether materials are suitable to use as Ceiling materials in our houses, schools and industries.

Heat is propagated in the interior spaces in buildings through roofs and walls and partly through ceiling panels by the process of conduction and radiation. This is because the common materials used as roofing sheets are materials like zinc and aluminum which have high thermal conductivities. To reduce the intensity of this heat, there is need to use materials of tolerable thermal responses as ceiling materials in buildings. Though the various ceiling types vary in their insulation property. Good insulating materials will have high value of thermal resistivity. This implies that, different types of ceiling materials will have different thermal behaviors.

Insulator is a material used to inhibit or prevent the conduction of heat or electricity. Proper selection of insulating materials is based on their thermal properties which include:

* thermal conductivity
* thermal absorptivity
* thermal diffusivity
* specific heat capacity

The primary function of insulator in buildings are to:

* conserve energy
* reduce heat loss or heat gain
* maintain a temperature condition
* maintain the effective operation of equipment or chemical reaction
* assist in maintaining product at constant temperature
* prevent condensation
* create comfortable environmental condition and protect personnel.

**OVERVIEW OF ACOUSTIC PROPERTIES**

**Acoustics Properties of Building materials**

It is very important to distinguish between sound absorption and sound transmission loss. Sound absorbing materials control sound within spaces and function by allowing sound to pass through them relatively easily. They are generally porous and absorb sound as a result of many interactions. Conversely, a material or system, that provides a good sound transmission loss is usually non-porous and a good reflector of sound.

**Sound Absorptive Properties of Materials**

Noise is generally controlled within a space using sound absorbing materials.

Sound absorption relates to the percentage that effectively disappears when the sound

wave hits a body or surface. Sound absorption is evaluated by measuring the reverberation time of a room. The reverberation time is defined as the time taken for the noise (sound pressure level) to fall to 60dB below its original level when a sound source ceases to operate. If the reverberation time is long then the room will be live and the conditions will be acoustically uncomfortable for most activities. If the reverberation time is too short then sounds such as music may appear flat and lack character. Assuming that the material has greater sound absorption than the room surface on which it is installed, the reverberation times which are again measured will now be shorter than in the empty condition. A hard concrete surface has a very low sound absorption coefficient (less than 0.05 at most frequencies), whereas a thick carpet and underlay can approach 1. Acoustic consultants use the absorption coefficients of materials to estimate the reverberation times of specific buildings. However, in many rooms for example small offices, it is sufficient to specify totally covering one or two surfaces with a good sound absorbing product such as carpet or a mineral fibre tile ceiling.

**Basic Factors in Acoustics Design**

Acoustics is a branch of physics which deals with the generation, propagation, reception, and analysis of sound waves. The factors affecting acoustics design are:

* Reverberation time
* Loudness
* Focusing
* Echo
* Echelon effect
* Resonance
* Noise

**CHAPTER THREE**

**APPARATUS AND EQUIPMENT**

|  |  |  |  |
| --- | --- | --- | --- |
| ITEM NO. | EQUIPMENT | DESCRIPTION | QTY |
| 1. | Frame | 2 inches angle iron | 1 |
| 2. | Cooking chamber | 3mm plate | 1 |
| 3. | Electric motor | Induction motor, 1400rpm | 3 |
| 4. | Mold | 3mm plate | 2 |
| 5. | Slider | 3mm plate | 2 |
| 6. | Threaded shaft | Mild steel rod | 2 |
| 7. | Rail | Mild steel block | 8 |
| 8. | Bearing | 30mm pillow bearing | 4 |
| 9. | Support plate 1 & 2 | 5mm plates | 4 & 2 |
| 10. | Press plate | 3mm plate | 1 |
| 11. | Mold holder | 3mm plate | 1 |
| 12. | Mold collector | 2mm plate | 1 |
| 13. | Motor pulley | Mild steel | 3 |
| 14. | Shaft pulley | Mild steel rod | 3 |
| 15. | 4-bolt flange bearing(UCF206) | 30mm flange bearing | 2 |
| 16. | Cooking shaft with paddle | 30mm & 20mm rod | 1 |
| 17. | Belt1-15 press1 | Fiber | 1 |
| 18. | Belt2-16 press2 | Fiber | 1 |
| 19. | Belt3-17 cooking | Fiber | 1 |
| 20. | Press base plate | 3mm plate | 1 |

**MANUFACTURING PROCESS**

The materials along with water when gotten in its right composition is poured all in the cooking chamber. It is all mixed with the help of the cooking shaft and the paddles. After thorough mixing the slurry is allowed passage through an opening close to the bottom of the cooking chamber into the press base plate. The slurry is spread evenly on the surface of the press base plate. The first motor is then turned on which then rotates the pulley via the pulley belt to lower the press plate down to the base plate along the length of the vertical threaded shaft (conversion of rotary motion to upward and downward motion). The press plate is allowed a certain downward distance to travel which helps it press on the slurry evenly without over compacting it. It is left for some time to solidify a bit.

After it has has partly solidified, the base plate is extracted manually to the second section where the patterned mold is inserted in place of the press plate like in the first section. The second electric motor is turned on and with the same principle as the first, the patterned mold is lowered and pressed upon the partly solidified sheet. It is left for about three days to dry for the patterned ceiling sheet to be ready.

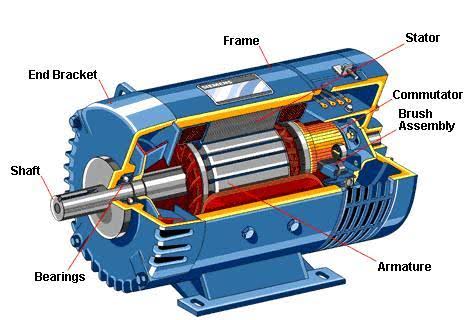


Fig 1: Electric motor

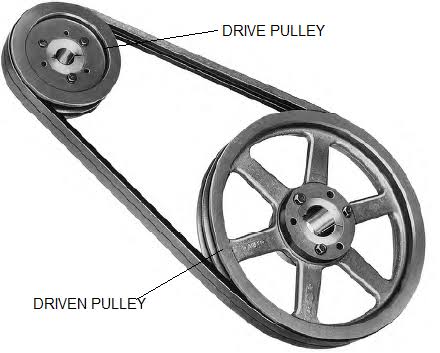


Fig 2: Motor pulley(driver), shaft pulley(driven) and pulley belt

