

## **A THERMOMECHANICAL PROCESS FOR RECYCLING PLASTIC WASTE, FLEXIBLE LAMINATED PACKAGING WASTE, AND MINERAL AGGREGATES INTO ECO- FRIENDLY BUILDING MATERIALS**

### **Technical Field**

[0001] The present invention belongs to the field of plastic waste mechanical recycling and relates to a process of producing highly performing building materials employing low-value plastic waste and flexible laminated packaging waste.

### **Background Art**

[0002] The subject matter discussed in the background section should not be assumed to be prior art merely because of it being mentioned in the background section. Similarly, a problem mentioned in the background section or associated with the subject matter of the background section should not be assumed to have been previously recognized in the prior art. The subject matter in the background section merely represents different approaches, which in and of themselves may also correspond to implementations of the claimed technology.

[0003] Plastic products' usage is prevalent in our lives and cannot be prevented due to its importance. Once the plastic product is utilized, it is discarded and called plastic waste. It is reported that about 70% of the plastic, used for packaging purposes, ends up as plastic waste in a short span of time. Plastic waste is one of the greatest hazards to marine ecosystems since 8 million tons of plastic waste get dumped in the oceans every year. Plastic waste is also dumped into landfills, with severe environmental harm owing to its slow degradation rate. Further, when plastic waste is combusted, it emits dangerous gases that harm human health. The disposal of plastic waste in a safe manner remains a huge concern for environmentalists. Though 60% of the plastic waste gets recycled in India, the country is yet to improve its recycling potential and put the plastic waste to best use. This should be accomplished to support the environmental concern too i.e., depletion of the natural resources to manufacture the construction materials. So, recycling plastic waste into construction materials will be an ideal solution to

tackle this problem (S Subha Pradha and K Saranya, IOP Conf. Series: Earth and Environmental Science, ICDIMSE-2022).

[0004] According to the Organization for Economic Co-Operation and Development (OECD), only 9% of plastic waste is being recycled worldwide because this is the portion that can be food-grade plastic waste and can be segregated from other types of plastic waste. The other 91% are plastic waste that is chemically or physically distorted which cannot be food grade anymore, or mixed plastic waste types which cannot be separated for mechanical recycling. This 91% of the plastic waste either goes to incineration, landfills, oceans, or open dumping which severely harms the environment.

[0005] Typical mechanical recycling solutions require plastic waste to be finely sorted by type and color and extensively cleaned to recycle specific polymers into their original shapes and applications. The most common thermoplastic polymer types that are involved in various industries include but are not limited to PE(LDPE/HDPE)/PP/PS/PET/PVC/ABS/PLA.

[0006] Flexible packaging (also referred to as flexible laminated packaging), which is being used extensively in the food packaging industry, has been solving multiple sustainability issues to food manufacturers, yet the industry has not to date solved its recycling dilemma. Flexible laminated packaging is highly challenging to recycle because it consists of multiple layers of thermoplastics, and in most cases also includes a layer of non-plastic material such as aluminum. Once these layers are extruded together, it is impossible to separate them mechanically. Recent chemical technologies of single layer extraction have been experimented to these materials, yet these technologies have not yet reached a mature level to be extensively used by the food packaging industry and recycling facilities and have comparatively excessive costs compared to mechanical recycling. Flexible packaging is the most widely known form of multi-layer plastics that also exists in many other industries.

[0007] The challenges related to having mixed plastic waste types and the presence of the hard to recycle materials, such as multi-layer plastics, have resulted in having a global plastic recycling rate of 9% because of technology gap that can handle the complex majority of plastic waste.

[0008] Several solutions attempting to mechanically tackle these mixed plastic waste types, either solely or by mixing them with other materials, are known from the prior art of the mechanical recycling field. However, they still face multiple limitations related to the feedstock and the treatment process, associated with excessive costs and low-performance products, and could not handle hard to recycle materials such as multi-layer plastics.

[0009] Most of the prior art patent documents describe various methods for creating a building material from a combination of unsorted thermoplastic waste and mineral aggregate. One method involves heating the mineral aggregate to 160-220 DEG C, mixing it with unheated thermoplastics, then combining the mixture with 70 DEG C heated filler and compressing it using compression molding or flat pressing. However, this method has drawbacks such as inefficient energy usage, inadequate melting of thermoplastics, and lack of information on impurity tolerance and resulting material characteristics. Another method involves heating heterogeneous waste to melt the plastic portion, mixing it in a rotating chamber or by stirring, and cooling it into composite material for various building materials. This method also has setbacks including uncontrolled processes due to unsorted waste, energy inefficiency, and low product pressure resistance. Additionally, there are methods for manufacturing paving slabs from LDPE plastic waste, glass waste, and porcelain waste which are limited to specific waste types and have high energy consumption and cost limitations. These methods do not address complex plastic waste types or incorporate mineral aggregates into the material composition.

[0010] Therefore, there is a need for a process of producing highly performing building materials employing low-value plastic waste and flexible laminated packaging waste.

## **Summary of Invention**

[0011] According to the first embodiment of the present invention, it aims to provide a substantial solution to recycle all types of plastic waste, especially the low-value and mechanically hard-to-recycle ones. The present invention is about a thermomechanical process which takes all types of thermoplastic wastes unsorted, and multi-layer plastic waste (flexible laminated packaging) and mixing

these plastic wastes with mineral aggregates extrude this mix into a sub-solid melt and mold the melt into the desired building material product.

[0012] In accordance with an embodiment of the present invention, mechanical recycling of all types of thermoplastic polymers waste including but not limited to LDPE/HDPE/PP/PET/PS/PVC/ABS/PLA.

[0013] In accordance with an embodiment of the present invention, recycling of all thermoplastic polymers mixed or separated, without affecting the quality and durability of the final products. The process can source these mixed low-value thermoplastic polymers that are heavily contaminated with any types of contamination from landfills/material recovery facilities/industrial facilities/water bodies/etc. which eliminates any limitations on the plastic waste feedstock.

[0014] In accordance with an embodiment of the present invention, utilizing Flexible laminated packaging is the most widely known application of multi-layer plastics and multi-layer plastic waste which is one of the most challenging materials to recycle since they are usually composed of 1 to 4 plastic layer(s) associated with aluminum foil and utilizing mineral aggregates as one of the raw materials to produce building materials through the proposed process.

[0015] In accordance with an embodiment of the present invention, treating mineral aggregates as a filler in the material structure that gives the final product(s) the anticipated strength and bulk density.

[0016] In accordance with an embodiment of the present invention mineral aggregates include but are not limited to all types of sand, gravel, sandstone, limestone, demolishing and construction waste, fly ashes and granite.

[0017] In accordance with an embodiment of the present invention a process defined for producing building materials from low-value plastic waste, mechanically unrecyclable plastic waste and mineral aggregates through a thermomechanical process of three main stages namely pre-processing, processing, and post-processing.

[0018] In accordance with an embodiment of the present invention, pre-processing stage, the three main raw materials are prepared for the later production stages. Thermoplastics and multi-layer plastics are prepared by shredding, washing, and drying.

- [0019] In accordance with an embodiment of the present invention, washing and drying stages are optional according to the raw materials' contamination types and levels.
- [0020] In accordance with an embodiment of the present invention, Mineral aggregates are prepared by shredding only in case they come in bulky sizes. Otherwise, they are used in their original conditions.
- [0021] In accordance with an embodiment of the present invention, the pre-processing stage comprising a material analysis step to analyze the types of plastic polymers present in the feedstock and the variations that may result from material degradation to specify the suitable processing parameters such as temperature ranges, pressure ranges, melt conditions and cycle times in the following stages.
- [0022] In accordance with an embodiment of the present invention the processing stage resembles the core stage of the process in which the raw materials are transformed from their original dry grain shapes into the final building material(s) form through mixing, extrusion, and cold compression molding.
- [0023] In accordance with an embodiment of the present invention the mixing stage, raw materials are physically mixed in a mixer at room temperature for 1-15 minutes according to the material types and batch size. It is optional to replace normal mixing with hot mixing in a range of 40 – 100 DEG C that can result in better homogeneity of the solid mix.
- [0024] In accordance with an embodiment of the present invention transferring the solid mix to the extrusion stage in which the mix is extruded by applying pressure and temperature inside an extruder machine that densifies the mix and gets the material into a moldable sub-solid state.
- [0025] In accordance with an embodiment of the present invention the temperature range of the extrusion stage ranges from 130 – 350 DEG C according to the present polymers in the mix, and the mineral aggregate type.
- [0026] In accordance with an embodiment of the present invention splitting the extrusion stage into two parallel extrusion stages to make the final product(s) of two layers is optional.

- [0027] In accordance with an embodiment of the present invention the melt is transferred to a cold compression mold that is installed on a hydraulic press to formulate the final product by shaping the product under a pressure ranging from 500 – 20,000 ton/m<sup>2</sup> of the final product(s) according to the product(s) thickness, and cooling the final product(s) to a temperature ranging from 30-80 DEG C according to the product(s) thickness.
- [0028] In accordance with an embodiment of the present invention a post-processing stage of the presented process is where optional secondary cooling, quality inspection and final product finishing, if necessary, take place.
- [0029] In accordance with an embodiment of the present invention secondary cooling takes place in cases where instantaneous packaging is required, and the output temperature of the desired product does not match the ultimate strength temperature is optional.
- [0030] In accordance with an embodiment of the present invention passing the final product through visual and mechanical quality inspection to validate the anticipated product standards then goes into a finishing step in case there is flash in the product to remove remaining flashes.
- [0031] Another preferred embodiment of the present invention is a building material that has superior mechanical specifications than concrete. The building material according to the current invention are ecofriendly, lighter, stronger, better resistant to abrasion, better resistant to water absorption, better noise and heat insulation, and better visual appearance. The building material according to the present invention is provided in a variety of colors and shapes.
- [0032] In accordance with the present invention is a process that marks energy savings of up to 62% compared with traditional processes of making concrete building materials.
- [0033] In accordance with the present invention paving tiles consume 35% less water than concrete paving tiles, with more potential savings using waste-water treatment unit since the water we are using is for plastic waste washing only, and is not part of the material mix, unlike concrete.
- [0034] In accordance with an embodiment of the present invention there is a noticeable decrease in the carbon emissions of the building materials of the

present invention because low-value and mechanically unrecyclable plastic waste that would otherwise go to landfills or incinerators is recycled (using an emission-free technology), carbon-emitting raw materials like cement are eliminated, and the local supply chain of raw materials (plastic waste) is established.

[0035] In accordance with an embodiment of the present invention the building material is provided with all bright and dark colors which aids keeping the Solar Reflective Index (SRI) of flooring tiles below 0.33 to eliminate the heat island effect and keep the roofing tiles SRI value above 80 to keep the building temperature. Although concrete building materials can have multiple, yet limited colors, they suffer from keeping these colors over their life span because of using oxides for coloring. On the contrary, the building materials in accordance with the present invention coloring materials are from the colors of plastic waste materials which keeps the coloring consistency over the life span of the products.

[0036] The building materials in accordance with the present invention have longer life expectancy than concrete materials. Since said building materials have better compressive strength, water absorption resistance and abrasion resistance than concrete.

[0037] The building materials in accordance with the present invention are entirely recyclable and may be crushed and used into new products. Although building and trash demolition are worldwide challenges.

[0038] In accordance with an embodiment of the present invention producing various building materials including but not limited to all paving tile types, roofing tiles, building bricks, cladding sheets, structural beams, and other products that are traditionally made from composite materials and/or concrete, the process presented produces.

## **Brief Description of Drawings**

[0039] So that the way the above recited features of the present invention can be understood in detail, a more particular to the description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, the invention may admit to

other equally effective embodiments. These and other features, benefits and advantages of the present invention will become apparent by reference to the following text figure, with like reference numbers referring to like structures across the views, wherein:

**Fig.1**

[0040] [Fig. 1] is a process map (flow chart) of a process of producing improved building material made from low value plastic waste and flexible laminated packaging waste as a preferred embodiment of the current invention.

**Fig.2**

[0041] [Fig. 2] illustrates a graph testing compressive strength, water absorption, abrasion resistance of a building material as another preferred embodiment of the current invention.

**Fig.3**

[0042] [Fig. 3] illustrates graphs 1 and 2 testing the relation between number of molding cavities and the compression force and the cooling capacity.

**Fig.4**

[0043] [Fig. 4] illustrates a graph testing the relation between the degree temperature and solidification of the final product.

**Description of Embodiments**

[0044] The present invention is described hereinafter by various embodiments with reference to the accompanying drawing, wherein reference numerals used in the accompanying drawing correspond to the like elements throughout the description.

[0045] While the present invention is described herein by way of example using embodiments and illustrative drawings, those skilled in the art will recognize that the invention is not limited to the embodiments of drawing or drawings described. Further, some components that may form a part of the invention may not be illustrated in certain figures, for ease of illustration, and such omissions do not limit the embodiments outlined in any way. It should be understood that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the invention is to cover all

modifications, equivalents, and alternatives falling within the scope of the present invention as defined by the appended claims. As used throughout this description, the word "may" is used in a permissive sense (i.e., meaning having the potential to), rather than the mandatory sense, (i.e., meaning must). Further, the words "a" or "an" mean "at least one" and the word "plurality" means "one or more" unless otherwise mentioned. Furthermore, the terminology and phraseology used herein is solely used for descriptive purposes and should not be construed as limiting in scope. Language such as "including," "comprising," "having," "containing," or "involving," and variations thereof, is intended to be broad and encompass the subject matter listed thereafter, equivalents, and additional subject matter not recited, and is not intended to exclude other additives, components, integers or steps. Likewise, the term "comprising" is considered synonymous with the terms "including" or "containing" for applicable legal purposes. Any discussion of documents, acts, materials, devices, articles and the like are included in the specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention.

[0046] This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiment set forth herein. Rather, the embodiment is provided so that this disclosure will be thorough and complete and will fully convey the scope of the invention to those skilled in the art. In the following detailed description, numeric values and ranges are provided for various aspects of the implementations described. These values and ranges are to be treated as examples only and are not intended to limit the scope of the claims. In addition, a number of materials are identified as suitable for various facets of the implementations. These materials are to be treated as exemplary and are not intended to limit the scope of the invention.

[0047] The present invention refers to a complete thermomechanical process of recycling plastic waste, flexible laminated packaging waste, and mineral aggregates into highly performing, eco-friendly, economic, and aesthetic building materials. The present disclosure will be best understood by reference to the following definitions.

[0048] Within the context of the invention, the term “plastic waste” refers to any item made from at least one plastic material, such as plastic sheet, tube, rod, profile, shape, massive block, fiber, etc., which contains at least one of: PE (Polyethylene), PP (Polypropylene), PS (polystyrene), PET (Polyethylene Terephthalate) or (polyester resin), PVC (polyvinyl chloride), PLA Polylactic acid or polylactide (PLA) /ABS It is a composite of acrylonitrile (A), butadiene (B), and styrene (S), which is also called ABS resin and possibly other substances or additives, such as plasticizers or mineral or organic fillers. Low-value plastic waste can be coming from individual, municipal or industrial sources while allowing any types and levels of contamination to the feedstock. Thermoplastic waste can be received either separated or in a mix of any range and diversity.

[0049] Within the context of the invention, the term Flexible packaging plastic waste (FPPW) is an omnipresent waste stream that includes plastic films, bags, flexible food packaging (including mono-layered and multi-layered) and other single-use flexible plastics. Enormous amounts of FPPW continue to flow into the natural environment annually.

[0050] Within the context of the invention, the term mineral aggregate means gravel, sand, clay, earth, shale, stone, limestone, dolostone, sandstone, marble, granite, rock, or other material prescribed under the Aggregate Resources Act.

[0051] Within the context of the invention, the term fine additives means materials that are added in minor percentages to acquire certain extra features in the final product(s) such as specific color or pattern of colors, UV resistance, slip resistance, fire resistance, etc.

[0052] Within the context of the invention A “recycling process” in relation to a plastic product refers to a process by which at least one polymer of said plastic product is degraded to yield, which are retrieved in order to be reused.

[0053] Referring to [Fig. 1] is a flow chart 100 of a complete process for recycling and treating plastic waste, flexible laminated packaging waste, and mineral aggregates as a preferred embodiment of the present invention. The present invention establishes a thermomechanical process that will be described in steps hereafter.

[0054] referring to [Fig. 1] the three raw materials; low-value plastic waste, flexible laminated packaging, and mineral aggregates are received and put through a series of stages in the first stage of the process, called pre-processing A, and core processing stages including processing stage B, and post processing stage C.

[0055] A pre-processing A involves the steps hereunder: shredding, washing, drying, densifying (optional) 102, and analyzing the material composition 104.

[0056] Referring to [Fig. 1] , step 102 includes the shredding process which incorporates low-value plastic waste and flexible laminated packaging debris. In the said step there is no set restriction on the size of the shredded plastic waste materials' grains, but it is recommended to keep them as small as possible and match the grain size of the mineral aggregates in order to maximize the bulk density of the raw materials, reduce the amount of time and energy needed to mix and melt them, and improve the coherence of the finished product. For rigid thermoplastic waste, the recommended grain size according to present invention ranges are from 5 to 25 mm; for flexible thermoplastic wastes and flexible laminated packaging wastes, the ranges are from 10 to 50 mm; and for mineral aggregates, ranges from 1 to 10 mm. In the shredding step 101 industrial shredders and granulators with single or dual shafts are used. The shredding machine is equipped with a metal detector/separator to provide safe operations, reduce maintenance expenses, and limit machine downtime.

[0057] The shredded plastic waste is then transferred to washing process 102, where they are cleaned in a one- or two-stage washing system with water at room temperature because the majority of the hard-to-recycle plastic trash is highly polluted. Frictional washing machines or sink/float washing tank(s) are used for the washing process. To reduce the amount of water consumed, it is recommended to install a waste-water treatment plant where wasted water can be recycled and reinjected into the washing cycle. To maximize the cleaning level of the materials, a hot washing stage in the washing process is optional.

[0058] To limit moisture content and dry plastic waste, cleaned wastes are injected into a drying process 102. This serves as a prelude to the subsequent core manufacturing stages. In accordance with the present invention the range for

humidity levels is between 2 and 8% to reduce the amount of energy needed for mixing and melting during later stages of manufacture. A frictional hot drying machine is used for the washing process. Heating is required for flexible or mixed plastic wastes but not for hard plastic wastes according to the present invention.

[0059] In accordance with the present invention if flexible plastics make up the majority of the plastic waste feedstock, adding a densifying process is optional. This will reduce the plastic waste's grain size in the range of 1 to 10 mm, which will help with subsequent production steps by maximizing the bulk density of flexible low-value plastic waste and/or flexible laminated packaging waste. This will also reduce the amount of time and energy needed for mixing and melting, resulting in better coherence for the finished product.

[0060] In accordance with the present invention, material analysis 104 is the final step in the pre-processing stage. It involves routinely analyzing dry, clean, shredded plastic wastes to ascertain the feedstock's composition and adjust the process parameters for the subsequent manufacturing stages accordingly. A computerized material analysis machine or manual standard on-site sample tests can be used for the material analysis process. It is optional to move the material analysis process before washing and drying stages if determining the contamination type and level and the existence of metal pieces is necessary.

[0061] In another embodiment of the present invention is the second stage of the aforementioned process namely processing stage labelled as B in [Fig. 1], the core production processes of mixing, extrusion, and cold compression molding take place.

[0062] In accordance with an embodiment of the present invention the mixing stage (105, 106), the raw materials are physically mixed to create a mixture that is comprising of 10% to 50% low-value plastic waste, 0% to 50% multi-layer plastic waste (optional), and 90% to 50% mineral aggregates thereof. The mixture hereby is mixed in an inclined frictional mixer machine for about 1-15 minutes per batch, depending on the material specifications obtained from the material analysis step 104. Additionally, fine aggregates can be added in the range of 1 of 1000 to 25 of 1000 of the whole dry weight of the mix if specific features such as

color, anti-slipping, anti-scratch, flame retardant, or anti-UV properties are required.

[0063] Extrusion stage 107 involves squeezing and melting the dry mix using one or two parallel extruders thereof. The output is a sub-solid dense melt at a temperature range of 130-350 DEG C controlled by four different temperature control zones. The extruders have a long L/D ratio ranging from 15 to 50 and mechanical parts treated for high wear resistance. In the cold compression molding stage, the one- or two-layer melt(s) are transferred to a compression mold installed on a hydraulic press. The mold may comprise one or more molding cavities, wherein the compression force is linear with the number of the mold's cavities as shown in graph 1 [Fig. 3] . The product is compressed, cooled, and shaped into the final product shape. Graph 2 [Fig. 3] shows the exponential relationship between cooling capacity and the number of molding cavities is further demonstrated in [Fig. 3] . The process may also include adding a top layer made of plastic waste only or plastic waste and mineral aggregates to minimize material costs. However, adding a top layer will require an additional mixing named top layer mixing step 106 and extrusion process 107. According to the present invention the process provides an innovative approach to recycling plastic waste and producing sustainable construction materials with economic and environmental benefits.

[0064] The mixture herein is ready for the cold compression step 108, whereby the mixture is compressed, molded, shaped, and cooled. Secondary cooling may take place in cases where instantaneous packaging is required, and the output temperature of the desired product does not match the ultimate strength temperature. As shown in the graph of [Fig. 4] , the relation between the degree temperature and solidification of the final product is exponential. Flash removal step follows 109 wherein excess material builds up on the outside of a molded part are removed, typically after leaking through the parting line of the mold. Preventing or minimizing flash can involve steps at both the mold making and molding stage. According to the present invention molds are less likely to produce flash, because of proper handling of the molding process.

[0065] Referring to [Fig. 1] , Visual and mechanical inspection step of the molded material follows, wherein visual inspection is the simplest and most common

inspection technique for injection molding. It involves checking the appearance, color, surface finish, and shape of the molded parts for any defects or deviations from the specifications. Mechanical inspection may include but is not limited to dimensional inspection which is the measurement of the size and geometry of the molded parts to ensure they meet the tolerances and dimensions required by the design. Pressure testing is the application of pressure to the molded parts to evaluate their strength, durability, and leak resistance.

[0066] Referring to the flow chart in [Fig. 1], if the molded material meets the quality standards 111, it will proceed to the product packaging step 113. If it does not meet the standards, the product will be moved to scrap shredding step 112.

[0067] Another preferred embodiment of the present invention, referring to [Fig. 2] illustrating a graph testing compressive strength, water absorption, abrasion resistance of a building material with mechanical specifications that outperform concrete in several ways. The building material according to the current invention are ecofriendly, lighter, stronger, better resistant to abrasion, better resistant to water absorption, better noise and heat insulation, and better visual appearance. The building material according to the present invention is provided in a variety of colors and shapes. The building material outperforms concrete in several ways, including being two to six times stronger, zero to twenty percent lighter, two to six times more resistant to abrasion, three to twenty times more water resistant, less thermally conductive, and better at insulating against sound.

[0068] In accordance with the present invention is a process that marks energy savings of up to 62% compared with traditional processes of making concrete building materials.

[0069] In accordance with the present invention building materials consume 35% less water than concrete products, with more potential savings using waste-water treatment unit since the water used in the present invention is for plastic waste washing only, and is not part of the material mix, unlike concrete.

[0070] There is a noticeable decrease in the carbon emissions of the building materials of the present invention because low-value and mechanically unrecyclable plastic waste that would otherwise go to landfills or incinerators is recycled (using an emission-free technology), carbon-emitting raw materials like

cement are eliminated, and the local supply chain of raw materials (plastic waste) is established.

[0071] The building materials in accordance with the present invention are provided with all bright and dark colors which aids keeping the Solar Reflective Index (SRI) of flooring tiles below 0.33 to eliminate the heat island effect and keep the roofing tiles SRI value above 80 to keep the building temperature. Although concrete building materials can have multiple, yet limited colors, they suffer from keeping these colors over their life span because of using oxides for coloring. On the contrary, the building materials in accordance with the present invention coloring materials are from the colors of plastic waste materials which keeps the coloring consistency over the life span of the products.

[0072] The building materials in accordance with the present invention have longer life expectancy than concrete materials. Since said building materials have better compressive strength, water absorption resistance and abrasion resistance than concrete,

[0073] The building materials in accordance with the present invention are entirely recyclable and may be crushed and used into new products. Although building and trash demolition are worldwide challenges.

[0074] The paving tiles specifications as an example of the above-mentioned embodiment versus concrete tiles are described in table 1:

[0075] [table 1]

| SPEC/PRODUCT                                     | Concrete Paving Tiles  | Present Invention's Paving Tiles | Comparison                         |
|--------------------------------------------------|------------------------|----------------------------------|------------------------------------|
| Product Density                                  | 2.4 g/cm <sup>3</sup>  | 1.8 to 2.1 g/cm <sup>3</sup>     | 10-25% lighter than concrete tiles |
| Compressive Strength ASTM C140/BS EN 1338        | 250 kg/cm <sup>2</sup> | 300-1500 kg/cm <sup>2</sup>      | 1X to 6X stronger                  |
| Water Absorption Resistance ASTM C140/BS EN 1338 | 4-6% of tile weight    | 0.2% of tile weight              | 20X better                         |
| Abrasion Resistance                              | ≥ 23 mm (grade 2)      | ≤ 20 mm (grade 4)                | 2X better                          |
| Unpolished Slip Resistance Value BS 7932         | Unspecified            | 44                               |                                    |
| Thermal Shock                                    | Unspecified            | Compliant to 10 cycles           |                                    |

|                                               |                          |                                                           |                                     |
|-----------------------------------------------|--------------------------|-----------------------------------------------------------|-------------------------------------|
| <b>Resistance ASTM C484</b>                   |                          | of 150 DEG Celsius without any visual defects             |                                     |
| <b>Acids, Salts, and Bacterial Resistance</b> | N/A                      | Plastics are highly resistant to such corrosive materials |                                     |
| <b>Color Availability</b>                     | Grey, red, black, yellow | Variety of colors and shades according to demand          | Wider color range and customization |

[0076] in accordance with an embodiment of the present invention the building materials includes but not limited to all paving tile types, roofing tiles, building bricks, cladding sheets, structural beams, and other products that are traditionally made from composite materials and/or concrete.

[0077] The present invention is not limited to the above embodiments and various changes and modifications can be made within the spirit and scope of the present invention. Therefore, to apprise the public of the scope of the present invention, the following claims are made.

## Claims

- [Claim 1] A thermomechanical process for recycling plastic waste and mineral aggregates into building materials, comprising pre-processing stage A, processing stage B, and post-processing stage C wherein pre-processing stage A comprises:- Shredding plastic waste debris into grains;- washing the shredded materials;- drying the cleaned materials;- optional material analysis; and- optionally densifying flexible plastics to reduce grain size. And processing stage B comprising:- physically mixing raw materials to create a mixture comprising of 10% to 50% plastic waste, and 50% to 90% mineral aggregates;- adding fine additives if specific properties are required; and- extruding the dry mix into sub-solid dense melt;- transferring the sub-solid melt(s) to a cold compression molding stage for product shaping. And post-processing stage C comprising:- flash removal;- quality inspection;- product packaging.
- [Claim 2] The process according to claim 1 wherein the plastic waste contains up to 50% multi-layer plastic waste (flexible laminated packaging waste).
- [Claim 3] The process according to claim 1, wherein material analysis is performed to during the pre-processing stage A to identify the percentage of existent polymers and decide the operating parameters of the processing stage B accordingly.
- [Claim 4] The process according to claim 1, wherein fine additives are used to produce said building materials in a variety of colors and shapes to meet diverse architectural and design requirements.
- [Claim 5] The process according to claim 1, wherein production not meeting quality standards is shredded and recycled by inputting it as a raw material in the process.
- [Claim 6] A building material comprising 10% to 50% plastic waste, 0% to 50% multi-layer plastic waste, and 50% to 90% mineral aggregates.