THE POTENTIAL OF USING NATURAL MATERIALS IN IRAQ IN PRODUCING SUSTAINABLE BUILDINGS

[1]KHALID ABDUL WAHHAB, [2] NAWFAL JOSEPH RIZKO

[1]Department of Architecture, College of Engineering, Al-Nahrain University, Baghdad, Iraq,326-34-163
[2]Department of Architecture, College of Engineering, Al-Nahrain University, Baghdad, Iraq,312-14-125
E-mail: [1]dr.khalid.abdulwahab@nahrainuniv.edu.iq

Abstract -
This paper uses a descriptive analytical method to clarify the great potentials of the actual existing natural resources in Iraq to be an important source in manufacturing of a new type of sustainable building materials via friendly production methods. For contemporary architecture in its current form needs the application of new principles or reuses the old ones that have been used in traditional architecture and have proven their success over time in providing an economical sustainable architecture. So that kind of architecture can be the source of inspiration to our new sustainable architecture in providing solutions to address world environmental problems, and achieve sustainability in the built environment. One of these principles is using the same affordable natural materials that have been used in our ancestor's traditional architecture, but in a new way. For it's important in creating a sustainable built environment. What helps in this matter is the wide diversity of natural environmental friendly materials and their multiplicity physical characteristics, as well as these materials are easy to use, abundant in nature which makes obtaining and using them is within low costs. That makes them ideal for usage inside and outside building. Hence emergence the research problem related to the shortage of local clarity about the possibilities and the advantages of re using the available natural materials in Iraq as raw industrial source in production sustainable building materials. Research hyposthesis supposes that by using natural banded material in Iraq will lead to new kind of Iraqi sustainable built environment and strengthen its cultural identity in healthier cities.

Keywords - Building Material, Palm Tree, Reed, Sustainable Material, Wood Plastic Composite.

INTRODUCTION

Today the modern building materials are produced and used globally without taking into account the nature of its local environment in which they are used, that caused damages to its natural environment due to the widespread usage of this type of construction materials. Beside that this leads to the loss of the local architectural identity and weakened its ability to distinguish. This coincided with a stage in which the world is facing many environmental problems represented in the rapid depletion of natural resources that caused increasing their prices besides the risks of products monopoly. Tough these indicators contradict sustainability principles. This required the search for new materials that are available, cheap, easy to produce and capable to preserve the local architectural identity and its distinctive character. This can be reached through using the local natural materials (Ilvitskaya S V and Lobkova T V ,2018). Therefore a modern trend emerged in the twenty- first century to find a new architecture that relies on local natural materials in its construction through modern manufacturing and production techniques, in a new developed form. These materials are characterized by different qualities like durability, availability, reliability and familiarity with their social local environment because they are not interfering with them and thus it contributes in enhancing the local mental image of architectural style in that region through continuous usage of these natural materials (Lobkov V A, Ilvitskaya, et al.,2018). Construction materials can be produced from natural resources to produce new sustainable building materials by new technologies that develop their characteristics or adding new specifications to them.
Or it is possible to reuse these natural materials in a new way to provide sustainability aspects in the modern architecture around the world. Here the inherited experiences of our ancestors in dealing with such materials over centuries should be relied on. Such as the thatched roofs or using wooden bricks as it was used in many traditional buildings.



Fig.1 wooden brick house
https://www.google.com/search?q=wooden+bricks&tbm=isch&chips=q:wooden+bricks,g_1:building:joRHiQY6JmI%3D&hl=en&sa=X&ved=2ahUKEwiurLbpr9L1AhUQgv0HHT6nA3UQ4lYoAXoECAEQHQ&biw=1349&bih=625#imgrc=8OCOnmWLF4UNcM

Past research experimented different wall sections using wood, earth, reeds and straw in several combinations and tested them in a living laboratory environment consistent with Danish climate. To detect U-values, Life cycle costs, Thermal performance, time lag and heat coefficient values in

addition to water and fire resistance. The results proved that using traditional materials can provide equivalent thermal performance outcomes as contemporary industrial materials with better indoor air quality and less impact on the natural environment through their minimal carbon footprint. The research concludes that there are still many challenges hinder the use of vernacular thinking in contemporary practice (Dabaieh, 2019).

This research urges to explore the possibility of using affordable natural materials in producing new sustainable building materials in Iraq concerning these subjects:

1- What are these natural materials?
2- How they were used in traditional architecture?
3- What are the sustainable products, and how we can use them?

Hence, we can find the nature of building materials havebeen linked with the environmental compatibility by integrating natural materials characteristics with production and installation techniques (Zayats IS, 2015). For example, the building that was built from (Straw Blocks) was characterized by sustainable economic performance for it reduces energy consumption by (90%), so it was widely used in France, Holland and the United States. One of the French companies produced a new type of brick, called the (Wooden - Lego- Brick), characterized by its multiple shapes and sizes, that provides great flexibility in design and erection. Natural materials are characterized by multiple qualities. For instance strength is found in; iron, stone, wood. thermal insulation, may fond; in soil, clay, wood,reeds, so we can integrate different characteristics to produce special element by combining more than one material with other in one time, so natural materials can be used to produce a modern sustainable building elements through new production or erection methods, to produce a comfortable, clean and sustainable environmental friendly buildings (Claire Weisz, 2018) Creativity, development and innovation in building materials and production methods draw attention to the possibility of using plants and agricultural waste as raw materials in production sustainable building materials, as this type of use, reuse or recycling will enhance the economic aspects in construction sector, as well as being an opportunity to introduce new building materials by developing and improving the qualities of natural, traditional local materials by means of advanced modern manufacturing techniques and processes (Burroughs1 and J Růžička, 2019))

Architecture and Natural Building Materials

The main goal of building erection is to be occupied by people, so architects through time, focused on affording human needs in designing those buildings. Building envelope became the main barrier that protects people inside the building from the outer harsh environmental conditions. Hence building materials usage evolved into:

1/ Metallic materials.
2/ Organic materials.
3/ Mixture of materials.

The famous Egyptian architect Hassan Fathy says "Look under your foot and build," these words may be the first concept that our ancestors have adapted, for organics was the first building material man has used in construction, as these materials are available, renewable and can be obtained in a simple and cheap coast. Therefore, they can be considered (ecological materials) with multiple good qualities, that made their usage good in construction and lasted for long periods (Brown LR.,1990).One of these materials is:

Reeds: is an organic material that can be used for construction with good water resistance and it contains a high percentage of silicone materials, which makes it durable and flexible at the same time (fig.2). Therefore, it is considered a good building material used for construction, though it is highly flammable. The high silica content makes it undesirable to be animal and insect food. Besides that, reeds represent an ideal insulation material; in addition its stem shape helps to use it in multi way (Elias P. Le Bilan, 1980). The task to build reed walls requires less effort than building brick one (Lauren F., 2000) and requires less workers skill, in addition reed buildings does not need maintenance. Reeds usage inspires innovation in design and implementation that leads to sustainable environmental friendly building, with good thermal insulation, energy conservation for cooling purposes, but it needs certain treatment especially for the exposed parts to the atmosphere to prolonging the building life.



Fig.2 reeds in Iraq
https://www.google.com/search?q=reeds+in+iraq&tbm=isch&ved=2ahUKEwiGyKz6sNL1AhUN1uAKHZMDA8sQ2-cCegQIABAA&oq=reeds+in+iraq&gs_lcp=CgNpbWcQDDoECAAQQzoFCAAQgAQ6BggAEAgQHlCXA1ioHmCLLmgAcAB4AIABmAKIAdALkgEFMC43LjKYAQCgAQGqAQtnd3Mtd2l6LWltZ8ABAQ&sclient=img&ei=ZMzyYYaGKY2sgweTh4zYDA&bih=625&biw=1349&hl=en#imgrc=o5mZGqRvIUO-rM

reeds was used also to improve the levels of thermal insulation forwalls or used as a supplement with other

construction materials to resistant earthquakes, especially in internal and external walls (Barreca, F.,2012), In Europe reeds used in (Encanicado) as a method considered a model for the use of reeds to construct roofs, for public and noble buildings, as in (Algarve) province, that consist two layers of reeds tied together and linked with Part of the main wooden roof of the building. Sometimes a layer of mortar is placed over the reed layer in order to make it leveled for tiles paving on the roof. In Portuguese architecture, we can find different types of walls, such as (Tabique) and (Palkiros), those used reeds in folk architecture, as the outer walls of the building consist of two layers of wood, with air gap between them, but sometimes these gaps were filled with reeds to improve thermal insulation of the walls (Fernandes, J,et al,, 2020) As for the (Tabique) model, in which partitions and wooden walls were replaced by reed panels, this global use of reed material encouraged its reuse in more sophisticated manner, because it is a natural material that can be introduced into the field of sustainable building materials. Therefore, several studies were conducted for the purpose of benefiting from reeds in producing building materials with good sound and thermal insulation potential, these studies focused on insulation levels (Fernandes, J,et al,, 2020)
the quality of reed panels proved a high ability to thermal insulation ranged between (0.045 – 0.056) (w \ mc) [12] Where plates of different densities and thicknesses and in different shapes and configurations were used. The maximum thickness of the cane (1.5 cm) and the thermal conductivity results ranged between (w \ mc) (0.65 -0.55).

The (Mudief) and the Ecological Reed Architecture in Iraq

If (Eco Architecture) is considered design with environment, then the (Mudief) is an ideal model of this architecture type. The Sumerian civilization produced the (ziggurats) and surrounded their cities with agricultural areas to provide food in a sustainable manner they were the first to produce the (Mudief) as a type of environmental architecture. It was built in the southern marshes of Iraq before (5000) years entirely from reed, Researcher (J.B.Fraser) in (1842) described the method of implementing the (Mudief) in an detailed manner; its structure relied on reed bundles, their lengths ranged from (20-15) feet. They were tied and planted in the ground like columns in two rows, then they are curved from their small free ends until these ends meet in the middle of the (Mudief) ceiling, to form a group of huge arches (fig.3), after that the two ends connected, later small bundles of reeds will be added to the ceiling at certain intervals attached to those arches. A woven reed mat will be installed on the (Mudief) sides to form the side walls, and then it is curved on the ceiling. Finally woven reed panels are installed vertically at the (Mudief) ends to enclose the whole structure with reeds in a simple smart design. This kind of buildings and structures has the potential to express its natural environment, and to represent the old model of sustainable built environment that resulted from its natural habitat (fig.4).
The (Mudief) also included environmental treatments by weaving the side panels in a way leaving openings in it to allow sun rays to enter, and take advantage of natural daylight. Beside that it included natural ventilation, through the openings made in the woven reed panels to allow air movement inside, in addition to the openings left on the woven side mat that allow air to move through the structure (Barreca, F.et al., 2019). This type of architecture managed to link design with climate, topography and existing natural materials, to reach a state of psychological and thermal comfort through the building design. (Fraser) also stated that this type of construction was more comfortable than the traditional black Arabic tents.



Fig.3 Mudief reed construction
https://www.google.com/search?q=reeds+in+iraq&tbm=isch&ved=2ahUKEwiyr4WEstL1AhUy7uAKHd0EAIgQ2-cCegQIABAA&oq=reeds+in+iraq&gs_lcp=CgNpbWcQDDoGCAAQBxAeUJgIWL4bYP4oaABwAHgAgAGzAYgBgwiSAQMwLjeYAQCgAQGqAQtnd3Mtd2l6LWltZ8ABAQ&sclient=img&ei=hc3yYfLYGrLcgwfdiYDACA&bih=625&biw=1349&hl=en#imgrc=2YUXSJHxpFP6bM



Fig.4 The Iraqi Mudief
https://www.google.com/search?q=reeds+in+iraq&tbm=isch&ved=2ahUKEwiyr4WEstL1AhUy7uAKHd0EAIgQ2-cCegQIABAA&oq=reeds+in+iraq&gs_lcp=CgNpbWcQDDoGCAAQBxAeUJgIWL4bYP4oaABwAHgAgAGzAYgBgwiSAQMwLjeYAQCgAQGqAQtnd3Mtd2l6LWltZ8ABAQ&sclient=img&ei=hc3yYfLYGrLcgwfdiYDACA&bih=625&biw=1349&hl=en#imgrc=2YUXSJHxpFP6bM

The New Use of Reeds

Today, reeds are used in a number of projects around the world in various forms and purposes, including its capabilities to be used for roofing external spaces, such as Project (reed work shop at Amaco) (fig.5), Reed roof sentiment in Korea (fig.6) other projects used it in wrapping building facades, such as in Greece hotel (fig.7), others used it for sustainable environmental treatments, like (Nina Maritz) project in Namibia, that used reeds as a means to provide thermal comfort through passive evaporative cooling (fig.8) (http://www.architectureweek.com/2007/0613/environment_1-2.html)



Fig.5 Reed modern Shelter
https://voltes.coop/en/projectes/taller-canyes-amaco/



Fig.6 Reed roof sentiment in Korea
https://www.architectural-review.com/awards/ar-emerging-architecture/reed-instrument-roof-sentiment-in-korea-by-society-of-architecture



Fig.7 Hotel reed facades in Greece by Alex A. Tsolakis Architecture
https://www.archdaily.com/903135/ecosuites-a-reed-clad-hotel-alex-a-tsolakis-architecture

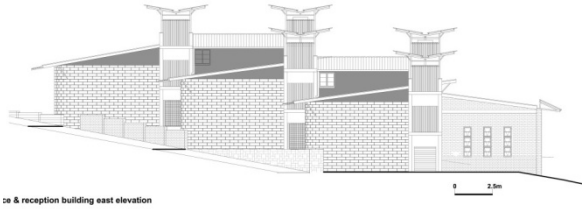


Fig.8 Nina Maritz housing complex in Nambia building with reeds and used car tiers
https://www.archdaily.com/903135/ecosuites-a-reed-clad-hotel-alex-a-tsolakis-architecture



Fig.9 Nina Maritz housing complex in Nambia building with reeds and used car tiers
https://www.archdaily.com/903135/ecosuites-a-reed-clad-hotel-alex-a-tsolakis-architecture

Palm trees

These trees are found in the Middle East in enormous numbers, Iraq has large quantities of date palms, that reached (17 million tree) in (2016), and reached (19 million trees) in (2020). Date palm is considered a renewable natural resource for it can be replaced relatively in short time. These trees produce large quantities of agricultural residues annually (W Ghori1,et al, 2018) A typical date tree generates about 20 kg. of dry leaves per annum Some studies assumed that Saudi Arabia generates more than 200,000 tons of biomass each year (fig.9). Usually date palm wastes burned in farms or disposed in landfills which cause environmental pollution (https://www.ecomena.org/biomass-date-palm-wastes/) so we can use this natural material in producing sustainable building material in Iraq.



Fig.9 Palm trees in Iraq

https://www.google.iq/search?q=palm+tree+in+iraq&tbm=isch&ved=2ahUKEwij8-23vNL1AhUR8rsIHTMNAMsQ2-cCegQIABAA&oq=palm+tree+in+iraq&gs_lcp=CgNpbWcQDDIFCAAQgAQ6BAgAEEM6BggAEAgQHlCOA1j_GGD8KGgAcAB4AIABsgGIAb0KkgEDMC45mAEAoAEBqgELZ3dzLXdpei1pbWfAAQE&sclient=img&ei=btjyYaOEHJHk7_UPs5qA2Aw&bih=625&biw=1366#imgrc=GuzRZ-M9TQRksM&imgdii=WjKR0BsOFrTHWM

Palm tree fibers

Palm tree fibers can be used in a number of industries because of its reasonable mechanical strength which is much greater than many materials such as aluminum. New products from natural materials has emerged called (Wood-Plastic-Composite) (WPC), this material characteristics is close to natural hardwood, in terms of physical and mechanical aspects (Matuana LM., 2009). The world began to shift towards using this product as an alternative to many natural materials as use it for external parts in buildings exposed to climatic conditions (Yeh Shu-Kai, 2009) It is also considered a good way to get rid of large amounts of biomass, in addition using this production method have to use plastic materials that can be collected from landfills that contain it in large amounts due to our modern life standards. By this way we can obtain renewable and sustainable building materials, with efficient and economic way to produce an environmental friendly artificial wood. Palm tree fibers are characterized as being unidirectional loading material in its thin or thick frond fibers. The process begins by collecting palm wastes that will be left in open air under the sun to reduce water proportion by (10-15%) after that it will be cut into small pieces less than (4 mm) after that they will be kept in bags to prevent it from moisture, then unlimited quantities of wasted plastic parts and bags collected from landfills will immersed in certain solutions for an hour, then washed and shredded into small pieces, then equal proportions of fiber materials and plastic will be mixed, and treated with special materials and after several stages of treatments the product will reach its final stage, to gain its determined hardness and its ultimate tensile strength of (57.05), which is considered within the levels of soft wood hardness which is (56.1) (Afrifah KA,et al. ,2010).

Palm tree fibers can be used as an alternative to (Synthetic Fiber) to produce different types of (Polymer) which can be used for structural or semi-structural purposes (Curtis P T, 1996). This will reduce polymer production costs and enhance its quality, improve its performance, lightness due to the light weight, strength and hardness of the natural fibers, despite the weakness factors related to the ability of this type of fibers to absorb water (Ma C C M, et al., 1998) for these reasons palm tree fibers became one of the fibers that achieved big commercial success in developing green building materials and components that fall within (Polymer Materials) which consists complex variant types of short and continuous materials fibers Bounded by (Organic Polymer Matrix) designed to transport loads across the mesh of the grouped fibers (https://en.wikipedia.org/wiki/Polymer_matrix_composite) Palm tree fiber is similar to other types of plant fibers (Lignocelluloses), which included in dry plant (Biomass).

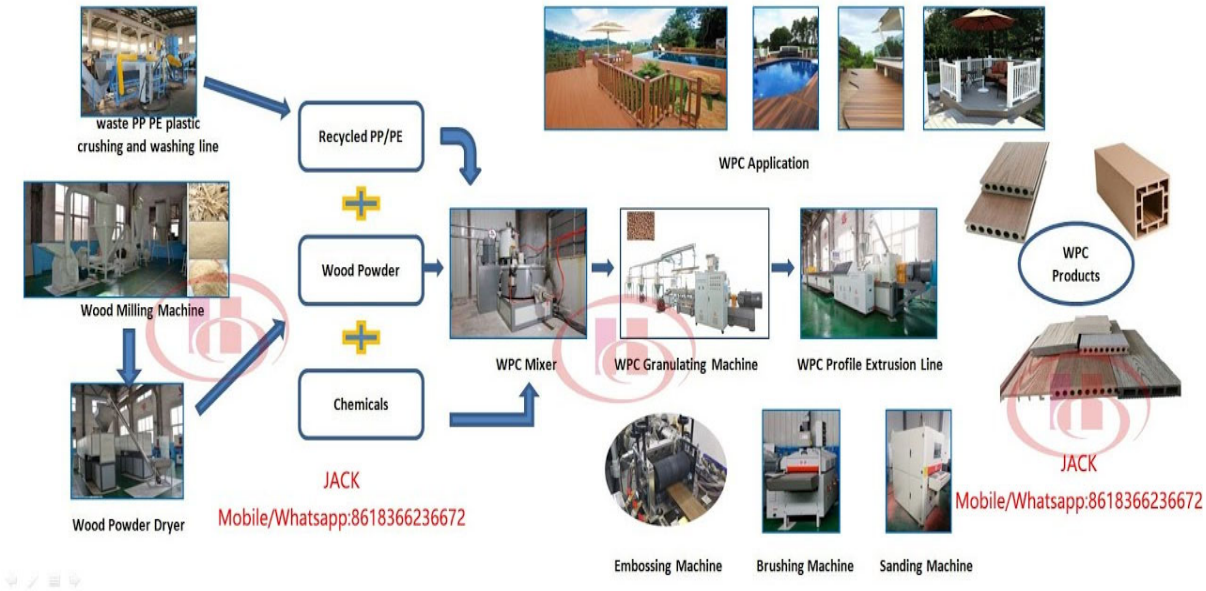


Fig.10 WPC process

https://www.google.iq/search?q=wood+plastic+composite+process&tbm=isch&ved=2ahUKEwjSpN62vdL1AhXxlP0HHe9bBbYQ2-cCegQIABAA&oq=wood+plastic+composite+process&gs_lcp=CgNpbWcQDDIGCAAQCBAeMgYIABAIEB4yBAgAEBg6BAgAEEM6BQgAEIAEUKkDWJ8eYNMtaABwAHgAgAGuA4gBnwySAQcwLjguNC0xmAEAoAEBqgELZ3dzLXdpei1pbWfAAQE&sclient=img&ei=eNnyYdKIIfGp9u8P77eVsAs&bih=625&biw=1366#imgrc=7L0v-DpmSLiwmM

The experiments concerning (WPC) production was not limited to wood and palm fibers, but extended to use reeds to explore the advantages resulted from this usage. These studies proved the benefits resulted from this usage as resulted in the following studies:

- **Preparation and study some of mechanical Properties for (Wood– Plastic Composites), (2020). Iraq**
  This study was carried out by a number of Iraqi researchers to study the effect of adding reeds to Polypropylene and its ability to improve the product (WPC) specifications, the results proved that this usage heighten the product mechanical properties besides improving it hardness speed, compressive and tensile strength, and makes the product suitable for outdoor structural use (Raya Ali Abed, et al., 2020)

- **Production and Characterization of Reed and wood particles on Resin Composite Board (2018). (Zimbabwe)**
  This study was carried out by a number of Zimbabwean researchers the study showed increasing manufactured panels strength resulted from adding reeds to the composite mixture and how it improve the product (WPC) ability to bear more loads and resist external conditions, that makes it suitable to be used in outdoor conditions , as well as it can be used for decoration and furniture industry besides its ability to compete economically, ecologically and socially (Notabo Hlabano, et al., 2018) .

- **Thermoplastic composite from natural reed (2015). Egypt**
  This study was carried out by a number of Egyptian researchers; the study demonstrated the ability of reeds in adding mechanical strength and improves the physical specifications of the product. It also improved the level of its (Tensile Strength) as an environmentally friendly and sustainable product (R. E. Abou-Zeid, et al., 2015).

Using (WPC) in Architecture

There are many examples of using (WPC) products in external and internal buildings walls, floors, furniture and decoration, In order to encourage using these environmentally friendly sustainable building materials and to be the alternative to the natural building materials that ruin our environment, consume energy, resources and causes different types of pollution to begin new type of sustainable constructions in the world as in common and Iraq in special environment (https://www.google.iq/search?q=wpc+in+buildings&source=lnms&tbm=isch&sa)

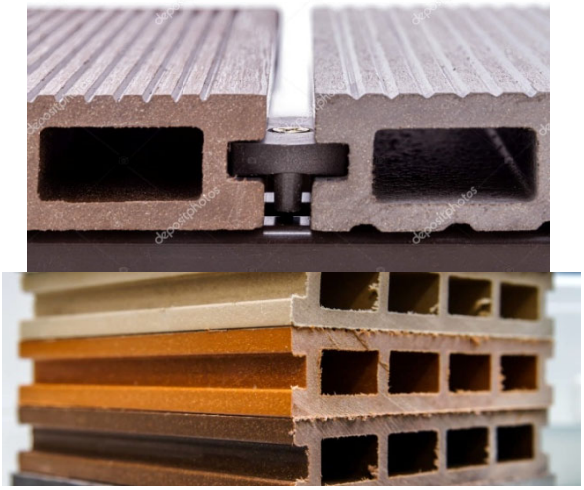


Fig.11 WPC
https://www.google.iq/search?q=wood+plastic+composite+&tbm=isch&ved=2ahUKEwiAyJLFvdL1AhWUlP0HHXcfCOsQ2-cCegQIABAA&oq=wood+plastic+composite+&gs_lcp=CgNpbWcQDDIFCAAQgAQyBQgAEIAEMgUIABCABDIFCAAQgAQyBQgAEIAEMgUIABCABDIFCAAQgAQyBQgAEIAEMgUIABCABDIFCAAQgAQ6BggAEAgQHjoECAAQGFC6CFi6CGDWFmgAcAB4AIABygGIAdsCkgEFMC4xLjGYAQCgAQGqAQtnd3Mtd2l6LWltZ8ABAQ&sclient=img&ei=ltnyYYClLpSp9u8P976g2A4&bih=625&biw=1366#imgrc=1qhByBtMuno3VM



Fig.12 WPC building exterior panels
https://www.google.iq/search?q=wood+plastic+composite+&tbm=isch&ved=2ahUKEwiAyJLFvdL1AhWUlP0HHXcfCOsQ2-cCegQIABAA&oq=wood+plastic+composite+&gs_lcp=CgNpbWcQDDIFCAAQgAQyBQgAEIAEMgUIABCABDIFCAAQgAQyBQgAEIAEMgUIABCABDIFCAAQgAQyBQgAEIAEMgUIABCABDIFCAAQgAQ6BggAEAgQHjoECAAQGFC6CFi6CGDWFmgAcAB4AIABygGIAdsCkgEFMC4xLjGYAQCgAQGqAQtnd3Mtd2l6LWltZ8ABAQ&sclient=img&ei=ltnyYYClLpSp9u8P976g2A4&bih=625&biw=1366#imgrc=F-X3ZMJNAwAgzM&imgdii=Ttyd-GrWRVD9oM



Fig.13 WPC building decorative interior panels
https://www.google.iq/search?q=wood+plastic+composite+&tbm=isch&ved=2ahUKEwiAy

CONCLUSIONS

1. / In Iraq there are many kinds of natural agriculture materials like reeds and palm waste that can be used as raw material in production a new type of sustainable environmental friendly building materials.
2. / The new type of building materials is (Wood Plastic Composite) and (Reed Wood Plastic Composite) that includes reed or palm tree mixed with plastic materials collected from household andindustrial wastes, after several treatments the final product can be used for building construction.
3. / It is possible to use panels or components produced by this way for the purposes of construction and implementation of sustainable buildings, in internal and external parts of the building; as walls, floors or ceilings, and can be used for decoration and furniture manufacturing, as these materials are characterized by strength, lightness and resistance to external weather conditions.
4. / These materials can be an alternative to natural wood used for construction purposes and thus it will reduce the consumption of natural materials, as part of the sustainability goals.
5. / The production of these materials will help to get rid of wasted agricultural residues or rapid growing plants besides it will help in getting rid of large quantities of plastic collected from landfills, so this process will reduce the impact of these waste materials on natural environment and reduce pollution levels, which is also one of the sustainability goals.
6. / The production of this type of building elements will be sustainable from economic point of view, due to the low cost of the raw material used in production.
7. / Because the production of this type building material will depend on affordable natural materials and plants that exist practically in certain area or region will enhance uniqueness of the architecture identity in the region, and that is also one of sustainability goals.

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