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Materials Management in Construction Industry: Energy Requirements for Selected Materials

Muntari Mudi Yar' Adua
Universiti Tun Hussein Onn Johor, Malaysia
mukhtaryardua1534@yahoo.com

Dr.Narimah Kasim (PhD)
Universiti Tun Hussein Onn Johor, Malaysia
narimah@uthm.edu.my

Muhammad Mustapha Gambo
Universiti Tun Hussein Onn Johor, Malaysia
gambomuhammad@yahoo.com

Universiti Tun Hussein Onn Malaysia, 86400, Parit Raja, Batu Pahat, Darul Ta'zim, Johor, Malaysia

Abstract
Materials management in the construction industry has become a major source of concern to all due to its effect on the social, economic and environmental well being. This has led to an increased pressure on the materials management on construction materials, which has a negative impact on the construction industry. This paper is aimed at reviewing the problems of management process and energy requirements of some materials in the construction industry. The review carried out from the current literature shows that the materials management processes has problems. It was found that poor planning and control, transportation, late delivery, inadequate storage and poor materials handling at site are the causes. The findings are expected to minimize these problems and benefit practitioners, stake holders in the construction industry, and government agencies in minimizing materials management in construction activities. This will also encourage the need for further research on materials management processes problems in the construction industry.

Keywords:
Material Problems, Construction Industry, Materials Management, Energy Requirements

1. Introduction

A problem that adversely affects the performance of the construction industry is the materials management process during site activities. The improper handling and utilization of materials affects the performance of construction (Jaselkis and El Salami, 2003). The major issues that affect materials management activities are materials handling and distribution, ordering and delivery of materials to the construction sites. Previous researchers have highlighted problems

of materials management that include storage requirement for large capacity of materials and equipment, transportation difficulties, late materials delivery (Aibinu and Odeyinka, 2006), storage of materials (Abdul Rahaman *et al.*, 2006) manual process, and also non compliance with specifications (Deny, 2001). Hence, 'materials management process remains a very big problem to the construction industry (Saudi projects, have the most frequently documented problems with materials management (Thomas *et al.*, 2005). Gould and Joyce, (2000); Makulsawatudom and Emsley, (2003). Assets that lack the proper materials management process are the major cause for low productivity and delays in most construction projects.

The materials for delivery to and from a construction site may be broadly classified as :

(1) bulk materials,

(2) standard off-the-shelf materials, and

(3) fabricated members or units.

The process of delivery, including transportation, field storage and installation will be different for these classes of materials. The equipment needed to handle and haul these classes of materials will also be different. This paper explores some local building materials, technologies, and materials management. Materials management problems are materials delivery, planning and controlling materials on site.All necessary efforts should be made to ensure that the quality and quantity of materials appropriately specified, are obtained at a reasonable time, and are available when needed.

1.1Methodology

The focus of this paper is to review problems of materials management in construction from past researchers work, conference papers, and published journals on materials handling in construction management. The paper will also highlight energy requirements and innovative technologies related to some building materials. Practices have evolved through ages. Housing and building conditions reflect the living standards of any society, soil, stone aggregate, timber products, and bamboo sticks represent the earliest sustainable building materials with low energy requirements used for the construction of dwellings. Durability of the materials is directly derived from above mentioned materials. Durable building materials are an ongoing phenomenon ever since man started construction activities on earth.

The selection of building materials, in general should aim at providing the most desirable levels of climatic comfort. Climatic comfort and, by implication, the thermal characteristics of the building materials used, are as important as their durability. In countries with hash weather conditions, especially where there are extreme seasonal daily variation in temperature, climate conditions of countries such as Africa, the Middle East, the Arabian Peninsula and Asia, although, generally, hot and dry, tend to vary sharply between summer periods and winter months, thus making climatic conditions of utmost importance in the choice of materials for housing and in fractures.

Soil construction

Unlike energy-dependent building materials which consume predominantly thermal energy resources, the energy requirements for modern soil construction are mainly in the form of electrical and mechanical energy to run a variety of mixing, extrusion, ramming and compaction of soil blocks. In this context, it could be argued that soil construction, even in its most technologically sophisticated form, are capital intensive and less energy demanding. In fact, in most small-scale operations, every stage of the soil construction process is manual, utilizing simple tools, and the only energy requirement is related to transportation of materials. However, where appropriate soils are obtainable near the construction site, there is hardly any expense in transportation and, perhaps, this is the greatest potential in soil construction as an indigenous low-cost material.

Building Stone, Sand and Aggregates

Building stone, sand and aggregates are the oldest, widely available and durable building materials, for the purpose of their processing and transportation, some energy would be required which will make them important and widely used materials, by themselves, could be considered as low-energy materials. The energy used is, principally, for mining, crushing and transporting. In the case of dimension stone, energy is required for cutting and polishing. This is done in stone cutting factories with sophisticated machinery and the use of electrical energy. In the case of sand and aggregates, which are the main ingredients for concrete and mortar making additional energy is used for screening, thus, making them suitable for the purpose of their use. In most developing countries and depending on the local circumstances, most operations related to the use of stone in building construction are carried out manually. Some values for the energy requirements from different sources are given in table 1 below. Shows the energy requirements of stone based materials in some countries. These values are exclusive of transporting of materials to the site and do not include the energy of manual work involved.

Table 1. Energy requirements of some stone-based materials

Material		Energy requirement (GJ/ton)	Source
Sand and aggregate:			
	Sand, the United Kingdom	0.03-0.3	Gartner and Rankin
	Crushed aggregate, India	0.22	Rai
	Building sand, India	0.015	Rai
	Stone rubble, India	0.1	Rai
Building Stone:			
	Building stone, Kenya	0.1	Spence

Global Overview of Construction Technology Trends: Energy Efficiency in Construction (HABITAT, 1995, 210 p.)

Timber and bamboo

Timber is the most important and widely accepted organic material that has been used for centuries in building construction and if extracted from managed forests while being used in a sustainable manner it can be used for ever. It can be used at any level of technology for a wide range of purposes ranging from its uses in rural areas to being processed in high tech factories for manufacturing structural and non-structural building elements as well as furniture.

As a natural and renewable resource, it is also a very low energy demanding material with superior characteristics which makes it quite attractive for many construction purposes. Various studies have shown that even though using timber as a building material involves the use of energy for logging, transportation, seasoning, cutting, processing etc., the sum of all energy used in all these processes per weight basis is much less than any other energy intensive than structural material such as steel, aluminum, concrete, bricks etc. Table 1 shows some examples of the primary energy requirements for some timber products.

Table 2: Energy requirements for timber production

Product	**Energy requirement (GJ/ton)**	**(GJ/m^3)**	**Source of data**
Softwood framing, USA[a]	0.7	0.34	Stein
Timber at site, Australia	2.0		Lawson
Timber processing, Argentina	0.4		Rai
Timber, Germany	1.04		Rai
Timber (concrete formwork), UK	1.6		Heseltine
Timber products, UK	5.4		Gartner and Rankin
Particle hoard, India	3.1		Rai
Particle hoard. USA[a]	9.2	4.6	Stein
Plywood. USA	13		Stein

Global Overview of Construction Technology Trends: Energy Efficiency in Construction (HABITAT, 1995, p.210 .)

After timber, bamboo is the second important organic product which requires much less energy for its processing and seasoning than timber. In fact, many researchers and professionals call bamboo as a “no-energy” material with very good structural property to be used in low-cost construction, particularly, in bamboo growing countries. Bamboo is a very fast growing plant and some species can reach their full height within 6 months (up to 35m height). However, it takes 3 to 6 years to develop adequate strength for use in structures. There are, in principle, two main types of bamboo, namely: Bamboo, found mainly in warmer regions, and “Monopodium” or running bamboo, found in the cooler areas.

The areas of application of bamboo include: frames (beams and columns), trusses for roofs, grids (spare trusses), scaffolding, fencing, bridges, etc. Sometimes, for special purposes, full culms are halved to produce two U shaped cross-sections for use in gutters, walls, and

purloins. Split bamboo strips can also be used for matting and woven panels, fencing, ornamental screens, etc. Even the bamboo fibers and chips can be used for manufacturing fiber boards, particle boards and fiber concrete.

Issues in Material Management

Materials management is an important element in project planning and control. Materials represent a major expense in construction Gould and Joyce (2000).Poor materials management can also result in large and avoidable costs during the construction period. Even worse, materials may deteriorate during storage or be stolen unless special care is taken. For example, electrical equipment often must be stored in waterproof locations. Second, delays and extra expenses may be incurred if materials required for particular activities are not available. Accordingly, insuring a timely flow of material is an important concern of project managers.

Materials management is also a problem at the organization level, if central purchasing and inventory control is used for standard items. In this case, the various projects undertaken by the organization would present requests to the central purchasing group. In turn, this group would maintain inventories of standard items to reduce the delay in providing material or to obtain lower costs due to bulk purchasing. This organizational materials management problem is analogous to inventory control in any organization facing continuing demand for particular items. Materials ordering problems lend themselves particularly well to computer based systems to insure the consistency and completeness of the purchasing process. Materials management problems includes planning and controlling, to ensure that the quality and quantity of materials are delivered at a reasonable time, and available when needed.

Material Management in Construction Process

Materials management is the planning and controlling of all necessary efforts to ensure that the quality and quantity of materials appropriately specified, are obtained at a reasonable time, and are available when needed Table. 3, illustrates the problems with construction materials management process, which is characterized as ordering, transportation delivery, storage and handling involved with almost all the process participants.

Material plann*ing:* Material planning is probably the most important part of the overall materials management process. Typical material plans are developed based on a number of other project plans such as detailed project design, Bill of Quantities, procurement plans, and resource plans; and then integrated into the project schedule. Therefore, (Mawdesley, et al 1997) emphasizes that the material planning process is not a static process; rather, it is dynamic and should be integrated with the monitoring and control process.

Site working and material monitoring*:* The site work should be done in a way which will could ensure that all the materials meet the material schedule decided in the planning phase Various preparation checklists may have been set and the details will depend on the level at which the material planning is being exercised. Material monitoring should track the status of material usage with all the key information and promptly report any changes.

Correlate information*:* The information here is the progress information collected in the monitoring phase which is to be correlated with the planning information. In this phase, the achievement is compared with the targets. Several technologies are available to help with this

and most texts on 'control' concentrate almost exclusively on the phases up to and including the correlation phase.

Control: Control action should be based on the results from the correlation of information and may be of the traditional reactive type in which action is taken to affect the work output based on recent information and past experience. For material management, control acts as measure to avoid shortage and waste during construction process . In order to achieve these two aims, detecting and realizing the problem in-time are necessary, which require the good cooperation of the project participant, from project manager to worker. Table 3 lists some of the typical problems in the four major phases of construction materials management.

Table 3:

Phases	Problems
Ordering	• Over-ordering, Ordering the wrong type, quality and size • Ordering standard lengths rather than the lengths required • Ordering for delivery at the wrong time
Transportation	.Delays caused by state road checks post which increases corruption and uneconomical operations .The conditions of national highways, states highways, city roads and roads linking rural areas. .Damages to culverts and bridges takes time to repair resulting to diversions resulting to break downs and higher accidents rates.
Delivery	.Damage during unloading • Delivery to inappropriate areas of site • Accepting incorrect deliveries, specification or quantity
Storage	• Exceed storage areas • Damage or contamination from incorrect storage, loss, theft and vandalism
Handling	• Damage or spillage through incorrect or repetitive handling • Unskilled site workers

RFID-Technology Houston (2003) facilitated construction materials management

Conclusions

The performance of indigenous building materials over long periods of time, in all climates, and for all structural conditions is still recognized, nor worked out. Nevertheless they hold a promise of ready availability, low energy costs and simplicity of equipment in their exploitation and utilization. This is an advantage over conventional materials. They also have a potential to enhance a sustainable construction practice.

Materials management problems are materials purchase, delivery, planning and controlling materials on site. All necessary efforts should be made to ensure that the quality and quantity of materials are appropriately specified. They must be obtained at a reasonable time, and available when needed. The major issues that affect materials management activities on site include constraints on storage areas, site logistics regards to materials handling, distribution and utilization, and also ordering and delivery of materials to the construction site. Other issues includes; manual handling process, and non compliance with specifications (Dey, 2001) late delivery Aibinu and Odeyinka, (2006), shortage of materials (Abdul-Rahman *et al.*, 2006).

Recommendations

The followings recommendations are suggested for addressing materials management in constructions industry.

i. The study of building materials should be introduced as part of the curriculum for construction education at both undergraduate and post graduate level to sensitize the students their potentials uses and benefits.
ii. Appropriate standards and codes of practice for building materials should be developed; this can be achieved by adopting a performance based approach.
iii. Research institutes should be established through public and private initiatives to study building materials exclusively.
iv. Further research on the failures and innate characteristics of building materials would place a different light on the future of building construction in general, and offer solutions to some of the problems outlined in this study.
v. Provide continuous control of materials throughout their life cycle. Materials should be monitored against preliminary schedule and should be established before ordering. Other functional areas such as engineering and projects schedules must consider materials requirements.
vi. Materials impacts should be known when plans and schedule are made, and should be known when changes in materials that can affect schedules.
vii. Achieve proactive involvement for all material management including ordering planning and controlling project requirements.
viii. Using modern automated technology such as electronic data interchange and bar cording to control materials throughout the project period.
ix. Adopt common materials codes recommended by international standard organizations for construction industry.
x. Adopt uniform standards for electronic data interchange and bar cording which can bring down transportation costs.

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