Modern Techniques of Using Timber in Building Structures and Components in Nigeria

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Abstract
Timber is a natural building material used for construction since prehistoric times. It is available in large quantities in the forested parts of Nigeria, and it has provided a broad range of building products and materials for construction. The extent of its usage by professionals in the building industry is determined by their understanding of the material, but also by their perception of the material. Proponents perceive timber as an attractive building material while opponents opine that it is unreliable for construction. This paper explores the modern uses of timber in building structures and components. The advantages of its physical and aesthetic qualities, workability, environmental sustainability, flexibility of space arrangement, dry construction, industrial production and comparative cost effectiveness are highlighted. Solutions are proffered to problems associated with its usage, including acceptability, attacks by insects, fungi and vermin; fire resistance, depletion of natural resources and inadequate research. This includes concrete-enhanced timber, composites, flame retardant and preservative treatments and mass production. The exploitation of the desirable characteristics by other nations is discussed. Techniques of using timber in building components and structures for sustainable building in Nigeria are proposed. This includes the use of modern shear connectors and fasteners; and modern construction techniques for floors, walls, roofs and ceilings.

1. Introduction
Timber has been used as a building material for over 400,000 years. It is the most common and best-known material for house construction including framing of floors, walls and roofs. In Nigeria, the roof structures and ceiling noggins of most buildings are constructed from timber using mainly abora, aye and afara (Tectonis grandis) species because of their workability and durability (RMRDC, 1998). Opepe (Nauclea diderrichii), a yellowish, very hard wood is used for doors and window frames because of its natural resistance to insect attack. Teak is used extensively for external doors and mahogany, mansonia, cedar and other fine upland timber enjoy prominence in house furniture. Plywood and particle boards are used mainly for furniture. Timber is easy to form, saw, nail and fit; even with simple hand tools.

Timber is natural and renewable. It has a high strength to weight ratio and is easy to work with, making it especially useful where only basic technology and procedures are available (Apu, 2003). Consequently it has become one of the most widely used materials and it is found in large quantities in Nigeria (Table 1). The many varieties of softwoods and hardwoods have allowed for flexible use of timber in building.

Table 1: Wood Raw Materials Demand and Supply in Nigeria (1996).

<table>
<thead>
<tr>
<th>Raw Materials</th>
<th>Demand</th>
<th>Quantity Available</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logs of 30cm diameter (m²)</td>
<td>76,312,437</td>
<td>662,934,500</td>
<td>Logs were available for adequate supplies to mills.</td>
</tr>
<tr>
<td>Poles (m³)</td>
<td>25,625</td>
<td>572,261,021</td>
<td>Enough quantity was available on the plantations.</td>
</tr>
<tr>
<td>Lumber (m³)</td>
<td>95,161</td>
<td>271,386,600</td>
<td>No deficits.</td>
</tr>
<tr>
<td>Plywood (m³)</td>
<td>122,109</td>
<td>52,372</td>
<td>Serious deficit.</td>
</tr>
<tr>
<td>Particle Board (m³)</td>
<td>35,676</td>
<td>76,720</td>
<td>Saw mills could produce enough wood raw materials.</td>
</tr>
</tbody>
</table>

2. Advantages of timber as a building material

The advantages of timber as a building material include availability, workability, environmental sustainability, flexibility of space arrangement, dry construction, industrial production and comparative cost effectiveness (Gregory, 1984; Nolan 1994 and Whitelaw, 1990)

Availability and Acceptability
Timber is locally available in most countries of the world. It can be purchased from local suppliers and transported to site using small vehicles or carts. Timber is widely accepted as an attractive building material in all cultures.

Physical and aesthetic qualities
Timber has a high strength to weight ratio making it an attractive framing material. Some species are highly resistant to rot, corrosion and marine damage. Timber withstands corrosive salt and humidity with less structural change than other building materials. Timber is very durable and there are numerous finishes available to protect and enhance the natural beauty of the material. These sealants and protective finishes promote its durability. If well protected and well installed, timber can last for centuries with minimum maintenance (Sturges, 1991). Timber ages in a protective manner with the result that long-term maintenance can be minimal. Timber is more fire resistant than bare steel, as charring forms an insulating layer that protects the inner core of the material. Heavy timber construction is less prone to damage by short-term high temperatures allowing for a longer period for evacuation in case of fire. Insurance companies are now recognising the favourable construction cost and fire resistance of engineered timber construction (FAO, 2002).

Workability and Versatility
Timber can be easily shaped by hand or machine by one person. It can be cut, planed, routed or chiselled. There are many ways to connect timber to timber or to other materials since timber is easily secured and fastened with nails, screws, bolts, or any of hundreds of other time-proven connectors (Plate 1). It is easy to work on timber to achieve desired results with simple tools. There are many design options possible with wood that are not practical with inorganic materials such as concrete or steel. The design performance required by a particular building application can be more flexibly matched by selecting timber of the appropriate density, compressive and tensile strength, colour, texture and fire resistance (Anderson, 1970).

Environmental Sustainability
Environmental sustainability recognises that human activity over time and the health of the environment are interdependent and that environmental health has necessary social, political and economic determinants. Probably the most significant environmental benefit of timber is its renewability and biodegradability (RAC, 1991, p. 298). It has low manufacturing process energy and benign air emissions (Townsend and Wagner, 2000). Timber is an excellent insulator against hot or cold weather. The old “log-house” remains a model for minimum energy consumption in buildings (Ogunsote, 1993).

Flexibility of Space Arrangement
Partitions made from timber can be easily moved around to change space layout in response to new functional requirements (Plate 2).

Dry Construction
Unlike concrete floors, timber floors do not require a curing period before achieving maximum strength. Construction is therefore faster (Plate 3). Finishing is also faster, since timber walls can be
painted immediately, unlike plastered walls which require several days to dry.

**Industrial Production**
Timber is especially well suited for mass production. Standard components such as doors, windows, boards for walling construction, floor, ceiling and roof tiles as well as skirting can be purchased in standard sizes.

**Comparative Cost Effectiveness**
The local availability of high quality wood and the abundance of local millers make timber production less dependent on imports. Prices are relatively stable, since they are less influenced by the volatile foreign currency exchange market. This gives timber a cost advantage over other materials that have high import content.

### 3. Problems associated with the usage of timber

Many of the disadvantages of using timber are exaggerated or a result of misunderstanding. Timber, being organic, cannot be compared directly with inorganic materials. These problems include acceptability, lack of quality control, attack by insects, fungi and vermin, fire resistance, depletion of natural resources and inadequate research.

**Acceptability**
The use of timber for walls and floors is commonly seen as being only suitable for low-cost housing. Low cost housing is perceived as cheap and low-quality housing. Even low income earners do not want to be seen to be living in cheap or substandard houses.

**Lack of quality control**
Members of the various sectors in the timber industry have found it hard to enforce quality control standards that will assure practitioners that the material supplied meets the standards for its satisfactory performance in use. An example is the widespread sale of unseasoned or poorly seasoned timber. The lack of large modern factories for production of timber components contributes to this lack of standards.

**Attacks by Insects, Fungi and Vermin**
Timber is readily attacked by insects, fungi and vermin. The insects that attack timber include beetles, termites and marine borers. Subterranean and dry-wood termites in particular feed on cellulose found in timber (Ezeji 1984). Timber is also attacked by both destructive and non-destructive fungi. Destructive fungi cause wet rot and dry rot when the moisture content of timber is above 20%.
Fire Resistance
Timber ignites at 250°C to 300°C and chars at about 1mm at 900°C to 1200°C for average species (Oyetola 2001). The charcoal that forms on the outside retards combustion, and large solid sections can survive longer in a fire than steel members of equivalent strength.

Depletion of Natural Resources
Timber production requires cutting down forests for wood. Trees are a finite natural resource and without a replanting programme there will be a depletion of this natural resource leading to environmental problems including deforestation, desert encroachment, drought and erosion.

Inadequate Research
There is little emphasis on timber in the research carried out by academic and research institutions. The problems associated with usage of timber can be solved through better funding of directed research and proper dissemination of these research findings.

4. Recommended solutions to problems associated with the usage of timber
Despite the disadvantages of timber discussed above, it is very widely used in numerous developed and developing countries for high quality building construction. This was made possible by applying research findings to the solution of the problems faced in using timber. The solutions include the development of composite timber products, use of special treatments and mass production.

Composites
The advantages of composite timber products include utilisation of smaller dimensions of timber as raw material to create large dimension composite beams and sheets. The products are lighter and stronger than timber. Composites have better performance, structural properties, stability and flexibility. They are homogenous and utilise low-grade materials, thus minimising waste. Examples of composite timber products include finger-jointed timber, laminated timber, medium density fibreboard, particle board, hardboard and plywood. The beams shown in Plate 1 are made from laminated timber.

Concrete-Enhanced Timber
Timber-concrete composite construction using mechanical connectors such as nails, spikes, bolts, dowels, glued block and cut notches can significantly increase the strength and durability of timber constructions (Ahmadi and Saka, 1993; Murthy, 1984 and Yttrup 2000).

Flame Retardant and Preservative Treatment
Preservatives are chemicals used to protect timber against attack by insects and fungi. They are in three categories: tar oils, water borne preservatives and organic solvent preservatives. These chemicals are applied to timber using pressure impregnation, hot and cold soaking, dipping, spraying or brushing. Flame retardant chemicals are used to slow down the rate at which flames spread over the surface of timber.

Mass Production
The quality of timber components available in the Nigerian market can be significantly improved through mass production. The large majority of these components are currently produced in small workshops using hand tools. Larger factories are required to make the use of power tools and automated production economical. This will in turn lower component cost while improving quality and standardisation. The economic advantage of industrially produced timber components can be fully realized when the components are repeated in sufficiently large number to offset the cost of setting up the machinery involved.

5. Modern Techniques of using Timber in Building Construction
The competitive challenges posed by modern architecture encourage the development of timber constructions. The different research, teaching, development and marketing programmes should aim not only at the quantity of material used, but also at the manifold quality of material stability, section variability, material diversity as well as widespread usage of the new techniques in timber
engineering construction (Natterer, 2001). This will help to significantly increase the use of timber as a construction material. The criteria for such developments are better evaluation of the timber quality, increased diversity, better treatment of material varieties and development of faster assembling techniques.

**Shear Connectors and Fasteners**

The strength or weakness of timber construction lies in the joints where members are assembled. The traditional construction method based the strength of connections on the use of tongue-and-groove joints, which is usually weak with limited strength of about 15-20% strength potential of the timber members. The conventional method added the use of metal bolts over the traditional system, resulting in longer spans of up to 10.5m (Apu, 2003).

Modern construction techniques advocate the use of modern shear connectors and fasteners for longer span (15m and more) to give joints adequate strength and rigidity (Figures 1 and 2). Common fasteners-connectors include framing anchors, split rings, shear plates, tooth rings, wire nails and metal frames (Izomoh, 1994). The use of composites and concrete-enhanced timber is also a modern solution for improved usage of timber.

**Timber Floor System**

Timber floor system can be constructed on supporting beams fastened to treated posts embedded in the soil or masonry piers to protect from termites. Construction of this type of support for the floor joist has a great advantage because grading is not required and thus it can be used in relatively steep or uneven slopes. Floor joists are fastened to these beams and the sub-floor nailed to the joists. The product is a level sturdy platform upon which the whole building is constructed (Olufemi, 2002).

**Walls**

Walls can be assembled flat on the sub-floor, raised in the “tilt-up” style and fastened to the perimeter of the floor platform. Exterior coverings, doors and windows are included after walls are plumed and braced. Timber wall has a structure formed from solid wood frame covered on both sides with solid wood boards, particle board or fibreboard. The space between the two covers could be left empty or filled with different materials with sound or thermal insulation properties (Wahab, 1991). It is important to ensure that the moisture content of wood used in various parts of houses is less than 15–19%.

**Roof**

Trusses and the conventional joist-and-rafters construction require some type of finish for ceiling. The decking or the beam and decking combination can both serve as interior finish and as a surface to apply the roofing material as shown in Plate 4. The portal rafter and column members shown in Plate 4 are 395x115mm glue laminated radiata pine. Epoxy steel dowels are used for many of the major structural connections. Dowels set in epoxy fix the rafter and columns where they butt together and the
steel bolting plates used for the base and ridge joints are fixed to the timber by the same method. Bolted steel brackets are used for the other joints. Hardwood blocks are used to fix the purlins to the rafters. Both are nailed on site with gas powered nail guns. The purlins are sawn pine, nail-plated together to provide the required length. Internally, the ceiling is lined with radiata pine boards.

**The ceiling**

This is constructed the same way as the wall except for smaller thickness. It consists of a solid wood frame and the covering may be restricted to only one side open to the interior part of the house. Generally the covering boards could be of small thickness (4-6mm) for plywood and hard fibreboard and up to 12mm for soft fibreboard.

**6. Conclusion**

Timber is highly favoured by architects because of its physical and aesthetic qualities. However, the use of timber components is often restricted to interiors, and timber is rarely used for structural components, with the exception of roof construction. The reason for this underutilization has been adduced to attack by insects, fungi and vermin and inadequate research among others. Novel solutions such as composites and use of flame retardant and preservative treatments have significantly reduced the problems associated with timber usage. The new techniques available for wall, floor and roof construction should be popularized through model housing while mass production and standardisation of timber components should be encouraged. If timber is used intelligently and efficiently by architects in durable, highly valued and beautiful buildings, then the potential for sustainable technologies to develop is likely to be greater than if the material is wasted on temporary, low value or poorly designed buildings.

**7. References**


