Available online at www.elixirpublishers.com (Elixir International Journal)

Sustainable Architecture

Elixir Substain. Arc. 76 (2014) 28400-28405

ISSN: 2229-712X

Improving the quality of roofing system of traditional buildings in rural area of Nigeria

Akinkunmi Joel Olukunle

Department of Architectural Technology, Faculty of Environmental Studies, Osun State College of Technology, Esa-Oke. P.M.B 1011, Esa-oke post office osun state, Nigeria.

ARTICLE INFO

Article history:

Received: 27 September 2014;

Received in revised form:

27 October 2014;

Accepted: 7 November 2014;

Keywords

Traditional building,

Roof failure, Requirement,

Quality roofing and Performance.

ABSTRACT

The persistent roofing problems of the leaking roof, collapse and the ripping off roofing system and the plight of the affected majority in the past few years throughout the country has prompted an undertaking a roof design verification survey of the affected roofing system in the rural areas of the following state Osun State, Ondo State, Sokoto State, Rivers State and Yobe State. The aim of which was to find out the main causes of the roofing problems affecting rural housing stock and National economy as a whole. The studies revealed that environmental degradation, bad roof construction practice, poor roof design and supervision, lack of maintenance, poor social economic situation and ignorance are the main causes of roofing problems. The total homelessness effect from annual roof problems has been enormous and from environmental considerations logs of wood are wasted on the reinstatement of roofs. Bad roof construction practices were identified during the survey and their corresponding recommended procedures have also been indicated to help improve the situation.

Introduction

The roof is a structure which covers the top of any building structure known as superstructure. Its main function is to ensure adequate protection and to provide shield of comfort to everything under it. Roofs in the tropics are designed to insulate building against heat penetration, also to shed off rain water very quickly from the roof surface to prevent leakage.

The roof structure basically consists of two components, the roof covering material which is directly exposed to the atmosphere and the roof understructure supporting the roof covering material. It has also been revealed that for the roof covering material to function effectively, it should exhibits the following qualities, very durable, must have high resistance against, the violet solar radiation and must resist the effect of oxidation and effect of adverse weather conditions such as violent storm and wind pressure, seasonal temperature and moisture variation. In order to get effective and more reliable roof structure, roof covering should be of high quality and must function adequately as coherent system (Kneeland and Godfrey, 1986). It must be sufficiently strong and rigid enough to withstand any anticipated wind pressure, the design and construction must appropriate, effective and adequate. It should span the structural support without any form of deflection. Environmental factors and impact that affect the performance of roof can be reduced through effective planned maintenance. Besides being one of the main structures in a building, roof may act as a weather shield, giving protection to users or occupants from rain and sun. Therefore, it is important to treat any aging roof promptly. In Nigeria, corrugated zinc and thatch roof have been widely used in the historic buildings. Common defects include the corrosion of nails fixing the zinc to battens and rafters, the decay of battens and deterioration of thatch as a result of adverse weather effect. (Gaddy *et al.*, 1987).

Research Methodology

This paper concerns an investigation of the roof failure in traditional buildings in rural areas of Nigeria. A preliminary study involving the professionals in the construction industry identified problems and defects associated with the roof of traditional building in rural area of Nigeria. The study used focus group to engaged rural dwellers in guided interview and discussion at the rural suburbs of Nigeria (Krueger,1994). The participants are experienced local house developers from rural dwellers, the focus groups were led by research fellows, who are aided by a discussion guide developed through prior interview with, experts in building local houses and experienced roofers. The focus groups are a form quantitative researches in which purposely-selected participants in the field of study are interviewed in a group setting. Such setting increases the efficiency of interviewing and interaction among the group members, it leads to more insightful response than attained through individual interviews. Such a pattern suggests the probability of a generalized view within the population being studied. Focus group also carried out structural failure investigation of the roof of traditional building, by collecting samples of wood specification used for roofing construction by local builders to determine the relative structural fitness of those specifications.

Sample Frame

Since it is impossible to cover all the households in Nigeria due to cost and time, Six rural areas that cut across Northern, Southern, Eastern and Western part of Nigeria were studied. The Local Government Areas include: Ata-kumosa (Osun state), Akure south (Ondo state), Opobo Nkoro (Rivers state), Binji (Sokoto state) and Geshua (Yobe state).

Roofing situation at the rural areas of Nigeria

Having carried out detailed studies in six states with the aid of effective professionalism in focus group. The prevailing roofing situations of traditional building in rural area are

Tele:

E-mail addresses: dayspring4emma@gmail.com

characterized with lack of good quality, poor roof construction management control measures, lack of maintenance, environmental degradation and lack of appropriate roof members. This resulted in several roof failures and total collapse. The performance evaluation of roofing system is very low due to incompetent builder and unacceptable low standard of workmanship, among others.

From the study, higher percentages of those building about seventy two percent have been existed for over thirty years without any maintenance measure administered over time. Majority of the rural housing stocks are characterized with partly collapsed, dilapidated and unsafe roofing situation that are dangerous for human habitation while those built in recent years constitute 18%, however there exists a correlation between relative habitation and age of the building. Fadamiro (1995) strengthens further that technical, functional and behavioral element of those building falls basically as traditional process, thus presenting an organic composition to maintenance and adaptability. These findings therefore emphasize the need for a comprehensive programme of effective rehabilitation for the improvement of technical, functional and behavioral performance of the existing rural indigenous dwelling.

Construction materials and methods

Wood from forest that are far less than appropriate roofing specification form the commonest material upon which roof constructions are based as ninety nine percent of all the buildings are constructed with inadequate material specification. However the use of those woods as a building material does not in itself build substandard and poor quality housing, but inability to strict adhering to adequate specification with regard to constructional detail and constant routine maintenance (Chudley and Roger, 2006). Wood of different typology exhibits different characteristics that may or may not be suitable for roof construction, the constructional processes that will enable high quality outcome depend apparently on the correct grade and sizes of wood material used.

Performance consideration of roofing coverings

Dupuis (1996) reported that the Performance or durability of roofing system is generally related to the fulfillment of the user's requirements, it means the actual functioning of a roofing system or element in service and the desired attributes of materials are the choice of builder. Obviously, these are considered the most important factors. Every roof cover, irrespective of the material or the manufacturer, must be capable of doing the following:

- Remain waterproof.
- Withstand all weather factors (such as wind, rain, snow, hail, solar radiation, temperature extremes, and thermal shocks) during its intended service life.
- Resist various stresses from internal or external causes during manufacturing, application and service.

It may be appropriate to define some of the terms related to the performance of roofing system, materials or components in general.

- Performance requirement is a qualitative statement describing what the roofing system or element is to accomplish.
- Performance criterion is a quantitative aspect of the acceptable or adequate performance level.
- Charaterisation method means a method for evaluating the compliance with performance criteria. Field work, (2011)

It should be noted that requirement and criterion are interchangeable and to some it implies both, i.e, the qualitative aspect is implicit in the statement of the quantitative aspects. The selection of a roof cover, like any other building component, must be based on its ability to meet the performance requirements for proper functioning throughout its life.

Analysis and interpretation of data

The roofing system in terms of quality, effectiveness and performance in relation to rural housing, socio-economic characteristics and housing provision are analyzed as follows.

Table 1: Analysis of Factors Causing Roof Failure

	Frequencies	
Predominant factors	Low	High
Effect of rainstorm	_	high
Effect of environmental degradation	low	_
Structural Inadequacy	_	high
Poor construction practice	_	high
Lack of maintenance culture	_	high
Poor economy factor	_	high.

Field work (2011)

Table 2: Analysis of Construction Practice (Structural Characteristics)

Predominant factors	Practices frequencies	
	Low	High
Ceiling joist separated from rafter	_	high
Truss tie with reinforcement from column	low	_
Eccentric arrangement of truss	_	high
Rafter not birdmouthed to fit into wall plate	_	high
Regular purlin spacing at the eaves	_	high
Wall plate not anchor into exterior wall	_	high
Web member in simple truss not stable	low	_

Field work (2011)

Causes of Roof Failure

A careful analysis from focused group revealed that main causes of roof problem in the country include:

Effect of rainstorms disaster

The collapse and ripping off of roofing system during rainstorms especially in the rural areas is a common phenomenon in Nigeria. During these rainstorms disasters homeless and housing properties worth several millions of naira are always destroyed. The situation is worse in rural areas of Nigeria, where replacement of damage roofs becomes always impossible due to their low incomes. Expensive roofs in Nigeria have become difficult with ever increasing cost of roofing timber and roof covering materials, it has become increasingly difficult to replace collapse roofs and these bring untold hardship to the affected people. It was revealed during this study that situation are worst off when delayed to replace these collapse roof during the raining season which lead to total collapse of the earth wall structure. It has been proven also by the focus group that the total house can be left to be eroded and may not be replaced even in distant future, thereby reducing the national housing stock and worsening housing situation in Nigeria (Field work, 2011).

The effects of environmental degradation:

The rural areas studied showed that sudden problem of frequent ripping off of roofing system can only be caused by destruction of the environmental forest. It has been revealed that most of old roofs, especially those in rural areas have been functioning for years, decades and beyond, without those problems, even though they are not properly designed or constructed. Thus clearing of forest and tress surrounding the building, that are acting as wind breaks which protecting buildings from full impacts of the wind loads. Most of the buildings are now exposed to suffer full effect of the wind loads on the roof surfaces. The effect of environmental degradation was seen during the random survey in one village called Kajola in Ata-kumosa local government in Osun state where about

fifteen houses had their roof blown off (Field work, 2011). In that particular case, the affected houses were opened up as a result of highway construction, all the trees around those buildings were possibly cleared with no natural wind breaks and were not replaced and were exposed to full impact of wind loads had their roof blown off.

Structural Inadequacy

Structural problem was found to be one of major causes of collapse and ripping off of roof structure in some surveyed areas. It was discovered by focused group that roofs are basically designed using growth design approach which relies on experience and common sense. In such a situation, those artisans who possess these qualities are used to size structural roofing members without resorting to design code and specification, since they have the understanding of what the correct size of roofing members should be. Chudley and Roger (2006) corroborate further that there are some of the other practice that is very common among the less experienced artisan in under sizing up structural roofing members, they always apply a total method of rule of thumb, which always resulted in very defective roofing system, which in most cases contribution to ripping off of roofing system. In the areas studied, especially at Npobo Nkoro it was also revealed that due to high cost of structural roofing members, people always prefer off-cuts and under-sized structural member which are relatively cheaper but structurally defective. The roof structures constructed from these defective timbers are not built to any design specification but left to the discretion of local artisans. The small height weight nature from smaller timber section makes the roof system to be highly susceptible to damage caused by strong. The principle of triangulation which provides good rigid structural system was completely ignored. In most cases in the rural areas where a ceiling joist could have been used as ties to restrain the spreading out of feet of rafter they were fixed to wall plate, turning the whole structure to a mechanism which can easily collapse under windstorm.

Poor construction practice

The report of focused group revealed that lack of adequate training of the artisans also contributed very greatly to the ripping off of roof systems, due to poor construction methods. In some situations where the roofing members were structurally adequate, due to poor construction, it becomes very defective and was easily blown off under serious wind storms. It was observed that either there was no anchorage of the roofing system to the rest of the building structure or the anchorage provided was not adequate. In some instances, purling were not firmly secured to the rafter, then purling ripped off together with the roof covering material especially zinc, leaving the rest of the roof structure behind (Chudley and Roger, 2006). Where the rafters are not firmly secured to the wall plates, the roofing system blew off leaving the wall plates behind. Wrong or inadequate fastener on the roof covering materials led to situation where roof covering materials blew off from the roof structure (Field work, 2011).

This study also revealed that nailing of the roof structure was done during the construction without detailed references to the edge distance, thus the nail does not get good holding in timber joints. The timber roof joints were easily distorted under any serious windstorm which resulted in the failure of such joints and collapsed. Also length of laps at roof timber joints in some cases were found to be inadequate leading to deterioration as the roof was subjected to constant vibrations. In other situations where end or side laps were not adequate or the roof covering laid in the direction of the prevailing wind, water splashed back, the wind forcing water through the covering sheets and thus causing leakages when these leakages were not rectified immediately, resulted in the deterioration of the timber of the roofing members and rusting of the roofing nail thereby wakening the entire roofing system which contributed to total collapse of roofing system (Hodges, 1989). Also, majority of local roof constructions were not compliance in design specifications and manufacturer requirements for the size of roof covering, especially where the roof slopes have been constructed below manufacturer's recommended slopes. These resulted in poor performances and are the major courses of leakages, these led to the deterioration of roof nails used in the timber joints and when this continues, roof structure deteriorate and eventually fails. The survey of roof construction practices in the country revealed that there was a complete lack of supervision during the roof construction by trained roof expert. The over reliance in the so called experience roof artisan is a major causes of the roofing problems facing traditional building in rural areas, since the most roofs constructed by artisan are usually defective and can easily collapse (Field work, 2011).

Lack of maintenance culture

This study revealed that most of the roofing systems have undergone continuous deterioration through leakages. Also, after long time exposure to various environmental factors in the course of their services lives, it was realized that lack of effective maintenance of roofing systems in the rural areas, to combat the effect of time, hostile environment and repairs of defective area in roof damaged contributed to final collapse of roofs in the visited rural areas (Field work, 2011).

Poor economic factors, cost reduction and poor level of information required

During this study, it was discovered that poor economic situation, attempt to reduce the cost, non-standard and low-grade roofing timber were used in most of the rural areas studied. Also out of their ignorance due to poor level of information about such roof timber. Observations from the focused group revealed that carpenters did not make use of basic principles of triangulation to increase the stability and rigidity of the roofing system, even though the sizes of the roof timber used were structurally inadequate and led to collapse of roofing system (Field work, 2011).

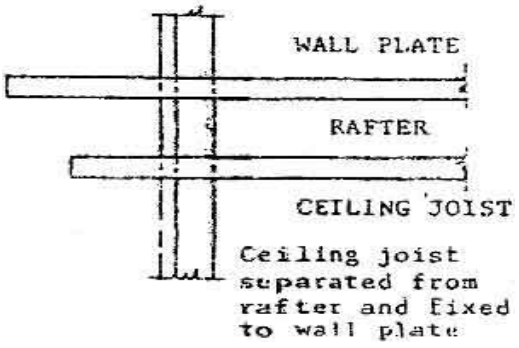
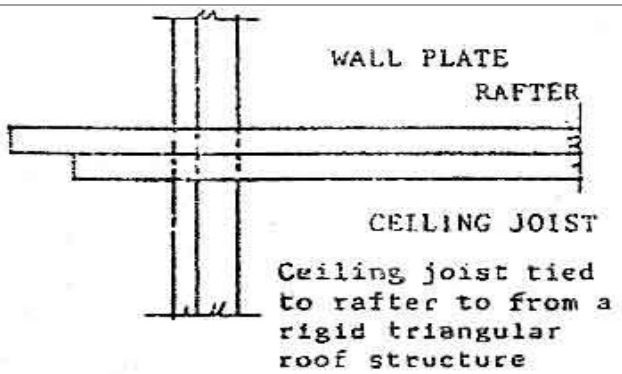
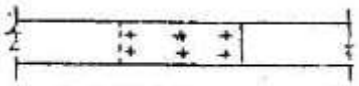
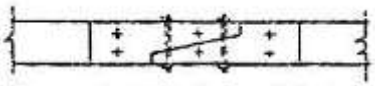
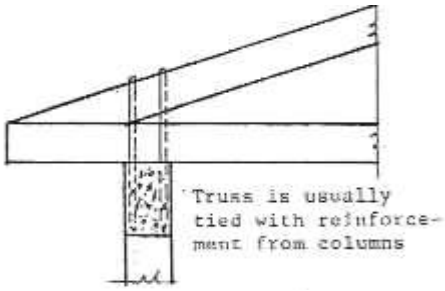
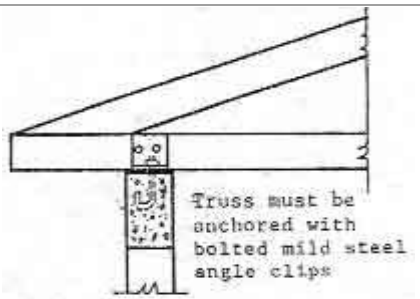
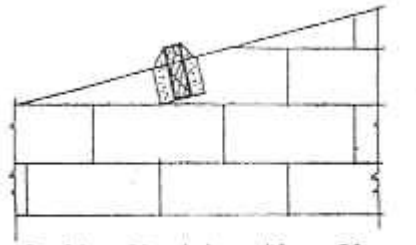
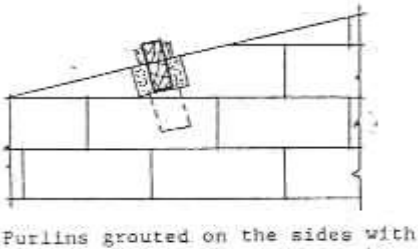
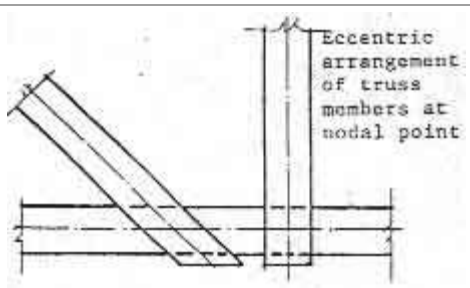
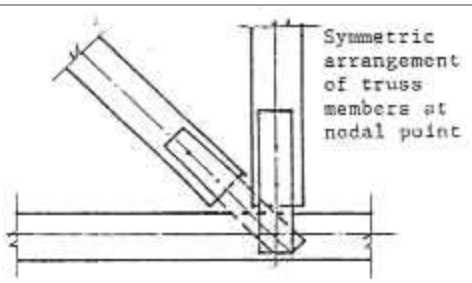
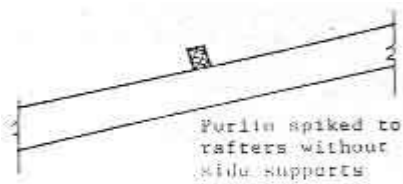
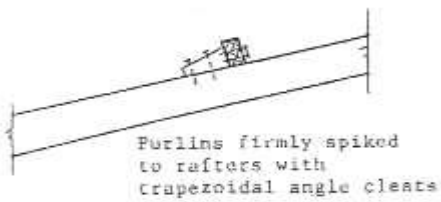
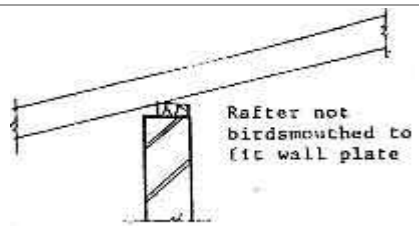
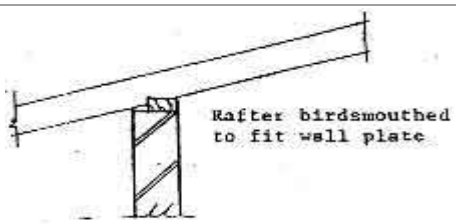
Identified bad roof construction practice and recommended good roof construction practice

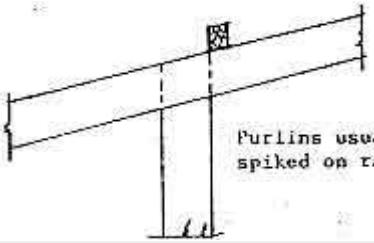
The performance evaluation of roof structure depends often on connector joints. Roof timber structure is as strong as its weakest joints, during this study it was revealed that, as it was always with other construction procedure, there were some wrong ways by which roofing system were constructed. To help improve the quality of our roofing system at the rural areas, typical wrong procedures of some roof-structure construction have been identified, as analyzed below in the table 3 with their right procedure of roof construction process (Fullerton, 1979).

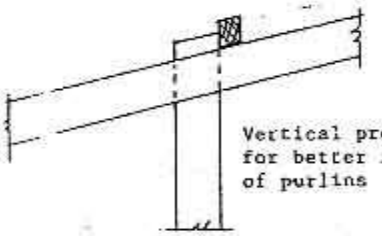
Performance Requirements

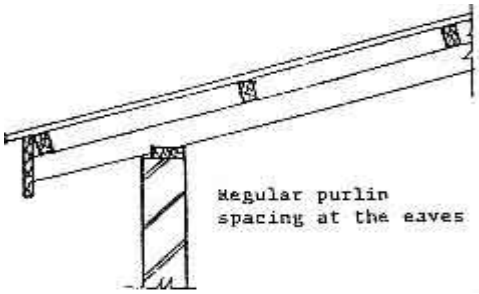
The performance of roofs as mentioned above, is related to numerous variables concerning weather factors and stresses. Other variables are the chemical composition of materials, the quality control of the constituent materials and products during manufacture, storage, transportation, instal1ation and, maintenance. Most of these conditions vary from one situation to another, so that a large number of performance requirements and criteria are identifiable. In this paper, the roof covers and other components within the roofing systems are discussed, e.g., the structural board, have an important influence on the overall perfomance.

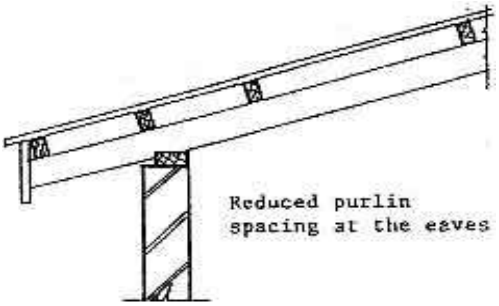
Table 3: Identified Bad Roof Construction Practices and their Corresponding Recommended Procedures

Identified Bad Roof Construction Practices	Recommended Roof Construction Practices
	
	
	
	
	
	
	

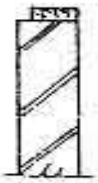

Purlins usually spiked on rafters


Vertical projected for better fixing of purlins

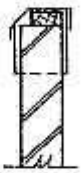

Regular purlin spacing at the eaves

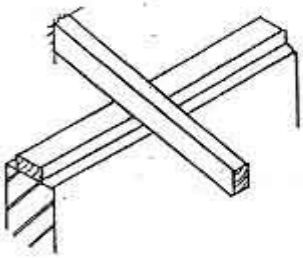

Reduced purlin spacing at the eaves

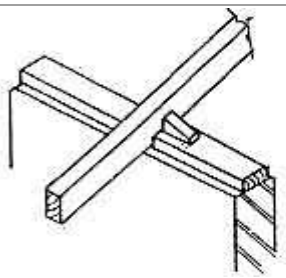
Wall plate not anchored to exterior wall

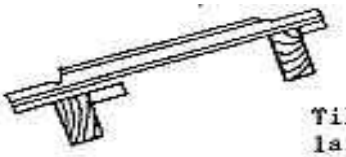


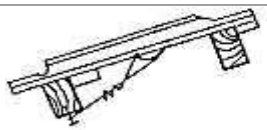
Wall plate firmly anchored to exterior wall with 6 mm. Ø mild steel 'U' bars



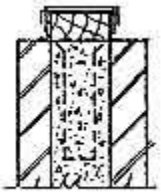

Rafters and sprockets are usually fixed to wall plates without triangular or trapezoidal timber cleats

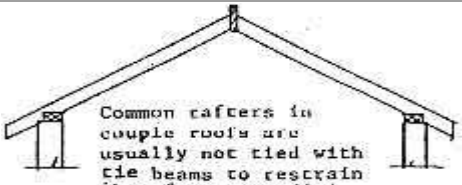

Trapezoidal or triangular timber cleats must be firmly fixed to the sides of rafters or sprockets after side nailing them to wall plates

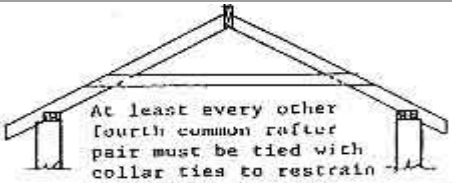

Tiles are usually laid freely on timber battens

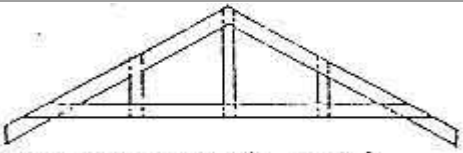

Tiles must be designed in such a way that it can be hooked to the fasteners at the eaves and verges

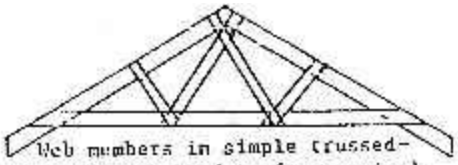

Mild steel metal straps are sometimes used to anchor wall plates in earth buildings


Concrete central core systems must be used to embed plain mild steel anchor rods for wall plates in earth buildings.


Common rafters in couple roofs are usually not tied with tie beams to restrain them from spreading


At least every other fourth common rafter pair must be tied with collar ties to restrain them from spreading


Web members in simple trussed-rafters are usually not constructed rationally and less stable


Web members in simple trussed-rafters can be used to form a simple 'W' trussed-raiter which is stable

One way to predict the performance of roof covering is to identify the physical, chemical and mechanical properties essential for its performance and to quantify them arbitrarily on the basis of experience. These criteria may be projected with or without modifications to other generic types of roof covering (Dupuis.1996). Research and practical experience with the deterioration of roofing covering over a number of years have shown that heat from the sun is one of the most potent factors that affects durability. The heat aging simulates the accelerated effect of solar heat that changes properties of roof covering.

Conclusion

According to Addai, to ensure effective performance of any roof system, the use of roofing material must comply with specification requirements. Also all roofing members and materials must be partially or totally replaced after their service lives have passed, due to deterioration, also causes of leakages in roofs must be found and immediately remedied.

There is an urgent need to train artisans who are directly involved in the functional roof realization especially those in the rural communities to at least know the basic construction techniques of a roofing system (Chudley and Rogers, 2006).

Recommendations

It is highly essential that specialist advice be sought in checking maintenance requirement of ensuring roofs of earth structure in the rural area, so that rate of deterioration can be reduced.

In the area of deforestation, where houses are exposed to full impact of windstorms tree planting programmes are highly recommended to serve as wind breaks. Also the rural artisans should be re-orientated that use of unseasonable timber for roof construction must be regarded as bad practice and it should be avoided. Well seasoned timber should be used at all time. Good anchorage of the roofing structure to the rest of the building structure is essential, mild steel anchor rods to anchor the roofing structures to external wall. The anchorages must at least come down at about 500mm down the external wall and spaced 2000mm centers to centers. The critical stressed area on any roof system such as eaves, verges and ridges, the fastener of roof covering materials to the roof structure should be such that the spacing are closer together. The roofing trusses should be birds mouthed together to form a rigid, untwisted roofing system. It must be cut to make a good contact with each other.

References

Addai, S, (1998): Perennial roofing problems of the collapse and the ripping of roofing system during rainstorms in Ghana, Ghana Engineer. Ghana.

Chudley, R and Rogers, G. (2006): Building construction handbook, Butterworth-Heinemann. Jordan Hill Oxford.

Dupuis, R.M, (1996): Roof system: Field survey and performance review, Professional roofing. Pp 18-22.

Fadamiro, J. A. (1995). Prevention of Windstorm on building as favour in the production and maintenance of a safe at AARCHES. 6th AGM/Workshop at ATBU Bauchi

Fullerton, R. L. (1979): Building construction in warm countries, Parts 1, 2. Oxford University Press. Paris.

Gaddy, G. D, Rossiter, W. J and Eby, R. K. (1990): Roofing research and standard development, ASMT STP. Pp 37-52.

Hodges, C. P, (1989): Roofing failures: What went wrong, Sliding Insulation Magazine. Pp40-46.

Kneeland, A. G. and Godfery, (1986): Roof membranes: new system, new problem, civil engineering, ASCE. Pp76-79.

Krueger, R. A. (1994). Forms group: A practical guide for applied research. Fond on sage publications.