RESEARCH PAPER International Journal of Agricultural Engineering | Volume 10 | Issue 1 | April, 2017 | 152-158

e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/10.1/152-158**

Design of log house for agro-tourism from ain wood

S.P. DIVEKAR, S.K. JAIN, CHANDAN KUMAR, R.B. MAHADIK AND V.M. DAWARE

Received : 14.02.2017; **Revised :** 18.03.2017; **Accepted :** 26.03.2017

See end of the Paper for authors' affiliation

Correspondence to :

S.P. DIVEKAR
Department of Farm Structures, College of Agricultural Engineering and Technology, Dapoli, RATNAGIRI (M.S.) INDIA

ABSTRACT : The presence of log house in agro-tourism is one of type of attraction to the tourists to come for agro-tourism. The tourists come for tourism and they stay in log house. The main advantage of a log house is a healthy living environment. The log house is made up with the locally available wood or light weight wood. The demand for wooden products is continuously increasing day by day. Wood is exposed to both periodic water absorption and desorption process. Understanding water absorption and desorption in wood are of practical importance since they also affect the mechanical properties of the product. In residential building and in industrial application some of the components are often wood (Ostman, 1985). For the purpose of the study, Agro-tourism for farmers is considered as a range of activities, services and amenities provided by farmers and rural people to attract tourist to their area in order to generate extra income for their businesses. Agro-tourism for tourists is considered as anything that connects tourists with the heritage, natural resource or culinary experiences unique to the agricultural industry or a specific region of the country's rural areas. The designed log house was safe from different loads point of view.

KEY WORDS : Log house, Dead load, Live load

HOW TO CITE THIS PAPER : Divekar, S.P., Jain, S.K., Kumar, Chandan, Mahadik, R.B. and Daware, V.M. (2017). Design of log house for agro-tourism from ain wood. *Internat. J. Agric. Engg.*, **10**(1) : 152-158, **DOI: 10.15740/HAS/IJAE/10.1/152-158.**

The presence of log house in agro-tourism is one of type of attraction to the tourists to come for agro-tourism. The tourists come for tourism and they stay in log house. The main advantage of a log house is a healthy living environment. The log house is made up with the locally available wood or light weight wood.

Wood is one of the earth's most valuable resources and it conforms to the most varied requirement. There are over 1600 different species of woods which are used for various purposes. Wood shows a remarkably wide range of variation in their properties, timber and the type of end use (Rajput and Shukla, 1996). Wood is a multiuse biological raw material with a high economic importance for a number of industrial sectors such as construction, furniture and the packing industry. It is much more variable than that of materials such as concrete or metal (Michael, 2016). Global production of wood is estimated at 3469 million m^3 in 2011, of which 1891 million $m^3$is fuel wood and 1578 million m^3 is industrial round wood.

Wood is a natural, renewable and valuable construction material. Since being thought of as naturally resistant to wood degrading organisms. Wood has been used as a shelter and has many outdoor applications thought out human history. However, the durability of wood varies depending on its tree species, chemical composition, and the environmental condition. Wood biodegradation occurs in different ways such as fungal, bacterial and insect attack. Fungal decay is the most widespread type of wood degradation.

The demand for wooden products is continuously increasing day by day. Wood is exposed to both periodic water absorption and desorption process. Understanding water absorption and desorption in wood are of practical importance since they also affect the mechanical properties of the product. In residential building and in industrial application some of the components are often wood (Ostman, 1985).

For the purpose of the study, Agro-tourism for farmers is considered as a range of activities, services and amenities provided by farmers and rural people to attract tourist to their area in order to generate extra income for their businesses. Agro-tourism for tourists is considered as anything that connects tourists with the heritage, natural resource or culinary experiences unique to the agricultural industry or a specific region of the country's rural areas.

The compression stress is one of the important parameter in building design. The Ain wood is selected for study because the compression stress of Ain wood is 1.3 x 10^7 kN/m^2 which is higher than compressive stress of commonly used teak wood *i.e.* 5 x 10^4 kN/m^2. Hence, present research work entitled "Design of Log House for Agro-tourism" was under taken.

METHODOLOGY

The various materials and the methodology used for the present study are as follows.

Ain (*Terminalia elliptica*):

Among the popular varieties of wood available in the Konkan region of India, Ain was selected for the study. Ain is deciduous tree which can grow upto 32 m in height. The leaves of the tree are elliptic to ovate with one or two glands at laminar and petiole junction.

Machine and instruments: Universal testing machine :

The following machines and instruments were used for the study.

Universal testing machine:

Universal testing machine was used for measurement of compressive and bending strength of Ain samples. The capacity of the machine is 50 kN.

Hot air oven :

The hot air oven was used for the determination of the moisture content of Ain wood sample.

Weighing balance:

Weighing balance having capacity 1000g was used for measuring weight of the Ain samples. Least count of weighing balance is 0.001g.

Methodology :

The properties of wood required for design of log house were determined with the help of above instruments. The properties determined were moisture content, shrinkage, compressive stress and bending stress.

Design parameter for log house:

The 12m × 5m area was selected for the design of the log house. The following design parameter was considered under this study.

Dead load:

The dead load includes its own weight, the weight of any permanent non-structural partitions, built in Cup-boards, floor surfacing materials and other finishes. It was worked out precisely from the known weights of the materials and the dimensions on the working drawings. The dead loads considered here are as follows.

Specification of roof :

Area of roof = 1.07 m × 3.66 m; Length of roof = 14 m. Total number of roof sheets required on both the sides =28 (considered roof sheets on one side = 14).

Specification of Purlins:

Dimension of purlin = 14m × 0.10m × 0.05m (L× B × T); Number of purlins on both sides = 6; Volume of purlin = (L× B × T) m^3;

$$\text{Density of wood} \; Z \; \frac{\text{Mass}}{\text{Volume}}$$

Weight of purlin = Volume of purlin × Density of wood

Specification of trusses:

Dimension of wood = 0.10 m × 0.05 m (B × T); Volume of truss = (L × B × T) m^3

Weight of truss = Volume of truss × Density of wood.

Specification of rafter:

Dimension of rafter = 12 m × 0.10 m × 0.10 m (L × B × T); Volume of rafter = (L × B × T) m^3; Weight of rafter = Volume of rafter × Density of wood

Specification of column:

Dimension of column = 2.6 m × 0.10 m × 0.10 m; Number of column = 12

Live load:

All the movable objects in the building such as people, desks, cupboards and filing cabinets produce an imposed load on the structure. This load may come and go with the result that its intensity was varying considerably. At one moment a room may be empty, yet at another packed with people. Imagine the extra live load at a lively party. Roof and Floor live loads are produced during maintenance by works equipment and materials, considering 95% for human + other weight *i.e.* 200 kg.

$$\text{Live load} = [(\text{Weight of human} + \text{other}) \times 9.81] \quad (1)$$

Wind load:

Wind has become a very important load in recent years due to the extensive use of lighter materials and more efficient building techniques. A building built with heavy masonry, timber tiled roof may not be affected by the wind load, but on the other hand the structural design of a modern light gauge steel framed building is dominated by the wind load, which will affect its strength, stability and serviceability. The wind acts both on the main structure and on the individual cladding units. The structure has to be braced to resist the horizontal load and anchored to the ground to prevent the whole building from being blown away, if the dead weight of the building is not sufficient to hold it down. The cladding has to be securely fixed to prevent the wind from ripping, it away from the structure.

For project study 50 year's highest wind speed (v_b) of 72 m/s was taken. This study was considered the value of the probability factor k_1 as l. The terrain, height and size factor k_2 of 1.0 had been considered since the proposed structure belongs to class A as per IS 875 part 3. Finally the topography factor k_3 had been chosen as 1.0. These factor results in a design wind speed of 72 m/s. The external and internal pressure co-efficients on the wall and roof are considered in accordance with IS 875 part 3.

Wind speed is calculated by following formula:

$$\text{Wind speed} = Vz = Vb \times K1 \times K2 \times K3 \quad (2)$$

Wind pressure is calculated by following formula:

$$\text{Wind pressure} = Pd = 0.6 \times Vz^2 \quad (3)$$

Wind load was calculated by:

$$\text{Wind load} = F = (Cf \times Ae \times Pd) \times 1.7 \quad (4)$$

where,

Cf= Force co-efficient for building.

Pd = Design wind pressure.

Ae= Effective area of the structure.

Total load:

Total load is calculated by using formula :

Total load = Wind load + Dead load + Live load

$$\text{Wind load} = F = (Cf \times Ae \times Pd) \times 1.7$$

Foundation:

Isolated type footing of rectangular shape was selected design following formulas were used for design of foundation

Area of footing :

$$\text{Area of footing} = 1.1 \times \frac{P}{Fb}$$

where,

P = Axial load on column

F_b = Safe Bearing capacity of soil.

Cantilever projection:

Cantilever projection of footing for bending about x-axis

$$Cx = \frac{(Lf - D)}{2} \quad (5)$$

Cantilever projection of footing for bending about y-axis

$$Cy = \frac{(Bf - b)}{2} \quad (6)$$

where,

D = Depth of column

b = Width of column

For equal projection,

$$\frac{(Lf - D)}{2} = \frac{(Bf - b)}{2} \quad (7)$$

or

$$Bf = Lf - D + b$$

Substituting the value of B_f in equ. (1) and solving the quadratic equation in L_f we get,

$$Lf = \frac{(D - b)}{2} \pm \frac{\text{root of } (D - b)}{4 \times Af} \quad (8)$$

Select the length of footing by rounding out the value of L_f recalculate,

$$Cx = \frac{(L_f - D)}{2}$$

$$Cy = \frac{(B_f - b)}{2}$$

where,

Breath of the footing = $B_f = b + 2 \times C_x$

L_f and B_f are the length and breadth of footing provided.

Area of footing provided (A_f)

$$A_f = L_f \times B_f$$

Upward factored soil reaction (W_u)

$$W_u = \frac{P_u}{A_f} \quad (9)$$

where,

P_u = Load factored × Axial force

= 1.5 × P

The value of W_u may be greater than the bearing capacity of the soil. This is not unsafe because the comparison can be made with the upward working soil reaction which can be obtained by dividing W_u by the load factor of 5.

The value of working soil reaction so obtained should be less than bearing capacity of the soil.

RESULTS AND DISCUSSION

The results of the study under taken are given in Fig. 1 to 6.

Compression stress:

The allowable compression stress of Ain wood found from present study was 1.3×10^7 kN/m^2.

Bending stress:

The allowable bending stressh of Ain (*Terminalia elliptica*) was found as 5.67×10^7kN/m^2.

Design parameter for log house:

The various loads going to act on the foundation of the structure were found as,

Dead load:

Dead load was calculated as follows.

Roof load:

Roof sheet size considered as= 3.5×12 ft. (1.07×3.66 m); Overlap = 0.07 m;

Total length of side = 14 m; Number of roof sheets = 14; Total number of sheet on both side = 28;

Weight of one roof sheet = 46 kg; Total weight = 46 × 28 = 1288 kg (= 12.63 kN)

Purlin design:

Number of purlins on both sides = 6; Dimension of purlins = 14 × 0.10 × 0.05 m;

Volume of purlins= 0.07m^3; Volume of six purlins= 0.07×6= 0.42m^3 ; Density of wood = 1250kg/m^3

Weight of purlins = 0.42 × 1250= 525kg (= 5.150 kN).

Roof load on purlins = 12.63 kN; Area of purlins = 14×0.1m= 1.4m^2

Number of purlins on both sides = 6; Total area = 1.4×6= 8.4m^2

Bending permissible (σ_{per}) stress = 5.67×10^7kN/m^2

Total load on purlins = Weight of sheets + wind load + live load = 12.63 + 15.23 +1.96 (= 29.82 kN).

$$\text{Stress taken by purlins} = \frac{29.82}{8.4} = 3.55 \text{ kN/m}^2$$

Bending stress permissible = 5.67×10^7kN/m^2

The of bending stress was 3.55 kN./m^2 which was lesser than permissible bending strength (5.67×10^7kN/m^2) for purlin. Hence, the design was safe for purlin.

Truss design:

Dimension of wood = 0.10 × 0.05 m; Total length of wood required for one truss= 18.08 m

Volume of truss = 18.08 ×.0.1× 0.05= 0.0904 m^3; Weight of one truss = 1250 × 0.0904= 113 kg

Number of trusses= 4; Weight of four truss = 113 × 4 = 452 kg (= 4.43 kN).

Load on truss = Load on purlin + Weight of purlin = 29.82 + 5.15 (= 34.97 kN).

Area of truss:

Bending = 3.66 × 2 × 0.1 × 4= 2.928 m^2

Compression = 0.05 × 0.1 × 3 × 4 = 0.06 m^2

$$\textbf{Stress taken, Bending} = \frac{34.97}{2.928} = 11.94\ \text{kN/m}^2$$

$$\textbf{Compression} = \frac{34.97}{0.06} = 582.84\ \text{kN/m}^2$$

Permissible stress, Bending = 5.67×10^7 kN./m^2, Compression = 1.3×10^7 kN/m^2.

The value of Compression and Bending stress were 582.84 kN/m^2 and 11.94 kN./m^2 which were lesser than the permissible compression and bending strength, respectively. Hence, design was safe for truss.

Rafter design:

Dimension = 0.10 m × 0.10 m; Total length of rafter =12 + 5 + 12+ 5 + 12= 46 m

Volume of rafter = 46 × 0.1 × 0.1 = 0.46 m^3; Weight of rafter = 0.46 × 1250= 575 kg(= 5.64 kN).

Load on Rafter = load on truss + weight of truss = 39.4 kN; Area of Rafter = 46 × 0.1= 4.6 m^2 ;

Stress taken, σ = 39.4 ÷ 4.6= 8.56 kN/m^2

σ_{per}= 5.67×10^7 kN/m^2

The value of bending stress was 8.56 kN/m^{2}which was lesser than the permissible bending strength (5.67×10^7 kN/m^2) for rafter. Hence, the design was safe for rafter.

Wind load:

Wind speed was calculated by taking Wind speed of Orissa (1999) was 72 m/s.

Velocity = 72m/s = 259.2 km/hrs.

V_z= 1×1×7= 72m/s

P_d= 0.6×72×72= 3110.4N/m^2

Wind load = $C_f \times A_e \times P_d + C_f \times A_e \times P_d \times 0.7$

$$\textbf{Solidarity ratio} = \frac{0.1 \times 18.08}{0.5 \times 5 \times 1.44} = 0.5$$

$$C_f = 1.6;\ \textbf{Frame spacing ratio} = \frac{2}{0.72} = 2.78$$

Wind load = 1.6 × 1.8 ×3110.4×1.7 = 15.23 kN

Live load:

Load of person + others = 200 kg

Live load = 1.96 kN

Overall load :

Overall load= (Roof + purlins +Truss +Wind +Rafter + Live load)= 45.04 kN

Considering factor of safety= 1.2

Total load= 1.2× 45.04 kN= 54.05 kN.

Column design:

Cross section area= 0.10 m ×0.10 m= 0.01 m^2 ; Load on column = 54.05 kN

Number of columns= 12; Compressive stress (σ_1) = 54.05 / 0.01= 5.405 × 10^3 kN/m^2

Permissible compressive stress (σ_2) = 1.3 × 10^7 kN/m^2

Column height = 2.6m; R_{min}=2 inches= 0.05 m

$$\textbf{Slenderness ratio}\ (\lambda) = \frac{l}{R_{min}} = 2.6 \times 0.8 \div 0.05 = 41.6$$

The value of compression stress was 5.405 × 10^3 kN/m^2 which was lesser than permissible compressive strength (1.3 × 10^7 kN/m^2) for column. Hence, the design was safe for column.

Foundation design:

Axial load on column = 54.05 kN; Bearing capacity of soil = 250kN/m^2

$$\textbf{Area of footing} = 1.1 \times \frac{54.05}{250} = 0.24\ \text{m}^2$$

$$L_f = B_f = \sqrt{A_f} = \sqrt{0.24} = 0.48\ \text{m}$$

D (Depth of column) = 0.1 m

$$C_x = \frac{(L_f - D)}{2} = \frac{(0.48 - 0.10)}{2} = 0.19\ \text{m}$$

$$C_y = \frac{(B_f - b)}{2} = 0.19\ \text{m}$$

Safe load (soil resistance) Wu = 1.5 P/A_f = 337.81 kN/m^2

Moments (Bending moments):

$M_{ux} = M_y = W_u \times L_f \times Cx^2 / 2$ = 337.81 × 0.48 ×0.19^2 / 2 = 2.93 kN-m

$Ru_{max} = 0.36\ f_{ck} ku_{max} (1 - 0.42\ ku_{max})$

$$Ku_{max} = \frac{700}{1100} \times 0.87 \times 250\ (\text{N/mm}^2) = 0.53\ \text{N/mm}^2$$

Ru_{max} = 2.97 N/mm^2

Let offset provided for setting column (e) = 0.025 m

D_1 = D + 2e = 10 + 2 × 2.5 = 15 cm = 0.15 m

Depth of footing, D_f

$$D_f = \sqrt{\frac{mux}{Ru_{max} \times D_1}} = 3.15\ \text{cm}$$

Total depth = 2 ×D_f = 6.30 cm

Design of footing having upward soil reaction 337.81

kN/m^2 was greater than soil bearing capacity (250kN/m^2). But this is not unsafe because the comparison can be made with the upward working soil reaction which can be obtain by dividing W_u by load factor of 1.5. Then it was seen that the value of working soil reaction so obtained (W_u / 1.5) was less than the bearing capacity of the soil.

The fresh Ain sample contains moisture content of 36.21 per cent. The average volumetric shrinkage of wood was 20.41 per cent. The compressive strength and bending strength were 1.3 × 10^7 kN/m^2 and 5.67 × 10^7 kN/m^2, respectively.

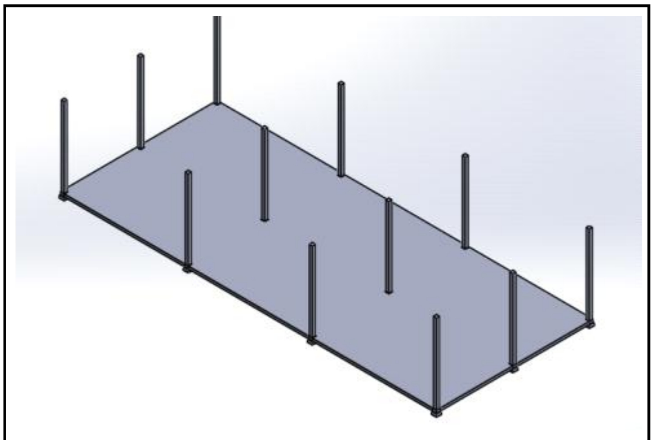

Fig. 1 : Isometric view of column

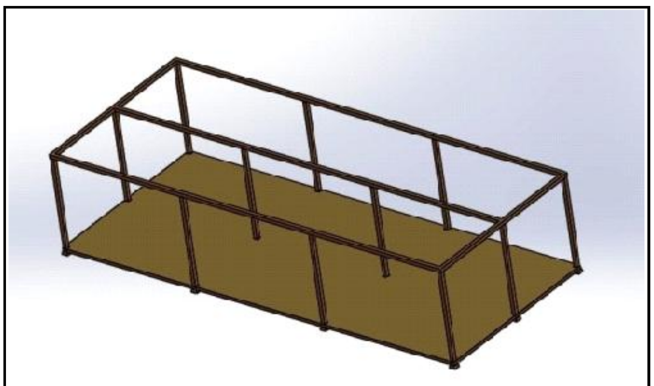

Fig. 2 : Isometric view of rafter

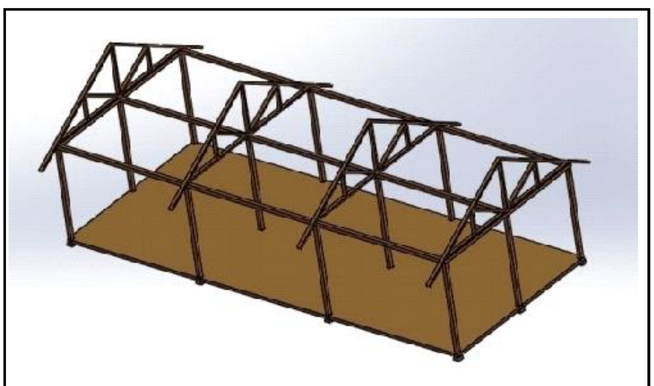

Fig. 3 : Isometric view of truss

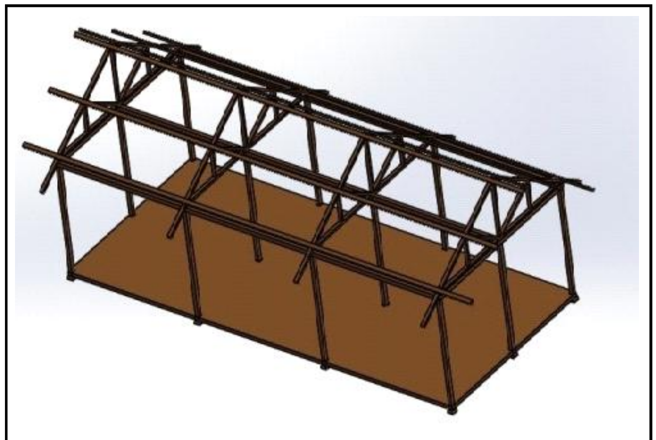

Fig. 4 : Isometric view of Purlin

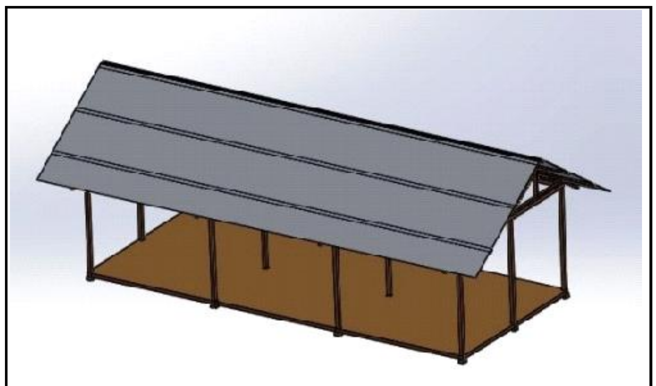

Fig. 5 : Isometric view of Asbestos cement roof sheet

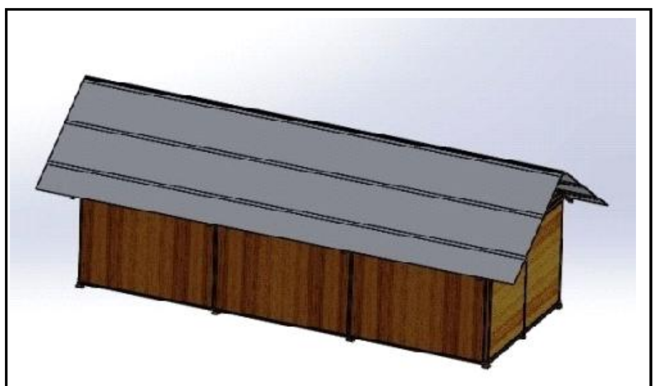

Fig. 6 : Isometric view of log house

The compressive strength and bending strength helps in design of log house for agro-tourism. The compressive strength of Ain and teak wood were 1.3×10^7 kN/m^{2}and 5×10^4 kN/m^2, respectively. It means that the Ain can be used as a Building material for construction of log house

Conclusion :

The total load acting on footing was 54.05 kN. Design of footing having upward soil reaction 337.81 kN/m^2 was greater than soil bearing capacity (250kN/m^2). But this is not unsafe because the comparison can be made with the upward working soil reaction which can be obtain by dividing W_u by load factor of 1.5. Then it was seen that the value of working soil reaction so obtained (W_u / 1.5) was less than the bearing capacity of the soil.

Authors' affiliations:
S.K. JAIN, CHANDAN KUMAR, R.B. MAHADIK AND V.M. DAWARE, Department of Farm Structures, College of Agricultural Engineering and Technology, Dapoli, RATNAGIRI (M.S.) INDIA

REFERENCES

BIS (1986). Methods of testing of small clear specimens of timber. Test code IS 1708 (Part 1):1996. Bureau of Indian Standards, New Delhi. 9.

BIS (1986). Methods of testing of small clear specimens of timber. Test code IS 1708 (Part 3):1996. Bureau of Indian Standards, New Delhi.13-15.

BIS (1986). Methods of testing of small clear specimens of timber. Test code IS 1708 (Part 6):1996. Bureau of Indian Standards, New Delhi.27-29.

BIS (1986). Methods of testing of small clear specimens of timber. Test code IS 1708 (Part 8):1996. Bureau of Indian Standards, New Delhi.35-37.

Gavanski, E., Kordi, B., Gregory, A. and Kopp, P.J. (2013). Wind loads on roof sheathing of houses. *J. Wind Engg. & Industrial Aerodynamics,* **114** : 106-121.

Kumbhar, V.M. (2011). Tourist expectation regarding agro-tourism. Empirical evidence from Ratnagiri and Sindhudurga District of Konkan. 82-91

Kunjalata, K., Das, N., Boruah, P.K. and Sarma, U. (2016). Development of a strain measurement system for the study of effect of relative humidity on wood. *Measurement,* **94** : 265-272.

Mazzanti, P. (2012). Drying shrinkage and mechanical properties of poplar wood across the grain. *J. Cultural Heritage,* 85–89.

Michael, H.R. (2016). The wood from the trees. The use of timber in construction. *Renewable & Sustainable Energy*, 333-369.

Negi, L.S. (1986). *Design of steel structures*. Mcgraw Hill Education Private Limited, New Delhi. 261-287.

Negi, L.S. (1986). *Design of steel structures*. Mcgraw Hill Education Private Limited, New Delhi.158.

Negi, L.S. (1986). Design of steel structures.Mcgraw Hill Education Private Limited, New Delhi. 201-204.

Niklewski, J., Fredriksson, M. and Isaksson, T. (2012). Moisture content prediction of rain-exposed wood. Test and evaluation of a simple numerical model for durability applications. *Building & Environment,* 126-136.

Ostman (1985). Wood tensile strength at temperature and moisture contents simulating fire condition. *Wood Sci. & Technol.,* **19** (2):103-116.

Rajput, S.S. and Shukla, N.K. (1996). Timber mechanics, strength, classification and grading timber. Indian Council of Forestry Research and Education.4-32.

Sailer, M. and Etten, B.V. (2004). Potential wood protection strategies using physiological requirements of wood degrading fungi, Netherlands, **49**(4):49-55.

Shah, V.L. and Karve, S.R. (2014). Illustrated Reinforced Concrete Design.Structures Fourth edition Publications Jal-Tarang, Pune.19-25.

Sparks, P.R., Schiff, S.D. and Reinhold, T.A. (1994). Wind damage to envelopes of houses and consequent insurance losses. *J. Wind Engg. & Industrial Aerodynamics*, **53**(1–2) : 145–155.

Taware, P. (2010). Agri-Tourism New Revenue Stream for Farmers through Rural-Urban Reunion.Financing Agriculture, Pune, 20-21.

Uematsu, Y. and Isyumov, N. (1999). Wind pressures acting on low rise buildings. *J. Wind Engg. & Industrial Aerodynamics,* 1–25.

WEBLIOGRAPHY

Kinoshita, S. (1990). Foundation for wooden house. *<https:/ / www.google.com/ patents/ US51036133>*