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Review Article

Creep Investigation Model for Timber: A Review

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ABSTRACT

Timber is a natural material from matured trees that can be used for structural applications. Material properties of timber such as light weight to strength ratio, good durability, good insulation against heat and sound impact makes it suitable for use as material for constructing roofing system, pedestrian or bicycle bridges and framing of other load-bearing structures, where strength is the major factor in its selection and usage. Unfortunately, time-dependent deformation affects the strength and stiffness of timber in service. The process of creep in timber, which is affected by variables such as temperature, moisture, species type, grain direction, loading influence, and timber's natural variability causes excessive deformations and even collapse of an entire construction. This paper reviews the work presented by various researchers on creep prediction/investigation models devised for timber. From the available literature reviewed, creep prediction models were developed for small timber species that are not widely used for construction/structural applications and do not undergo large moisture fluctuations, therefore mechano-sorptive creep effects are minimal. Looking at local content, there is need to develop mathematical models that would be used to predict/investigate long term creep for Nigerian grown timber species. There is no record of an existing unified or generalized creep prediction model that could be used for estimating long term creep of all timber species, because each of the mathematical models developed contain a great variety of constants that can only be determined by rigorous and large experimental sample tests.

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1. INTRODUCTION

Timber is a natural structural material from matured trees which serves various purposes in construction and furniture industry (Aguwa et al., 2015). It is one of the most frequently used building materials in both ancient and modern engineering constructions. Recently, the use of timber structures has increased in the construction industry due to attributed advantages such as environmentally friendly nature of timber, fully renewable potential and low handling costs (Hassani et al. 2014a). Moreover, the inherent material properties such as light weight to strength ratio, good durability, good insulation against heat and sound impact makes it widely used as a structural material for roofing system, pedestrian or bicycle bridges and framing of other load-bearing structures, where strength is the major factor in its selection and usage (Jimoh and Ibitolu 2018). Also, it has low modulus of elasticity compared to concrete and steel implying low stiffness capacity and consequent poor resistance to deflection in service (Shuaibu 2010). In Nigeria, timber is the most widely available natural resources, which when properly utilized; it will be of immense benefit to the country in terms of reduction in the cost of construction.

The hygroscopic character of wood basically affects all its related mechanical properties most importantly time-dependent deformation, leading to degradation of material stiffness and strength over the service life. The time-dependent behaviours of wood has been widely investigated, and the following measures of time-dependent response are commonly used in experimental investigation: creep, the increase of the deformation with time, under a sustained applied load; relaxation, the stress decay under constant deformation; stiffness variation in dynamic mechanical analysis (Ferry, 1980); and rate of loading (or straining) effects (Boyd and Jayne, 1982).

The process of creep in timber causes inadmissible deformations and even collapse of an entire construction. The purpose of this work is to review the status of devised rheological and mathematical models for creep investigation used in predicting the long-term creep behaviour of timber structures.

The aim of this work is to review all available literature with a view to the methodology and approach for the development of creep investigation models for timber through, critical examination of the concept of creep, exploration of developed models with their application and identifying possible research area gab. Research outcome will serve as a reference academic material and baseline survey to intending researchers of creep investigation for timber structures.

2. LITERATURE REVIEW

Accurate prediction of the long-term performance of timber elements is of crucial importance to structural engineers when designing timber structures as timber is particularly susceptible to large creep deformations when stressed for long periods of time. Creep effects in timber elements can be divided into two main categories, namely, viscoelastic creep and mechano-sorptive creep (Granello and Palermo, 2019). The viscoelastic creep component is defined as the deformation with time at constant stress and under constant environmental conditions, which is typical of indoor conditions. Under variable environmental conditions, additional mechano-sorptive creep and swelling/shrinkage behaviour occurs (O'Ceallaigh et al., 2018).

2.1. Viscoelastic Creep Behaviour of Timber

For many structural applications, the most important mechanical property of timber is its resistance to deflection, including both elastic and creep deflection. The contribution of creep deflection to the total deflection is generally much more significant in the case of timber structures to those made of steel or concrete (O'Ceallaigh et al., 2018). The creep behaviour of timber also more complex as it is a function not only of timber but also environmental conditions, which change the moisture content of the material. When stressed in a constant climate condition, a timber element undergoes an instantaneous elastic deflection followed by viscoelastic creep behaviour with time. Under this constant climate condition, the level of viscoelastic creep depends on the stress level, temperature, and moisture content of the timber.

Senft and Suddarth (1971) examined small specimens ($41.3 \times 50.8 \times 203.2$ mm^3) of Sitka spruce (*Picea sitchensis*) under compression load at stress levels of 10, 20, 40 and 60% of ultimate strength for load durations up to twenty days. The moisture content remained constant throughout to exclude the mechano-sorptive effect and focus solely on viscoelastic creep. They found that the viscoelastic creep behaviour increased with increasing stress levels and significantly. They also found that creep deformation can occur at stress levels as low as 10% of ultimate strength. It was also reported that, at higher stress levels (>55%), specimens are susceptible to creep rupture resulting in failure (Senft and Suddarth, 1971; Toratti, 1992). Similarly, an increase in temperature has been shown to result in higher viscoelastic creep deformations.

Davidson (1962) performed creep tests on three different species at a series of constant temperatures; it was shown that the rate of creep increased slightly with increasing temperature from 20 °C to 50 °C. Armstrong and Kingstone (1960), Armstrong and Christensen (1961) and Armstrong (1972) shows that the magnitude of viscoelastic creep depends on moisture content of the timber.

In a study by (Hering and Niemz, 2012), the viscoelastic behaviour of European beech timber elements subjected to four-point bending was investigated and the longitudinal creep compliance at three different moisture contents (8.14%, 15.48% and 23.2%) was examined. Each timber specimen was loaded to approximately 25% of the ultimate bending strength for a period of approximately 200 hours and the viscoelastic creep behaviour was found to increase linearly with increasing moisture content.

Another study designed to examined if the rate of creep eventually decreases towards a creep limit was performed (Hunt, 2004). Experimental creep tests on solid timber elements were carried out in a carefully controlled environment over a 13-week period. Creep functions were matched to these experimental test results and to creep test results by (Gressel, 1984) over a much longer period of time (8 years). The curves were extrapolated to estimate the viscoelastic creep after 50 years under sustained load. No evidence was found to suggest a viscoelastic creep limit exists in timber when stressed in a constant climate condition. This demonstrates the potential for timber elements to deform throughout their service life and demonstrates the importance of understanding its behaviour.

2.2. Mechano-soptive Creep Behaviour of Timber

Mechano-sorptive creep is found in several materials: Wood, paper, wool, synthetic fibres and concrete (Johan, 2004). Mechano-sorptive creep was independently reported in the literature for wool (Nordon, 1962) and in wood (Armstrong and Christensen, 1961; Armstrong and Kingstone, 1960). In the 1990s mechano-sorptive creep was also observed in some synthetic fibres, for example Kevlar, as reported in literature (Wang et al., 1993; Wang et al., 1992). A similar phenomenon is found in concrete (Mangal, 2019). The most important load cases in packages are compression and bending, and many of the experimental results reflect this. It is assumed that mechano-sorptive creep is a result of heterogeneous hygro-expansion producing a transient redistribution of stresses during moisture content changes, which in combination with non-linear stress dependence will lead to an acceleration of creep. Mechano-sorptive creep is then a natural consequence of the regular creep properties of wood and other fibres (Strömbro and Gudmundson, 2008).

Armstrong and Kingstone (1960), first reported observation of mechano-sorptive creep in wood. It had previously been observed that moisture content changes in wood increased the creep rate and the total creep. The authors were able to confirm these observations for small wooden beams. They studied creep in bending at three different moisture conditions: Never dried wood at constant moisture content; never dried wood allowed to dry and dried wood at constant moisture content. They found that creep of the specimens allowed to dry was at least twice that of specimens held at constant moisture content. This discovery resulted in a more extensive investigation (Armstrong and Christensen, 1961). In this investigation bending of wooden beams of different sizes was studied during moisture cycling between a completely dry state and a wet state. When the specimens were loaded in the dry state, awfully slow creep was observed after the initial, elastic deflection. During the first adsorption the deflection increased rapidly. The deflection increased further during the following desorption, and during subsequent moisture content cycles, the deflection of the specimens decreased during each adsorption and increased during desorption. The final result was a total deflection, which was several times larger than the initial deflection. According to the authors, the sorption rate did not affect the increase in deflection. Drying of never dried wood specimens confirmed the independence of sorption rate. If the range of the moisture content cycles was made smaller, the total deflection decreased, but the principal behaviour remained. If the deformed specimens were unloaded in the dry state, little recovery other than the initial deflection occurred. However, if the moisture content was changed to the wet state after the unloading, a large recovery occurred. With further moisture cycling after unloading, the recovery was slightly enhanced. Since the initial investigation, many experimental studies on mechano-sorptive creep in wood have been carried out and described previously (Hearmon and Paton, 1964; Grossman, 1971; Leicester, 1971b; Armstrong, 1972; Ranta-Manus, 1975; Hunt, 1986; Hunt and Shelton, 1987; Hunt, 1989; Martensson, 1992; Mårtensson and Svensson, 1997). Mechano-sorptive creep has also been found in wood based materials, like particle-board as reported by (Bryan and Schniewind, 1965) and in hardboard by (Armstrong, 1972).

2.3. Mathematical Models for Creep in Timber

Mohammed' et al. (2019), derived a simplified mathematical model of compression creep simulation for Terminalia ivorensis (Black Afara) timber. They reported that logarithmic expression devised best correlate the compression creep for Terminalia ivorensis with experimental values. Brokans and Ozola (2014) developed a mathematical model for the description of creep based on the concept of burger body. Their study proved that the mathematical model developed can be used for the prediction of long-term behaviour of timber beams in bending. They recommended further study to examine how creep behaviour is influenced by mechanical and physical properties of wood and its structure per se. Mahmoud (2010) developed a model to investigate the long-term flexural creep behaviour under sustained triangular loading of structural insulated timber panel (SIP) in which experimental creep for the panel recorded for about 9 months was extended theoretically using Burger model. The result obtained for the predicted deflection of the SIPs was in the order of 20 times the instantaneous deflection. He concluded that Burger model cannot be used as a representative for flexural creep of the basement walls under soil pressure. He recommended that the study should be extended by including other non-linear creep models that have decreasing creep rate over time and further studies should be conducted to develop creep constant equations that include the effects of temperature and relative humidity on the creep response. Francisco (2002) studied an overview of how other variables in addition to temperature affects the compression property of wood and experiments undertaken to obtain compression properties as a function of moisture, stress and temperature. He further described a creep (time-based) model for wood at high temperatures and the incorporation of the creep model into a structural model for walls and panels. In his conclusion, he identified the significant types of creep as creep due to the presence of moisture, heat, and stress. The model incorporated creep directly and can be used to predict ranges of variables, including load and wall height, for which creep can be a problem limited to applications in which the wood is subjected to temperatures, moistures and stresses similar to values that occurred in the experiments. Siedried et al. (1989) proposed a rational approach towards the identification of long-term behaviour of wooden structures base on the effects of constant and transient moisture and temperature condition and suggested the concept of polymer viscoelasticity to enhance predictive capabilities. König and Walleij (2000) developed two sub-models for the design of timber frame members in floor and wall assemblies exposed to ISO 834 standard fire exposure; charring model for the determination of residual cross section of the timber member and mechanical model designed to determine the strength and stiffness parameters (time-dependent) of the residual timber cross section using temperature, strength property of material and elastic modulus for tension and compression variables. The results from his developed models were used to reflect the performance of timber and discovered that the dependent parameters for gypsum plaster board lining failure time are temperature of mechanical degradation of the material and length of fasteners where charring occurs behind the lining. Leicester (1971a) presented a rheological model for approximation of creep based on mechano-sorptive phenomenon. The validity of the model was assessed by tests on small messmate Stringybark (*Eucalyptus obliqua*) beams under load in bending. Comparisons to experimental results showed that the developed model could explain about 85 % of the total deformation. The model was also validated in two other articles (Grossman, 1971; Leicester, 1971b), which showed that the model could be used to describe the behaviour of drying wood. Ranta-Manus (1975) developed a generalized viscoelastic model for wood that includes moisture changes. He expressed the creep strain arising from variations in moisture content in integral (hereditary) form based on hydro viscoelasticity theory. The model was applied to published experimental results. Bazant (1985) proposed a speculative model of the effects of variations in moisture content and temperature on creep based on thermodynamics of the process of diffusion of water in wood. The model reflects qualitatively some experimental results. Quantitative fitting of test data was not attempted. Mukudai and Yata (1986, 1987) proposed a model for viscoelastic behaviour of wood under moisture change. Good agreement was observed between the model responses and published experimental results. Schaffer (1972) introduced a model to explain the change of creep response with changing moisture content by considering the effect of diffusion of moisture within the loaded specimen. Schaffer (1982) developed a nonlinear (in stress) viscoelastic-plastic model based on thermodynamic constitutive theory (Schapery, 1966). The model was correlated with experimental creep data, and the author concluded that the resultant qualitative model sufficiently characterizes the viscoelastic-plastic response of dry wood parallel to the grain. Oudjehane et al. (1998) developed a model to predict the consolidation of wood mats during part of the hot-pressing cycle. The model was extended to different formed mat structures using random and oriented layout of flakes, and despite slightly higher values were obtained with the model due to the viscoelastic behaviour of the loose mat, the creep model showed an incredibly good agreement with the experimental data. William et al. (2000) developed a viscoelastic constitutive model for wood that accounts for experimentally observed mechano-sorptive creep effects and is implemented within the framework of the proposed numerical scheme. The model parameters are fitted to the unreinforced specimen test results, and the model is then shown to accurately predict the observed relative creep displacements of the reinforced specimens. Parametric studies are conducted that clearly demonstrate the effectiveness of Fibre-reinforced polymers (FRP) tensile reinforcing in reducing creep deformations in glulam beams. Moutee et al. (2010), developed a model to predict creep behaviour of timber element loaded at free end based on the principle of equilibrium equations of cantilever beam theory. The analysis although can be extended to any type of rheological model but is restrained to a modified Burger model. In their conclusion, they pointed out that his approach can be used to stimulate experimental creep bending test in the presence of moisture content gradient. They further recommended the appropriation of bending tests to identify both viscoelastic and mechano-sorptive creep parameters. Hassani et al. (2014b), developed a 3D orthotropic elastio-plastic, visco-elastic, mechano-constitutive model for wood based on finite element analysis. They described the universality and flexibility of their model in predicting of mechanical behaviour of different species by demonstrated analysis of a hybrid wood element. The proposed model was validated by comparisons model stimulation with experimental test results. Urbanik (1995) suggested a model to describe deformation of corrugated board subjected to a constant compression load during humidity cycling. In this model the total deformation is the sum of the hygro-expansion and the mechano-sorptive creep. The mechano-sorptive creep function was derived from the assumptions that the mechano-sorptive creep rate is proportional to the magnitude of the rate of change in moisture content and that the moisture content is proportional to the hygro-expansion. The model was found to fit experimental data well.

3. RESULTS OF CRITICAL REVIEW

Table 1 provides critical review summary for this study. Models were dominantly devised for foreign grown timber species and other timbers that are not widely used for construction/structural applications engineering. While others were constraint to predict a particular type of creep behaviours in timber that do not occur in true state or while in use. Moreover, Creep prediction models were developed for small timber species do not undergo large moisture fluctuations; therefore, mechano-sorptive creep effects are minimal.

Table 1: Critical review summary

Author	Research done	Outcome	Critics
Senft and Suddarth (1971)	Examined small specimens of sitka spruce (*Picea sitchensis*) under compression load at constant moisture content	Reported that viscoelastic creep behaviour increases with increase in stress levels and at higher stress levels (>55%)	Failed to develop any model for investigating creep

Author	Research done	Outcome	Critics
Davidson (1962)	Performed creep test on three different species at series of constant temperature	His research shows that the rate of creep increased slightly with increasing temperature from 20 to 50 ^{o}C	Conducted separate experiments for each specie. No model was developed.
Armstrong and Kingstone (1960)	Studied mechano-Sorptive creep in wood	Observed that moisture content in wood increases the creep rate at the total creep	Failed to developed model
Armstrong and Christensen (1961)	Investigated bending of wooden beams of different sizes during moisture cycling between complete dry state and a wet state.	Found that creep of the specimens used when allowed to dry was at least twice that of specimens held at constant moisture content.	Failed to develop model
Hering et al. (2012)	Investigated the viscoelastic behaviour of European beech timber elements subjected to four-points bending.	Viscoelastic creep behaviour was found to increase linearly with increasing moisture content.	Studied creep for a foreign timber specie. No model was developed
Hunt (2004)	Examine the rate at which creep eventually decrease towards creep limit in timber.	Found no evidence to suggest a viscoelastic creep limit exists in timber when stressed in a variable climate condition.	Studies should have suggested mechano-sorptive creep since variable climate condition is adopted for this study. Model was devised according to creep functions presumed.
Wang et al. (1992)	Investigated creep in synthetic fibres.	Observed mechano-sorptive creep in some synthetic fibres.	Specimen studied not widely used for structural/construction purpose. No model was developed.
Hohmoyer et al. (1989)	Investigated the mechano-sorptive creep mechanism of wood in compression and bending.	Reported that slip plane formation is dependent on the breaking of hydrogen bonds and the change in micro fibril orientation in slip plane zones cause an increase of longitudinal shrinkage/swelling and decrease of the modules of elasticity.	Introduced a model which links the mechano-sorptive behavior of wood subjected to moderate and high compression or bending parallel to grain to the formation of slip planes in the cell wall.
Hunt, (1989)	Conducted a study on the linearity and non-linearity in mechano-sorptive creep of soft wood in compression and bending	Experimental results in bending tension and compression showed that the compression test process departed from linearity at total stream around 0.14% to 0.15%, and bending test showed a slight evidence of non-linearity at about the same strain, whilst the tensile pieces were approximately linear up to 0.18% strain.	No model was developed.
Hunt et al. (1988)	Described an adapter for the compression of a higher accuracy tensile creep machine to compression loading.	Found that mechano-sorptive creep limit could be obtained by a suitable load reduction after moisture cycling.	No model was developed.

Author	Research done	Outcome	Critics
Hunt (1986)	Described new design of bending creep machine for accurate measurements of mecheno-sorptive creep.	Found that the mechano-sorptive creep susceptibility correlates with the mean microfibrillar angle of the S2 layer in a continuous relation that includes two pure species.	Two separate foreign species (S2) were investigated, and no model was developed.
Torrati (1992)	Modelling creep of timber beams	Resulted in developing model that is used to model 10years and 50years creep behaviour of timber and natural outdoor humidity conditions.	Developed a model for predicting behaviour of foreign timber specie.
Martensson and Svensson (1997)	Studied mechanical behaviour of wood exposed to humidity variations	Their analysis showed that the mechano-sorptive effect in the tested materials (slot pines) is larger if restraint is imposed on the wood than if the load is constant.	Developed a model that can be used in timber creep simulations in practical drying situations of slot pines (foreign specie).
Fridley et al. (1992)	Further Investigation on the creep behaviour model for structural lumber	Modified an existing 4-elements viscoelastic model to stimulate creep response of lumber as function of load to account for thermal and moisture effect including mechano-sorptive effects.	Developed a model from available creep data from a large population of Douglas (foreign specie) for nominal 2-inch by 4 inch lumber.
Dinwoodie (1990)	Conducted comparative study on the use of 4 and 5 parameter rheological models to predict creep in chip board at 7 to 10 years with actual deflection	Comparison with actual deflection confirmed the unsuitability of the 4-parameter model as a prediction tool, while the range in prediction errors over 20 specimens for the 5-parameters model was +23% to 26%. Thus 95% confidence limits in predicting deflections at 2555 days from 39 weeks data was +13% to 20% for all data.	Specie investigated not widely used in construction. Also compared in his studies the efficiency of two separate existing models.
Chassagne et al. (2006)	Studied creep phenomenon based on the physical and chemical mechanisms that occur at micro and ultra-structural levels of wood during moisture diffusion.	He was able to describe creep and recovery phenomena under variable humidity conditions	Formulation a 3-dimensional nonlinear hydro-visco-elastic model, combined with hydro-expansion effects in foreign specie.
Dubois et al. (2005)	Presented a numerical modelling of creep in wood under variable climate conditions.	With his formulated model, succeeded in stimulating the viscoelastic behaviour and accelerated creep during moisture content changes in timber.	Developed a model using a generalized Kelvin-voigt model for foreign specie.
Pierce et al. (1985)	Investigated creep in chip board.	Put forward a 5-parameter model superior to the 4-parameter model reported in earlier papers for the long-term predictions of creep deflections particularly at the lower stress level.	Developed model for chip board.
Leicester (1971)	Presented a rheological model for approximation of creep based on mechano-sorptive phenomenon.	Result shows that the developed model could explain about 85% of the total deformation and can best be used to describe the behaviour of dry wood.	Developed a model for small messmate specimen.

Author	Research done	Outcome	Critics
Schaffer (1972)	Studied a change of creep response with changing moisture content by considering the effects of diffusion of moisture within the loaded specimen.	Presented model that describe creep responses in changing moisture content.	Developed model
Ratha – Manus (1975)	Developed a generalized viscoelastic model for wood that include moisture changes on basis of viscoelasticity theory.	Model produced good agreement to published experimental results.	Developed model.
Schaffer (1982)	Uses thermodynamics constitutive theory to develop nonlinear viscoelastic – plastic creep model.	The qualitative model sufficiently characterized the viscoelastic –plastic response of dry wood parallel to the grain.	Developed model.
Banzant (1985)	Proposed a speculative model of the effects of variations in moisture content and temperature on creep based on thermodynamic theory.	Model reflects qualitatively some experimental results.	Developed model.
Makudai et al., (1986 and 1987)	Proposed a model for viscoelastic behaviour of wood under moisture change.	Good agreement was observed between the model responses and published experimental results.	Developed model.
Urbanik (1995)	Devised hygro expansion-creep model for corrugated fiber board.	His model describes deformation of corrugated board subjected to a constant compression load during humidity cycling.	Developed model
Oudjehane et al. (1998)	Developed a model to predict the consolidation of wood mats during part of the hot-pressing cycle.	Creep model showed an incredibly good agreement with experimental data.	Developed a model that is validated with experienced data instead of experimental data.
William et al. (2000)	Described a viscoelastic constitutive model for wood that accounts for experimental observed mechano-sorptive creep effects.	Developed model accurately predicts the observed relative creep displacements of the reinforced specimen.	Developed model that simulate mechano-sorptive behaviour under cyclic moisture conditions.
König et al. (2000)	Developed two sub-models for the design of timber frame members in floor and wall assembles exposed to fine.	Results from their models were used to reflect the performance of timber and discovered that temperature of material and length of fasteners are dependent parameters for failure.	Developed model
Moutee et al. (2010)	Presented creep prediction model for timber element loaded at free end.	Their approach as reported can be used to stimulate experimental creep bending test in the presence of moisture content gradient.	Developed creep prediction model but restrained to a modified burger model.
Mahmoud (2010)	Developed model to investigate the long-term flexural creep behaviour of (SIP) structural insulated timber panel.	The predicted deflection of the SIPs was in order of 20 times the instantaneous deflections.	Developed a model

Author	Research done	Outcome	Critics
Mohammad et al. (2014)	Presented a 3D orthotropic elasto-plastic, viscoelastic, mechano constitutions model for wood based finite element analysis	Reported the universally and flexibility of his model in predicting the mechanical behaviour of different species by demonstrated analysis of a hybrid wood element.	Model is validated by comparison model stimulation.
Brokans and Ozola (2014)	Presented a mathematical model for the description of creep based on burger body concept.	His devised model is validated by experimental data and proved worthy for the prediction of long term behaviour of timber beams in bending.	Developed a model
Mohammed et al. (2019)	Presents creep investigation model for Terminalea ivorensis (Black Afara) timber.	Reported that logarithmic expression devised best correlated the compression creep for the studied material.	Developed compression creep model for a Nigerian grown timber. There are several other Nigerian timbers that need to be investigated /studied.

4. CONCLUSION

The status of modelling long-term creep in timber structures is reviewed. Creep in timber is an extremely complex phenomenon and is affected by many variables including temperature, moisture, specie, grain direction, loading conditions, and timber's natural variability. Extensive creep prediction/stimulation models have been developed by researchers for numerous timber species. However, because of conflicting experimental objectives, not all of these are directly applicable to modelling the long-term behaviour of all wood structures. Data have been collected for species that are not widely used for structural applications, while other species, belonging to the family of Nigerian grown timber, have not been adequately characterized and investigated; in addition, mathematical models derived contain a great variety of constants to be determined by large and rigorous experimental sample tests. There is possible research gap that can be studied by identifying other species of Nigerian grown timber family and carryout investigation on creep prediction models, because most of the previous studies have devoted considerable effort to studying foreign grown species and mechano-sorptive creep behaviour in smaller specimens. However experimental evidence suggests that large wood members used for interior applications do not undergo large moisture fluctuations and therefore mechano-sorptive creep effects are minimal. Moreover, for members exposed to large cyclic moisture conditions, such as exterior exposure, mechano-sorptive creep effects should be considered.

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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