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Formulation of Mathematical Model of Lap Joints of Strips of Different Types of Bamboo with Proper Adhesives Subjected To Tensile, Compressive and Shear Load

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Abstract: *This paper presents design of experimentation for formulation of mathematical model of lap joints of strips of different types of bamboo with proper adhesives subjected to tensile, compressive and shear load. With the help of dimensional analysis the experimental work is carried out significantly. In this paper, the various steps of design of experimentation like dimensional analysis, identification of variables in mechanical properties of bamboo, reduction of variables and the formation of mathematical models' equations are presented in detail. There are many factors which affects the mechanical properties of the*
bamboo. In this paper the work is made to present the design of experimentation in detail and to generate design data in the form of experimental data based on models for various Dependent/ Independent variables of bamboo types and different adhesives by carrying out experimentation.

Keywords: *Dimensional Analysis Mathematical model, tensile load, Compressive load, Shear load, Experimentation, Dependent Variable, Independent Variable, Buckingham's pi theorem, Adhesives*

I. Introduction

Dimensional analysis is a method for reducing the number of variables which describe a given physical phenomenon, by applying a compacting technique to form a complete set of independent nondimensional variables. Dimensional analysis can lead to a huge reduction in the size of the test matrix necessary to fully resolve the behavior of a system, thus greatly reducing the associated costs and time. It significantly reduces the complexity of test results by causing data to collapse onto a few curves from which empirical relationships can be derived The evaluation of the mechanical properties of different bamboo species by using existing adhesive which is already available in market. The properties such as tensile strength, compressive strength and shear strength were tested on specimens of bamboo species with different adhesives. Specimens were prepared with the lap joint and test was carried out on universal testing machine. Consider the reading for the independent and dependent variables. The formulation of quantitative analysis is not possible in the case of complex parameter. There is no possibility of formulation of theoretical model i.e. logical based model, only alternative is left to formulate experimental mathematical data based model. This reasons cause to use an experimental approach to establish the experimental mathematical data based model. Hence this investigation formulate such model

II. Materials and methods:

2.1 Material

The properties such as tensile strength, compressive strength and shear strength were tested on 50 specimens of bamboo species with different adhesives for each test. The test was carried out on universal testing machine machine. Ten specimens were prepared with the lap joint for each adhesive for testing. The different adhesives are reinforcing with the bamboo species for seven days. Mechanical Properties of the Bamboo species with different adhesives determine using length 25 cm and width 10cm

2.2 Different types of adhesives were used for making lap joint.

The details of different adhesives are used for the preparation of the samples. These adhesives are already exist in the market

1) Fevicol SR998
2) Dendrite Supreme
3) Fevicol Heat X (Heat Proof)
4) Araldite
5) Asian Paints (Loctite touch)

Fig 1. Sampling

	Fevicol SR 998	**Dendrite Supreme**	**Fevicol Heat X**	**Araldite**	**Asian Paints**
Usage	For laminate to wood and Plywood	For fixing of laminates of wood ,boards etc	Best for inside laminates of Shutters	It is Suitable for variety of metals, ceramics, glasses etc	Transparent on appearance to make usable in visible application
Key Features	More resistance to heat and Sunlight	Highly Inflammable	High heat resistance capacity up to 170 0C	Lower Shrinkage ,Good resistance to dynamic loading	High strength lower water adsorption
Draying Time	3-5 minutes	8-10 minutes	10-15 minutes	100-150 minutes	5 hours
Viscosity	---	2200+_ 100CPS	---	30-45 pas	---
Temp	---	30 to 50 0C	---	---	---
Benzene Contain	Benzene Free	---	Benzene Free	---	Epoxy adhesive

III. Design of Experimentation:

A number of experiments were conducted to study the effects of various mechanical properties. These studies have been undertaken to investigate the effects of various load on the bamboo species for tensile, compressive and shear Strength. During experimentation specimens with lap joints were tested on universal testing machine. The output is measured and stored in personal computer for further analysis.

Based on the qualitative physical characteristics, identify the dependent and independent variables. The experimentation becomes time consuming, tedious if system involved large number of independent variables. With the help of dimensional analysis one can reduce the number of variables. These reduce the dimensional equations and form a mathematical model.

Test planning consists of test on universal testing machine. Lap joint are tested for tensile, compressive and shear load. Test sequence and plan of experimentation set to reduce the dimensional equations

It is necessary to evolve the physical design of experimental set up in setting up the test points, adjusting the test sequence, execution of proposed experimental plan, noting down the responses and provision for necessary instrumentation for deducing the relation of dependent pi terms of the dimensional equation in terms of independent pi terms. Experimental set up is designed in such a way that it can accommodate the ranges of independent and Dependent variables within the proposed test envelope of experimental plan. After noting down the responses and obtained dimensional relations of Dependent pi terms of dimensional equations, the exact mathematical model can be formed within the specified test. [1]

IV. Dimensional analysis

Dimensional analysis is an extremely useful mathematical technique used in reduction of variables by forming non-dimensional groups of the variables which are called as pi (π) terms. Deducing the dimensional equation for a phenomenon reduces number of independent variables pi terms in the experiment. The exact mathematical form of this dimensional equation is the targeted model. Thus this method of dimensional analysis provides a systematic experimental planning and permits the presentation of results in more useful and concise format. [1]

4.1 Identification of Variables

Depending upon the lap joint specimen of the bamboo tested for tensile, compressive and shear load. The various dependent or response variables, independent variables and extraneous variables affecting the phenomenon. Table 1 shows various dependent and independent variables involved in the phenomenon with their symbols, units, dimensions, nomenclature and nature.

Table -1: Various Dependent and independent variables with symbols, units, dimensions, nomenclature and nature

Sr.No.	Variables	Unit	Nature (Dependent/ Independent)
1	σt=tensile strength of lap joint of bamboo specimen	kgf/cm2	Dependent
2	A=Tensile strength of Bamboo	Kgf/cm2	Independent
3	B=Adhesive Drying Time	Seconds	Independent
4	C=Area of adhesive	cm2	Independent
5	D=Thickness of adhesive	cm	Independent
6	E=Pressure Applied	Kgf/cm2	Independent
7	θ=Temperature under which pressure applied	^{0}C	Independent
8	G=Time of clamping	Seconds	Independent
9	g=Acceleration due to gravity	cm/seconds^2	Independent
10	θ_B=Boiling point of water	^{0}C	Independent

It is seen from table 1 that there are total ten variables which affect the phenomenon of bamboo lap joint for tensile, compressive and shear load. The fundamental physical dimensions to express all these ten variables are only three i.e. Mass (M), Length (L) and Time (T), Temperature (^{0}C). Out of these total ten variables the first variables are the Dependent/ response variables and the later nine variables are independent variables.[2]

4.2 Formation of Pi (□) Terms

The Buckingham's Π- Theorem method is used to form the pi (π) terms for all Dependent and independent variables affecting the phenomenon of lap joint of bamboo.

4.2.1 Formation of pi (□) terms for independent variables:

The process of dimensional analysis is followed step by step as explained below: Consider the 50 reading for the independent and dependent variables .Tensile strength, compressive strength and shear strength value are taken for the depended variable. The independent variables are tensile strength of bamboo(A),drying time of different adhesives(B),Area of adhesive with length and breadth(C), thickness of adhesive(D),Pressure applied on the adhesives (E),temperature under which the pressure is applied(θ),time of clamping for seven days(G), acceleration due to gravity(g) and boiling point of water(θ_B).

In the similar way the all remaining pi (π) terms for independent variables are calculated by dimensional analysis and are listed in the following table 2. The table 2 shows total eleven pi terms for independent variables:

Table -2: Pi terms for independent variables

pi terms	pi terms equations
∏1	A/E
∏2	B/G
∏3	C/D^2
∏4	θ/θ_B
∏5	D/G^2g

In the similar way the all remaining pi (π) terms for dependent variables are calculated by dimensional analysis and are listed in the following table 3. The table 3 shows total three pi terms for dependent variables:

Table -3: Pi terms for dependent variables

pi terms	pi terms equations	Parameters
∏D1	**□ t/E**	Tensile strength
∏D1	**□ t/E**	Compressive strength
∏D1	**St/E**	Shear strength

4.3 Reduction of Variables

To reduce the complexity and to obtain the simplicity in the behavior of the phenomenon, the pi terms of independent variables are reduced by reduction of variables method as suggested by Schenk Jr. The pi terms related to the independent variables like tensile strength of bamboo to pressure applied on the adhesives (A/E), drying time of different adhesive to time of clamping for seven days (B/G), area of adhesive with length and breadth to thickness of adhesive sq., temperature under which the pressure is applied to boiling point of water and thickness of adhesive to time of clamping for seven days sq. into acceleration due to gravity.

4.4 Dimensional Equation

First approach to solve with the Exponential type of model

$(\frac{\sigma t}{E})= K[(\frac{A}{E})a(\frac{B}{G})b(\frac{C}{D2})c(\frac{\theta}{\theta B})d(\frac{D}{G2g})e]$

Next step term is to find out the log terms of each independent variable

$\log (\frac{\sigma t}{E}) =\log K+a \log(\frac{A}{E})+b \log(\frac{B}{G})+c \log(\frac{C}{D2})+d \log (\frac{\theta}{\theta B}) +e \log (\frac{D}{G2g})$

$(\frac{A}{E})= \prod 1 , (\frac{B}{G})= \prod 2, (\frac{C}{D2})=\prod 3, (\frac{\theta}{\theta B})=\prod 4 , (\frac{D}{G2g})=\prod 5$

$Z=K[(\prod 1)a (\prod 2)b(\prod 3)c(\prod 4)d(\prod 5)e$

Solve the model with multiple regressions Analysis

$\log Z=\log K+ a \log\prod 1+b \log\prod 2+c \log\prod 3+d \log \prod 4+e \log \prod 5$

With the help of regression analysis once calculated the valves of log K, a, b, c, d and e with forming the 6x6 matrix and solve it with software. Calculated valve of indexes are infinite. Therefore approaches the second alternative.

In the second alternative calculation is carried out for the

Values of Z terms

$Z1=f1 (\prod 1x\prod 2x\prod 3x\prod 4x\prod 5)$

$Z2=f2 (\frac{\prod 1x\prod 2x\prod 3x\prod 4}{\prod 5})$

$Z3= f3 (\frac{\prod 1x\prod 2x\prod 3}{\prod 4 x\prod 5})$

$Z4=f4 (\frac{\prod 1x\prod 2}{\prod 3x\prod 4x\prod 5})$

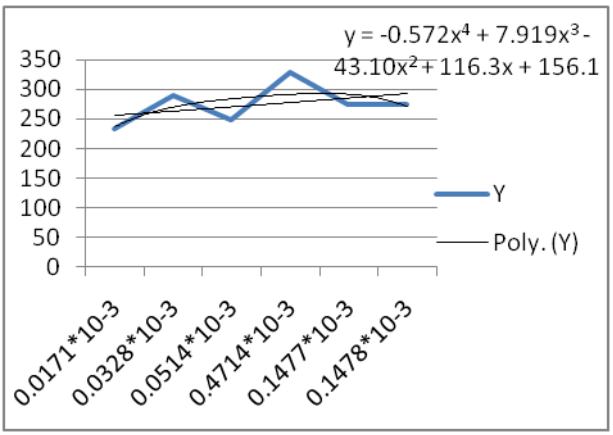
$Z5=f5 (\frac{\prod 1}{\prod 2x\prod 3x\prod 4x\prod 5})$

The values are calculated in the form of X. For plotting the graph calculated valve X on x axis and universal testing machine tensile strength observation on y axis. With same processes plot the graph for compressive strength and shear strength.

V. Test methods and graphs

With the calculated valve of X and Y is taking tensile strength, compressive strength and shear strength.

Sr.No	X	Y
1	$0.0171*10^{-3}$	233
2	$0.0328*10^{-3}$	288
3	$0.0514*10^{-3}$	249
4	$0.4714*10^{-3}$	328
5	$0.1477*10^{-3}$	275
6	$0.1478*10^{-3}$	275



VI. Conclusions

Out of these graphs select the graph having minimum peak In tensile strength select graph with Z4, compressive strength graph Z1 and for shear strength graph Z4 Though the lap joint of bamboo is complex phenomenon due to effect of various independent parameters over dependent parameters, due to the method of experimentation adopted in this work it made possible to achieve generalized quantitative relationship between the variables affecting the phenomenon.

References

[1]. Hilbert Schenck Junior, Theory of Engineering Experimentation, McGraw Hill, New York.
[2]. S. K. Undirwade, Dr. M.P. Singh, Dr. C.N. Sakhale,''Design of Experimentation for Formulation of Experimental Data Based Model for Bamboo Sliver Cutting Operation Using HPFM'' International Research Journal of Engineering and Technology (IRJET), Volume: 02 Issue: 03 | June-2015
[3]. S. D. Moghe& J. P. Modak, "Design and development of Human Powered Machine for Manufacture of Lime-fly-ash-sand-bricks", Human Power, Technical Journal of the IHPVA Spring 1998, Vol. 13, No. 2, pp 3-7.
[4]. Sohoni V. V. et al., "Manually Powered Manufacture of Keyed Bricks", Building Research and Information, Vol.25, No. 6, UK 1997, pp 354-364.
[5]. Gopala Krishna, Alluru Mallikarjuna Rao, K. Optimization of machining parameters for milling Operations using a scatter search approach International Journal of Advanced Manufacturing Technology, 3-4, 219-224(6)
[6]. Hinduja S, Petty D J, Tester M, Barrow G, Calculation of optimum cutting conditions for turning operations. Proc. Inst. Mech. Eng. 199(B2): 81–92, (1985).
[7]. Jeong-Du Kim, Dong Sik Kim, Theoretical analysis of micro-cutting characteristics in ultra-precision machining, Journal of Materials Processing Technology 49 (1995) 387-398
[8]. H.Sehenck Jr, "Test Sequence And Experimental Plans" Theories of Engineering Experimentation, Mc Graw Hill Book Co, New York, P.P. 6.