Laboratory Testing Methodology for Panel Products against Termite Resistance

ABSTRACT

A host of new eco-friendly preservatives and treatments for protection of panel products are being developed. Engineered wood products require extra caution while testing with termites, due to high moisture conditions during field tests, a composite panel may subject to delamination making it difficult for a proper rating and determination of damage due to termite activity. This work focuses on development of a laboratory testing method for plywood and block board resistance against termite species *Heterotermes indicola* and *Coptotermes heimi*. The termite species preferability test was done in order to find out the most palletable wood species. Determination of maximum vigorous activity of both the termite species were done by monitoring wood consumption and survival. Sample size and time period of the tests were optimized. A non-destructive and quantitative approach of X-Ray analysis was adopted for result evaluation giving more reliable result. All important factors such as control wood sample most suitable for termite species, determination of maximum vigorous activity of termites, time period for exposure of wood samples, that are required for development of a viable testing system was checked in order to provide a reliable testing system. A viable and efficient system required by *H. indicola* and *C. heimi* for plywood and blockboard testing was developed.

Keywords: Termite, X-Ray analysis, Panel Products, economic loss

1. INTRODUCTION

Termites are distributed throughout the tropical and subtropical regions of the world, with the highest species diversity being found in tropical forests (Eggleton, 2000). For the Afrotropics, approximately 660 species belonging to about 170 genera are currently described. (Uys, 2002) Termites consists of more than 2600 described species from seven families (Abe et.al., 2000). In India, total of 337 species of termites are known and about 92 species are wood destroying

termites. 58 species of termites as important wood destroyers were reported by (Roonwal and Chhotani, 1967). Sen Sharma et. al., (1975) in surveying all of India collected 64 species of wood destroying termites, 11 of those being major wood destroying termites. Roonwal (1979) listed 72 species of wood destroying termites from South East Asia. As cellulose, present in wood and wood products, is the principal food of termites, they avidly consume and destroy materials such as paper, fabrics and wooden structures and therefore constant effort is directed towards their control. Globally, termites are a huge problem in both agricultural and urban areas as they cause significant damage to crops, plants, buildings and woodwork and account for considerable economic loss [26,27]. To make cellulose digestible and ready for assimilation, termites live in a strong mutualistic relationship with a variety of hindgut – inhabiting endomicrobes (flagellates, bacteria and archea). These endomicrobes, mainly flagellates, produce the enzyme cellulose, which makes the plant celluloses suitable for assimilation. (Breznak, 2000)

The IPIRTI, Field Station Kolkata is a testing and study site. The location stands at above mean sea level being 9 metres. The climate is tropical wet and dry. The mean maximum daily temperature during the hot weather (Mar-Oct) ranges from 35^{o}C to 39^{o}C and the mean minimum temperature from 29^{o}C to 31^{o}C. June to September are the rainy months which is about 500 mm of rainfall. The mean maximum temperature during winter (Nov. – Feb.) ranges from 22^{o}C to 25^{o}C and the mean minimum temperature from 13^{o}C to 20^{o}C. During winter, a small amount of rainfall is received. Cyclones from Bay of Bengal are also very frequent in this region.

New testing methods are being developed all around the world and existing testing methods are being modified with the upgradation of technology, for better assessment of the quality of newly developed preservative treatment for engineered wood products

Panel products are engineered, hence a study is required to find out how the termites infest on these products. Some products are not meant to be utilized for outdoor use, therefore they are customized and manufactured as per general standards. Exposing such products for field testing in field conditions (rainfall, high humidity) for substantially long time doesn't yield to be conclusive due to delamination in such conditions, it is difficult to give a proper rating. To combat this drawback, the lab testing method will be very useful to get a proper determination of termite damage of those products that are prone to delamination under field conditions. Therefore different methodologies are required to be developed for different kind of panel due to

its variation and orientation of components. This project will attempt to develop testing methodologies for plywood and blockboard. A lot of field testing data of many wood species are available over the last century. For inground performance test standard such as Anon. (2014), Anon. (2010) and Anon. (2014) are available. Anon (1993) – Methods for field testing of preservatives in wood. For above ground testing many different methods are reported (Meyer et.al. 2014) but only a few methods are harmonised and applied by several research groups. A series of statistical methods and graphical interpretations are done to address the variability of the field test results of Teak, Makha, Radiata Pine. (Bongers et.al, 2016)

Laboratory testing methods are done to check whether a potential preservative is capable of resisting termite attack or not. There are many International Standard formulated by different countries for accelerated Laboratory evaluation for termite resistance such as British Standard – Anon. (2012) titled Wood Preservatives. Determination of toxic values against *Reticulitermes* species (European Termites) (Laboratory Method), Anon. (2018) – Wood Preservatives. Determination of preventive action against *Reticulitermes* species (European Termites) (Laboratory Method) American Standard – Anon. (2008)- Standard Test Method for Laboratory Evaluation of Wood and other Cellulosic Materials for resistance to Termites, Anon.(2007) - Standard Method for Laboratory Evaluation to determine resistance to Subterranean Termites, Japanese Standard – Anon. (2004) – Wood Preservatives – Performance requirements and their test methods for determining effectiveness. Indonesian Standard Anon. (2006) Test of resistance wood and wood products against wood destroying organisms.

The termite species selected for study at IPIRTI, Field Station, Kolkata is *Heterotermes indicola* and *Coptotermes heimi.* In India, *Heterotermes indicola* has been reported earlier in Delhi (Mahapatro 2013) and Jammu & Kashmir, Maharashtra, Uttar Pradesh (Shanbhag, 2013) *Coptotermes heimi* has been reported from Andhra Pradesh, Karnataka, Kerela (Shanbhag 2013).

One very notable factor of data collection is the ratings given by visual evaluation of the samples for collecting data. It is a qualitative form of evaluation that needs upgradation. (La Fage, 1986) However skilled or trained person may be utilized in data evaluation, drawback of visual method will always exist. These drawbacks of qualitative evaluation were addressed by some authors (La Fage, 1986). The objective of this study was to develop a laboratory test method for testing of

plywood and blockboard with the termite species viz. *Coptotermes heimi* and *Heterotermes indicola* available at the climatic conditions of Kolkata.

2. MATERIALS AND METHOD

The wood species as given in Table 1 studied was obtained from M/s. Chopada and identified in inhouse testing facility available at IPIRTI, Field Station, Kolkata.

The termite species viz. *Coptotermes heimi* and *Heterotermes indicola* studied was identified by the Isoptera Division, Zoological Survey of India, Head Quarter, Kolkata.

Termite Collection Method:- The termite collection was done as per La Fage et.al. (1983). The experimental groups were established on the same day of the collection. Single backed corrugated fibreboard strips are cut from large rolls. The rolls were made of diameter 10 cm. The length of the unit was 15 cm. These units were sprayed with little amount of water and placed at the termite sites for 5 days. Substantial amount of termites were collected per trap ranging from 5gms to 10gms.

In order to select the control samples, it is very important to test the most preferable wood species by *C. heimi* and *H. indicola*. Though feeding preferences of *C. heimi* has been reported (Ashraf and Rasib, 2014). It is important to test the species that are used for plywood manufacture under the climatic and field conditions of Kolkata. Therefore termite wood prefer ability test was done – For each wood species taken, 20 stakes with dimensions 2 cm x 2 cm x 6 cm (equivalent to sample size of X-Ray analysis) were installed at the test field of IPIRTI, Field Station, Kolkata. Every six months the samples were visually evaluated with respect to termite attack according to IS 4833 - 1993. 21 species were studied with respect to timber species used in India for plywood, Blockboard manufacture. 6 species of plywood of UF and PF resin were studied viz. *Populus sp. Mangifera sp. Dipterocarpus sp. Betula sp. Eucalyptus sp. Shorea assamica*. The list of timber species studied are provided in table 1. This method was replicated for three times.

In order to develop a good testing environment, it is necessary to determine that the termites are healthy and vigorous. Therefore, determination and standardization of maximum vigorous activity of the two termite species – *Coptotermes heimi* and *Heterotermes indicola* was done

according to Lenz. Wood consumption and survival are the most commonly used indicators for termite vigour in laboratory (Lenz et.al., 1984). Three sets of experiments were set up simultaneously with *Mangifera sp.* plywood of UF and PF resin and *Pinus sp* blockboard. 3 different container volumes were taken for group size of 2gms of termites. The density of the termite groups were 0.020g/ml, 0.004g/ml, 0.003g/ml for *H. indicola* and 0.0013 g/ml, 0.0010 g/ml, 0.0008 g/ml for *C.heimi*. Each set of experiment were set with 3 replicates. The result has been provided in table no. 2.

For determination of the size of sample, trials were taken with reference of JIS (K), AWPA, ASTM standard sample size. Different sample size were tried and 2 cm x 6 cm x 1.2 cm for plywood and 2 cm x 2 cm x 6 cm for blockboard was seen satisfactory.

Experimental assembly was made with plastic container of different volume. The matrix was made up from different amount garden soil. Before laying the matrix 1 layer of wet corrugated cardboard was used at the bottom of the container. The containers were placed at 30^{o}C at BoD incubator with frequent moistening every 7-9 days and time period was monitored till 30 days (Refer Fig. 1)

Effort has been made for quantification of the test results. In order to detect and report the termite damage, a quantitative approach was taken for determination of termite damage. X-Ray analysis of the samples were done from M/s. Scanex X-Ray and Ultrasonography, Kolkata – 61 with Fuji Digital X-Ray Machine.X Ray detection of termites were used by (Peng Lee, 2005). Some work on X Ray tomographic analysis of termite detection was done by (Himmi, 2014).

The method of calculation of termite attack by X-Ray imaging is as follows:

1. The dimension of the sample in length and breadth were recorded with vernier calliper in order to be incorporated for actual known sample scale in the image analysis software.
2. The X Ray plate was clipped to the LED X-Ray View box.
3. The image of X-Ray plate was taken with Olympus digital SLR camera E-410.
4. The image was imported in image analysis software - Olympus CellSens Dimension.

5. The area and percentage of attack was analyzed and calculated using the tools available in the image analysis software.

Example of Image analysis with area and percentage measurements in software and data sheet is given in image 4.

3. RESULT AND DISCUSSION

The termite species that were collected from different field testing site and was identified to be *Coptotermes heimi* and all indoor collected samples were identified to be *Heterotermes indicola* within the campus of IPIRTI, Field Station Kolkata. From the results obtained from Table 1 it can be seen that the minimum time taken by *H. indicola* and *C. heimi* was *Pinus* sp. and *Mangifera* sp. for consumption. Therefore, they were chosen as the control samples for the test. This method was replicated three times and all the time the most preferable samples resulted to be *Pinus* sp. and *Mangifera* sp.

From the results obtained from table no. 2 it can be seen that the ideal group density of *Heterotermes indicola* is 0.004 g/ml as the total wood consumption of all 3 sets were maximum and termite survival was maximum. The ideal group density for *Coptotermes heimi* was 0.0008 g/ml as the total wood consumption of all 3 sets were maximum and termite survival was maximum. Hence, these condition parameters were incorporated in the developed method. Different size of the samples were standardized and the time period determined for test was 24 days for both the Termite species based upon the observation that wood consumption and termite survival started to decline after 24 days. Image of termite attack in control sample is given in Image no.1.

As a result of this study, the test method developed for *Heterotermes indicola* and *Coptotermes heimi* is:-

1. Plywood or blockboard test specimens of 2cm x 6 cm x thickness size shall be taken for the test. Control samples of *Pinus sp./Mangifera sp*. for blockboard of size 2cm x 6cm x 19 mm or *Mangifera* plywood of size 2cm x 6 cm x 12mm/ 19 mm shall be taken.

2. For *H. indicola*, plastic container of 500 ml volume shall be taken. A matrix shall be made up from 100gms of garden soil. Before laying the matrix 1 layer of wet corrugated cardboard sheet shall be laid at the bottom of the container.

Or

For *C. heimi*, plastic container of 2500 ml volume shall be taken. A matrix shall be made up from 500gms of garden soil. Before laying the matrix 1 layer of wet corrugated cardboard sheet shall be laid at the bottom of the container.

3. The specimen sample and the control sample was placed in the soil. 2gms of termites were added to the container and sealed. Few holes were pierced in the top of the container for ventilation.
4. The set up was kept undisturbed for 24 days inside BoD incubator at 30^{o}C. Every 7-9 days of the start of the test, some distilled water shall be added to the matrix to keep the system moist.
5. After 24 days the samples shall be taken out and X-Ray analysis shall be done.
6. The % termite attack shall be determined by the formula: $\frac{\text{affected area}}{\text{Total area}} \times 100$

c

The X- Ray image of termite attack in wood and plywood is shown in image no.2 and 3 respectively.

CONCLUSION

The termite species available in the field station were identified to be *Heterotermes indicola* and *Coptotermes heimi*. The termite species preferability test was done in order to find out the most palletable wood species to determine the control samples for the test, which was found to be *Pinus* sp. and *Mangifera* sp. Determination of maximum vigorous activity of both the termite species were done by monitoring wood consumption and survival. From the results, it can be concluded that the maximum vigorous activity of *Heterotermes indicola* was at population density of 0.004 g/ml, whose test parameters were incorporated in the developed method and the maximum vigorous activity of *Coptotermes heimi* was at population density of 0.0008 g/ml,

whose test parameters were incorporated in the developed method. Sample size and time period of 24 days were determined. A non-destructive and quantitative approach of X-Ray analysis was adopted for result evaluation. Based upon the findings, test method for Lab testing Method was developed for plywood and blockboard with both the termite species was formulated.

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TABLES

Table 1 :Field exposure to *Coptotermes heimi* determine the most palatable wood species as per IS 4833: 1993.

Wood Species	6 months	12 months	18 months	24months	30 months	36 months
Betual sp.	0	0.5	1.0	1.0	2.0	3.0
Phoebe sp.	0.5	1.0	2.0	4.0	-	-
Artocarpus chaplasha	0	0.5	2.0	2.0	3.0	3.0
Gmelina arborea	0	0	0	0.5	1.0	2.0
Dipterocarpus sp.	0	0.5	1.0	4.0	-	-
Artocarpus heterophyllus	0	0.5	0.5	1.0	1.0	3.0

Shoreaassamica	0.5	1.0	2.0	4.0	-	-
Mangifera indica	4.0	-	-	-	-	-
Acer sp.	0	0.5	1.0	4.0	-	-
Poplar sp.	0	2.0	4.0	-	-	-
Bombax ceiba	2.0	2.0	4.0	-	-	-
Dalbergia sissoo	0	0	1.0	2.0	2.0	3.0
Tectona grandis	0	0	0	0	0.5	1.0
Shorearobusta	0	1.0	1.0	2.0	2.0	3.0
Juglans regia	0	0.5	1.0	4.0	-	-
Michaelia sp.	0	0.5	1.0	4.0	-	-
Pinus sp.	4.0	-	-	-	-	-
Adina cordifolia	0	1.0	1.0	4.0	-	-
Chukrasiatabularis	0	1.0	2.0	4.0	-	-
Eucalyptus globulus	0	0	1.0	2.0	2.0	3.0
Plywood						
Poplar sp.	0.5	3.0	4.0	-	-	-
Mangifera sp.	2.0	3.0	4.0	-	-	-
Dipterocarpus sp.	0	1.0	3.0	4.0	-	-
Betula sp.	0	2.0	4.0	-	-	-
Eucalyptus sp.	0	1.0	3.0	4.0	-	-
Shorea assamica	0	1.0	3.0	4.0	-	-

Numerical Ratings :-

0 – No attack

0.5 – trace attack

1.0 – Light attack

2.0 – Moderate attack

3.0- Heavy attack

4.0- Very heavy attack

Table 2 : Lab test to determine the wood consumption and survival of *H.indicola* and *C. heimi*

A. Heterotermesindicola					
Sl no.	Container vol.,ml	Group size, g	Density, g/ml	Avg. Wood Consumption, %	Avg. Survival, %
1.	100 ml	2g	0.020	5.5	52
2.	500 ml	2g	0.004	12.8	81
3.	650 ml	2 g	0.003	8.1	68

B. Coptotermesheimi					
1.	1500 ml	2g	0.0013	8.5	58
2.	2000 ml	2g	0.0010	10.2	51
3.	2500 ml	2g	0.0008	11.6	64

Image 1. Image of *Mangifera* sp. wood consumption by *Heterotermes indicola*

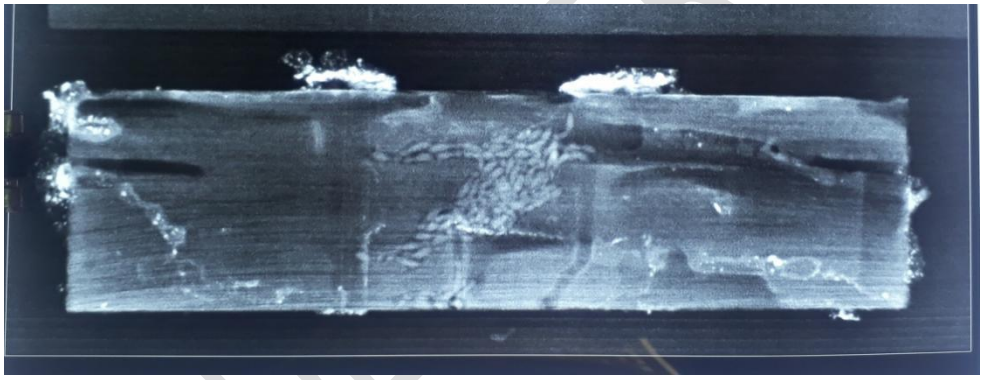
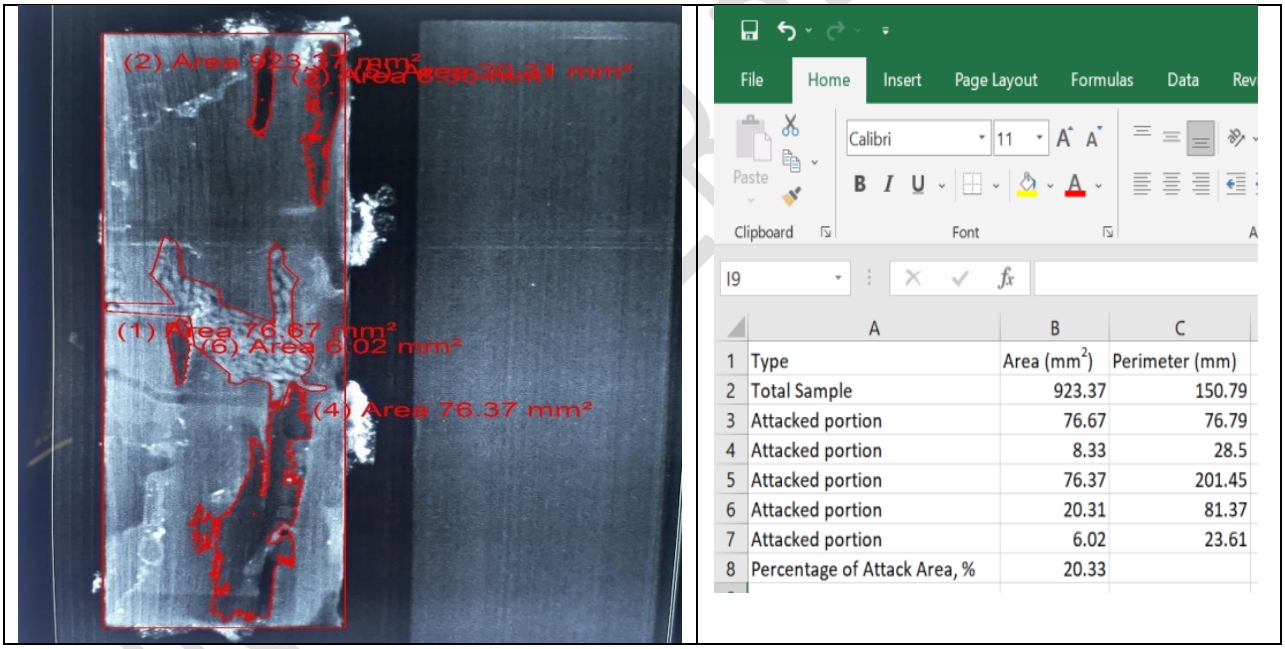


Image 2. X-Ray image of *Coptotermesheimi* inside wood.

Image 3. X- Ray image of *Heterotermes* inside plywood.



	A	B	C
1	Type	Area (mm^2)	Perimeter (mm)
2	Total Sample	923.37	150.79
3	Attacked portion	76.67	76.79
4	Attacked portion	8.33	28.5
5	Attacked portion	76.37	201.45
6	Attacked portion	20.31	81.37
7	Attacked portion	6.02	23.61
8	Percentage of Attack Area, %	20.33	

Image 4: Example of image analysis in Cellsens Dimension calculating attack area, % attack.

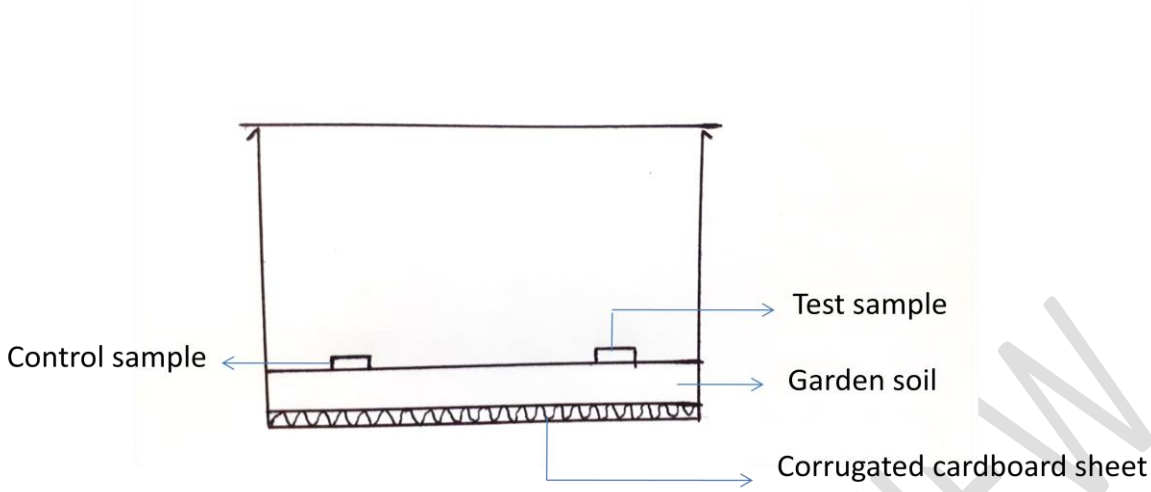


Image 5: Schematic diagram of assembly of the rearing matrix used for test.