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INVESTIGATION OF AN APPROPRIATE METHODOLOGY FOR PRESERVATION OF TRADITIONAL SRI LANKAN MURAL PAINTINGS

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A THESIS SUBMITTED TO THE UNIVERSITY OF MORATUWA FOR ASSESSMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ARCHITECTURAL CONSERVATION OF MONUMENTS AND SITES, UNDER A GRANT GIVEN BY THE SENATE RESEARCH COMMITTEE OF THE UNIVERSITY

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INVESTIGATION OF AN APPROPRIATE METHODOLOGY FOR PRESERVATION OF TRADITIONAL SRI LANKAN MURAL PAINTINGS

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Content of the thesis: Testing of validity and applicability of the hypothesis '*it is possible to reduce the rate of decay of mural paintings and probability of generation of defects in them by controlling their behavior*'

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JULY 2006

DECLARATION

I do hereby declare that the material present in this thesis was resulted from research exclusively carried out by me under the supervision of Prof. T.K.N.P. De Silva. The thesis contains the results of my own independent research except where due references have been made. Persons who provided technical assistance for my research work are duly acknowledged. This thesis has not been previously or concurrently submitted in whole or part to any university or institution for the same or any other degree.

UOM Verified Signature

T.D.N. Perera,
Candidate

Date: Sep. 23, 2005

I certify that the work reported in this thesis was carried out by the candidate, is of suitable standard for the degree for which it was submitted and worth of consideration.

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Prof. T.K. Nimal P. De Silva,
Supervisor

Date:

Publications by T.D.N. Perera relevant to the thesis

1. 2003, 'Architectural conservation of traditional mural paintings: the Sri Lankan experience', *Built environment Sri Lanka,* 4, 1, pp. 13-19
2. 2004, 'A non-destructive method to measure the rate of decay of mural paintings', *Built environment Sri Lanka,* 4, 2, pp. 55-58

Abstracts

1. 2002, 'A simulated study on the correlation between stable behavior and the rate of decay in traditional Sri Lankan mural paintings', *SLAAS Proceedings part 1 (abstracts)*, p. 92
2. 2002, 'An investigation of the usage of traditional material to preserve traditional Sri Lankan mural paintings', *SLAAS Proceedings part 1 (abstracts)*, p. 93
3. 2002, 'The identification of traditional Sri Lankan painting techniques', *SLAAS Proceedings part 1 (abstracts)*, p. 94
4. 2002, 'The investigation of behavior patterns in traditional Sri Lankan mural paintings', *SLAAS Proceedings part 1 (abstracts)*, p. 95
5. 2003, 'Determination of degree of effectiveness of repair intervention on the simulated samples of traditional Sri Lankan mural paintings using an indirect method of measurement of rate of decay', *SLAAS Proceedings part 1 (abstracts)*, p. 127
6. 2003, 'Measurement of behavior of traditional mural paintings in relation to its principal actions', *SLAAS Proceedings part 1 (abstracts)*, p. 128
7. 2004, 'Identification of gamboge used in traditional mural paintings with special reference to implications of its decay', *Chemistry in Sri Lanka,* 21, 2, pp. 24-25
8. 2004, 'Preservation of southern paintings deteriorated by formation of subflorescence', *SLAAS Proceedings part 1 (abstracts)*, p. 129
9. 2005, 'A methodology for preservation of traditional Sri Lankan mural paintings', *SLAAS Proceedings part 1 (abstracts)*, p. 127
10. 2005, 'Impact of decay on the structure and behavior of traditional mural paintings', *SLAAS Proceedings part 1 (abstracts)*, p. 33

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ABSTRACT

This research was founded with an objective of finding the most effective method of preservation of traditional Sri Lankan mural paintings. Investigation was separated into three main areas. These are determination of necessary actions in preservation, investigation of preservation mechanisms and investigation of applicability of these methods. Actions needed in preservation were identified by analyzing present condition of paintings. Paintings were classified into several logical groups to facilitate analysis. A criterion for classification was developed considering all possible factors of sorting. Classification of paintings according to the period of production was the most appropriate criterion since this automatically classified paintings on technique, school, climate, pattern of decay, pattern of deterioration and the degree of deterioration. Analysis of condition of paintings disclosed following facts:

1. all paintings are in a rapid rate of decay
2. deterioration is a result of natural decay and accelerated decay due to dilapidation
3. intervention based on synthetic resins prevented fragmentation and loss of material but accelerated the rate of decay

This information led to the decision that adequate repair and prevention of deterioration would be the most needed actions in conserving Sri Lankan paintings. Analyzes of these facts emphasized that there was a definite need to develop a viable method of reduction of the rate of decay of paintings. Development of the most appropriate method needed following background information: principles of traditional technology; social aspects that led to creation, usage and maintenance of paintings and traditional methods of conservation and maintenance. There were few direct and indirect sources to gather this information. These were traditional technical texts, historic records, legend memory and information generated from physical and chemical analyses. Present social conditions that led to survival and destruction of paintings were also analyzed. Technical analyses were based on structure, composition and behavior of Sri Lankan paintings and survival and performance of different types of paintings in different climatic zones. Most appropriate chemical and physical analytical methods were used in the analysis.

Constant nature of structure, composition, production process and procedure of painting in paintings belonging to a particular class and analogy among different classes indicated strict adherence of production techniques to rules and regulations of traditional technology. Seven major Sri Lankan painting techniques were identified. Classical, medieval and southern are the dominant techniques among them. The most major difference among these techniques is the structure and composition of ground. Two major techniques were therefore defined based on the usage of the process of carbonation in the ground. The characteristic feature of Sri Lankan painting techniques is the use of biotechnology.

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A heavy amount of microbiological actions and enzymatic reactions had been used to attain key properties not gained by other means. Use of most stable material is a law of traditional technology. Certain principles of traditional technology that realized appropriate coordination between paintings and environment were identified. A particular traditional painting technique fulfilled the needs of the corresponding painting school and users of paintings produced by that technique. Usage and maintenance also followed definite rules, regulations and guidelines. These were identified by analyzing later modifications to paintings.

Special attention was given to understand actions occurring in paintings. These actions were identified as interactions of paintings with the environment. Interactions with environment and response of paintings to these interactions were defined as behavior. Water transmission and thermal movement of paintings were identified as main actions of behavior. These dynamic physical actions bear on most other physical, chemical and microbiological actions. Paintings on masonry and wood support absorb water through support, transmit towards the surface and evaporate on the surface. Paintings on rock support absorb water through the surface and disperse throughout the ground. Porosity of ground and permeability of paint layer are important parameters in both of these absorption types.

Most actions occurring in paintings are detrimental to them and called actions of decay. Few favorable actions called actions of preservation were also identified. Various factors become favorable or detrimental in specific ranges and combinations with other factors. Decay is a continuous process associated with every painting. Decay results in a change of material, material properties and structure. These changes bring about deterioration, i.e. formation of defects. The rate of decay accelerates with the formation of defects. Behavior of every painting becomes destructive with the formation of defects.

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Prevention of decay is the principle action necessary in preserving paintings. This is the key task necessary to preserve deteriorated traditional mural paintings. Prevention of fragmentation and loss of material are other important needs. This investigation was centered on determination of the most effective method of minimizing the rate of decay. Simulated samples of paintings were used in the investigation. Production processes of these simulated samples were determined using information obtained from traditional technical texts and chemical and physical analyses of samples of paintings. It was found that two types of samples could represent all Sri Lankan paintings. These are samples with lime ground and samples with clay ground. It was decided to produce samples at four categories of increasing complexity to reduce errors during analysis. Elementary samples simulated the painting ground, basic samples simulated the multilayered structure of paintings and advanced samples simulated complex structure of paintings. Advanced samples had heterogeneous paint layers and complex ground.

Representative samples represented the actual paintings. Enzymatic and microbiological actions mentioned in traditional technical texts were used to produce representative samples.

This investigation needed methods to measure behavior and the rate of decay. Behavior could be adequately measured using parameters of main actions of behavior. An indirect method based on intensity of defects and difference in hue was used to measure relative rates of decay. Methods of reduction of rate of decay tested were removal of factors of decay, environmental control, repair of defects, induction of equilibrium behavior and few specific actions of preservation. These different methods were successful at various degrees. Removal of some factors of decay reduced the rate of decay at all instances. However, it had a limited amount of success due to the fact that total removal of some factors like water and thermal energy increased decay. Environmental control remarkably reduced the rate of decay. However, this did not guarantee the long-term existence of paintings. Furthermore it was difficult to adopt. Natural actions of preservation takes very long durations and difficult to manage. Maintaining conditions that enhancing these actions was the only external intervention possible. Further analysis of these methods of reduction of rate of decay disclosed the fact that all of these mechanisms were effective when they induce equilibrium. Special attention was therefore given to test possibility of reducing the rate of decay by inducing equilibrium behavior. Existence of a relationship between the degree of equilibrium and the rate of decay was the main hypothesis tested in this research.

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Relationship of equilibrium behavior and the rate of decay was studied at four levels using four categories of samples. A completely randomized design was used. Relationship between behavior and the rate of decay was tested with elementary, basic and advanced samples. Behavior was changed by altering input physical factors. A distinct relationship was observed. Relationship of degree of equilibrium with the rate of decay was also investigated with these samples. Equilibrium was quantitatively changed by allowing the samples to absorb moisture at different known rates under different known temperatures and relative humidity. A definite correlation existed. These relationships were significant ($p<0.5$) or highly significant ($p<0.1$) in each category of all types of samples. Definite relationship existed between the degree of equilibrium in behavior and rate of decay of traditional paintings was established with a high confidence level. It was found that the degree of deviation from the optimal equilibrium is the factor that determined the rate of decay. Further analysis done with representative samples disclosed the fact that each painting technique has a set of optimal ranges of equilibrium. There is an optimal point of equilibrium for each action and optimal range of overall equilibrium in each class of painting. This optimal level could be defined in terms of input parameters. Optimal level of equilibrium for each technique of painting could therefore be determined.

Equilibrium reduced the probability of generation of defects. Equilibrium at optimal level reduced the rate of decay too. Analysis of mechanisms of reduction of rate of decay disclosed the fact that all methods of reducing the rate of decay minimize decay by inducing equilibrium. It was therefore emphasized that induction of equilibrium at the optimal level is the most effective method available to reduce the rate of decay of mural paintings. Mechanism of reduction of rate of decay by induction of equilibrium behavior was investigated using simulated samples. Paintings in equilibrium maintained all factors at their moderate rates. These intermediate levels approached optimal levels of most actions. Equilibrium brought about proper coordination between all actions. It did not allow any action to grow beyond the favorable limit. It reduced tear and wear. It tremendously decreased the probability of formation of defects. These factors are important to all paintings.

Method of inducing equilibrium behavior at the most optimum level is called stabilization. Possibility of practical induction of stabilization was tested on simulated samples. All possible methods of stabilization were investigated. These are repair of defects, environmental control and application of controlled amounts of input factors. All ancient paintings have defects as a part and parcel of their structure. Adequate repair of these defects is compulsory. Special emphasis is therefore given to test possibility of stabilization by repair of defects. Samples were subjected to destructive intervention to generate defects. Their behavior was measured and compared with normal samples. Repair was done with traditional material and synthetic material. Quality of repair done with synthetic material was better than traditional material. Quality of repair with traditional material was also at an acceptable level. Repair with synthetic material however deviated behavior away from equilibrium. Repair with traditional material was effective in bringing equilibrium closer to the original level.

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It was therefore decided that repair of defects with traditional material could reduce the rate of decay of traditional mural paintings. Possibility of practical adoption of the method was also investigated in five selected sites. Necessary actual measurements were done; conservation plans were developed. It was found from this study that repair of paintings with traditional material and maintaining their environment within acceptable ranges were adequate for stabilization. Elaborate measurements were not necessary to adopt the stabilization method. It was established that the stabilization method can be adopted as a systematic process of reduction of rate of decay and decreasing the probability of emergence of defects.

PREFACE

The objective of performing research in the field of painting conservation is the desire to study natural actions without set artificial boundaries within different fields. Painting conservation is the field where researchers enjoy the freedom of performing research without restrictions under a defined field. This essentially demands and promotes a multidisciplinary approach. Research in painting conservation is however a challenging task. Complex nature of paintings brings about a vast number of interrelated actions that analysis becomes difficult. This research is primarily concerned with the actions necessary to arrest the natural action of decay. Analysis of complex behavior, decay and deterioration as a singular sequential process was the mechanism used in this research. The study concentrates on nullification of decay actions by the coordinated functioning of paintings with their respective environments.

Preservation is the most essential attribute in architectural conservation and hence in conservation research. This study primarily investigates traditional Sri Lankan mural paintings and their preservation methods. Principles of traditional technology applied during production of paintings, usage and maintenance are taken as the basis for the development of viable preservation methods. Preservation methods are analyzed in relation to the interaction of paintings with their environment. It was understood that conservation measures perfectly suited for modern paintings destruct traditional paintings. This is a result of difference in mode of interaction of these paintings with the environment. Root of the problem existing within present methods of conservation lies on this factor. Preservation method developed in this research took this fact into account.

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Main obstacle met in this research was the random nature of variables encountered. Inherent random nature is a result of various combinations of factors involved. A similar problem exists in biology and medicine. Biostatistics is used in research in these fields. A similar approach was used in this research. Limitation of intervention on genuine paintings to a minimum was a major objective in this study. Simulated samples were used to realize this goal. These samples provided the additional benefit that tests could not be carried out on genuine paintings could be performed on them. Special attention was taken to produce samples that accurately simulated genuine paintings. All techniques of traditional mural paintings are included in the study. Attributes common to all these paintings and contrasting features could therefore be identified.

Content of the thesis is original materials generated from laboratory and field investigations. Sources of information gathered from literature survey are duly acknowledged. Analytical research was carried out at the ACOMAS Laboratory of the Department of Architecture and the Microscopy Laboratory at the Department of Materials Engineering. Sites where investigations were done are mentioned in the thesis.

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CHAPTER BREAKDOWN

This thesis consists of seven chapters. Content in each chapter is given below.

Chapter One: The present context of traditional mural paintings

The fist chapter contains the results of a preliminary analytical study of the remaining traditional Sri Lankan mural paintings done with an objective of identifying the research problem. Empirical information obtained is presented under characteristic features of mural painting tradition, conservation and maintenance practices adopted during different eras, results of these actions, present condition of paintings, survival and necessary research in preservation. It finally deals with the necessary areas of research.

Chapter Two: The structure, behavior, decay and conservation of mural paintings

The second chapter contains information obtained from a survey done to identify methods available to solve problems mentioned in chapter one or to develop such methods. This information is categorized under structure and composition of paintings, mechanisms of decay, methods of conservation intervention, results of intervention and methods used in conservation analysis.

Chapter Three: Preservation of decaying paintings

An accurate understanding of interaction of mural paintings with their environment was the initial task necessary in this research. This chapter contains methods used in such analysis, results and inferences realized. Content of the chapter is categorized under actions of behavior; processes of behavior; decay; patterns of behavior, decay and deterioration and mechanisms of survival. It finally deals with the methods of solving the research question. The method of investigation and experimental design are included in this description.

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Chapter Four: Investigation of methods of reduction of rate of decay

This chapter describes the research methodology used in testing of hypothesis, results obtained from this investigation, inferences and conclusions realized. Information present in the chapter is divided into following areas: production of simulated samples, methods used in the measurement of behavior and decay and testing of mechanisms of reduction of decay. The chapter finally deals with the most effective method identified.

Chapter Five: Investigation of methods of intervention to stabilize behavior of mural paintings

This chapter contains information on the investigations carried out to identify relevant methods of implementation of the theoretical method. The chapter is arranged on following sub topics: impact of behavior on paintings, investigation of methods and results of intervention.

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Chapter Six: Investigation of applicability of stabilization: case studies

This chapter consists of descriptions about research done in specific sites. It deals with the applicability of selected methods of intervention on selected sites. Investigation done in each site is described separately with developed conservation plans. The chapter contains material on following topics: methodology of investigation, findings and plans of preservation.

Chapter Seven: Systematic conservation of mural paintings

The final chapter contains conclusions drawn out from analyses. This discussion is divided into following topics: analyses necessary in preservation, relevant actions of intervention, methods of repair of defects, methodology of minimization of decay and stabilization of monuments in the built environment by enhancing their user values. Procedures of preservation of different paintings are described in detail.

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