Project Completion Report

Project Identification

Title	:	Research on Utilization of Tropical Timber in Construction
Serial Number	:	PD 12/87(1)
Executing Agency	:	Forest Research Institute Malaysia (FRIM)
Host Government (s)	:	Malaysia
Starting Date	:	January, 1991
Actual Duration (months):		Sixty (60) months
Actual Project Costs (US$):		US$ 273,884
Funding Received (US$) :		US$ 195,884 (RM 527,709.49)

PART I. Executive Summary

1. Background Information About the Project.

The socio-economic importance of timber for the country can be revealed from the fact that the 1980 Housing Census in Malaysia indicated slightly more than half (i.e. 56%) of the occupied housing units in Peninsular Malaysia had their outer walls constructed of planks (Khoo, 1986). The vast forest resource available in Malaysia has allowed her to become one of the world major producers and suppliers of tropical timber and timber-based products. In 1986, wood and wood products exports ranked second, after petroleum and petroleum-based products, and earned an export revenue of RM4,660 million for Malaysia (Maskayu; 1987, Timber Trade Review;1987).

The construction sector is, by far, the largest consumer of domestically produced timber in Peninsular Malaysia. The advent of advanced technology has, nevertheless, reduced the importance of timber as a construction material. Other materials particularly plastics and aluminium are making good inroad into the construction industry to replace timber.

The slowdown in economical activities experienced locally and globally has not only affected the price, supply and demand situations in the local market but also the timber export trade of Malaysia. This setback has brought fresh awareness to the timber traders and the Government alike to the awareness of excessive dependence on export and neglecting the domestic market. The Government is currently promoting local utilization of timber products for housing in Malaysian cities and villages as one of the steps taken to remedy this adverse situation.

It should be pointed out that despite rapid growth in the housing sector since independence, the use of timber in construction has not been consistent with increased timber production in Malaysia. In addition, despite the readily available timber resource in the country, the amount of timber utilized per capita in Malaysia is lower than that in the United Kingdom and the United States of America.

Timber is a versatile material with wide range of applications in building construction. For example it can be used in the building of formworks, foundation piles, structural components (e.g. columns, beams, joists), roofing (e.g. rafters, purlins and bracing), battens, staircase, flooring (both boarding and parquetry), walling (e.g. partitions and boarding), fascia boards, ceiling frames, door and window frames, built-in fittings and furniture etc. Additionally, timber is an essential component in the production of particle boards, fibreboards, cement boards, blockboards, laminated boards and a whole range of other panel materials for building purposes. Hence, it shows that practically every building component of a house can be fabricated from timber. It is, therefore, possible for the prefabrication of a timber house using only timber alone.

In Malaysia, the demand for housing in the 80's till today far outstripped the supply. Consequently, house prices escalated beyond the affordability of those in the low-income groups (Tan, 1983). In recognition of the importance of housing as a basic social need, the Government takes a serious view of this problem. A number of measures have since been taken to counteract the situation. In the Fifth Malaysia Plan (1986 - 1990) priority has been given to provide adequate shelter to all needy Malaysian. It provides for an extensive housing programme involving the construction of a total of 835,500 units of

houses of which 626,600 units will be low-cost houses. This clearly shows that the Government is committed to the construction of low-cost houses for the low-income people.

Prefabricated methods of construction has already been introduced into Malaysia a number of years ago (Shen, 1976). Such method permits speedier construction of houses than other conventional approaches. Hence, more houses can be built within a given time. Furthermore, it has been suggested that fabrication allows houses to be built at more competitive prices (Wee, 1976). Equally important is that prefabrication provides better quality control of structural components than in-situ construction as the components are made in the factory environment. Prefabricated houses using timber components may prove to be both economically and technically viable and will help to fulfill the housing target of the plan, especially in the low-cost category.

The housing industry has encountered numerous problems such as high interest rates charged on housing loans, inadequate housing land, delay in granting approval for land conversion, difficulty in obtaining bridging finance, etc. (Tho 1986, Wong 1976). In addition, timber housing industry in Malaysia experiences some problems unique to its own. When used in the 'right' manner, timber is a very good building material. However, inadequate guidelines concerning proper timber use for housing in the rural areas have often resulted in houses being generally built from ungraded, untreated and air-dried timber without exploiting the full potential of the material. Consequently, the poor design and lack of proper utilization as well as high maintenance cost have led to low acceptance, if not rejection, of timber houses by the public.

The use of timber houses, particularly in the urban areas is still facing a number of legislative and social constraints. The Building By-laws and building codes, financial institutions and insurance agencies are sceptical over the use of timber as a construction material. Furthermore, the social stigma about living in timber houses still strongly prevails in the minds of many Malaysians particularly the urban dwellers.

The specific Objective(s) and Output:

Long-term objectives:

i. To develop for local housing industry and for the export market optimised prefabricated timber house system consisting of standard sized modular components.

ii. To develop designs of timber house that are suitable for mass production. This will help to achieve the low-cost housing target stipulated and at the same time alleviate the current acute housing shortage problem.

iii. To establish FRIM as an information dissemination centre of new technology relating to timber construction particularly in the prefabricated housing field.

iv. To render FRIM as a centre offering efficient and effective testing services on timber housing construction.

v. To upgrade timber utilization technology and to encourage further value-added processing of timber products in the building construction industry.

Short-term objectives:

i. To create greater awareness and to demonstrate to the public that with proper design timber can be used effectively and efficiently for the construction of houses.

ii. To assist the relevant authorities, in the light of positive research findings, to review the status of timber as a building material and to revise the current legislation that are not conducive to timber utilization in construction.

iii. To upgrade general timber construction technology through the development of standard testing procedures, design guides and manuals.

Outputs to be produced by the project to meet its objectives includes (i) technical papers, (ii) design guides, (iii) illustrated manuals and (iv) reports. All reports and technical papers will be submitted to ITTO for dissemination to member countries. This project will expand our knowledge of tropical timbers in house construction and will therefore benefit all ITTO members and the timber trade in general.

The strategy adopted in carrying out the project was by training FRIM experts, hiring specialist, establishing structural testing laboratory in FRIM to perform full scale testing on various components. Designs of prefabricated timber houses were also produce and test were done on the full size component to assess their performance. These include the various jointing system used.

The project were plan to be carried out in Five (5) years, starting from January 1991 and to be completed by December 1995, with estimated cost of US$ 273,884.

2. Project Achievements

The project achievements were as brief under the following headings;

i) Output Achieved:

The following technical reports were produced as results of the research activities conducted:

i) Selection of Standard Size Components, (Unpublished)
ii) Strength of Nailed Joints in Mengkulang, FRIM Tech. Infom. No. 60.
iii) Strength of Metal Plate (punched-plate) Joints in Mengkulang, FRIM Tech. Infom. No. 62
iv) Strength of Bolted Joints, FRIM Tech. Infom. No. 61.
v) Strength of Trussed Rafters in Mengkulang, FRIM Tech. Infom. No. 63.
vi) A Guide for the Construction of Prefabricated Timber House, (Unpublish)
vii) Structural Size Testing of Mengkulang : Joist, Beam and Column, (Unpublish)

viii) Racking Resistance test of Wall Panels (using plywood and wood cement board as paneling and timber framing), (unpublish)

ix) House Components testing. (unpublish)

These technical reports were re-produced and publish under FRIM Technical Information Series publication. Some of which are attached as Appendices.

Two units of miniature house based on two different designs of fabricated timber house were constructed to a 1 in 5 scale for demonstration purposes.

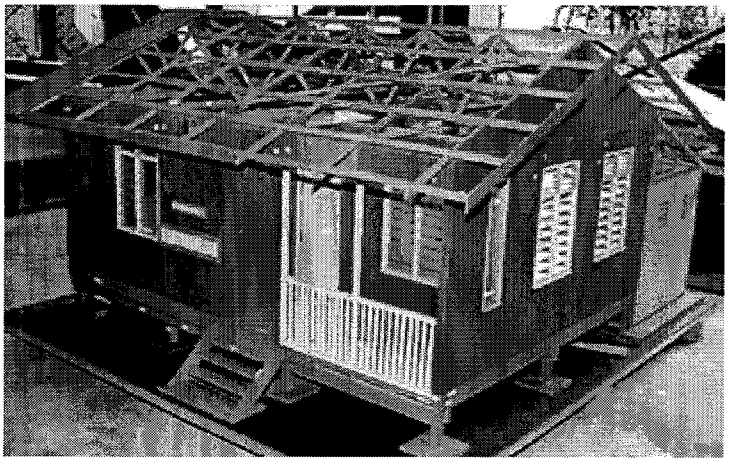

Fig. 1: Model House Constructed

A structural size testing rigs and its related data acquisition system was established which enable FRIM to conduct tests on structural size housing components.

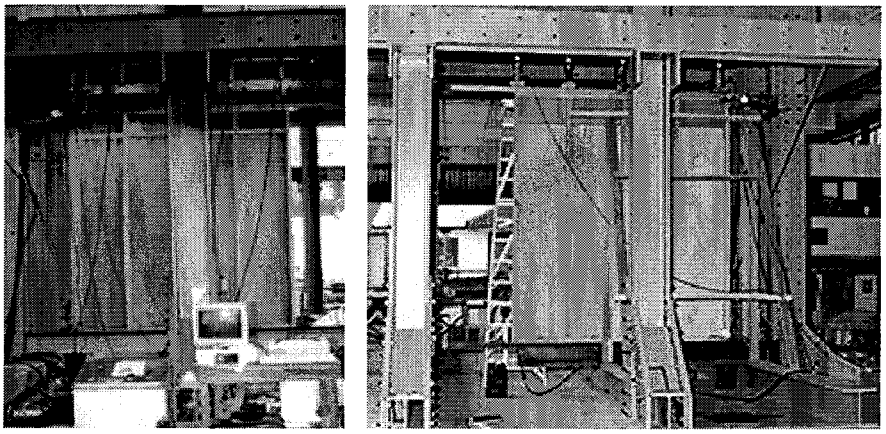

Fig. 2: Structural Testing of Wall Panel

A book entitle "Construction Manual of Prefabricated Timber House", FRIM Technical Information Handbook No. 5, was produced based on the results and finding of the project. This comprehensive manual will be very useful to the public, individuals or developers, who wish to construct timber prefabricated house.

ii) Specific Objective(s) Achieved:

A book entitle "Construction Manual of Prefabricated Timber House", as FRIM Technical Information Handbook No. 5, was produced based on the results and finding of the project. This comprehensive manual will be very useful to the public, individuals or developers, who wish to construct timber prefabricated house. The manual is also useful as reference book for university students. The Public Work Department, Malaysia has taken this book as their reference for formulating / preparing their handbook on

prefabricated house construction using cement slab as building material. The book has been on sale at FRIM Publication Units and the response was very encouraging. A few dozen of the books has been purchased by interested parties and individuals from the industries, universities, architects, engineers, designers and housing developers.

The Economic Planing Unit, of The Prime Minister Department was very keen and has started together with FRIM and Forestry Department, to utilise one of the desings of the houses produce in this project study for construction of model houses. These model houses will be constructed at tourist and recreational areas and will be constructed using *Acacia mangium* timber, a major fast growing plantation species planted in Malaysia. Additional allocation was specially given to FRIM, under the 8th. Malaysian Plan, by the Economic Planing Unit, Prime Minister Department, Malaysia, for this purpose (at the time preparing this report, the construction of the said house are in progress).

iii) Contribution to the Achievement of the Development Objective:

Besides the above construction activities FRIM management has decided to build two houses of from the designs produced from this project. They will be used as staff quarters, one at FRIM new Sub-Station in Terengganu and one in the North-Eastern State of Peninsular Malaysia. The construction of the two units is near completion and is being built by local contractor. These houses will be monitored from time to time and studies will be carried out on the service performance of the house.

3. Target Beneficiaries Involvement

The construction industry through its corporation with FRIM researchers, has been given throughout the duration of the project. One roof truss fabricator, Pryda Malaysia Berhad, works very closely with FRIM in the implementation of this project. The company even has allowed FRIM to use and install their computer added software in FRIM's computer for designing our truss rafters. A few timber building component manufacturers and

fabricators have supplied the metal punched-metal plates for the joints, and helped to fabricate the truss rafters that use punched-metal plates as jointing and connectors system in their factories. In return the manufacturers and fabricators were given all the relevant research results and findings of this project. They use these results in the designs and calculations of roof trusses in some of the companies housing development projects.

4. Lesson learned

a) Development Lesson

- The project should be designed to have wider coverage by trying to investigate more on the legislative constrain, such as, the Uniform Building By-laws, Codes of Practices, towards revising/updating them with latest information/data. They are parts of the areas that could contribute towards the success the development objectives. The study should be done together with other relevant authorities and agencies. Such as the Local/Town Council, Standard Institutions, Housing Ministry, Fire Departments, Insurance Agencies and the Financial Institutions.

- Additional arrangements that could improve cooperation between the relevant parties interested in the project including, arrangements with the Ministry of Housing and Local Government, land development agencies like FELDA, FELCRA and the State Economic Development agencies should have been made. Possible studies on housing development plan requirements and designs of the houses, using ITTO/FRIM project findings and should be encouraged. While timber house fabricators should be allowed to utilize the project findings such as on information on data properties of the lesser known species, jointing systems, and components and designs.

- Factors which will most likely affect project sustainability after completion includes high timber price, scarcity of good quality timber, competition with other construction materials such as cement bricks and hollow concrete block. Supply

of irregular timber sizes, malpractices by the timber preservers and misconception by most Malaysians towards timber houses earners are also as contributing to the project sustainability. The restrictions stipulated in the local Uniform Building By-Law and Building Codes on the use of timber houses, particularly in the urban areas are still a constrain. The By-Laws and lodges need to be revise, as the financial institutions and the insurance companies are not willing to provide financial and insurance coverage because of the limitations clause stated in the both documents.

b) Operational Lesson

- The project organization and management was proper by implemented with the Head of the Division as the Project Head/ Overseer and a Senior Research Officer as the project leader responsible for carrying out the project together with other researchers. However, the control of the expenditure was done by an accountant and the Division Head Finance and Administration as the approving officer for the expenditure. The project leader should be given authority on the approving of the purchase of small equipment and test materials.

- Project documentation was done by the project leader including preparation progress reports and technical reports. The reports were sent to ITTO Head Office every six (6) months normally at the end of March and September throughout the project duration. The original copies of these reports were kept at the Forest Products Technology Division's Office, FRIM.

- The project monitoring and evaluation exercise carried out half-yearly by the ITTO head office Project Monitoring Team was very useful in keeping track on the progress of the project. In addition, any minor changes on the proposed research activities/areas could be discussed together with ITTO teams members.

- The project planing was well adopted. However, the project implementation was slow and not according to the plan. This could be attributed to several reasons such as change of project implementing officers and activities, change of overseers, late arrival of the research funding do happens during the earlier stage of the project. In addition, the tendering procedures for acquiring research equipment/facilities and construction of the model house are inconvenient and time consuming.

- The roles and responsibilities of the institution involved in the project implementation are clear and well defined. FRIM is the only implementing agency involved in carrying out the research activities, data collection, documentation, and report preparations as agreed in the project. However, FRIM should/could invite and seek participations from other agencies especially the timber, construction and the housing industry.

- To avoid variations between planned and actual implementation (schedule, costs, etc.), a regular monitoring and evaluation by both the supervisor/head of the project and the representatives from ITTO should be done. Regular meetings and discussions between the researchers and the head of the project should be organized to monitor and correct any deviation from the planned activities and expenses.

- External factors that influenced the project implementation and that could have been for seen are as follows:

  Visits from timber industry, fabricators, developers and architects during the visits and interviews.

  -The loggers and the sawmillers in getting the raw materials (timber).

  -Suppliers of timber connectors.

  -Reliable contractors for the construction of the houses.

  -Late supply of specialised testing equipment.

- External factors that influenced the project implementation and that could not have been foreseen are as follows:

  -Weather conditions.

  -Other research activities involvement by the project research team members.

  -The researchers are also involved in the administrative of activities other projects.

  -Occasional break down of testing equipment.

5. Recommendation

The overall finding of the project is that using solid timber in constructing a reasonably low cost house is no more economical, especially in Malaysia. Sawn timber especially the popular species normally used for building construction are scarec and expensive. The use of mixed hardwood, including the under-utilized or the lesser-known species could in some extent help to over come this situation. These mixed hardwood species are as good as the conventional construction species in term of their strength properties, except some require preservative treatment. Combination of solid and reconstituted wood panel products, such as plywood and wood-cement board, could also contribute to overcome some of the possible solution. The plywood panels with solid wood framing could be used for load bearing or non-load bearing components such as weather boarding, partitioning and ceiling. The wood-cement board panels could be used for wall panels in areas where moisture is likely to be high, for example in the kitchen and the bath room areas.

As being mentioned in the 'Construction Manual of Prefabricated Timber House' one of the publications of the project, plywood could be use as gusset plates for connectors in roof truss rafters, especially when the fabrication is done on site. However punched-metal plate connectors would be used preferably if it they are available. The load carrying capacity truss rafters using plywood gusset are as strong as punched-metal plates connectors, provided the design and recommendation in the manual are strictly followed.

These two systems of connectors for truss rafters are physically loaded and tested at FRIM testing laboratory.

PART II.

Project Results

Comment on the following issues:

- Situation existing at project completion compared to the pre-project situation;

  More inquiries about the use of timber from industry are on the properties and the use of lesser-known species, and their the suitability, as structural and non-structural building components. This shows that the industry is aware and starting to use the timber for construction purposes, especially in the construction of the prefabricated timber houses or building components in particular the roof trusses, window and door frames. Some of these fabricators are using mixed species for these purposes.

  FRIM officers have been invited to give series of lectures in the government institutions dealing with construction, like the Public Work Department and other land development authorities, where they have housing construction schemes for their settlers. The topics covered during the lectures design of timber structures, proper detailing with timber, proper use of timber and maintenance of timber structures. The Public Work Department is conducting a training programme for their staff, every quarter on 'Design and Maintenance of Timber in Construction', for one week where FRIM officers are invited as the resource persons.

- Extent to which the project Specific Objective(s) was achieved;

Most of the project specific objectives either long term or short tem were achieved.

The long term objective:

i. To develop for local housing industry and for the export market optimised prefabricated timber housing system consisting of standard sized modular components: The Construction Manual of Prefabricated Timber House published as a result of this project has been used by the Public Work Department as its main reference book for the preparation of their manual for low cost prefabricated concrete block houses. Number of copies have been sold to timber house or component fabricators and interested individuals.

ii. To develop designs of timber house that are suitable for mass production. This objectives helps to achieve the low-cost housing target stipulated and at the same time alleviate the current acute housing shortage problem: Three (3) designs of timber prefabricated house that are suitable for mass production have been produced at the end of the project. However, due to the increase in price of timber, including the lesser known timber species, and other construction materials, the stipulated low-cost house limit set by the Malaysian government (< RM 35,000.00 per unit including land) is difficult to achieve. All the three (3) prefabricated timber houses produced under the project have been estimated by local house building contractors and fabricators to cost between RM 35,000.00 – RM 45,000.00 per unit (excluding land cost).

iii. To establish FRIM as an information dissemination centre of new technology relating to timber construction particularly in the prefabricated

housing field: This objective has not been achieved fully. Though FRIM has always become information dissemination centre for forestry and forest products research findings, particularly on timber and timber based products, due to shortage of researchers in this field in FRIM no compilation on related new technologies has not been gathered during the project duration. However, in terms of material research findings (wood and wood-products) it is well documented and disseminated through distribution and sale of FRIM's various technical and semi-technical publications.

iv. To render FRIM as a centre offering efficient and effective testing services on timber housing construction: The full size structural testing facilities purchased and established as part of the project activities has offered and enabled the construction industry and the timber fabricators to test the strength performance of their structural / house components, such as roof trusses, wall panels (load and non-load bearing), timber beams, and connectors in FRIM's structural laboratory. A few of the timber house fabricators have send their roof trusses, wall panels and partitions, engineered beams, such as box-beams and I-beams and jointed components for strength testing in the laboratory.

v. To upgrade timber utilization technology and to encourage further value-added processing of timber products in the building construction industry: Attempts have been made to introduce the timber grading system by mechanical means such as Computermatic Stress Grading Machine (a Non-destructive Testing method) but because of poor response from end users the system does not materialise.

Short-term objectives:

i. To create greater awareness and to demonstrate to the public that with proper design timber can be used effectively and efficiently for the construction of houses: As mentioned earlier FRIM receives a lot of enquiries and invitations to give lectures on timber designs and related subjects. Sales of the Constructional Manual and published articles related to this project show that the public is now aware of the proper timber house design. In addition, the construction of the model houses both at FRIM main campus in Kepong and at FRIM's research sub-stations has made people aware that with proper design, timber can be used effectively and efficiently for house construction. This is shown by the numbers of individuals that have approached and asked FRIM for the full design drawings and plans of the houses to be used for building their own private houses.

ii. To assist the relevant authorities, in the light of positive research findings, to review the status of timber as a building material and to revise the current legislations that are not conducive to timber utilization in construction: Some of the research data and results are being used and incorporated into the revised Malaysian Standard Code of Practice on the Structural Use of Timber, MS 544 (which are currently being revised). These data are used to revise on timber sizes, timber strength properties and strength groups, joints and connectors.

iii. To upgrade general timber construction technology through the development of standard testing procedures, design guides and manuals: The Construction Manual of Prefabricated Timber House published.

Synthesis of the Analysis

(a)	Specific Objective(s) Achievement	**Realised**
		Partly Realised
		Unrealised
(b)	Outputs	**Realised**
		Partly Realised
		Unrealised
(c)	Schedule	In advance / on time
		Delayed but not seriously
		Seriously delayed
(d)	Actual Expenditures	**Below planned**
		More than 10% above planned
		More than 20% above planned

PART III

CONCLUSIONS AND RECOMMENDATIONS

The main conclusions drawn from the project implementation and project results are as being spelt out in the Part I – 'Recommendation Section'- of this report mentioned above. The specific recommendations, derived from the lessons learned, that could improve the effectiveness and efficient of future projects are as follows:

a) Development lessons:

- The project should have wider coverage including local legislative constraints, revision and updating of the Uniform Building By-laws and Standard Code of Practice and should work closely with other related agencies.
- Involvements of both public and private sectors should be made during the preparation drafting of the standards related to building construction and housing development plan requirements.
- Continuous supply of reasonably low price timber which are suitable for structural construction purposes are needed in order to sustain the development and usage of timber in the building sectors.
- As price of the popular timber are no longer cheap the use-lesser known species are encouraged.
- The use of mixed species of timber having almost similar, in term, of physical and mechanical properties should be practiced.

(b) Operational Lesson:

- To ensure smooth running of the project, the managerial or overseers concerned should be involved continuously through out the project duration.
- Proper documentation of the project activities, including data collection and analysis of results should start right from the beginning of the project.
- Regular monitoring/ evaluation by ITTO team and more discussions should be organised to stress out any discrepancy or deviation happen along the project duration.
- To seek more involvements, commitments and coorporation from the industry.

(c) Recommendations for Future Projects, regarding:

- *Identification:*

  Promotion and extension of the design system developed in new housing projects, especially in the developing tropical countries.

- *Design:*

  To look into the suitability, stability and durability of the design system when constructed in countries prone to strong wind.

- *Implementation:*

  To be successful, implementation of the design system in new housing industry should be supported by Government policy on timber house construction.

- *Organisation:*

  The project should be collaborated with relevant local government authority and related agencies.

Appendix I

Expenditure:

Component		**Amount spent (RM)**
1. Salaries and allowences		100,649.60
2. Infrastructure expenses: (inclusive of equipment and assessories plus printing of manual)		
1. Enepac Hydrolic cylinders, Hose and fitting	9,192.00	
2. Enepac Control panel	9,900.00	
3. 2 unit Load Cell, 100 kN.	7,800.00	
4. 2 unit Load Cell, 250kN	8,600.00	
5. Data aquisition syatem	4,500.00	
6. Digital Multimeter	480.00	
7. Potanle Electronic Moisture Meter	2,300.00	
8. 2 unit TML load cell, 10 ton	9,980.00	
9. Steel Structure Loading/Testing Rig	181,563.38	
10. Upgrading Computer	1,470.00	
11. 2 unit NMB load cell, 50kN	8,111.82	
12. 8-Channel Signal Conditioner	1,800.00	
13. Repair Avery Universal Testing Machine	5,440.00	
14. Portable Makita Circular Saw	450.00	
15. 3 unit NMB Load Cell, 5 ton	9,840.00	
16. Computer	9,890.00	
17. Memmert Oven	6,632.00	
18. Fabrication or Cylinder and Loading Roller for item (9) above.	4,378.00	
19. Printing of Mannual	3,800.00	
		286,127.20
3. Operation expenses:		
1. Research expenses, includes, timber, steel bars, angle irons nails, printing papers, drafting pens, etc.	25,302.26	
2. Travelling	38,543.47	
		63,845.73
Total spent todate 31. 3.1998		450,622.53

Note:

1. Actual amount received by FRIM	527,709.49
2. To date spent (31. 3. 1998)	450,622.53
Balance	77,046.46
3. Less Committed amount for cost of construction of Model house , now completing.	43,100.00
4. Expected balance upon completion of the project	33,946.46