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COST MODELLING FOR ROOFING MATERIAL SELECTION

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ABSTRACT

During recent decades new building techniques have been developed and many new materials have been introduced to the construction market. The material market has become more profitable for contractors and construction material producers than for the client.

Not having being a functional and performance oriented roofing material selection system, domestic clients are in a very tight situation when selecting a suitable roofing material according to their requirement, without they being misled from sales exaggerations.

This paper elaborates preparation of a cost model which can be used for selection of roofing materials for domestic purposes, giving adequate consideration on cost and some other performance factors. Cost comparison of roof covering, ceiling and insulation materials those are available in the Sri Lankan market are investigated along with the other performance factors of materials. Further, the current status of the roof construction and design in the Sri Lankan context is also explained.

1 INTRODUCTION

Shelter has been one of the three basic needs of human beings ever since evolution. The roof is a main component of any shelter, which gives protection from natural elements and climatic conditions such as sun, rain, wind, heat and cold.

There are many debates over the relative merits of roofing materials selection for domestic construction. The client and designers could not select the most suitable roofing materials for domestic construction due to the fact that they do not have sufficient sources and very little reliable published data in existence.

Having identified the requirement of a cost model to analyse roofing materials; a cost model was developed by analysing some commonly used roof covering, ceiling and insulation materials in terms of cost and some other performance factors. The roof design complexity was adequately taken in to consideration for the purpose of modelling.

This paper describes a cost model for roofing material selection for house construction purposes. A critical review of the literature on cost modelling and the roofing systems is also carried out in this paper. Further performance factors of roofing materials and analysis of roofing cost are also provided.

2 METHODOLOGY

Having identified the need for the development of a cost model to select roofing material for house construction a model was developed to provide basic cost and performance information to the user. Since one roof type does not represent all the features of a roof and the fact that the design of a roof affects its cost it was decided to model costs based on three types of designs of varying complexity. These designs represent Simple, Medium complex and Complex types of roofs. Most commonly used roofing materials were selected for comparison purposes. Adequate consideration was given for roof frame, covering, ceiling, insulation, rainwater goods, painting or polishing of ceiling and all the other cost items that can influence the total cost of the roofing system.

In the Sri Lankan construction industry in practice it is often found that either small-scale contractors or individual craftsmen carry out house construction works (except in the case of large housing schemes and super luxury mansions). In such type of construction it is found that the labour cost is little higher when compared to the large-scale building construction works. Therefore, prevailing labour rates in the domestic labour market in Colombo district were used for the purpose of roof cost calculations. Cost of different roofing systems were estimated separately under few categories viz: Basic cost, Ceiling cost, Insulation cost and Total cost for the benefit of different types of users of the model to select roof covering, ceiling and insulation systems separately, according to their requirements. These are defined as given below.

Basic cost: represents the roof covering, structure, rainwater goods and all the other items of a roof, excluding ceiling and insulation cost.

Total cost: represents the overall cost of the total roofing system (i.e. the cost of structure, covering, ceiling, insulation, rainwater goods and all the other items of a roof.

Roofing materials were ranked according to the knowledge through literature, observations, interviews with material manufactures, users (house occupants) and by analysing product data.

The subsequent sections of the paper briefly analyses the cost modelling techniques and explains in detail the model construction and the main findings.

3 INTRODUCTION TO COST MODELLING

A model can primarily be physical, mathematical or statistical. Cost Modelling is defined as the symbolic representation of a system, expressing the content of that system of the factors, which influence its cost (Ferry &Brandon, 1991). Brandon (1987) states that the purpose of cost modelling seem to be to provide a reference point where the cost adviser can refer before applying his own experience and to increase understanding and/or predict or influence the future. He further states that the role of a cost model is to predict a future situation and to give an economic dimension to the problem.

According to Ferry and Brandon (1991), a good cost model shall provide better cost information quickly, more in quantity with more reliability at an early stage in the design process and in a more understandable form as possible. Further, using a good cost model shall provide an economic assurance to the client with regard to the cost of his project, and will link the cost control at the design and the construction stages and may be helpful to cost advisers for cost advising purposes and for representation of building in such a way that its cost can be tested and analyzed. A computer integrated cost model shall fulfill most of the above mentioned requirements successfully.

Cost modelling can be classified considering its use, purpose and the stage at which the cost model is used (Refer Figure 1). Several methods can be used for cost modelling purposes as empirical method, Algorithmic methods, Simulation, Heuristics and a combination of these methods.

Emperial models: are symbolic models, which are derived from observation, experience and intuition. They have been developed largely on the basis of "right feeling"(Ashworth, 1982).

Algorithmic methods: are developed using statistical relationship between design variables and cost. Here, the regression analysis technique is used to find a formula or mathematical model (Ferry & Brandon, 1991).

Simulation method: tries to simulate a series of future events. This method allowes sampling a large number of possible solutions to discover the best solution (Ferry & Brandon, 1991).

Heuristics: are essencially rule of thumb procedure, which enables a near optimum solution to be produced once the model has been built. These approaches are an attempt to discover the qualities of the expert and to incorporate these into the model (Ashworth, 1982).

Combine methods: are attempts to combine two or more methods identified above into a computer-integrated environment.The selection of most suitable cost modelling technique depends on the requirement of the model to be

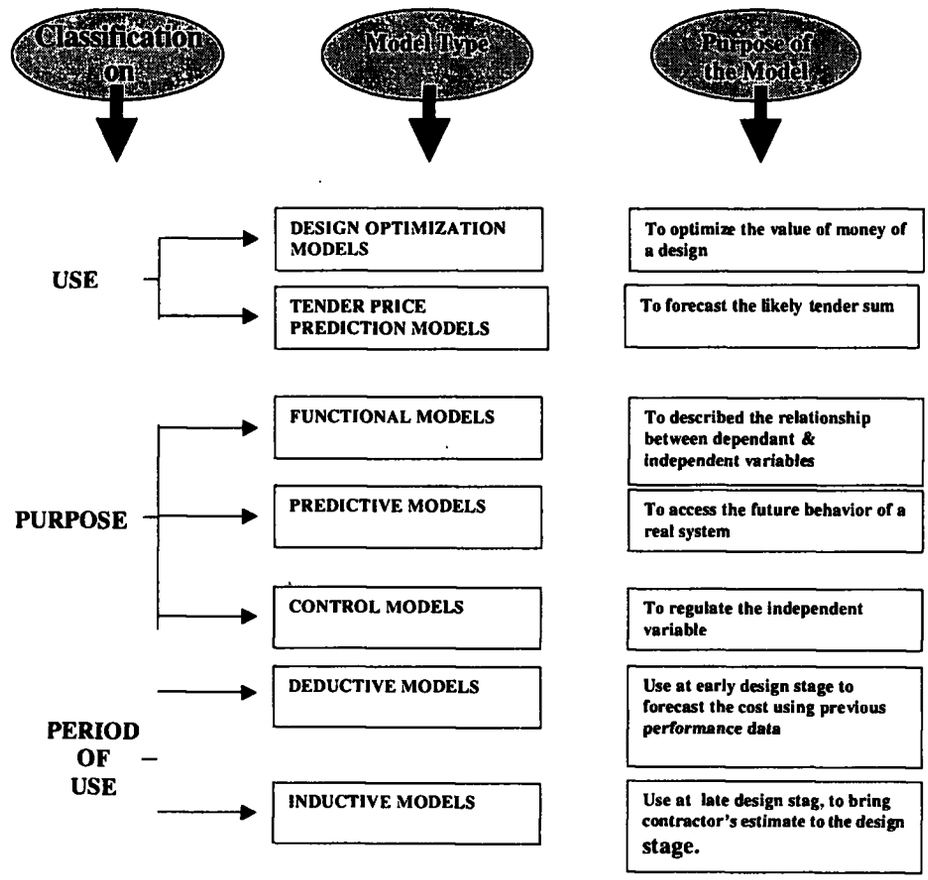


Figure 1: Cost Modeling

developed. Drawbacks of traditional cost models have lead to the modern day cost models using combined methods and knowledge based systems.

3.1 DEVELOPING A COST MODEL FOR ROOFING MATERIAL SELECTION

3.1.1 The Need of a Cost Model

Having abundance of material options for roof covering, insulation and ceiling materials in the construction market, selection of materials according to requirement has been a difficult task for domestic client as well as for construction professionals. There is hardly much product information available at hand to the domestic client or to the construction professionals to advise a building client. Information available is piece meal and hardly any comparative analysis available. Therefore, it is obvious that there should be a proper advisory system to select the most suitable materials that best satisfy client requirements in order to gain the maximum benefits.

3.1.2 Advantages of Having a Cost Model for Roofing Material Selection

Developing a cost model to select roofing materials for domestic purposes will provide numerous advantages to domestic clients, designers and cost advisors in various ways. The cost model will be helpful to select suitable roofing materials giving adequate consideration on cost factors as well as for other performance factors like thermal performance, water tightness etc.

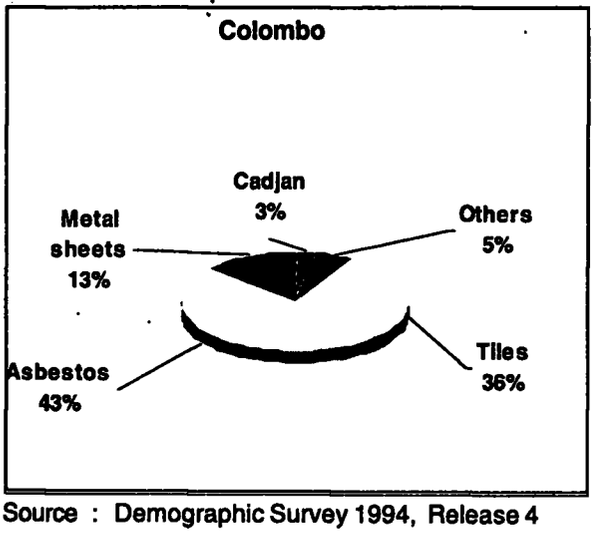
- The cost model will be helpful to get a decision of suitable roofing material by giving consideration on cost factors as well as for other performance factors like thermal performance, etc.
- By having the model a laymen shall not need to depend on sales exaggerations. He will be able to form an independent decision on selection of roofing materials.
- The designers and cost advisors shall put adequate consideration on cost factors when selecting a suitable roofing system for domestic purposes.
- The client and cost advisors shall be aware of all-inclusive average cost figure for a roofing system.

4 THE ROOF

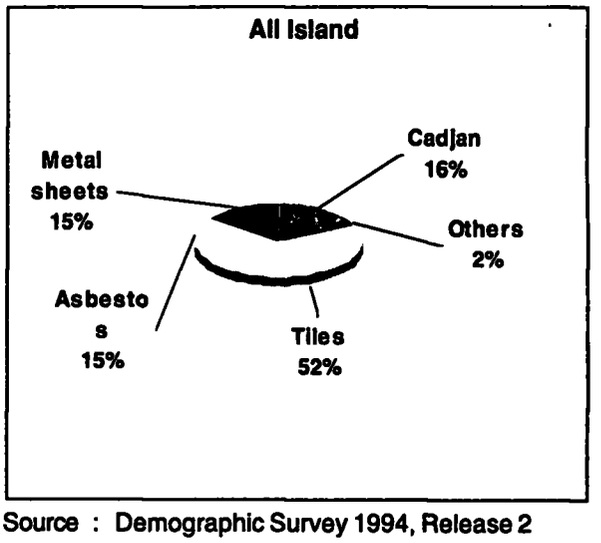
Roof is the building element most exposed to the climatic conditions. The impact of solar radiation, loss of heat by long wave radiation during the night, the rain, and other climatic elements affect the roof more than any other part of the structure (Givoni. B, 1976). The primary function of the roof is to protect the inside of the building from the hostile elements (Lakshman K. D, 1992). Break up of elemental cost shows that the roof cost takes a considerable portion of total cost of a house construction. It is approximately 10-20percentage of the total cost (Perera J, 1992). The roof is one of the main elements exposed to the out side. Consequently its contribution to the aesthetics of a house is also greater. Therefore, to make the house more attractive, it is often required to have an attractive roof.

The roof is not a contemporary product, but it is a result of many experiments and experiences (Lakshman, 1992). New roof systems have been introduced from time to time with additional features like greater thermal comfort, less cost, greater durability, easy of fixing, greater weather tightness and many other aspects of performance to satisfy the requirements of the customer (Coates, 1993).

The uses of roof covering materials are subjected to change from time to time. A greater part of roofs in Sri Lanka had been constructed using cadgen in the early days and it has now gradually converted wards the use of more durable materials. Figure 2 below shows the usage of roofing materials within Sri Lanka by year 1994. Usage of Asbestos cement sheets is more common within the city of the country and Calicut tiles in rural areas.



Source : Demographic Survey 1994, Release 4



Source : Demographic Survey 1994, Release 2

Figure 2: Roof Material Use in Sri Lanka

4.1 ROOFING MATERIALS

The roof is basically a combination of several major components as shown in the table No 1. In order to have a comfort living condition inside a house and to construct the roof economically, selection of proper combination of roof covering, roof structure, ceiling and insulation material is essencial.

Table 1: Materials used for roofing components in Sri Lanka

Roof Component	Available Materials in Sri Lankan Market
Roof covering	Cadjan, G.I sheets, Half round clay tiles, Calicut tiles, Asbestos cement sheet, Colorcon tile, Micro Concrete Roof tiles (MCR), Zn /Al sheet, Coir fiber cement sheet, Reinforced concrete deck.
Roof frame	Timber – Red ballow, Kampus, Mee, Tualang, etcSteel Reinforce concrete
Roof insulation	Glass wool (16Kg /m3 or 24Kg/m3, 25mm thick) with single side Al foil Double side Al foil Polyuthaleen (3,8,12mm thick) Polystrene (for flat roofs) Regiform (for flat roofs)
Ceiling	Timber (Lunumidella, Pine wood) Plywood sheets Asbestos ceiling sheets Hawood plastic ceiling panels.
Rainwater goods	PVC, Zn / Al, G.I
Water proofing	Sheet applications – ECOGUM, DESERT SHIELD MEMBRANCES Liquid applications – SHIELDKOTE, ROOFTEX

Out of various roof covering insulation and ceiling materials, most commonly used materials in Sri Lanka are selected for detailed analysis. Selected materials for the detail analysis are;

Roof covering materials : Calicut tiles, Asbestos cement sheet, Colorcon tile, Micro Concrete Roof tiles, Zn /Al sheet, Reinforced concrete deck.
Insulation materials : Glass wool, Double side Al foil, Polyethylene, Polystyrene.
Ceiling materials : Timber, Plywood sheets, Asbestos ceiling sheets

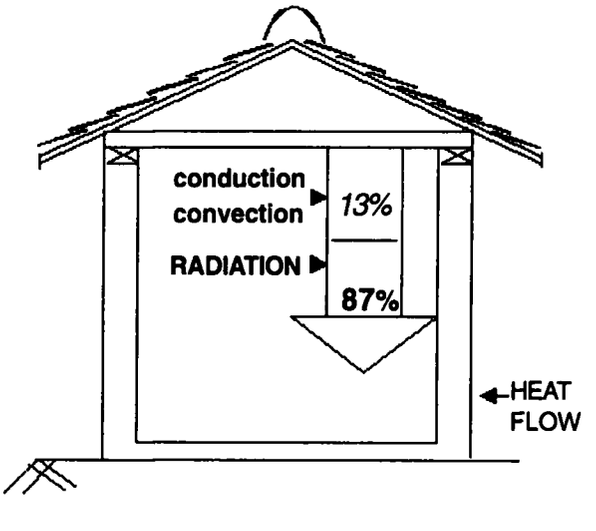
4.2 PERFORMANCE OF ROOFING MATERIALS

Clients basically raise certain common questions, when purchasing or deciding to use roofing material for their houses; as whether the material fulfil the requirement of thermal comfort, water tightness, noise control, durability, easy to maintain and erection, aesthetic appearance, strength, protection from health hazards and economy. In most of the cases, out of all aforementioned factors much more consideration is given for thermal comfort level, water tightness, economy and aesthetic appearance; and priority depends on the qualities of the client like their income level, complexity of house that he required etc. These factors are analyzed in detail in the following sub sections.

4.2.1 Thermal Comfort

Roof modifies the internal temperature, when appropriate properties are chosen. It will be possible to achieve and maintain comfortable internal temperature over a wide range of external conditions (Lakshan, 1999). The roof is the only element, which is unprotected against the radiant heat load from the sun. Increase in the temperature of the ceiling is transmitted to the occupants of the room mainly by radiation as shown in the Figure 3 below.

Figure 3 Proportion of heat flowing down wards from ceiling



To be satisfactory a roof must therefore, absorb as little radiant heat as possible and offer almost complete resistance to heat flow from the outside to the inside (Koenigsberger .O,1965). The factors that may influence the thermal performance of the roof are (Giovni. B, 1976);

a) The thermal resistance of the roofing materials.
b) External surface colour.
c) Ventilation of the attic space.
d) The ceiling height.

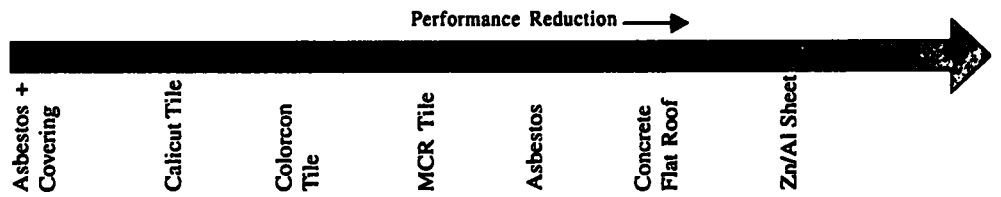
A house to be thermally comfortable, the roof should be designed to have "U" value below 1.5BTU. Lakshan, (1999) ranks some roofing materials available in the Sri Lankan market according to the outcomes of a laboratory test which was carried out to test the thermal performance.

Table 2 : Roof covering materials rank on thermal performance

Roof Covering Material	Rank
Asbestos with covering tiles	1
Calicut tiles	2
Asbestos with whitewash	3
Asbestos	4
Zn/Al	5

The nature and colour of the external surface determine the amount of solar radiation absorbed in the roof structure during the day and the amount of long wave radiant heat loss into the room at night (Giovni .B, 1976). A light external colour is essential in warm regions to have the thermal comfort inside the house. It was found that white washing on the cement based tiles reduce the daytime ceiling temperature to a greater extent (Giovni .B, 1976). Some roofing materials provide adverse thermal performances after its becoming old. Koenigsberger (1965) states that the cement based unpainted roof covering materials gives verse thermal properties after a considerable period of time. Further, the temperature and air exchange rate in the attic space shall be influenced by the ceiling temperature of a house. The airflow across the attic increase the thermal comfort, particularly, if air can infiltrate through gaps between roof covering (David, 1997). Air flow is very high in the case of Calicut, Colorcon and MCR tiles and it is low in the case of sheets like Asbestos, Zn/Al. Roofing materials are ranked according to the knowledge obtained by literature, observations, interviews with material manufactures, uses and by analyzing product data. Given below in diagrammatic and tabular forms are for easy of reference.

Figure 3: Thermal Performance of Roofing Materials

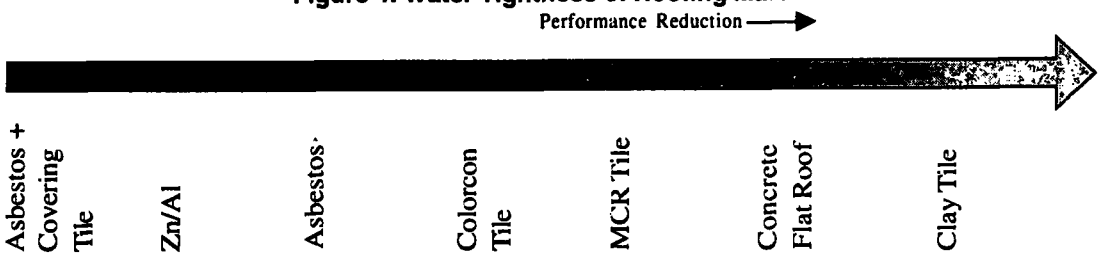


4.2.2 Water Tightness

Table No 03 – Water Tightness of Different Roofing Materials

Calicut Tile	❖ Provide the lowest water tightness, due to not having proper end and side interlocking and high water absorption rate. ❖ Shape of the tile can be changed over wet & dry process and thereby create gaps.
Colorcon Tile	❖ The water absorption rate is low with comparison to Calicut and MCR tiles due to having a smooth external surface-waterproofing layer. ❖ End and side interlocking are better than the Calicut and MCR tiles.
MCR Tile	❖ Having external smooth surface the water absorption is little lower, but not as low as Colorcon tile. ❖ End and side interlocking are better than Calicut tile, but not as Colorcon tile.
Asbestos & Zn/Al	❖ Being sheet materials provides best water tightness ❖ Water absorption is very low.
Concrete Flat Roof	❖ Concrete not being a waterproof material, additional waterproof layer is needed to prevent water absorption and leakage. ❖ The water tightness shall depend on the quality of workmanship and the type of waterproofing materials.

Figure 4: Water Tightness of Roofing Materials



4.2.3 *Durability and Maintenance*

Table 4: Durability And Maintenance of Different Roofing Materials

Calicut tiles	❖ There is a high possibility for calicut tiles to get damaged, so replacing of tiles from time to time is needed. ❖ Fungus are grown on tiles, so, periodical cleaning is needed.
Colorcon tiles	❖ Cleaning of tile is needed to maintain the appearance and thermal properties of the roof. ❖ Re-painting is not needed.
Asbestos sheet	❖ External surface becomes dull gray colour, so, periodical painting is needed to maintain the thermal properties and the appearance. ❖ If white washed on roof surface to get thermal performance, re-painting is required at least once in two-years.
Asbestos with covering tiles	❖ Covering tiles are subject to slip over the time, so, periodical re-arrangement of covering tile is needed.
MCR tiles	❖ Color tiles are subjected to discolour, therefore re-painting is required once in five years time. ❖ There is a possibility for growing of fungus on colour-less tiles.
Zn/Al	❖ Damage to outer coat during transport and erection lead to corrosion of the base material. ❖ Regular cleaning of surface by hosing and removal of debris is essential to preve nt corrosion. ❖ There is high possibility to corrode the cladding in corrosive environment like co astal areas. ❖ No re-painting cost.
Concrete flat roof	❖ Reinforced concrete is usually of excellent durability provided adequate care is taken with the design mix, choice of ingredients, mixing, placing, compacting and curing.Further, the care must be taken to provide adequate clear cover and proper waterproofing system.(Sperling .R,1987)

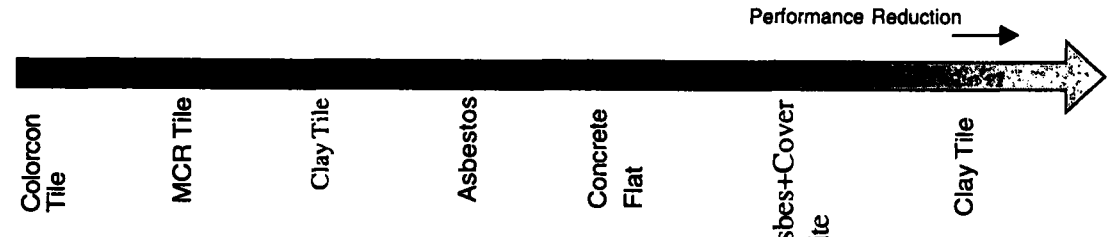


Figure 5: Durability of Roofing Materials

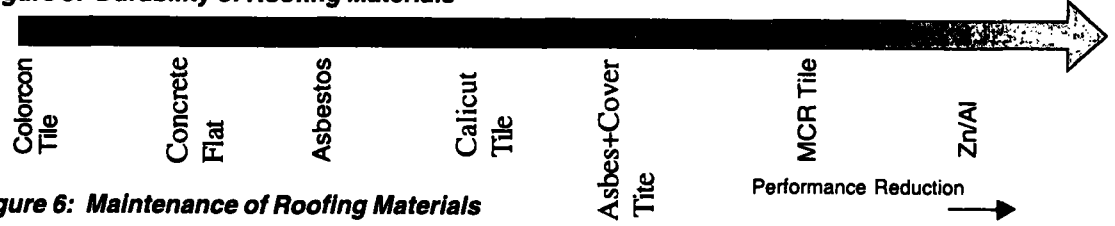


Figure 6: Maintenance of Roofing Materials

3.2.4 Erection, Strength and Weight

Table 5: Erection, Strength and Weight of Different Roofing Materials

Clay tiles	❖ Fixing method is familiar to workers. ❖ Fixing takes a considerable time, due to the complexity of roof structure and tile laying method.
Colorcon tiles	❖ Fixing method is familiar to workers. ❖ Tiles are little heavy and not easy to handle as calicut tiles. ❖ Fixing of tiles using nuts is possible.
Asbestos sheet	❖ Method of fixing is familiar to workers. ❖ It takes the lowest time for erection, but handling of sheet is a little difficult hav ing high weight. ❖ Care must be taken in transporting and handling to avoid damages.
Asbestos with covering tiles	❖ It will take a considerable time for laying the covering tiles.
MCR tiles	❖ Fixing method is familiar to workers. ❖ Take a considerable time for erection, but not as calicut and colorcon tiles.
Zn/Al	❖ Fixing is not much familiar to normal workers. ❖ It is needed to follow correct methods, those specified by the manufacturers to get all the specified performances. ❖ Short period for erection.
Concrete flat	❖ Construction is difficult and takes a considerable time period. ❖ It is needed to follow correct methods and specification to overcome the proble ms of water leakage etc. ❖ Strength highly depends on the design and the quality of work. Further it is nee ded to design the roof in proper manner by a qualified person.

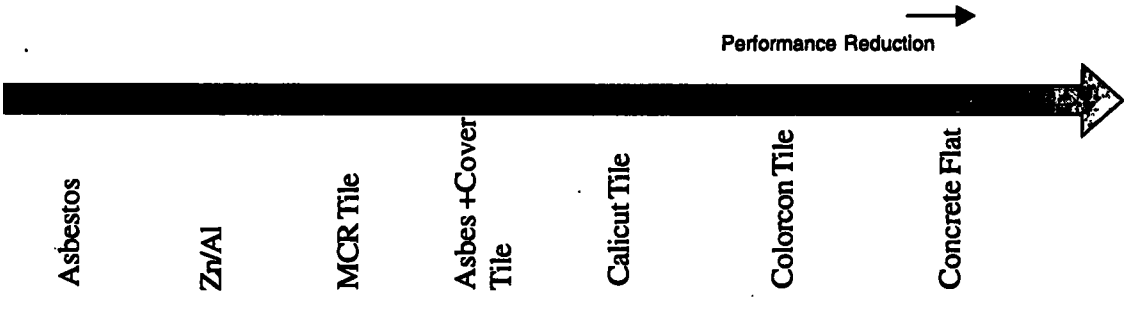


Figure 7: Erection of Roofing Materials

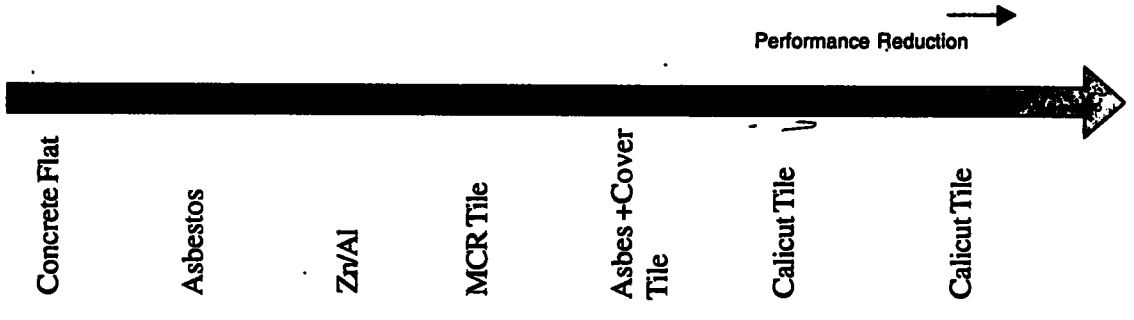


Figure 8: Strength of Roofing Materials

4.2.5 Availability

Table 6: Availability of Different Roofing Materials

Calicut tile	❖ Availability is little low in Colombo area, but commonly used in rural areas. ❖ There are no options for colours and different sizes.
Colorcon tile	❖ Availability is limited. ❖ Different colour tiles are available, but no options for size.
Asbestos sheet	❖ Available almost at every hardware within Colombo area, but it is not so in out side villages. ❖ Few options for sheet sizes(6', 8', 10', 12') and being large size sheets the wastage is high when using for complex type roofs. ❖ No option for colours.
Asbestos with covering tile	❖ Availability of covering tile is very limited within Colombo area.
MCR tiles	❖ Availability is very limited due to not having a considerable number of manufacturers in the country. ❖ Available in two sizes.(600x600 & 500x250mm) and also available in any colours.
Zn/Al	❖ Available only from manufacturers and there are considerable number of manufactures within the Colombo District. ❖ Purchasing of any cut length (up to 12m length) and various colour sheets possible.
Concrete flat	❖ All required materials are normally available in the market other than waterproofing and insulation materials.

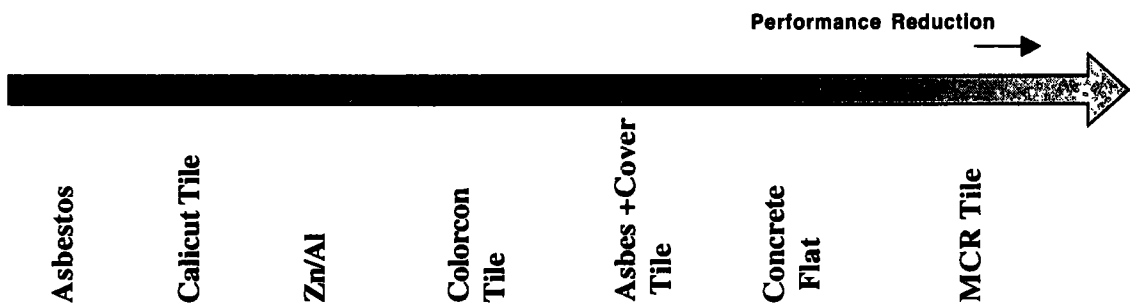


Figure 9: Availability of Roofing Materials

4.2.6 Health Hazard

None of the roofing materials other than Asbestos cement sheets have been suspected as affecting the health of habitants. Asbestos cement sheet are made up of microscopic fibres which, when inhaled in its pure form may constitute a serious health risk. It is associated with two debilitating and terminal illnesses namely, lung cancer and asbestosis (Taylar, 1994). However, the Asbestos roofing and ceiling sheets are widely used in Sri Lanka. There are no records, research nor conclusive proof of any ill effects of the use of asbestos roofing products found in Sri Lanka. Reasons for this may be that the low or minimum quantity of asbestos fibres being used along with a high proportion of cement in the asbestos products manufacturing process.

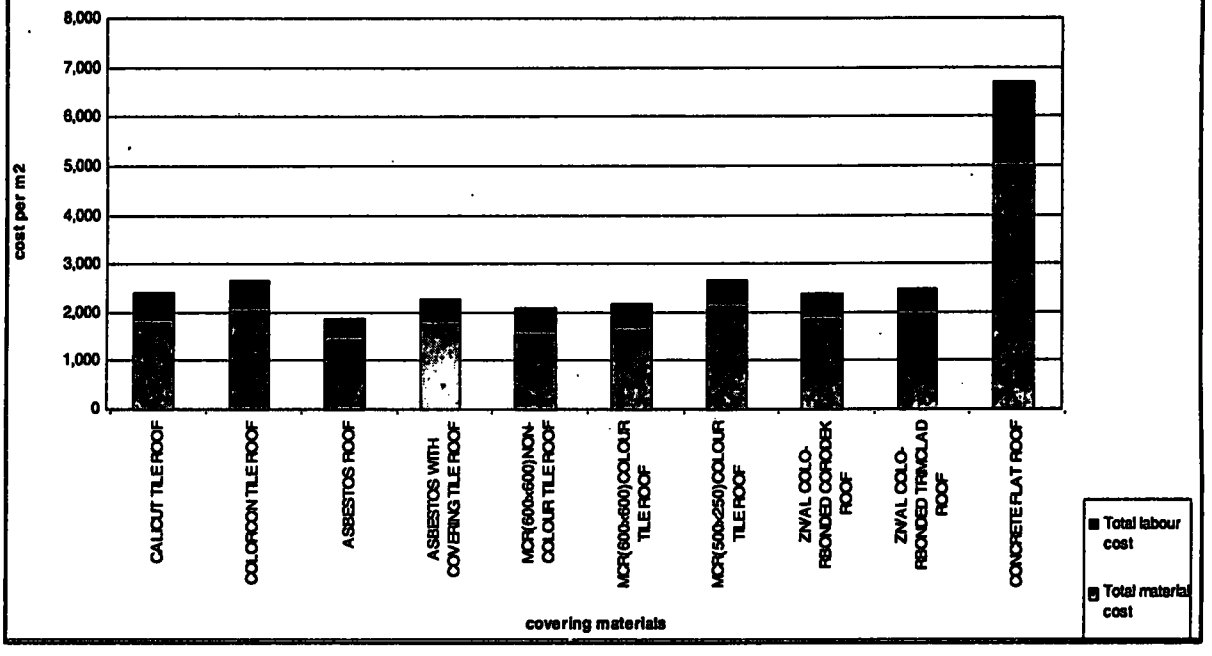
4.3 ROOFING MATERIAL COST

The roof cost not only changes according to the type of roofing material used but also according to the design of the roof. Three different roof designs as simple, medium complex and complex those represent pitched roof, hip roof and roof consist of several levels respectively were selected for the analysis. Basic cost, ceiling, insulation costs and cost of total roofing systems are shown separately. Basic costs represent the cost of roofing systems excluding ceiling and insulation costs.

4.3.1 Basic Cost of a Simple Type Roof

It was found that in terms of basic cost of a simple type roof, the Asbestos roofing system cost was the lowest. It was due to its less material requirement for the construction of the frame and low labour cost. Cost of Asbestos roofing system is 11%, 21%, 27%, 29% and 42% lower than the MCR non-colour tile (600x600mm), Asbestos with covering tiles, Zn/Al CORRODEC, Calicut tiles and Colorcon tiles respectively.

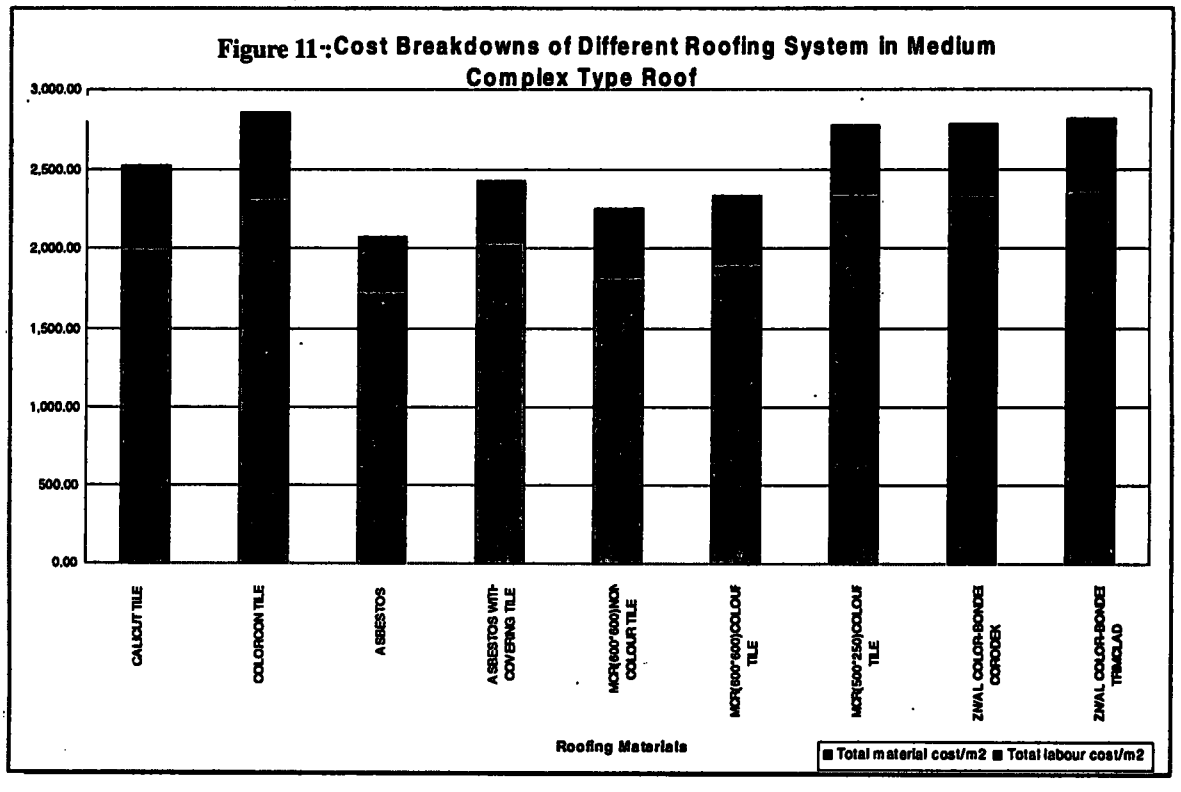
Figure 10: Cost Breakdown of Different Roofing Systems for a Simple Type Roof



4.3.2 Basic Cost of a Medium Complex Type Roof

Asbestos roofing system being the least cost option provides cost saving of 8%, 17%, 21%, 34% and 37% over the MCR (600x600mm) non-colour, Asbestos with covering tile, Calicut tile, ZN/Al CORRODEC and Colorcon tile respectively.

Figure 11:Cost Breakdowns of Different Roofing System in Medium Complex Type Roof

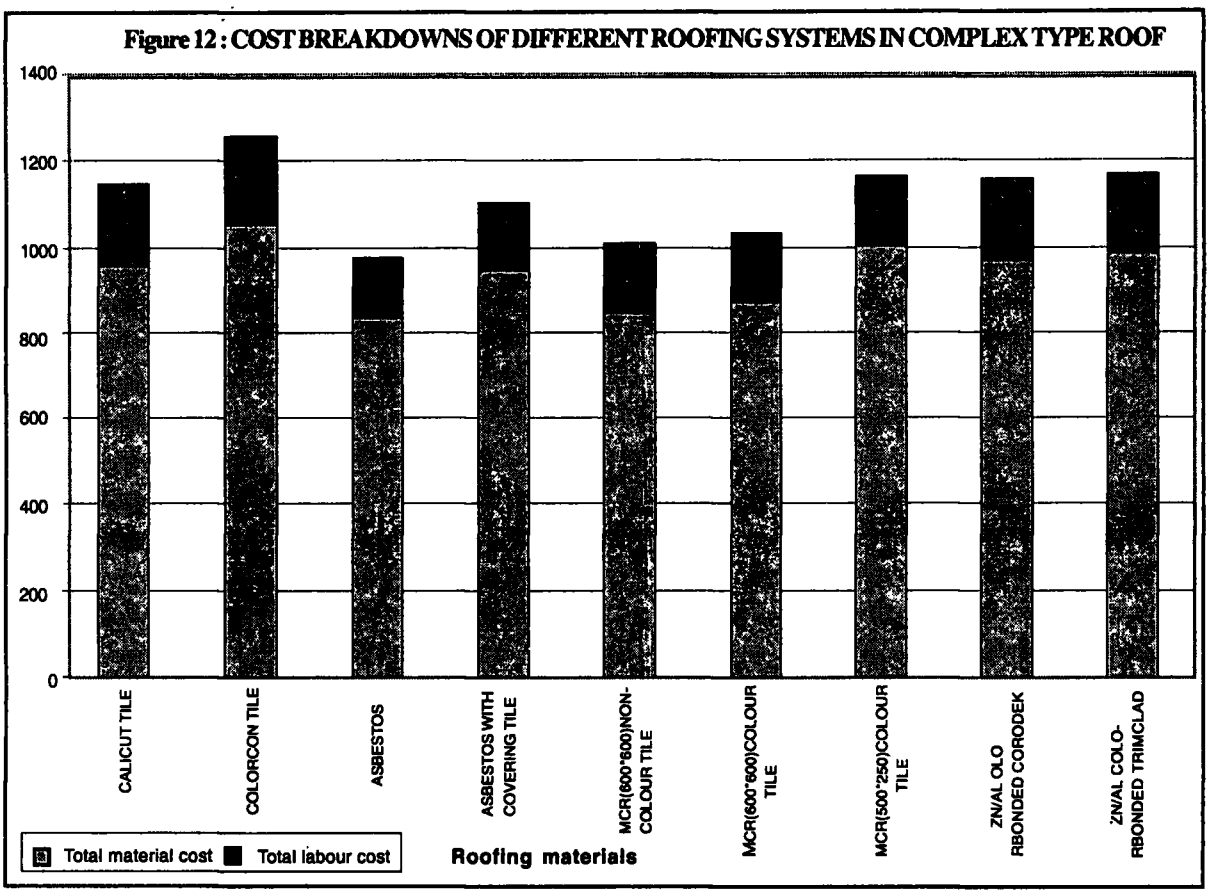


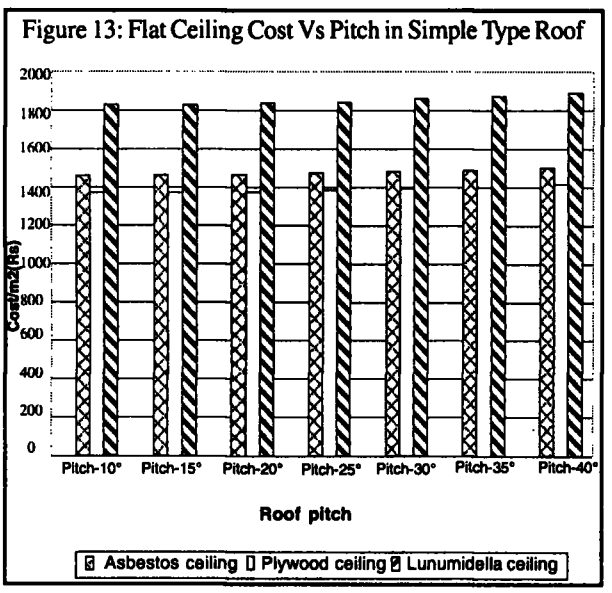
4.3.3 Basic Cost of a Complex Type Roof

Asbestos roofing system gives the lowest cost system even for a complex type roof. It is approximately 3percentage, 12percentage, 17percentage, 18percentage and 28percentage lower than the MCR(600x600mm) non-colour, Asbestos with covering tiles, Calicut tile Zn/Al CORRODEC and Colorcon tile respectively.

4.3.4 Ceiling Cost

Selecting a ceiling type is commonly based only on cost of ceiling material without giving adequate consideration on additional requirements like painting, polishing, labour cost, additional brick work plastering at gable ends particularly in sloping ceilings. Costs of Asbestos and Plywood sheet ceiling are somewhat identical and considerably lower than Lunumidella timber ceiling. Further, it is found that a significant cost saving can be achieved by constructing a rafter exposed Asbestos ceiling with an Asbestos sheets covered roof.





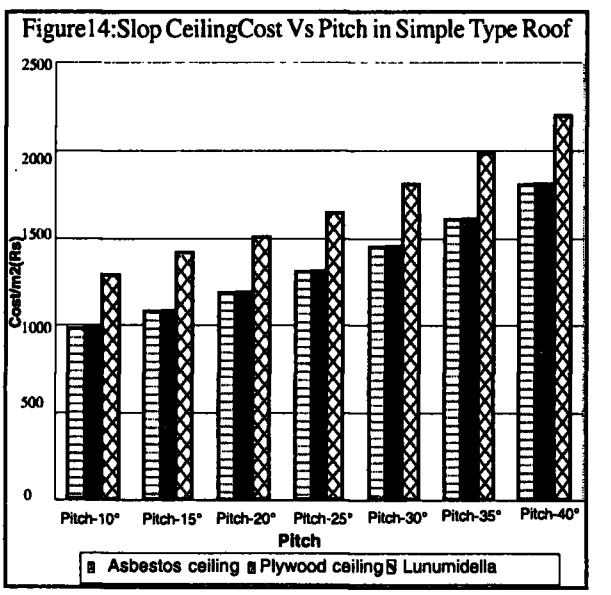


Figure15: Ceiling Cost of a Medium Complex Roof

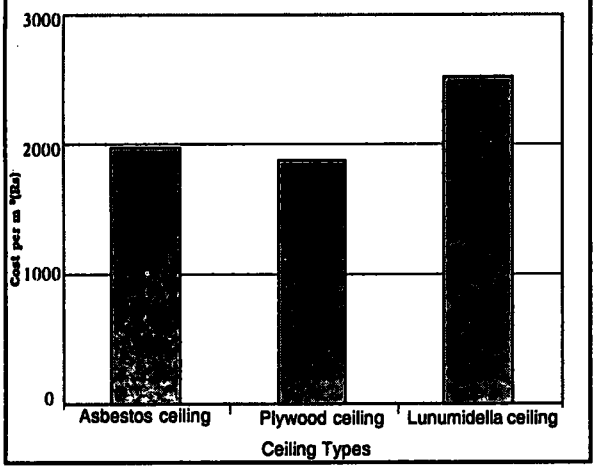


Figure 16: Slop Ceiling Cost of a Medium Complex Roof

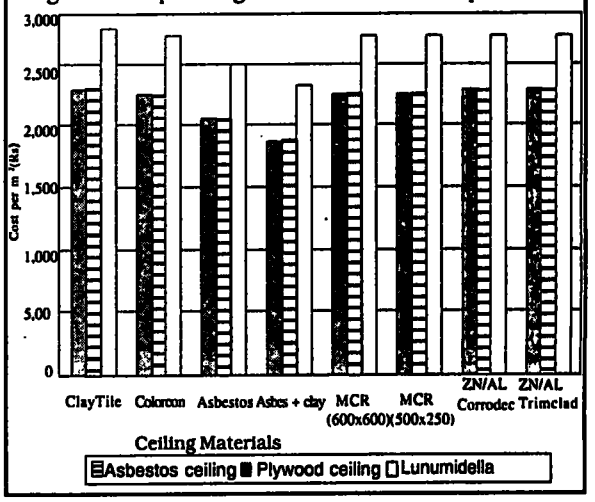
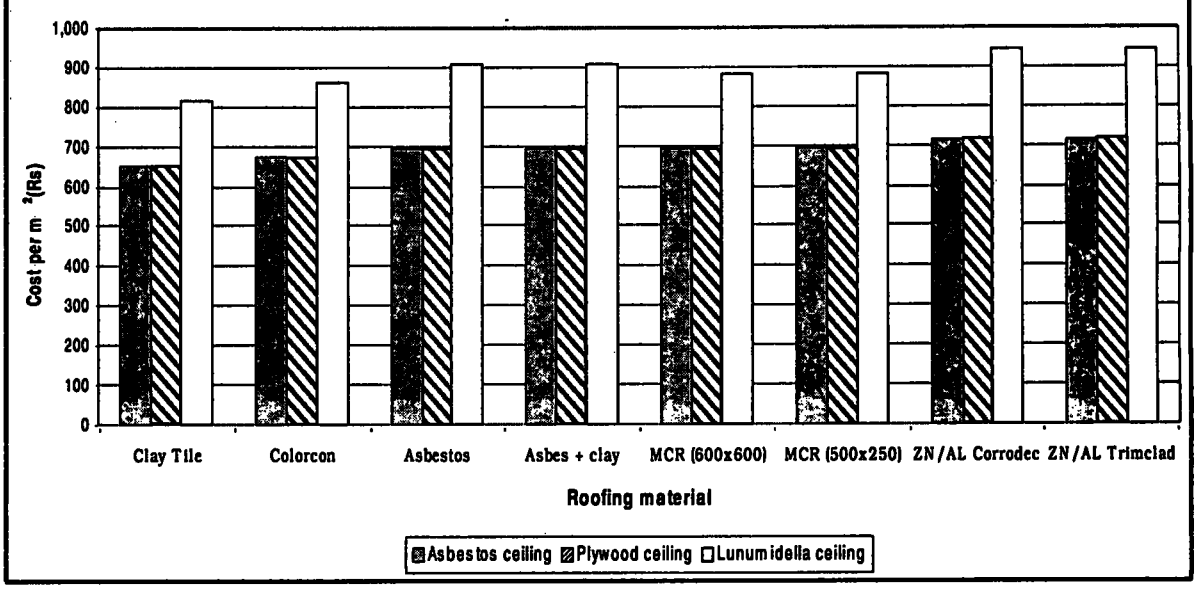


Figure 17: Ceiling Cost of a Complex Type Roof

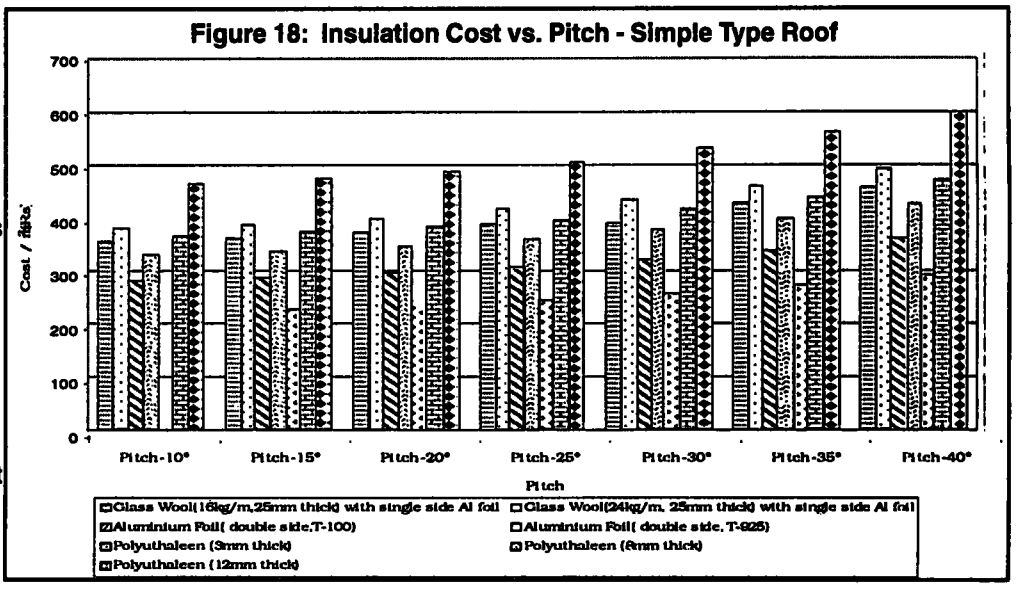


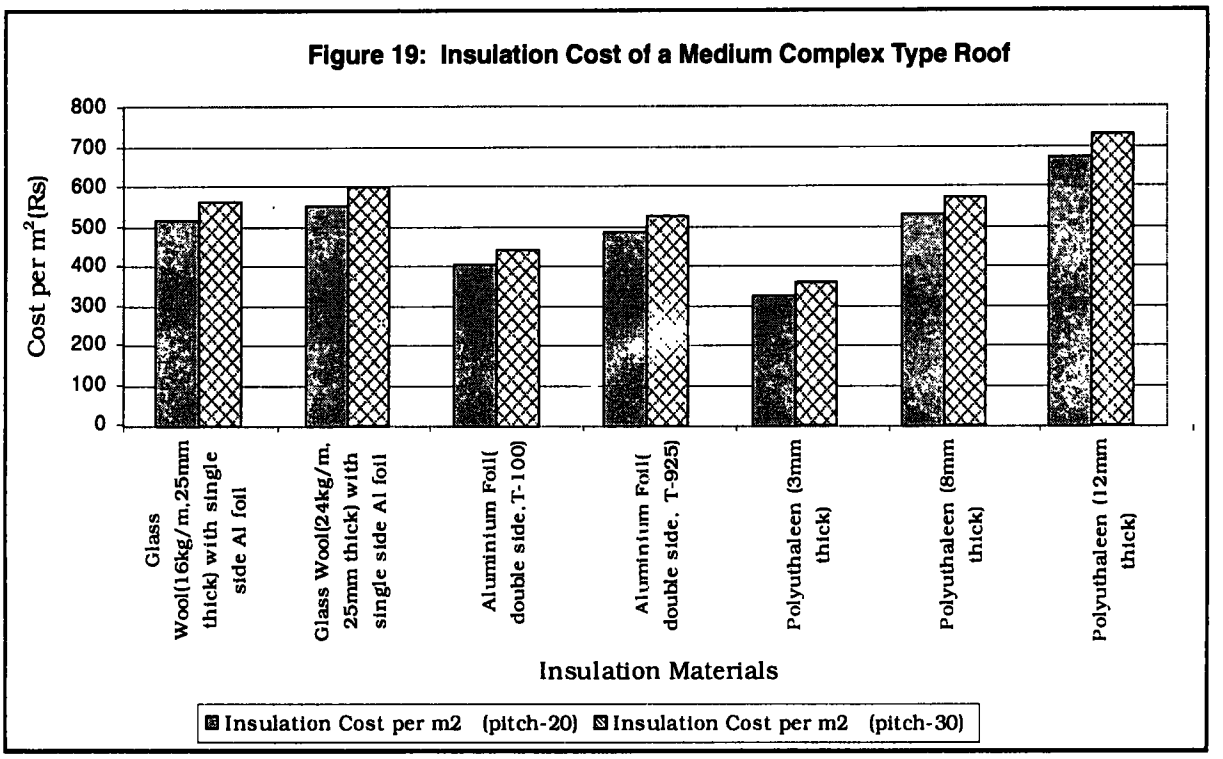
4.3.5 Insulation Cost

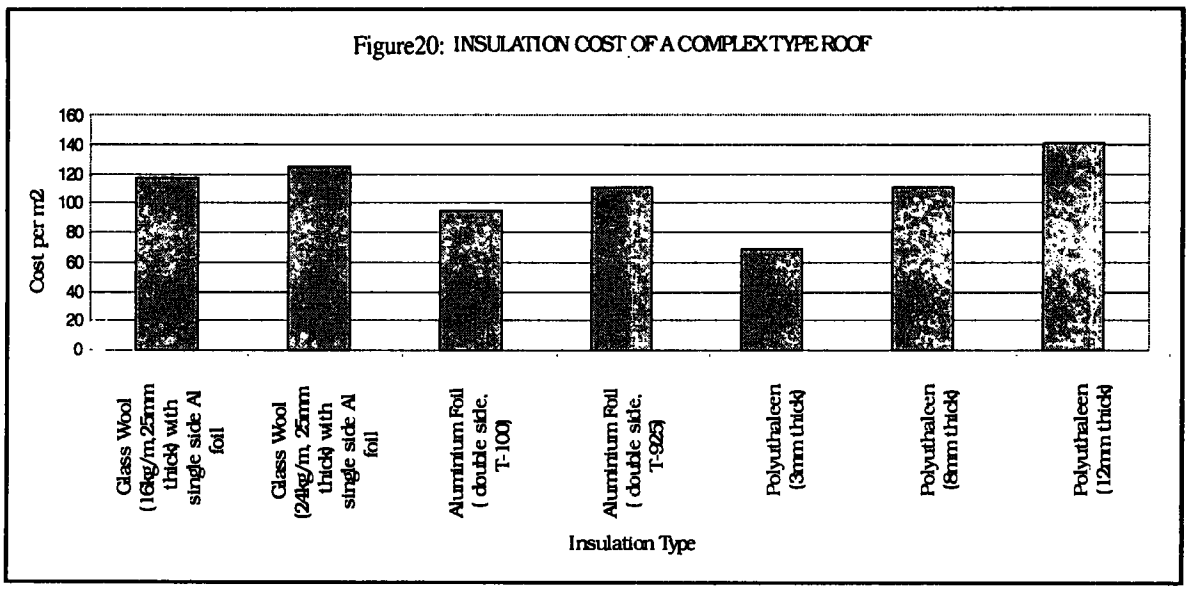
Figure 18: Insulation Cost vs. Pitch - Simple Type Roof

3mm thick Poluthaleen is the least cost insulation material for all roof types. Roof pitch highly influence the insulation cost. As shown in Figure 18 insulation cost increases significantly with roof pitch. It was found that insulation cost increases by about 28% for a roof pitch change from 10° to 40°.

Figure 18: Insulation Cost vs. Pitch - Simple Type Roof







4.3.6 Total Roof Cost

The total roof cost refers to the total of basic roof cost, ceiling cost and insulation costs. Different roof covering, ceiling and insulation material combinations gives different total roof costs for different roof designs. Analysis of total roof cost shows that the lowest cost combination (total cost) for all simple, medium complex and complex type of roof design is given by the Asbestos roof covering with slope rafter exposed asbestos ceiling and 3mm thick Poluthaleen insulation.

3.4Summary of Roofing Materials Performance

Table 7: Summary of Roofing Material Performance

ROOFING MATERIAL	THERMAL PERFORMANCE	WATER TIGHTNESS	NOISE	DURABILITY	MAINTENANCE	ERECTION	STRENGTH	AVAILABILITY	AESTHETIC APPEARANCE	HEALTH HAZARD	BASIC ROOF COST		
											SIMPLE TYPE	MEDIUM COMPLEX TYPE	COMPLEX TYPE
CLAY TILE	2	7	2	3	4	5	6	2	5	1	5	4	4
COLORCON	3	5	2	1	1	6	7	4	1	1	6	6	6
ASBESTOS	5	3	2	4	3	1	2	1	6	2	1	1	1
ASBESTOS WITH COVERING TILE	1	2	2	6	5	4	5	5	4	2	3	3	3
MCR600x600(non-colour)	4	6	2	2	6	3	4	7	3	1	2	2	2
ZN/AL	7	1	3	7	7	2	3	3	2	1	4	5	5
CONCRETE FLAT	6	4	1	5	2	7	1	6	7	1	7	-	-

NOTE – Number 1 represents the best performance.

5. CONCLUSION

The break up of total cost of a building in to elements shows that the roof takes a considerable portion of the total cost of a house construction. This ranges from 10 percentage to 20 percentage of total cost.

The roof is the building component most exposed to the climatic elements. Experiences and experiment on roof performance factors such as cost, durability, thermal performance, etc lead to the improvement of the living condition inside a house. New roofing materials are being introduced to the materials market. The use of Asbestos cement sheet is becoming popular in the Colombo district, whereas in most of other district calicut tiles are still widely used.

When analyzing roofing materials on its performance it become evident that none of roofing materials perform to the highest levels. The importance of performance factors differs from one person to another and is governed according to the client requirements and their income levels. However, thermal comfort, water tightness and economy were identified as performance factors considered important by the majority.

Asbestos cement roofing system was to be found to be having lowest cost over all the other roofing systems considered in each of simple, medium complex and complex type roof designs. It was found that the cost of using other materials reduces considerably with increase of design complexity of the roof. This can be seen as one of main factors to consider in designing roof and selection of roofing systems by the architects.

Another important factor that came in to light was that the cost of Asbestos and Plywood ceiling appears to be identical and is considerably lesser when compared with traditional timber paneled ceiling (eg:- Lunumidella). Further, the use of the method of exposed rafters for ceilings reduces the structural cost of ceilings considerably with a net saving of percentage over traditional flat ceilings.

The use of 3mm thick Polyuthaleen provides thermal insulation of a roof at a lower cost. Adequate consideration should be given to achieving optimum roof pitch as it has a significant effect on the roof cost. The selection of low roof pitch will cut down the roof cost by a greater portion particularly, where rafter exposed ceilings or insulation is used.

The roof system comprising of Asbestos cement sheet covering/Asbestos or Plywood ceiling/ 3mm thick Polyuthaleen insulation gives the lowest cost roofing system cost for a domestic roof. The cost reduction is in excess of percentage compared with the next lowest alternative.

The selection of roofing material must be based on not only the cost factor, but also on other performance factors like thermal comfort, appearance etc. Such a cost model will be helpful to laymen, designers and cost advisors in advising and selection of roofing system for domestic buildings. With the use of this cost model it is planned to develop a knowledge based system that would advise on roofing system selection. This part of the research is in progress at present.

World Wide Web is a place, which anyone can access information from anywhere in the world. A web based information dissemination method on roofing material selection is sure to bring numerous advantages to many stakeholders in the construction industry. It will be an informative decision support tool for the people involved in house construction in their decision making process on roofing material selection.

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