

C 112	C 119	C 126	C 133	C 140	C 147	C 154
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C 114	C 121	C 128	C 135	C 142	C 149	C 156
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## C 112

### **The thermal comfort effects of urbanization: bio-climatic and land-use changes in the Colombo Metropolitan Region (CMR)**

Research on the so-called “Urban Heat Island” (UHI) phenomenon has rapidly progressed from descriptive to complex spatial and temporal variability studies. But the effect of urbanization upon human comfort has received less attention. This is especially the case including cities, including those in Sri Lanka.

In this study, we evaluate the relationship between the UHI and land cover changes in “hard surface” and “green cover” categories in the CMR. Analysis is based on historic climate records from the three first-order weather stations in the CMR (Colombo city, Katunayake and Ratmalana) and land cover changes in these localities digitized from time-series aerial photographs.

It was found that statistically significant climate change has occurred in the CMR. The rate of change varies between the three weather stations in the region: the fastest change has occurred at the fastest increase in “hard” land cover. Based on this finding, policy implications and directions for further study are considered.

## C 113

### **Effect of roof materials on the thermal performance of passive buildings**

For houses built in Sri Lanka, roof is one of the main sources of heat gains. Therefore, it is useful to select an appropriate combination for the roof covering and ceiling materials possibly with insulation to minimize the thermal gains. It is also necessary to strike a correct balance in this material selection since the strategies used to minimize the heat gains can inhibit the cooling of the structure during the night. This could make the indoors too warm when the outdoor is quite pleasant.

It is shown with computer simulations that the calicut tile roofs can perform better than cement fibre roofs. Still, tile roofs fail to achieve the indoor temperatures desirable to provide thermally comfortable conditions such as 30 °C with enhanced ventilation. When polystyrene type insulation material is used along with the reflective type, the performance did not change appreciably. The performance of the cement fibre sheet roofs during daytime can be marginally improved by covering the sheets with two layers of half tiles. The most significant improvement was noticed when the reflective

type aluminium foil is used to reduce the amount of heat transferred. Thus the ideal roof from for Sri Lanka is cement fibre sheets or calicut tiles with reflective type insulation.

#### **C 114**

##### **Material properties of slip-forward load bearing wall punch for low-cost medium-rise buildings**

The special composite material under consideration consists of cement, crusher dust and coir and it is begin used to build walls of structures using a special construction technique called slip-from method. This technique was first introduced by Dr. A.N.S. Kulasinghe in mid 80a as a low cost and rapid method of construction.

Now the slip-formed walls are used as load bearing walls combined with pre-cast pre-stressed columns and composite slabs in multi storeyed buildings with repeated floor plan. However, the application of this technique is limited to 5 storeyed buildings as yet and a thorough investigation is required to explore the possibilities of extending the same technique to 8-12 storeyed buildings.

The results of a comprehensive experimental program, carried out to obtain the essential mechanical properties of the composite material are as follows for mix proportions increasing from 1:12 to 1:8 cement: quarry dust by volume. The Young's modulus increasing from 2.4 GPa to 9.3 GPa and Possion's ratio decreases from 0.17 to 0.11 with the increasing cement content. There is also a progressive increase in compressive strength with age which range from 0.505 MPa (1:12 at 1 days) to 5.193 MPa (1:8 at 28 days).

Using above results, the allowable compressive strengths can be determined at each floor level for different wall thickness at different ages. This was compared with the ultimate vertical load at different floor levels for unit length of the load bearing wall, due to factored dead and imposed loads. As this is only an initial measure off feasibility, the effect of slenderness of the wall was not taken in to account. The results indicate that this material can be used up to 8 storeyes, keeping the wall thickness at 9 inches. It is envisaged that the number of floors can be further increased using a stronger mix proportion such as 1:6 while maintaining a consistent wall thickness at lower floor levels. The characteristic strength of the composite material for different mix proportion and the appropriate factor of safety for material can be introduced to the design guidelines once sufficient test data are available.

From this preliminary investigation it can be concluded that this composite material can be used to construct load bearing walls up to 8-12 storeyes and it is worthwhile extending this experimental program to explore the other material properties such as tensile strength, flexural strength and also the material properties of mix proportion 1:6.

#### **C 115**

##### **A new composite construction material for low cost underground water tanks**

There is a great need to construct low cost underground water tanks in the dry zone of Sri Lanka to enable rainwater harvesting. A research is conducted to introduce the said tanks with the use of low cost materials. Mainly cylindrical tanks with spherical domed roofs were analyzed.

Analytical results revealed that high tensile develop near top and bottom joints of the cylindrical wall. As the tank diameter increases, the tensile stresses near the joints also increase. Lesser the depth of cylindrical wall, lesser the earth confinement, resulting in high tensile stresses near the joints. Therefore tensile strength of construction materials is a governing factor which will limit the storage capacity.

Maximum tank diameter that can be achieved using brick masonry is only about 2.0 - 2.5 m, since the tensile strength of brick masonry reinforced with wire mesh for the cylindrical wall. With this new composite material, diameter of cylindrical wall can be increased up to about 6m, as it possesses a fairly high tensile strength.

It is necessary to reinforce both inner and outer surfaces as high tensile stresses develop on both sides. Outer wire mesh can be extended only up to a required distance from the joints, where the tensile stresses are high, but it is recommended to have the inner one on the entire surface area to minimize shrinkage cracking of brick walls.

## **C 116**

### **Evaluation of usability of Gamboge for paintings and interior decoration**

Gamboges is a brilliant yellow coloured organic pigment that had been widely used in the Kandyan period mural paintings. It is the hardened latex objective of improving the quality of the pigment in order to promote its contemporary usage. It needs the determination of the quality, performance and survival pattern of gamboges paint, mechanisms of its decay and selection and testing of improved preparation methods of the paint.

The chemical composition of gamboges latex was studied. The tests used for the preliminary detection of the pigment in sites and confirmatory tests done in the laboratory are discussed. The traditional method of preparation of the paint was investigated. The survival patterns of the paint were studied in respective sites with a thorough investigation of problems present and the possible causes of them. The performance of paint in each site was determined.

The causes of deterioration of the pigment were analyzed and relevant methods for the improvement of the quality of the pigment were investigated. Particular attention was given to the enhancement of the paint with contemporary technology. Its applicability for modern painting and interior decoration is discussed giving particular attention to the preparation of the paint and relevant internal conditions for the survival of the paint. The feasibility of using the water-soluble portion of the latex as a dye is also studied. Detailed studies have been done to use the dye to colour porous building material.

C 117

### **Quantifying level of sustainability in construction projects through Eco-labeling of materials**

With the emerging era of sustainable development, the term “environmental friendly construction” becomes a major theme in construction industry. So that, there is a considerable need to have a measurement criteria for quantifying the level of environmental impact of a construction project.

This paper examines closely and objectively on all sustainable construction indicators. The study has identified ten key indicators out of which, the building materials and their environmental impacts are further analyzed to provide Eco-labeling Indices.

According to this analysis, it was clearly shown that clay bricks, clay-roofing tiles, stone and sand are the most e-friendly construction materials because of the simplicity of production process and scarcity of natural resources. This material index provides a good foundation to measure the level of sustainability achieved in construction projects.

Hence, this index can be recommended to be used in sustainable construction planning monitoring and analysis during the whole project life cycle. The format of the Bill of Quantities can be modified to incorporate this index to achieve the “Social cost” of a project against the traditional “Project Cost”. Finally, the government can use this as an important monitoring instrument to decide incentives for mitigation measures taken or quantify penalties for environmental damage caused during a construction project.

C 118

### **A novel method of tiling cement floors without chipping the surface**

Floor tiling with ceramic tiles, porcelain tiles, marble slabs or granite slabs is the present trend. Compared to cement, terrazzo, terra-cotta and wooden floors, which have to be polished at frequent intervals, tiled floors are durable and easier to maintain. Hence, in many newly constructed houses and commercial buildings the floors are tiled. In many existing houses and commercial buildings too, cement and terrazzo floors are being converted into tiled floors.

The traditional practice, when lying tiles on existing cement or terrazzo floors, is to manually chip the surface with chisel and hammer to create sufficient roughness on the surface, so that the new layer of cement mortar will adhere well to the old surface. However, this practice is extremely inconvenient, because of the sound, the dust and the debris. This problem is compounded, if the process is carried out in a upper floor in a multi-storey building. Due to the vibrations created during the chipping process, cracks can develop in the floor and the adjacent walls, causing structural weaknesses. Since the process is manually carried out in a dusty environment, a uniform roughness cannot be created by this process.

The proposed novel method is clean and convenient. It consists of two stages. During the first the floor is dewaxed and cleaned using a wax stripping detergent. During the second stage the floor is roughened to a desired level of roughness, by using a mixture of chemicals.

Since, wax is removed and the floor is uniformly roughened to the desired level, the adhesion of tile bonding material to the floor will be very good, resulting in high strength. The process is noiseless, clean, no dust or debris, no damage to the floor or walls and no inconvenience to the occupants and the neighbours. The wax stripping detergent used is a mixture of anionic and non-ionic surfactants and petroleum solvents. The roughening chemical used is a mixture of hydrochloric, sulphuric and phosphoric acids.

## **C 119**

### **Seed lime bricks using level raw materials**

Calcium Silicate brick generally known as sand-lime brick is considered to be one of the improved building materials when compared with common clay bricks. The research on sand-lime bricks was focused on the following aspects:

(i) study on use of local raw materials, (ii) optimization of processing condition, (iii) study on properties of brick samples made in the laboratory. Laboratory trials were carried out using the following types of hydrated lime and sand.

Shell lime: obtained from Lanka Ceramic Ltd, at Hungama, Dolomitic lime: Obtained from State Engineering Corporation at Matale. Lime made in laboratory: Hydrated lime samples prepared in the laboratory from Miocene limes samples collected from Aruwakkalu. Dune sand: Sand having a very fine particle size gradation was collected from dunes in Puttalam area. Crushed rock sand: Available as a by-product of metal quarrying collected from Keangnam quarry at Athurugiriya. Steel mould (100 mm x 100 mm x 600 mm), hydraulic pressure machine and laboratory type autoclave were used for the trials. Test samples were prepared as follows to study the properties of lime-sand bricks.

Raw materials → Sieving → Mixing → Water spray → Pressing → Autoclaving

Results of laboratory trials indicated that attempts to make bricks made out of dolomitic lime was not successful because of expansion on autoclaving. Samples made from shell lime (from Hungama) and dune sand showed a 70% increase in strength over burnt clay bricks of type 1 (compressive strength  $\sim$  N/mm<sup>2</sup>). However, samples made out of laboratory made lime showed comparatively low strength.

Manufacture of sand-lime bricks can be easily carried out in Sri Lanka using local raw materials. It will not further exploit the use of valuable clay resources which could be used for purposes other than brick making.

## **C 120**

### **Sand lime bricks using level raw materials**

Cement mortar and concrete are used extensively to construct foundations of buildings, load bearing walls, columns and beams, partition walls, concrete roofs prefabricated columns and beams, partition walls, concrete roofs, prefabricated columns and beams and a host of other activities such as plastering of walls, paving of floors of floors and the like. In many instances steel is used as the reinforcing material. Cement mortar and concrete have surface porosity as well as internal porosity. Most of the components made out of cement are exposed to natural elements. Acidic, alkaline as well as saline solutions of water, resulting from rain, dew, sea breeze and ground water can seep into these pores and chemically attack the cement as well as the steel reinforcement. This process, if not controlled, could adversely affect the strength and the life span of the building.

Surface waterproofing of cement mortar and concrete could minimize the surface porosity, thereby minimizing the absorption of water and hence, the chemical attack on the cement as well as the reinforcement steel. This paper presents results of research conducted on surface water proofing of cement mortar and concrete by applying inorganic and organic chemicals on the surface. The inorganic chemicals that have been tested are aqueous solutions of calcium chloride (CC), sodium silicate (SC). The organic chemicals that have been tested are solutions of alkyd resin (AR), microcrystalline wax (MW) and paraffin wax (PW).

Test results indicate that surface water proofing can be achieved by application of these chemicals. However, the durability of the water proofed surface can be ranked as follows, where rank 1 gives the highest durability.

Rank 1: Non-aqueous solution of Microcrystalline Wax (MW), Rank 2: Non-aqueous solution of paraffin wax (PW), Rank 3: Aqueous solution of calcium chloride (CC), Rank 4: Aqueous solution of sodium silicate (SS), Rank 5: Non -aqueous solution of alkyd resin (AR).

## C 121

### **Surface water proofing of cement mortar and concrete**

The extensive use of traditional building materials like bricks and sand has caused considerable environmental problems in Sri Lanka. Therefore, there is a need to find alternative building materials that will reduce the use of sand and bricks. Cement stabilized soil blocks manufactured with laterite soil is one of the alternatives. These are generally manufactured using machines. This makes it less accessible to communities in rural areas. Therefore, it is useful to determine the strength characteristics of manually compacted blocks.

It is shown with a detailed experimental programme that blocks produced with either 2% or 4% cement contents can give good strengths when the fines content is less than 30%. The compaction ratio is 1.65. The estimated wall compressive strengths for these blocks were in excess of 0.9 N/mm<sup>2</sup> which is quite sufficient for single storey houses. Any laterite soil can be modified by adding sand to contain the fines less than 30%. When soil is available at site, even with the paid labour the cost of a block was Rs.3.50/= or Rs 4.50/= with 2% or 4% cement respectively.

Since the dimensional accuracy is high the block walls can be given a pleasing appearance without plastering, thus the demand on sand also can be reduced. Therefore, manually compacted cement stabilized soil blocks can be considered as an environmentally friendly cost effective material.

## **C 122**

### **Settlements of wide foundations in laterite formations**

The construction of tall structures on laterite formations using a raft foundation is rare because of the inability to estimate accurately the settlements of such foundations. Very little published information of such settlements is available. Large scale testes are rarely attempted because of the costs involved unless they are made part of the construction process. However, when such testes are carried out, their results can be made use of to establish geotechnical parameters for future design.

This paper presents the results and analysis undertaken on the field settlements measured in Water Load Tests on two tanks of diameter 22 m in a hard laterite formation of average thickness 12 m. Settlement measurements were made on the foundation ring beam at 8 stations equally spaced on 45° sectors on the periphery of the tank during the cyclic loading and unloading of the tank. Several sets of readings were taken during the cyclic loading and unloading of the Water Load up to maximum design load of 165 kN/m<sup>2</sup>.

These settlements were first analysed to determine the rigid body settlements and out-of-plane settlements of the rigid ring beam. This showed that i) the settlements obtained during first loading consisted of an immediate settlement which increased non-linearly with load, together with a creep settlement at constant load; (ii) during the first loading of the virgin soil, whereas total rigid body settlements of 150 mm had been measured at maximum design load, the maximum out-of-plane settlement was only (3-4) mm ; (iii) very little settlements were associated with an increase in tilt of the tank; and a decrease in out-of-plane settlement. Analysis was then carried out with elastic theory, and the equivalent elastic modulus at maximum design load associated with the laterite formation of average SPT values in range of (15-20) was found to be 5300 kN/m<sup>2</sup> .

## **C 123**

### **Modification of the conventional laboratory tri-axial testing apparatus to test unsaturated soils**

In many tropical regions, including the hill-country of Sri Lanka, slope instability during rains poses a major problem. In the partially saturated zone of the soil cover in these regions during dry seasons, negative pore-water pressures are set up due to surface tension, giving rise to high matric suction values. The term matric suction refers to the difference between the pore-air and pore-water pressures. High matric suction gives rise to high apparent cohesion, resulting in higher safety margins against slope instability

during dry season. Saturation during rainy season destroys the high matric suction, thus lowering the safety margins and triggering landslides.

In order to investigate the variation of shear strength with moisture content of a partially saturated soil, it is necessary to carry out tri-axial testing with separate pore-air and pore water pressure measurements. The existing conventional tri-axial apparatus was modified for this purpose, by introducing means of applying distinctly different pore-water and pore-air pressures to the soil sample, along with the use of high air-entry disks to prevent air in the sample from migrating to the pore-water pressurizing system.

The efficiency of the modified tri-axial test apparatus was tested by using soil obtained from Dambulla International Stadium site. Two specimens were prepared for tri-axial testing from the above soil under density and optimum moisture content (as determined by the Proctor Compaction Test). The results obtained by tri-axial shearing of the two specimens are identical for all practical reasons, indicating the repeatability of the shearing testes. This result verifies the reliability of the modified tri-axial apparatus, which can hereafter be made available for developing shear strength functions and soil-moisture characteristic curves of local soils.

## **C 124**

### **DTA testing for expansive characteristics of some local soils**

Expansive soils and their related engineering problems have been reported in many countries. In recent years during the constructions of the one million housing programme, there were various complaints about cracking of buildings from the Kataragama, Ambalantota and Hambantota districts. Later it was realized that those sites contained expansive soils. Expansive soils found in Sri Lanka are probably those formed from the metamorphic rocks which have undergone considerable weathering to form the montmorillonite mineral.

Differential thermal analyses (DTA) are useful when the presences of deleterious materials, particularly the clay minerals are expected. The different temperatures required to extract structural water from the lattices of clay minerals reflect the clay-mineral types. In this test a curve of the temperature difference between the test material and reference material (alumina) is drawn on an automatic recording drum. Each type of mineral yields a typical characteristic curve.

DTA testing was carried out for soil samples collected from five sites, these being the Dambulla International Stadium Site and the landslide sites of Naketiya, Kahagalla, Walhaputenna and Beragala. The purpose was to investigate whether these are expansive soils or non-expansive soils, and classify them as such. When the DTA testes were carried out, the resulting DTA plots indicated that none of the samples contained the montmorillonite clay mineral. Therefore all these soils can be classified as non-expansive soils.

**Methods of improvement of engineering properties of peat - A comparative study**

The need of the improvement of engineering properties of peat is higher with the development, especially in Colombo and suburbs of Sri Lanka, since lands with good sub soil conditions are already used up. Therefore development of cost effective methods for strength and stiffness characteristics of peat is the major challenge for the Geotechnical Engineers. The improvement methods of pre-consolidation and deep mixing with cement or lime were studied through a series of laboratory tests conducted for peats with different degrees of humification. Improvements in both primary and secondary consolidation characteristics were studied. Effectiveness of the techniques were compared considering the behavior of; a completely remoulded with the addition of 5%, 10% and 15% by weight and peat specimen remoulded with the addition of 15% lime. It was shown that the pre-consolidation causes a significant improvement in both primary and secondary consolidation characteristics irrespective of the degree of humification. No significant improvement was shown in fibrous peat even after mixing of 15% cement or 15% limes. A significant improvement was shown in all types of peats. Some improvements of untrained shear strength were also shown with the addition of cement and the degree of improvement was higher over the amount of cement addition and over the curing time. However, the improvement was not as high as reported case histories for inorganic clays.

**Studies on bamboo reinforced earth retaining structures**

Different forms of internally stabilized systems based on the reinforced earth principles had been developed in various parts of the world. For developing countries further advantages could be gained by incorporating locally available material. Model studies were carried out in this research to study the behaviour of Bamboo reinforced earth retaining structures and to develop a rational design method.

Model earth retaining structures were constructed using Bamboo reinforcements and Aluminium facing in a Perspex box, kept inside a self contained loading frame in the laboratory. The box was fabricated with slotted angle sections and Perspex sheets were used in three sides to observe the failure patterns. No Perspex sheet was used in the side of the wall facing.

Models were done with both sandy materials and lateritic fill materials. A sandy soil that was made moist by adding 10% of water was used. Lateritic fill material was compacted at its optimum moisture content with a compaction effort equivalent to that in the Proctor Test. Models constructed inside the Perspex box was loaded vertically by jacking against the self contained loading setup. Vertical load was applied in stages and the outward movement of the wall facing was measured. Careful observations were done through sides of the Perspex box to identify the development of cracks and failure patterns.

Two types of loading; A load applied within the reinforced zone and a load applied behind the reinforced zone were used. The first case represent a situation where the load is applied mainly on the on top of the reinforced wall. The latter case represent a case of a wall done at the foot of a slope to provide stability. Models could be loaded to very high loading intersities when loaded on top of the reinforcements and they failed at much lower loads when loaded behind the reinforced zone. However, the failure loads were much higher than that correspond with a conventional gravity wall of similar weight.

Pullout resistance of bamboo meshes was also determined experimentally. Based on these information obtained a design method was developed for Bamboo reinforced earth retaining structures. In order to study the long term stability of these structures, Bamboo reinforcements treated with copper sulphate, potassium dichromate and coar tar were buried in an embankment along with untreated Bamboo reinforced earth retaining structures could be good alternative to the more expensive forms.

## C 127

### **Use of Soil nailing Technique in Stabilizing the Natural Slopes in Central Sri Lanka**

Slope failures are a common occurrence in many parts of the hill country in the periods of heavy rain causing loss of lives and property. Remedial measures taken have not been effective in some cases. Therefore it is necessary to develop new methods to stabilize such slopes.

Soil Nailing is a practical and cost effective technique to stabilize slopes and embankments through the introduction of reinforcing elements in to soil mass. Nails can be driven or inserted into pre-drilled holes followed by grouting. Nails are not stressed initially, but as the soil mass moves, tensile forces are mobilized in them to stabilize the slope. The technique is widely used in many countries around the world and the proven adveantages of low cost, speed of construction, design and construction flexibility and compatibility with the environment led us to investigate the applicability of the technique to Sri Lankan conditions.

Main objective of the research is to study the behaviour of soil nailed structures in Sri Lankan conditions and to find the improvements achievable in the stability of the slope. Records from the past slope failures n=have shown that the failure surfaces in these lateritic formations are sometimes non circular. Therefore two analytical models were developed considering both circular and non circular modes of failure. The two models utilize the Bishop,s simplified method and the Janbu's simplified method respectively. Parametric studies were done to illustrate the potential of soil nailing technique.

Laboratory test programs were conducted to obtain the pullout resistance of nails in Sandysoils and in lateritic soils. Pullout resistance was expressed in terms of the bond coefficient  $f_b$ . As the second phase of the research, laboratory model slopes will be constructed and loaded to failure. Data relating to the failure surfaces will be recorded and the models slopes will be bank anltyzed using the models developed. A model slope without nails was already tested with a sandy soil.

In the final phase, soil nailing arrangements will be designed to stabilize some critical slopes in the hill country and the effectiveness of the technique will be evaluated.

## C 128

### **Analysis of Municipal Solid Waste (MSW) generation and waste characterization in Sri Lanka**

Disposal of Municipal Solid Waste has become a major problem in Sri Lanka. The impact of this problem is sensitive to our social, health and economic development. Since, Municipal Solid Waste is qualitatively heterogeneous; it is difficult to find a unique solution for proper disposal. I.e. The solution is always an integrated one, which consists of biological/thermal/chemical treatment, recycling and land filling. However quantification and characterization of solid waste is an important factor prior to select the suitable technology. Therefore, it is required to find the waste quantity, composition, density, moisture content, annual growth rate of waste generation and calorific value of waste ect. As the moisture content and organic fraction is reasonably high and lack of high thermal value materials in solid waste stream, has led to overall calorific value of MSW in Sri Lanka.

Some waste analyses were done with simple methods to find out the waste density, composition and total waste quantity in selected areas. Then the composition was categorized as Non-biodegradable, long-term biodegradable and short-term biodegradable materials. After that, the results were compared with the data in "Database of Municipal Waste in Sri Lanka" published by the Ministry of Forestry and Environment. In district basis analysis, it was found that more than 80% of the waste stream is biodegradable while in certain rural areas, it was varied from 39% to 95%. Waste density was varied from 217 kg/m<sup>3</sup> to 350 kg/m<sup>3</sup>.

Therefore the composition analysis gives more important evidences for resource allocation to collect and transport the waste selecting and designing appropriate method to treat the solid waste etc. however, standard sampling and statistical methods should be followed to estimate the reasonably accurate values.

## C 129

### **Decision support tool for solid waste management in Pradeshiya Sabas of Sri Lanka**

Municipal Solid Waste (MSW) management in Sri Lanka involves the consideration of interrelated series of options aiming at waste avoidance / reduction, re-use, recycling, waste treatment (Compost/Biogas) and disposal. When considering the many options available to solve MSW management problem. It is necessary to identify the factors that hampered finding solutions in the past.

By considering present situation and the past experience in solid waste management, Decision Support Tool is developed to guide decision markers in Pradeshiya Sabhas to find the most suitable solution to the solid waste management activities with the available resources in the area. The main objective is to develop a model that can guide

the local government authorities to find the best answers to all aspects of planning, decision-making and operating the solid waste management activities.

The Expert System model consists of several sub models; composting process and control pictorial database, site selection, technology selection, waste analysis reports, expertise information, Government rules and regulation on Solid Waste Management, Information Desk for researchers and Training tool.

Being a developing country, it is not easy for every local government authority to access the expertise that is mostly available in the urban areas. This model will therefore play an important role in finding the best solution and providing information to NGOs, researchers, as well as information seekers in solid waste management hierarchy.

### **C 130**

#### **Development of an environmental suitability index for wall materials used in Sri Lanka**

This study seeks to develop an index which estimates the environmental suitability of selected wall materials. The wall materials studied are, brickwork with one-side cement: sand plastering, cement block-work without plastering, and "cabook" with one side cement: sand plastering. The environmental suitability is estimated in terms of embodied energy, life cycle cost and reusability. Calculations based on these three parameters help to rank the materials according to their environmental suitability.

Such an index will help professionals like architects to carry out their work with best consideration for environmental suitability in selecting wall materials. More research along these lines on other building materials is necessary to develop a comprehensive system of evaluating the environmental suitability of Sri Lankan building products.

### **C 131**

#### **Groundwater levels related to irrigation water management in Suriyawewa**

Residents have dug shallow wells next canals on the left bank of the Uda Walawe irrigation system near the town of Suriyawewa, these wells are reported to fall dry between cropping seasons, which suggests that the groundwater in the wells is recharged by seepage from irrigation canals. Our study investigates whether this really is the case.

Along an unlined irrigation canal, water levels have been measured in shallow dug wells and piezometers, at least once a week during almost a year. In addition, water levels in canals as well as irrigation water releases have been monitored.

Groundwater levels closely follow changes in canal water releases. When the canal is closed for a few days, groundwater levels drop rapidly too. Outside the growing season, when the canal is closed, groundwater tables drop further, sometimes below the bottom

of the well. Residents have to look for alternative water sources in the inter-cropping season and often revert to surface water.

A rehabilitation program is currently underway to concrete line the canal to reduce seepage and increase the canal conveyance efficiencies. If canals are proven to be the source for groundwater recharge, this rehabilitation will be highly effective from an irrigation point of view. For the residents however, other water uses may be more important, be it indirect from shallow wells, and the effects of canal lining may be undesirable to them.

## C 132

### **The application of single layered concrete armour units in breakwater design**

Recent developments in concrete armour units been strongly influenced by the lessons learnt from a series of major breakwater failures which took place in the late seventies and the early eighties. It was widely accepted that breakwater designers have been engaged in excessive extrapolation without recognizing the limits of the prevalent state of the art of breakwater design. Research on the design and construction of breakwaters has led to the development of new concepts and further examination of alternative design practices. One such alternative is the use of single layered concrete armored breakwaters. The results of detailed hydraulic model investigations (at scales of 1:20 and 1:36) relating to the hydraulic performance of rubble mound breakwaters armoured with two types of single layered concrete units are presented. The investigations were designed to obtain a complete profile of the energy dissipation characteristics of the structures for a range of incident wave conditions. The results are discussed in the context of the importance of the geometry of the armour units, the porosity and the permeability of the structures and their application in practice.

## C 133

### **Artificial muscles based on conducting polymer polypyrrole**

Systems which are capable of converting electrical energy into mechanical energy can be defined as actuators, or more specifically in the case of softer materials, artificial muscles (AM). In this study we have characterized using deflection and force measurements. Fabrication of bilayer muscles was done on a strip of polyimide film. To get the electrical contacts, the polymer strip was coated with a gold layer. Deposition of PPy on the strip was done electrochemically using sodium decylbenzenesulfonate electrolyte. Deflection measurements were done by applying a potential in an electrochemical cell containing sodium perchlorate. To measure the force, the free end of the muscle was connected to a microbalance. Force variation with respect to the applied potential (-0.85 to 0.30 V) and the cyclic voltammogram were simultaneously recorded. Deflection measurements showed that during the oxidation of the PPy film, (lower potentials) deflection increased and at higher potentials deflection decreased. This increment may be due to contraction of PPy film as a result of release of cations and the decrement due to expansion of the film as a result of insertion of anions. Force measurements on bilayer muscles showed that

the force changes are always associated with peak positions of the cyclic voltammograms. It is very important to note that almost all the force is generated in a rather narrow voltage interval. This is an important implication of these Am.

#### **C 134**

##### **Circularly polarized microstrip antenna array**

A microstrip antenna has a very thin small metallic patch or patches on a dielectric substrate, which is a small fraction of wavelength above a ground plane. The radiating elements and the feed lines are photo etched on the dielectric substrate. It is a low weight, low profile antenna. It can be also made non-planer. It is easy to manufacture and is inexpensive. These patch antennas have certain limitations such as the restricted bandwidth of operation and therefore they can be used in narrow band applications. These types of antennas are very popular for use in the microwave and millimeter wave regions particularly in air applications.

A circularly polarized square patch antenna array with patches was designed. It can be easily mounted on an aircraft ski where the geometry and the weight of an antenna are subject to constraints. The thickness of the antenna is 1.6 mm and has an area of 6.4 cm x 9 cm. Resonance cavity model was used to analyze the antenna radiation pattern and transmission line model resonates at a frequency slightly above the resonance frequency of the patch antenna is  $(f_1+f_2)/2$ . Matlab was used to obtain the necessary design parameters. Matlab was also used to obtain the theoretical radiation patterns. Ensemble was used for 2D modeling. A microstrip transmission line feed network was used to feed the antenna array therefore the resultant antenna unit is fully integrated.

The design criteria and the results of a "four square patch antenna array" that was constructed to radiate or receive electromagnetic waves with right hand circular polarization are also presented. The antenna was designed to operate at a frequency of 9.4 GHz. It was etched on an epoxy glass fiber substrate, which has a relative permittivity of 2.91. The antenna far-field radiation patterns in the E and H planes were measured and compared with the theoretical patterns. They both showed an almost hemispherical radiation pattern in both planes. The antenna has a gain of 4.5 dBi at the design frequency and it has an axial ratio of 1.4. Thus with a slightly higher gain it would be a promising antenna for an application such as for aircraft to satellite communication.

#### **C 135**

##### **A low cost device protector for telephone-interfaced equipment**

In Sri Lanka, most of the telecommunication line interfaced equipment can be damaged due to voltage surges associated with lightning strikes. Most such equipment include protection from high voltage surges up to some extent and they could be further protected by using expensive devices such as UPS', which may not be affordable to most users.

A low cost device was developed that could replace the expensive protection devices available in the local market. The main advantage of this device is that it can completely isolate the equipment from the telephone line resulting in no damage whatsoever to the equipment.

The constructed device is composed of two independent sub units, one that is connected to the telephone line and other to the equipment. The unit connected to the telephone line has two LEDs and an Opto transistor in addition to a few semi-conducting devices. One of the LEDs detects the ring signal and other transmit the data signal to the second unit. Opto transistor senses the data signal from the second unit connected to the equipment. Similarly the unit connected to the equipment contains an LED, an LDR and an Opto transistor. The LDR detects the ring signal and the LED sends the data signal to the first unit. Even for very high voltage surges, only the unit connected to the phone line can be damaged and it can be replaced at a cost less than Rs. 100. The full device can be constructed for under Rs. 500 /- and it is capable of riving two or three loads in parallel.

### **C 136**

#### **A new mud wheel with retractable lugs for power tiller**

In Sri Lanka, land preparation for the cultivation of paddy land is done mainly using the Power Tiller. The moisture content of Paddy soil is usually very high. Therefore, Power tillers that are operated in the saturated or flooded conditions often require special devices called "Mud wheels" in place of wheels.

Rotating ring Cage Wheels with Retractable Lugs for Power Tillers were designed and developed to provide easy road transportation and to improve performance in wetland operations. A pair of cage wheels was constructed after testing first wheel and implementing necessary modifications. The developed wheel consists of an inner ring and an outer cage. The 12 lugs were hinged on the inner ring resting on cross bars of outer cage those guide the lugs when the wheel was expanding or retracting. The 4 pulleys were provided on the inner side of the inner ring to rotate it smoothly when the wheel diameter was changed.

Two experiments were conducted in two locations (dry and wet soil conditions) to compare the performance of the developed wheels with conventional cage wheels. Effective field capacity, time per hectare, traveling speed, travel reduction, the pull developed at 100% slip and wheel cost were considered in evaluation.

From the results, it was observed that the performance of designed cage wheels were significantly higher in both locations. Increase in pull and power of the developed cage wheel over conventional was about 1.5 and 1.6 in both soil conditions, respectively.

### **C 137**

#### **Seeing is believing' - Understanding structural behaviour via models**

Structural engineers may be capable of using quantitative techniques to analyze a structure, but do they possess a qualitative understanding of structural behaviour. One who understands how a structure behaves should be able to differentiate between a structure and a mechanism, identify load paths and structural actions by which the load is transmitted, predict the deflected shape of the structure and the variation of shear forces and bending moments in the structure. It is difficult to teach these concepts in a formal, conventional classroom atmosphere.

The writer discusses a project that was undertaken to develop a feel or awareness of how structures behave where a series of inexpensive models demonstrating various aspects of structural behaviour were constructed. The aspects included the behaviour of tension and compression elements in trusses and the provision of lateral stability by the method of bracing; the effect of support conditions and the stiffness of the material of the slab on the load carrying capacity of slabs. The behaviour of single span and continuous beams, buckling of columns under axial load and funicular shapes were other structural aspects demonstrated.

The effect of models on understanding structural behaviour was studied with the co-operation of undergraduate student volunteers who participated in a questionnaire survey. The results showed that the students do have a basic understanding of some of the simpler concepts and that the models made a positive contribution to their understanding of structural behaviour albeit to varying degrees.

## C 138

### **Integrated cost information systems for construction projects**

Contractors generally obtain jobs through competitive bidding. Generally, the contractor who submits the lowest offer will get the contract. Thus, a contractor has a couple of tasks, to be successful in business; to arrive at a lowest bid and to control his project cost within the estimated limit.

In order to achieve these targets, contractors need accurate, reliable and timely information regarding all the cost related activities within a site such as resource management, progress management, billing process and so on.

There are many computer software and management Information Systems, to help many processes for contractors such as 'MS Project' for planning and 'Billest' for estimating. However, a system which integrates the site cost-related activities and project progress is yet to be developed. On the other hand, the available systems of other contractors do not satisfy the requirement of Sri Lankan construction industry. And also, they are too expensive for local contractors. These issues demand the development of an integrated Information System for the construction management process of projects.

This research aims at providing a Management Information System for integration of cost of site activities and progress on sites. The function of this system is to capture site information for routine cost-related activities within site progress related activities. To achieve this objective, a thorough survey is conducted to identify the types of

information and their flow within the organization. Then an analysis could be done to configure the system needs, information model and output.

## **C 139**

### **Developing an internet based information centre for the Sri Lankan construction industry**

Present day organizations regard information as an important corporate resource vital for organizational success. The developments in the field of information technology have opened up new avenues for efficient and effective management of information in construction. The following is a brief summary of a research initiative carried out at the University of Moratuwa, to develop an internet based information center for the Sri Lankan construction industry.

The literature reviewed recognizes the important role of information in organizations of the construction industry. Having analysed the information set-up of the Sri Lankan construction industry, the research identified the following as some of the prominent features. 1) Majority of standard information is available only in paper form and is not accessible from a central location. 2) Lack of indexes to guide the users who need access to information. 3) Absence of a central location that could be used as a window to inform the revisions done to standard industry information. 4) Absence of a proper mechanism to document and communicate updated information to the ultimate users 5) Most project information exchange is done in paper form.

When providing central access to a wide variety of industry information, the research identified several challenges that need to be overcome. 1) Common information required are generated, compiled and used by different organizations located countrywide. 2) The format in which different users require information is not homogeneous. 3) The information provided should be available in a form, which could be directly used as inputs to IT enabled information processing. 4) Information should be updated and communicated to the end users. This research effort is focused on exploiting the Internet and allied technologies to address the crucial information needs of the construction industry. Following are some of the components of the outline structure of the information centre. \* Industry calendars, \* Directories, \*Research forum, \* Cost information, \* Industry news, \* Electronic tendering, \* Virtual project teams, \* Search engines, \* E-commerce Construction IT zone, \* hosting web pages.

The ability to be updated rapidly and the potential to be self-financing are two of the many highlighting features of the end product of this research.

## **C 140**

### **Cost modeling for selection roofing material**

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

Most people in Sri Lanka try to construct their own dwelling without much guidance from qualified professionals. Often an Architect is retained as the designer but is not employed during the construction phase due to various reasons. Further, the abundance of numerous material options for selection makes it even a difficult task for construction professionals. Further, there is hardly much product information available at hand to the construction professional to advise a building client. Information available is piece-meal and hardly any comparative analysis available.

This research was aimed at preparation of a cost model which can be used for selection of roofing materials including roof covering, ceiling and insulation materials for domestic purpose, giving adequate consideration on cost and some other performance factors like thermal comfort, water tightness, durability, etc. In the creation of model adequate consideration has been given to difference in roof design complexity and materials are ranked for each type on aforementioned factors.

Different roof covering, ceiling and insulation material combinations gives different roof costs in total for different roof designs. Analysis of total roof cost shows that the lowest cost combination for all simple, medium complex and complex type as the Asbestos roof covering with exposed rafter slope Asbestos ceiling and 3 mm thick Polyurethane insulation. Further, the research is extended to publish the model on the Web to overcome the limitations of using cost models and to develop a web knowledge based cost model which can be used for material selection for building construction.

## **C 141**

### **Feasibility of optimum type designs for houses**

The inflation of the cost of building materials is much higher the average increases in people's incomes. Therefore the construction costs of house are becoming more and more difficult to afford. One way of arresting this problem is by the use of optimum designs for houses. Further the inflation of timber prices is much higher than the other building materials. Therefore optimum design methods to reduce the use of timber or to replace the use of timber will have a good potential for application. Hence the roof and the ceiling have a high potential for the application of optimum designs.

The main objective of the study was to establish the feasibility of new methods for roofs and ceilings. Several optimum type designs were carried out with the aid of computer and for the use of available steel sections such as T, L, flats etc. these designs were compared with published optimum timber designs. The costs of designs were calculated using standard estimating methods as well as obtaining quotations from steel fabricators. Further life cycle costing was incorporated since different materials have different life spans.

It was found that the optimum steel designs could reduce the cost of roof by 6.9% to 8.25% while for ceiling cost can be reduced by 48% to 51%. The combine ceiling and roof can reduce the cost by 14% to 19%.

## C 142

### **A preliminary study of the stresses in walls and columns of a low - cost medium rise building**

Load-bearing walls reduce building cost a but their use is normally restricted to buildings of not more than two or three stories height. In a novel low-cost technique (pioneered by Dr. A.N.S. Kulasinghe,) walls are constructed of mortar rammed between nominal RC column elements of same thickness as walls, and this technique has been proposed for the construction of buildings as high as 13 -14 stores. However a detailed analysis of such a building has not been done so far, even though it is an essential requirement for a proper design.

This study is aimed towards fulfilling this requirement, and its objective is to do a preliminary analysis of wall panels of such a building 13 stories height. Centrally located wall panels over the full height of the building and framed by column elements, and under the vertical loadings were considered without openings as with door and window openings. The panels were analyzed using the finite element method and the stresses in the walls and columns were obtained.

The results indicate the necessity of using stronger mortar or thicker wall panels towards the bottom of the building. More analyses considering other types of wall panels and loadings as well as 3D models, needed to be done for a complete understanding of the behaviour of this type of building.

## C 143

### **Single storey houses with hand moulded chip concrete blocks for Sri Lanka**

Sri Lanka is presently facing serious environmental problems due to extensive use of building materials such as sand and bricks. Therefore, there is an urgent need to reduce their use. One alternative to this is hand moulded chip concrete (HMCC) blocks. It can use by-products of metal crushing industry such as 6 – 8 mm chips and quarry dust. When hand moulding is used solid blocks of width 125 mm can be produced. The length and height are 300 mm x 200 mm. this is ideal for the external walls of single storey houses since the building regulations need a thickness of 125 mm. these can b used without plastering since it can give a good finish. HMCC blocks are specially suitable for housing projects planned with self-help type construction by governmental and non-governmental organizations.

With an experimental programme it was found that a mix of 1: 8: 14 cement, fine aggregate (either sand or quarry dust) and chips can be used for HMCC blocks. A characteristic compressive strength of 0.9 N/mm<sup>2</sup> could be achieved when 1: 5 cement sand mortar is used for wall construction. This strength is quite sufficient for single storey construction.

A cost study based on the actual material quantities have indicated that the cost of blocks will be Rs 12/= and Rs 9.50/= for 125 mm and 100mm blocks, respectively, with

unpaid labour. Two labourers can manufacture about 30 blocks in two hours. This is a competitive cost for an environmentally friendly material.

#### **C 144**

##### **A cost effective foundation for hand moulded chip concrete block walls in weak soils**

The need to search for alternative building materials is quite important in today's context with serious problems associated with clay and sand mining. An alternative building material that can reduce the demand on bricks and sand is hand moulded chip concrete (HMCC) blocks. The mix recommended is 1:8:14 cement, fine aggregate (sand or quarry dust) and chips of 6-8 mm. the blocks of thickness of 125 mm and 100 mm can be used for external and internal walls, respectively. Since these blocks could be used to construct houses at various areas in Sri Lanka, it is useful to develop a cost effective foundation system that can be used at sites with weak soils.

One such foundation is a composite system consisting of block wall constructed on rubble work where two tie beams are provided at the plinth level and the window sill level. Such foundations can be designed based on the deflection ratio method. For the structural design purposes, it is necessary to find the shear strength and the elastic modulus of HMCC block walls. It is found experimentally that a shear strength of 0.15 N/ mm<sup>2</sup> can be recommended for HMCC block walls of thickness 100 mm or 125 mm. the elastic modulus of HMCC block walls in axial direction is 0.3 kN/mm<sup>2</sup>.

A case study carried out with an appropriate foundation with tie beams has indicated that only nominal reinforcement is required in the tie beams. Those will be either 2 or 3 numbers of 10 mm diameter high yield steel. Therefore, this foundation can be quite cost effective than other alternatives such as inverted T-beam or Vierendeel types since it uses much less steel and concrete. Thus this foundation system can be used to fulfill one of the primary requirements in introducing alternative building materials; it should have either a comparable or a superior behaviour than the traditional building materials.

#### **C 145**

##### **Practice based knowledge: from craftsman to engineer**

The focusing on theoretical knowledge in engineering faculties has caused a gap between academic training and professional practice, as latter of tern calls for practitioner judgment and experience. At the same time there is some confusion in engineers, especially when carrying out routine tasks, regarding their role (i.e. How it is different to that of a craftsman).

Polanyi stated that we often know more than we can tell, because such knowledge is embedded in practice. Hence, such Knowledge has to be passed on more through apprenticeship rather than textbooks. Heidegger insisted that purposeful action, where subject and were linked in a seamless interaction, was more "primordial" than the so called "fundamental" properties of objects that was sought by science. These properties

became important when there was a “breakdown” in action that required deeper reflection. Such ideas give value to the essentially practical activity of engineers, who are nevertheless schooled in the fundamental sciences in order to deal with breakdowns.

The craft based approach to engineering design is characterized by empirical processes that result in traditional products. In the technical rationality approach, the scientific view of the product is stressed and the process is one of optimisation. In the reflective practice approach, an engineering view of the product is sought, while the process is interactive. Although the reflective practice approach to engineering may be viewed as a return to practice from theory, it has to be supplemented by technical rationality that is employed at breakdowns of practice.

## **C 146**

### **Project management in consultancy organizations: Case study**

Project management is simply defined as the art of directing and coordinating human and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, quality and participant satisfaction. In this context it is imperative that the Project objectives.

Consultancy organizations provide consultancy services such as architectural and engineering design feasibility studies environmental studies, contract management, construction management etc. Consultancy organizations should consider these works as projects with specific objectives that have to be accomplished by them to the satisfaction of the clients. Therefore, they should appoint an in-house Project Manager to lead their consulting team and provide project management services so that their objectives are achieved.

This paper explains such project management services deployed by a consultancy firm for their projects so that the satisfied clients will return with more work. The paper is based on a case study undertaken by the author in a USA based large consultancy firm.

The study revealed that a Project manager in a consultancy firm has five primary responsibilities viz; to accomplish what the client expects, to take charge, to serve the client, to meet the schedule, and to stay within the budget to make a profit. To achieve this the Project Manager should assume twelve basic roles. The paper explains these roles with reference to the case study highlighting how these are undertaken to maximize the profit in a consultancy firm.

## **C 147**

### **International construction contractors operating in developing countries: The case of Japanese contractors in Sri Lanka**

The trend of International Construction has shown a dramatic increase in the recent past. As a developing nation, Sri Lanka too has opened the gates for foreign contractors

to carry out construction. These contractors have become more and more successful and competitive in the local construction industry.

This study explored the reasons for the Japanese firms to come to Sri Lanka and the way they have established their firm locally. For this, comprehensive case studies of five selected Japanese contractors on the basis of interviews and informal discussions were carried out.

According to the survey, Japanese would vie for local contracts due to the fact of high competitiveness in winning projects; cheap labour; less overhead component; very few restrictions; and lesser demand for civil engineering feats requiring advanced technologies. Also, Japanese contractors consider themselves more superior, thus, their conviction is that they could handle the local staff at their whims and fancies. Also Japan is one of the largest aid donors for Sri Lanka, hence with the aid contractors are Japan, get opportunities to involve in above work. They would be able to absorb a proportion of the money that is given as aid or loans.

Usually marking joint ventures among themselves or with a Sri Lankan firm the most common way of establishing Japanese firms here. Though they have better strategies; problems occurring through cultural differences, foreign exchange risks, low quality of local materials, insufficient local regulations etc. cannot be avoided when carrying out construction in Sri Lanka. However, they handle local projects more effectively than Sri Lankan contractors. It would be concluded that like Japanese does, implementing proper safety practices, training procedures, effective schedule monitoring and controlling systems, etc. can be adopted by local contractors as well, to complete projects on time and within the required budget to the required quality.

## **C 148**

### **Solid waste minimization at narrow fabric production mill**

Now a days, Organization of all kinds are increasingly becoming concerned to achieve and demonstrate sound environmental performance by controlling the impact of their activities, product or services on the environment. Environmental performance by controlling the impact of their activities, product or services on the environment.

This study was on the solid waste minimization in a narrow fabric production mill. The industry sector today uses a significant amount of synthetic and rubber yarns as a raw material. The waste generation of this would pollute the soil. The study has been included a general observation of the total production process, with special attention on the point and operation where high amount of waste is generated.

The international standard (ISO 14001) specifies requirements for an environmental management system, to enable an organization to formulate a policy and objectives taking into account legislative requirements and information about significant environmental impacts. It applies those environmental aspects, which the organization can control and over which it can be expected to have an influence.

The extent of the application will depend on such factors as the environmental policy of the organization, the nature of its activities and the condition in which it operates. The scope of any application of this international standard must be clearly identified.

The important objective of this investigation was to find out the reasons for the waste generation and introduced reliable action plans to reduce total factory solid waste percentage as much as possible.

#### **C 149**

##### **Effective of solvents on rice bran oil extraction**

Rice bran oil is becoming popular as an edible oil and also as an ingredient in pharmaceutical manufacturing industry due to its excellent characteristics such as ability to reduce the blood serum cholesterol level and high oxidative stability. Solvent extraction using organic solvents is the commonly used method for extraction of rice bran oil.

In this study extraction of rice bran oil using organic solvents were compare with aqueous extraction. Rice bran oil was extracted from pretreated rice bran using hexane, isopropyl alcohol (IPA) and water as solvents and the results showed that the two organic solvents showed similar extractability compared to aqueous extraction. Rate of extraction for hexane was slightly higher than that for IPA. The solubility Of rice bran oil in water is less than that in organic solvents and hence higher solvent / bran ratio higher degree of agitation were required for aqueous extraction.

Significant increase in yield was shown in increasing temperature for both hexane and IPA. However, the effect of temperature on the yield in aqueous extraction was negligible. Increasing yield for aqueous extraction was shown with increasing pH and the aqueous extracted oil was comparatively pale in colour due to low temperature operation and low solubility of pigments and wax in water. Aqueous extraction eliminates the contamination of the oil with organic solvents and atmospheric pollution from solvent mist. However, high pH residual water should be treated before disposal.

#### **C 150**

##### **Use of waste biomass for colour removal in textile industry**

The discharge of colored wastewater is not only aesthetically displeasing but also impedes light penetration thus upsetting various biological reactions such as photosynthesis within a stream. Adsorption is an effective method for colour removal from wastewater and activated carbon is the commonly used adsorbent for this purpose. Due to the inconvenience and relatively high cost of continuously transporting solid particles in steady state operation, usually state fixed bed adsorbers are widely used in practice.

In this work, utilization of waste solids, saw dust and tea dust, as decolourization agents for textile dye effluent, has been studied. Data necessary for design and scale-up o industrial fixed bed adsorption units were determined.

The waste solid was chemically activated using  $ZnCl_2$  to produce the adsorbent. The batch testes showed that the equilibrium data follow standard Langmuir and Freundlich isotherms for both types of adsorbents. The coefficients in the isotherms were obtained and the values were compared with those for commercial activated carbon. Typical S-shape *breakthrough curves* were obtained from fixed bed isothermal adsorption experiments. *Breakthrough time* decreases with decreased bed height, increased rate of flow of fluid through the bed and increased initial colour of the feed. Break through time, length of the unused bed and degree of saturation at break point were determined.

## C 151

### **Uniformity of different low cost emitters in trickle irrigation**

The demand for irrigation water is overcome by increasing, water use efficiency through drip irrigation, which applies water to the base of the plants in frequent low volumes, to the plants. The emitter flow variation and the uniformity of water distribution low volumes, to the plants. The emitter flow variation and the uniformity of water. Emission uniformity, statistical uniformity and Christiansen's uniformity were analyzed for locally available low cost emitters. The objective of this computation was to present an analytical expression of flow variation within the lateral lines.

Assembly parts of the drip system, tank filter, delivery tube, laterals and different type of low cost emitters were fabricated. Eight type of emitters were selected namely: 5% cement sand emitter, 30% and 50% clay sand emitter, pure sand emitter, plastic thread screw number 20 & 24, micro tube and coral. The field evaluation of uniformity was made from emitter discharge taken from six locations along the lateral lines at 4 times for 550 cm water pressure. The same measurements were repeated for different type of emitters.

Statistical uniformity and Emission uniform values for plastic thread screw 20 and 24, micro tube and coral emitters were more than recommended value of 90%. The 50% clay sand emitter was nearer to 90% in emission uniformity (88.67%) and exceeded 90% in statistical uniformity. Other emitters were not satisfied the requirement. In Christiansen's uniformity, the values ranged between 100 - 99% are considered as good for new emitters. The plastic thread screw 20 showed the photo finished value as good for new emitter. The plastic thread screw 20 showed the photo finished value as good (89.2%). Plastic thread screw 24 (87.96%) and micro tube emitter (88.9%) was nearest to acceptable range. Hence, these computations could be used in drip irrigation to obtain high uniform application efficiency.

## C 152

### **Effects of passive elements on thermal comfort in residential buildings**

Sri Lanka is presently facing a serious energy crisis due to rapid increase in energy demand. One of the solutions for this is energy consideration, and one consideration is residential buildings. The energy used for thermal comfort could be reduced using passive elements.

To determine the effects of passive elements, computer simulations with DEROB-LTH program was used. The average climatic data for of the warmest months of the year, March, was used. The thermal performance of a house with desirable passive features was compared with one planned with no regard for passive elements. The same internal loads are used for both cases. The thermal performance of a volume sheltered by an upper floor and a volume sheltered only by the roof were considered.

A comparison of similar volumes in two houses indicated that there can be a temperature rise of about 4 ° C when passive elements are disregarded. Most importantly, the indoor temperatures of the houses with passive elements remained below 30 ° C, which can be considered as an upper limit for providing thermal comfort with enhanced ventilation. Thus the houses with passive elements offer a greater possibility to operate avoiding forced ventilation offered by fans. This could lead to saving in energy for operating the houses. Such savings could have benefits at national level since large energy savings could be possible if a large number of houses are designed with passive elements.

## **C 153**

### **Effects of roof orientation on the thermal performance of passive buildings**

Sri Lanka has a warm humid climatic condition. In majority of single storey houses, the indoors are somewhat thermally uncomfortable, especially in the afternoon and during the night. Generally, when the indoor temperature is above 30 °C, it is difficult to provide thermal comfort with natural means. Thus it is useful to determine the effects of the roof orientation on the indoor temperatures.

For this study, a double pitched asbestos roof with a ridge in east-west direction and north-south direction was considered as two cases. The house selected was properly planned with many desirable passive features like properly oriented windows with shading devices and light colours. The effects of flat and sloping ceilings were also investigated. For this study, computer simulations are carried out using DEROB-LTH program. The climatic conditions are simulated by using the average climatic data available for the month of June for Colombo.

The indoor temperature result indicates that there was no significant effect due to the roof orientation. The flat ceiling gave a marginally lower temperature (less than 0.5 ° C) than the sloping ceiling in most cases. The maximum indoor temperatures reached about 31.5 ° C when the outdoor of single story houses by relying on the orientation. It will be essential to use roof insulation that will cut own part of the thermal gains. It is also shown that the effects of windows on undesirable orientations (east or west) can have a much prominent effect on indoor temperatures than the orientation of the roof.

**C 154**

### **Unprotected Road users and Road Safety Improvements**

Road accidents are causing a considerable economic loss to Sri Lanka in addition to the pain and grief suffered by the victims and relatives. About 50% of the accident victims are pedestrians and cyclists who can be considered as the unprotected road users. Thus, these users are at great risk on Sri Lankan roads. This situation has to be improved gradually which will need extra investment for road safety. Whenever there is extra expenditure, it is necessary to provide economic justification for such expenditure.

In this study, it was shown that the total cost of accidents involving unprotected road users is Rs 2.507 billion in the year 1998. This has to be compared with the total investment on the road sector of Rs 5.783 billion in year 1998. This clearly indicates that at least a small percentage of the accident cost should be invested for the improvement of the number of accidents are reduced even by a small percentage planned continuous investment over few years, it would be possible to bring in economic benefits and tremendous social benefits, by reducing the number of fatal and grievous accidents suffered by the unprotected road users.

**C 155**

### **Improvement of Road Safety at T-junctions**

Analysis of past accident records have show that a most of the fatal and grievous accidents occurred on straight stretches of roads and at T-junctions. Both these can be attributed to high speeds. Therefore there is an urgent need to introduce some counter measures to bring down the speeds at accident prone locations which in turn will reduce the severity of accidents. It is necessary to develop a technique that would force the drivers to slow down. The use of a set of transverse bar markings located at gradually reduced spacing has been adopted in other countries. The usefulness of this technique to Sri Lanka has to be investigated by finding the response of the drivers to it. There is also a need to determine the appropriate strategy to make it a success in Sri Lanka.

It was found with field studies that the response of the drivers of fast moving vehicles to the transverse bar markings is only marginal. Therefore, it should be accompanied by thermo-plastic strips that would give the noise effect to the drivers. An educational campaign is also necessary so that drivers will understand the presence of an accident prone location as they come across the transverse bar markings. These bar markings have the particular advantage of giving notice to the drivers about 200 m prior to the junction and also to give the warning continuously as they approach the junction. These will be advantage than humps and rumble strips since bar markings will affect only the fast moving vehicles. Therefore, this measure should be adopted at least on trial basis at few locations in Sri Lanka.

**C 156**

### **Fuel susceptibility of surface dressings using and patch method**

Once a road is opened to traffic it starts to damage. More frequent damage can be observed especially in front of petrol stations, at bus bays and upgrades where spillage of fuel is very common. Consequently the aggregate within the fuel patch will be thrown off under the action of tires damaging the road surface.

This test was designed to find out the effect of a binder or modified binder for susceptibility of fuel and hence suitability of the binder for a particular surface dressing. The test can also be modified to assess the deterioration due to spillage of fuel on road surfaces. The deterioration is determined in terms of changes in properties of the surface caused by fuel spillage.

The macro texture of the road surface is one of the properties that change under the action of fuel. The sand patch method, which is explained in the standards, ASTM E 965-1987.

The surface dressing which was to be tested was applied on to a model that simulates a substrate of a flexible type of pavement. Texture depth of the surface is measured by using the sand patch method before applying fuel.

Final texture depth is measured in a similar way after storing the fuel-applied models for the designed time period in laboratory at room temperature. The arithmetic difference between the two values explained as a percentage gives the damage due to the fuel spillage.

## C 157

### **Improvements to bitumen emulsions for the better performance of surface dressing**

Surface dressing can be used as a successful and economical method on any type of roads, from trunk roads to gravel roads. The main object of surface is seal the existing road pavement; thereby arresting disintegration and providing a proper road network.

However premature failures can be observed on surface dressings in many instances. Therefore a research study was carried out in order to find the causes for this unsatisfactory consistency. As the preliminary stage field investigations were carried out on existing surface dressed roads to identify the failures. On going construction sites were investigated, focusing more on the quality control measures taken at the sites as well as the quality of the material.

Database of the test results on the samples of binder collected at the sites as well as from the manufacturing plant were established. More emphasis was given to the properties, which are frequently out of the specification limits, and effect of these properties was studied. Further research was carried out for the methods to improve the quality of the binder.

Best choice of emulsifier from the chemical stand for surface dressings, optimizing the particle diameter, type and speed of the manufacturing plant, type and penetration of

bitumen used and settings of the plant such as temperature and pressure are some of the important factors which should be controlled. A modifier which is cheap and locally available in plenty could be recommended to improve the rheological properties of the binder.