# Natural Stable River Section Design Using Fluvial-12

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## *ABSTRACT*

Sediment transporting capacity, curvature effects as well as composition of channel bed and bank materials need to be considered by the engineer during the design process of natural channels. Neglecting these effects would normally result in instability problems because channel morphology usually changes with time.

Mathematical model (FLUVIAL-12) has gradually become popular in designing stable sections because it is more economical compared to physical model. The model is capable of predicting instability effects such as riverbed changes due to erosion and sedimentation during flood, thereby providing the necessary information for the design or bank protection work. In this paper, the application of FLUVIAL-12 for Raia River shows that the study reach can be preserved to its natural characteristics provided that the river bank should be covered with natural protection which produce the flow resistance to the value of Manning's n = 0.045.

***Keywords:*** *Stable River Design, Sediment Transport, River Modelling, FLUVIAL-12, River Conservation*

## 1.0 INTRODUCTION

### 1.1 Characteristics of Natural Rivers

Materials comprising the beds of alluvial rivers have an important influence on river geometry. Bed slopes at the headwaters of rivers are steep, and the bed material is relatively coarse. In general, both river slope and bed material sizes decrease in the downstream direction.

Figure 1.0 shows bed material of Rio Grande River range in size from boulders and cobbles to silts and clays, generally decreasing in a downstream direction. On the Rio Grande, median particle size decreases from 0.5 mm at Otowi, New Mexico, to 0.14 at a point 200 miles downstream.

Figure 2.0 shows natural river exhibiting non-uniform bed materials at different locations along the river course. It's imperative to maintain these natural features of the river to preserve the river equilibrium.

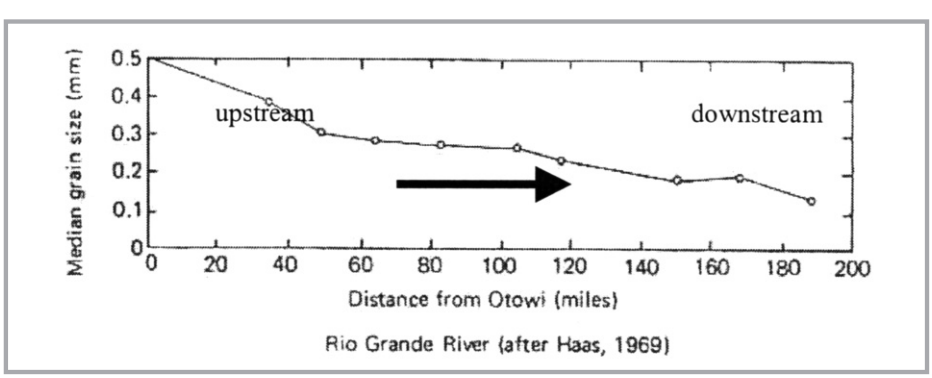


*Figure 1.0: Grain Size Degradation of Rio Grande River (Peterson, 1986)*

### 1.2 Bank Materials

Bank material normally changes with distance along a stream. It is important to note that banks are generally not composed of uniform materials throughout their height, but rather are stratified with layers of gravels, silts, sands and clays.

Riverbanks may generally be classified as cohesive, non-cohesive, and stratified (composed of layers of materials of different size, permeability, and cohesion characteristics).

### 1.3 Definition of Stable Section

Lane (Chang, 1988) presented an excellent definition of stable or regime channels as follows;

*"A stable channel is an unlined earth canal for carrying water, the banks and bed of which are not scoured by the moving water and in which objectionable deposits of sediment do not occur."*

Thus from the definition, small amount of erosion and deposition may occur within river channels but for a long period of time, bank and bed will attain toward stability.


*Figure 2.0: Natural River Exhibiting Non-Uniform Bed Materials (8th January 2003)*

## 2.0 MATHEMATICAL MODEL (FLUVIAL-12) FOR CHANNEL DESIGN

The FLUVIAL-12 (Chang 1980, 1982, 1984, 1985, 1986, 1988, 1990) model has been formulated and developed for water and sediment routing in natural and man-made channels.

Briefly, this model, for a given flood hydrograph, simulates time and spatial variations in flood level, sediment transport, and bed topography (Figure 3.0). In the prediction of river-channel changes, scour and fill are tied in with width variation and the effect of secondary currents under the changing channel curvature. In the model, scour and fill are computed on the basis of longitudinal imbalance in sediment discharge.

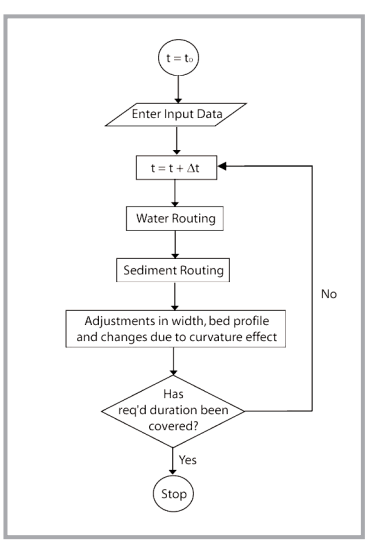


*Figure 3.0: Flow Chart Showing Major Steps of Computation for FLUVIAL Model (Chang 1988, 1993)*

In this paper, FLUVIAL-12 was applied to Raia River reach near Ipoh. The aim of the study is to identify the best effective geometry natural section (Darus, 2002). Comparison with the Simons & Albertson Regime method (Chang, 1988) is also made (Figure 4.0).

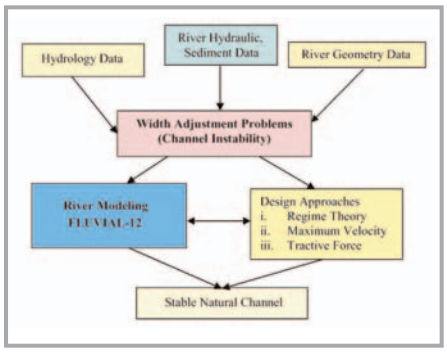


*Figure 4.0 Methodology for Identifying, Analyzing and Modeling Instability Problem (Darus, 2002)*

## 3.0 METHODOLOGY

### 3.1 Case Study of Raia River

Raia River is an important tributary of Kinta River. It has a catchment area of 192 km$^2$ covering the areas in Ipoh and Kinta Valley. Figure 5.0 shows Raia River study area started at Kampong Tanjung Bridge (Ch. 2800m) and extends upstream for a distance of about 2.8 km.

### 3.2 Study Procedures

Simulations using the FLUVIAL-12 mathematical model carried out by using several input data such as hydrograph and rating curve obtained from DID. Bed and bank material as well as cross sections profiles at selected gauging stations shown in Figure 6.0 were taken for comparison with the simulated results. Cross sections used in the simulation process were obtained from a DID survey plan in 1999.

## 4.0 DESIGN CONFIGURATION OF RAIA RIVER

### 4.1 Selected Cross Section

An appropriate cross section was identified and selected to convey maximum discharge and furthermore the important task is to minimize the

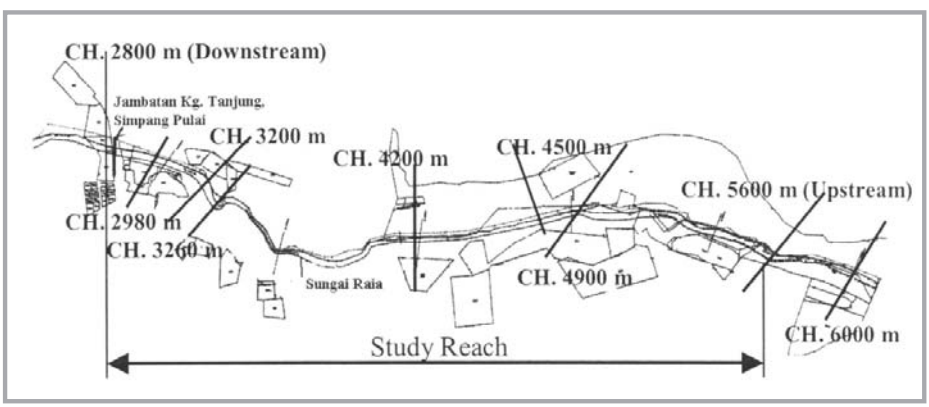


*Figure 6.0 : Study Reach of Raia River (Darus, 2002)*

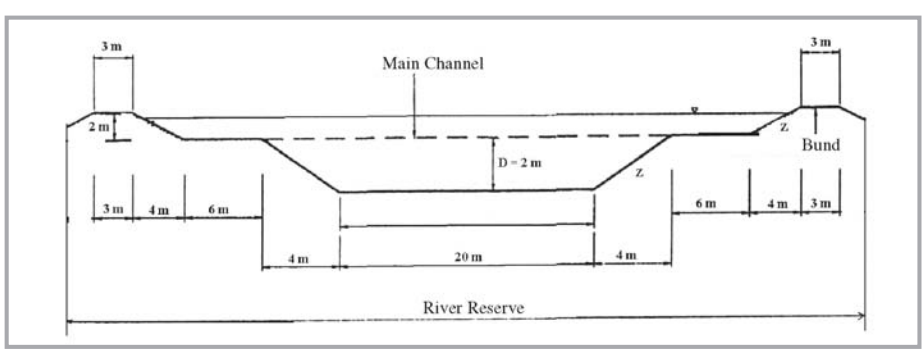


*Figure 7.0 : Selected Cross Section Design for Raia River*

instability problem. Due to inadequate river reserve at site, the cross section as shown in Figure 7.0 was adopted (uniform for all cross section).

### 4.2 Hydrology

*a). Hydrograph*

Figure 8.0 shows the predicted hydrograph based on land use until 2020 that was used for the design process (Darus, 2002).

*b). Flow Rating Curve*

The rating curve for the simulation process was derived from the downstream section using Manning's formula (Figure 9.0)

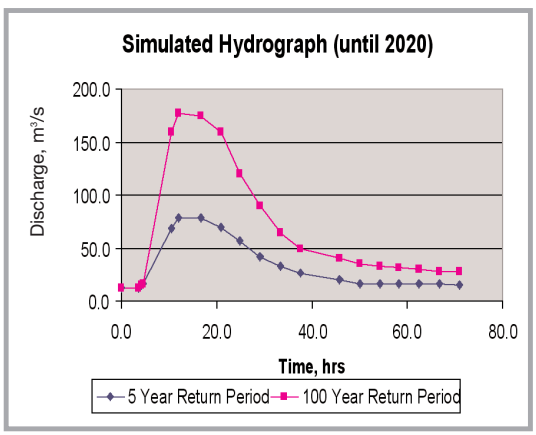


*Figure 8.0: Simulated Hydrograph Until 2020 for Raia River (Darus, 2002)*

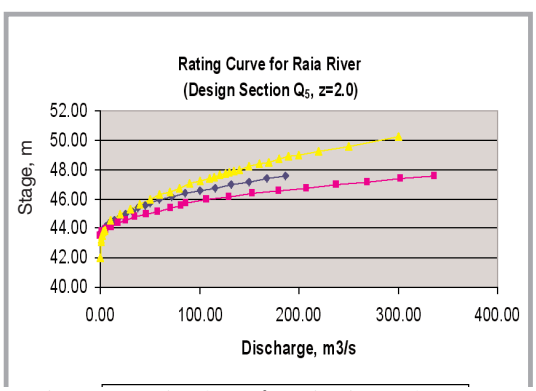


*Figure 9.0: Rating Curve for Raia River at CH2800 m*

### 4.3 Bed Material

Bed material samples from each section, i.e. downstream and upstream of design reach were used for the simulation process (Figure 10.0). Each sample is divided into five size fractions, and the size for each fraction is represented by its geometric mean diameter. The mean size of the bed material decreases toward downstream showing the natural characteristics of the Raia River at the study reach.

### 4.4 Bank Material

Sample of bank materials for each station, left and right bank was taken at mid-point between bed and water level. The characteristics of these sample associated with bank cover will determine the erodibility factor Fh value for each particular river section.

The presence of vegetation along the river banks once more shows the natural characteristics of the study reach.

### 4.5 Simulation Process

The mathematical model, FLUVIAL-12 was employed to simulate and to identify the instability problem occurring in the design reach especially at the riverbank. A total of 89 cross sections were employed to represent the riverbed geometry. Graf's equation for sediment transport was used for this sand-bed river. The parameters used in the simulation process are as follows:

a) Different design cross sections were used in the simulation process ranging from side slope of z = 2.0, z = 1.5 and z = 1.0. The purpose of this process is to identify which section produces the best stable section that has minimum erosion and sedimentation in the channel.

b) Comparison of two bank erodibility factor of Fh = 1.0 and Fh = 0.5 was also made to establish the various changes occurring at the section and bank.

c) Roughness in terms of Manning's n obtained from calibration results of 0.045 and 0.025 were used in the model process to identify the variation in the channel capacity.

## 5.0 SIMULATION RESULTS

Figures 11.0 and 12.0 demonstrate different methods of designing the natural stable channel and FLUVIAL-12 seem to produce and agree with the measured cross-section at site.

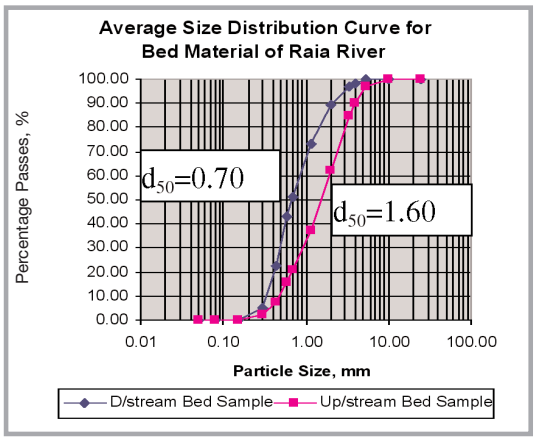


*Figure 10.0: Average Size Distribution of Raia River Bed Material*

## 6.0 SUMMARY AND CONCLUSIONS

A mathematical model for water and sediment routing through alluvial channels was employed to simulate riverbed changes and the instability problem during a specified flow, thereby providing the necessary information for design or other bank protection work.

Simulated results show a cross section with a side slope of z = 2.0 is capable of carrying a maximum discharge of 177 m³/s and also demonstrate minimum changes in bed level and a high degree of stability.

Simulated results also show that channel-bed scour is affected by the

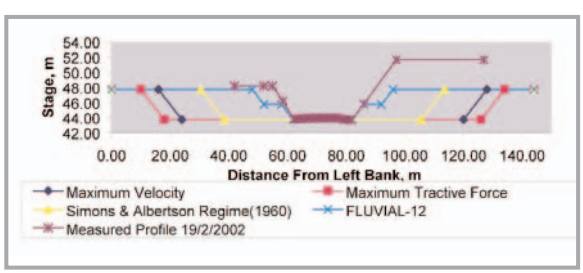


*Figure 11.0: Comparison of Different Design Methods for Natural Stable Channel for Raia River (Darus, 2002)*

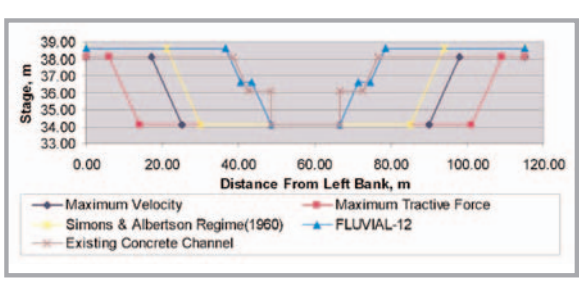


*Figure 12.0: Comparison of Different Design Methods for Natural Stable Channel for Pari River (Darus, 2002)*

channel curvature. The scour depth increases as flow enters a bend; maximum scour is generally reached at the bend exit, followed by a gradual decrease in transverse bed slope and scour depth with the decline in spiral motion.

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## *CONDOLENCE MESSAGE*

With deep sadness, the Institution would like to announce the demise of IEM Council Member, **ALLAHYARHAM IR. MOHAMAD NIZAR BIN HAJI HASSAN (M 13444)** on **20th March 200**4 and wish to extend our condolences to his family. The Institution would like to thank him for his past support and contributions.

# Wastewater Treatment for the Recycled Pulp and Paper Industry

*By: Ir. David C. Keow, CG Environmental Systems Sdn. Bhd.*

## Introduction

Before, when it came to industrial wastewater treatment, Malaysian corporations usually relied on foreign experts to design and build the treatment systems for them.

Now, our local wastewater treatment companies have gradually developed the technical expertise in this specialized field and they are capable of designing systems that are equally effective or even better than their foreign counterparts. In addition, Malaysian companies rely mostly on local fabrications, and hence, can maintain a low cost.

This article summarizes treatment processes for recycled paper mill effluent. They have been proven to work well for the three leading recycled paper mills in the country. The systems were installed by CG Environmental Systems Sdn. Bhd. (www.cges.com.my)

## Treatment technology

Figure 1 shows the treatment technology used in these three factories.

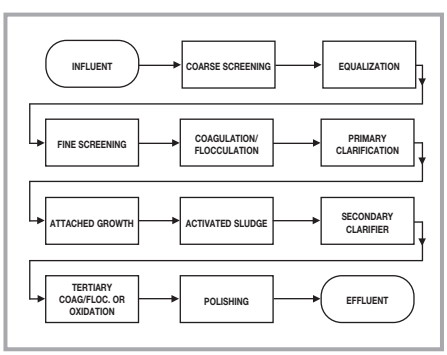



*Figure 1 : Flow chart WWTP*

## Part I : Primary Treatment

Coarse solids (cans, paper) are removed using an automatic bar screen. Wastewater flow and contaminants are equalized in an equalisation tank that uses coarse bubble diffusers for mixing.

Fine solids (fibres) are removed using a static fine screen. Fibres can be recycled back to the factory for reuse.

Chemicals are added to condition the wastewater in the coagulation and flocculation processes. This aids in the removal of suspended solids before the next stage of biological treatment. Without the removal of solids, biological systems will not work well. This is because:

- Solids replace biomass and less will be available for contaminant removal.
- Solids need to be broken down by the biomass that is intended for removal of other contaminants (in dissolved form.)
- Some solids could be toxic to the biomass.

*Figure 2 : Static screen*

Solids separation from the wastewater is done with a dissolved air flotation clarifier. Solids, mostly in suspended form, are floated to the surface with the aid of small air bubbles. From the surface, they are skimmed off into a sludge holding tank.

*Figure 3 : Dissolved Air Flotation Clarifier*

## Part II : Secondary Treatment

Secondary treatment is mainly intended for dissolved contaminant removal. A two-stage biological system is used in the secondary treatment. The first stage consists of a trickling filter tower (TFT). The second stage is an extended aeration system (EAS).

The advantages compared to a single stage biological system are:

- Higher COD removal efficiency.
- Greater shock-load resistance: TFT absorbs shock-load better than single EAS.
- Lower sludge production: TFT has low sludge production.
- Lower energy consumption: TFT uses energy more efficiently then EAS.

The trickling filter tower is an attached growth system using cross-flow plastic media to support the growth of a biomass slime layer. Different types of bacteria will grow on the layer:

- The inner layer consist of mainly anaerobic biomass.
- The outer layer is predominantly aerobic biomass.

Wastewater is pumped to the top of the tower from where it is sprayed down onto the media. It then trickles down the tower. The trickling filter tower will also assist in cooling down the wastewater to the temperature for optimum bacterial activity.

*Figure 4 : Trickling Filter*

The extended aeration tank is a suspended growth system. The aerobic biomass uses oxygen to break down the organic pollutants in the wastewater. The supply of this oxygen to the biomass requires the highest amount of energy in

*Figure 5 : Aeration Tank with Diffused Aeration System*

*Figure 6 : MMF and Secondary Clarifier*

the treatment plant. It is therefore important to carefully evaluate both capital and operating costs of available aeration systems (fine/coarse bubble diffuser, surface aerator, and jet aerator.)

Wastewater is then clarified in the secondary clarifier.

## Part III : Tertiary System

Tertiary treatment is required in a more stringent discharge limit area (Standard A) or if there is high level of recalcitrant contaminants that cannot be removed in the secondary system. Tertiary coagulation or oxidation process is proven to work well for this type of wastewater.

Tertiary treatment is always exponentially more expensive to operate than biological treatment. Table 1 shows the cost for the biological systems and tertiary treatment processes. It is clear that TFT is the most energy efficient process. The cost to remove the refractory COD in the tertiary system is very high.

| [RM/kg COD] | Mill 1 | Mill 2 | Mill 3 | Ave. |
|---|---|---|---|---|
| TFT | 0.14 | 0.12 | 0.17 | 0.14 |
| EAT | 0.18 | 0.25 | 0.28 | 0.24 |
| Tertiary | 6.6 | - | - | 6.6 |

*Table 1 : Treatment cost comparison*

Polishing with a multi media filter (MMF) can be used as a final step for removal of suspended solids from treated water. A multi media filter uses different sizes of sand and anthracite to remove these solids.

## Part IV Sludge Management

Minimizing sludge generation in wastewater treatment systems should be considered, examples are:

- Recycling the fibre back to factory.
- Implementing a low sludge yield biological system (such as the two-stage system.)
- Optimizing aeration in aeration tank.
- Optimizing chemical usage.

Final dewatering of the sludge is commonly done with either belt or screw press type de-watering equipment.

An option to include in the system is recycling of treated wastewater. However, the total dissolved solids (TDS) in the treated water can be high and total recycling of treated water may not be practical due to increase of TDS overtime. Partial recycling, of treated water up to 50% of the volume, is being practiced in some of the mills.

## System Design

The design of the system depends on several factors:

- Wastewater characteristics have to be checked and evaluated.
- Integration of existing components in the new system.
- Land availability.
- Site condition.

Recycled paper mills produce a variety of products like tissue, brown paper, liner, newspaper, etc. Various production techniques are used in the productions of these papers. Depending on the paper quality that is required, sometimes a bleaching process is used.

These variations result in a variation in the quantity and strength of the wastewater produced:

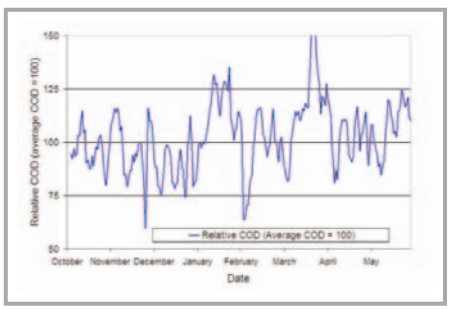
- Higher water consumption → lower strength (pollutants in wastewater are diluted.)
- Higher quality paper → higher strength (pollutants from paper end up in wastewater.)

This variation occurs between different mills as shown in Table 2.

The variation also occurs within one mill. Figure 7 shows the variation in COD of the incoming wastewater.

**Table 2 : Parameters Paper Mills**

| Parameter | Unit | Mill 1 | Mill 2 | Mill 3 |
|---|---|---|---|---|
| Water usage | $m^3$/ton | 15 | 25 | 40 |
| Flowrate | $m^3$/day | 10,000 | 8,500 | 15,000 |
| Raw COD | mg/l | 5,000 | 3,500 | 3,000 |
| Raw BOD | mg/l | 1,500 | 1,200 | 1,000 |
| Raw TSS | mg/l | 4,000 | 1,500 | 1,200 |
| COD after coag/floc | mg/l | 2,000 | 1,200 | 900 |




*Note: Trendline is the 4-day moving average*

*Figure 7 : Variation in raw COD Mill 1*

## Conclusions

- A two stage biological system can save costs due to reduced power consumption and sludge production. It can also reduce upsets to the treatment plant.
- Attention has to be paid to the option of recycling sludge and wastewater.
- Design of the system requires great attention. Even though the treatment concept for the three mills is the same, design parameters are different due to the variation in incoming wastewater strength. ■

## CONGRATULATE MESSAGE

The Institution would like to congratulate

**IR. DR ANDY SEO KIAN HAW** (F 13276)

on being awarded the

**"Darjah Kebesaran Setia Mahkota Selangor (SMS)"**
**from the**
**Sultan of Selangor in conjunction with His Royal Highness's 59th Birthday**
**on**
**13th December 2004**

and also conferred the

**Honorary Degree of Doctor of Science (Hon. DSc.)**
**from**
**The University of Hertfordshire, England, United Kingdom, London**
**on**
**20th March 2005**

The visit to PETRONAS Penapisan (Melaka) Sdn Bhd (PPMSB) organised by the Oil, Gas and Mining Technical Division scheduled on 23 April 2005 (Saturday) has been postponed to 18 June 2005 (Saturday).

Members who are interested to join the visit, please contact Puan Jamaliah at 03-79684012 or e-mail to jamaliah@iem.org.my.

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# The Future of Hydropower in Malaysia

*By: Ir. Zainal Abidin bin Othman, Managing Director, SMEC (Malaysia) Sdn. Bhd.*

## Introduction

Hydropower is the only renewable energy technology that is presently commercially viable on a large scale. It has four major advantages, namely it is renewable, it produces negligible amounts of greenhouse gases, it is the least costly way of storing large amounts of electricity, and it can easily adjust the amount of electricity produced to the amount demanded by consumers. Hydropower accounts for about 17% of global generation capacity and about 20% of the energy produced each year [1].

Hydropower provides about 10% of the electricity in the United States. Norway produces more than 99% of its electricity with hydropower and New Zealand uses hydropower for 75% of its electricity [2]. Malaysia uses hydropower for 11% of its electricity [3].

Hydropower energy is widely used throughout the world, varying in size from small (mini-hydro) to mammoth schemes serving several countries or regions. Industrialised countries have utilised their hydro potential to a considerable extent, although in the developing world, particularly in the equatorial and tropical belts, the use of hydropower is an option with considerable potential for satisfying energy needs.

## How is Hydropower Generated?

Most conventional hydropower plants will include four major components:

- Dam. Raises the water level of the river to create falling water. The dam also controls the flow of water and the reservoir created is in effect stored energy.
- Turbine. The force of falling water pushing against turbine blades causes the turbine to spin. A water turbine is much like a windmill, except that the energy is provided by falling water instead of wind. The turbine converts the kinetic energy of falling water into mechanical energy.

*400MW Kenyir Hydropower Station in Terengganu*

- Generator. Connected to the turbine by shafts and possibly gears so when the turbine spins it causes the generator to spin as well. This converts the mechanical energy from the turbine into electrical energy. Generators in hydropower plants works like generators in other types of power plants.
- Transmission lines. Conducts electricity from the hydropower plant to houses and businesses.

Examples of major hydropower plants in Malaysia are those belonging to TNB, namely the Kenyir Sultan Mahmud Power Station with 400MW installed capacity, the Pergau Hydroelectric Power Station with 600MW installed capacity and the Temenggor Hydroelectric Power Plant with 348MW installed capacity.

The current total installed capacity for Peninsular Malaysia as of August 2004 is 17,326MW with hydro making up 11.0% of the total [3]. The detailed breakdown of energy sources is as follows:

- Hydro – 11.0%
- Conventional thermal (coal) – 21.2%
- Combined cycle – 11.8%
- Conventional thermal (oil/gas) – 6.9%
- Gas turbine – 9.2%
- Diesel – 0.4%
- IPPs – 39.5%

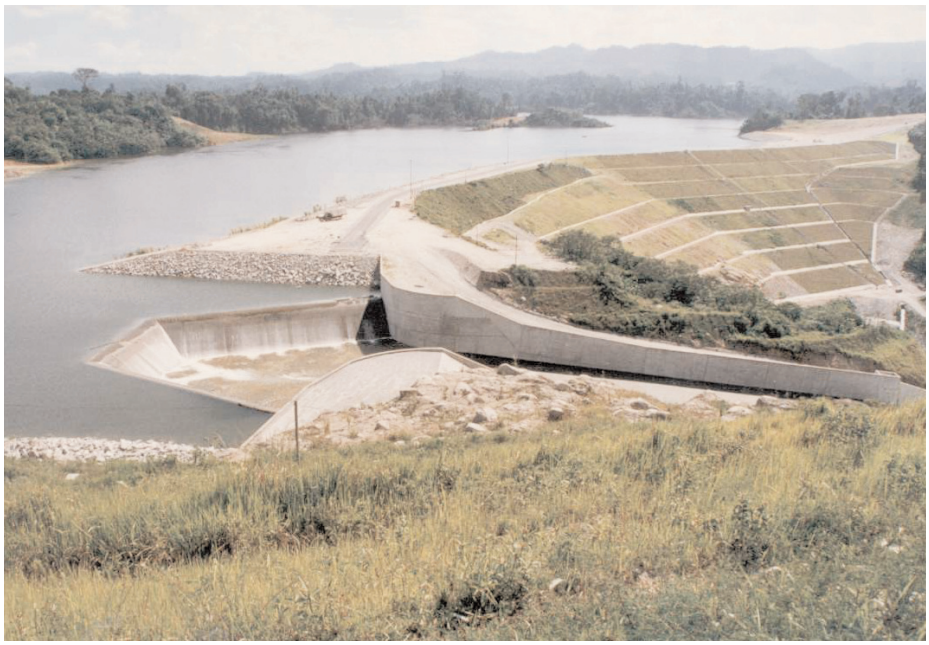
In Peninsular Malaysia, TNB operates a mixed hydro thermal system which is in line with the Government's policy on fuel diversification. The Independent Power Producers (IPP) make up almost 40% of the total energy supply [3].

## Overview of Hydropower Development

Let us briefly look at the history of hydropower dam development in Peninsular Malaysia. The first major dam, the Chenderoh Dam, was constructed in 1939. There followed a long gap before construction recommenced after the Second World War, starting with the Sultan Abu Bakar Dam (Cameron Highlands) in 1963.

A temporary lull in construction activity occurred between the late 60s and early 70s when fuel oil was still very competitively priced as to offer a viable thermal alternative for power generation.

The oil price increase in the mid 70s shifted attention back to hydropower in



*Kuala Yong Dam in Pergau, Kelantan*

the overall energy development plan. This eventually led to the construction of four more dams between 1974 and 1984. These are Temengor (1974), Bersia (1980), Kenering (1980) and Kenyir (1980).

The 90s saw the development of two more hydro schemes, namely Sg. Piah (1993) and Pergau (1991).

Currently the only major hydro project under construction is the Bakun hydro in Sarawak.

## Status of Hydropower Potential

Malaysia has a total land mass of 332,000 km$^2$ and its mean elevation is about 300m. The average rainfall is slightly more than 2,600mm per year. The total gross hydro potential is 414,000 GWh/year, of which about 85,000 GWh/year is available in Peninsular Malaysia. Hence, whilst Peninsular Malaysia has 39% of the land area, its share of hydropower resources is only slightly more than 20% [4].

Geographically, the peninsula is relatively narrow, and its main range of low mountains, the Titiwangsa Range, runs along the interior to form the main watershed. Thus, the river basins formed are moderately small. The largest river basin is Sg. Pahang with a drainage area of 28,500 km$^2$. In addition, topographic features and rainfall are comparatively less favourable than Sabah and Sarawak. These are the main factors which contributes towards the limited hydropower resources in the peninsula.

Of the 85,000 GWh/year gross potential, the utilised resources amount to 4,900 GWh/year (6%) whilst another 5,000 GWh/year (6%) has been identified. The Sg. Perak river basin is the most developed in terms of hydro-power development utilisation (2,500 GWh/year), and it is reaching the limit of hydropower potential development. For Peninsular Malaysia, it has been estimated that the economic limit of hydropower utilisation is unlikely to exceed 10,000 GWh/year.

## Future development

As for future hydro development in Peninsular Malaysia, several projects have been identified and studied at feasibility and pre-feasibility levels. These potential projects have to compete with alternative energy sources such as coal and gas in terms of economic viability.

From the economic point of view, it is clear that hydropower requires substantial initial investment costs which can be a deterrent to potential developers. It has been proven in some countries of the inability of the private sector to undertake such investments. However, this should be balanced against the long life and low operating costs of hydro plants, and the fact that there is no consumption of fuel for energy generation. Globally, in comparison with other plants, and considering the quality of the energy produced, the balance shows a clear advantage for hydropower.

At the 17th Congress of the World Energy Council in 1998, it was concluded that clear priority should be given to the development and use of appropriate renewable energies with the aim of limiting emissions resulting from the use of fossil fuels. This declaration supports the recommendations of the International Hydropower Association as listed below [5]:

- The remaining hydro potential should be developed to the maximum possible extent, provided it is implemented in a technically, economically and socially acceptable way;
- Hydropower development should go hand-in-hand (rather than in competition) with further development of other renewable sources of energy;
- The cost of the kWh produced by a hydro plant is competitive. The initial investment is substantial but the life of the plant is long (about 100 years). This is part of the sustainable character of hydropower. The operating cost is low. Financial solutions will have to be found to facilitate the initial investment in hydropower in developing countries without requiring the owners to give guarantees that they cannot afford;
- The state cannot totally entrust hydropower development to the private organisation (as is the case for thermal plant). It should be involved in the planning and development process;
- It has been demonstrated in many countries that hydroelectric potential is a form of potential wealth and sustainable development. Its implementation, with a strong backing of the state, contributes to the well-being of society. ■

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# 2-Cycle Moment Distribution For The Analysis of Continuous Beams And Multi-Storey Framed Structures

*By: Ir. Chan Kam Leong, B.Sc(Eng.), MSc, P.Eng, C.Eng, MICE, MIStruct E, MIEM, MACEM*
*K.L. Chan & Associates, Consulting Engineers*

## INTRODUCTION

The usefulness of the 2-Cycle Moment Distribution cannot be over-emphasized. It is considered necessary to revise my article published 36 years ago to include beam and frame for easy reference.

As the name suggests, the 2-Cycle Moment Distribution only 'distributes' twice regardless of the number of spans in continuous beams and frames. And both D.L. and T.L. are distributed simultaneously to obtain critical moments at supports as well as at spans. It is simpler, faster and more flexible than the conventional Hardy Cross Method. This can be demonstrated by the following examples.

## MAXIMUM MOMENTS AT SUPPORT AND SPAN

Figure 1 shows a continuous beam. The methods of calculating maximum moments at support and span are as follows:

**Method for maximum moment at support**

Step 1. Write down D.F., $M_{D.L}$ & $M_{T.L.}$

Step 2. Calculate and write down C/O. C/O = $\frac{1}{2}$ x D.F x ($M_{T.L.}$ - $M_{D.L}$)

Step 3. Obtain total unbalanced moment ($\sum M$) by adding $M_{T.L.}$ to C/O

Step 4. Balancing moments are of opposite sign to reduce larger moment.

Step 5. Add $\sum M$ to balancing moment for maximum moment at support.

**Method for maximum moment at span**

Step 1. Write down mid-span moment due to total load as if beam is fully fixed at each end.

Step 2. Calculate & write down 'adjustment' due to left hand support, i.e. Adj. $M_1$ = - $\frac{1}{2}$ (1 + D.F) x C/O

Step 3. Calculate & write down 'adjustment' due to right hand support, i.e. Adj. $M_r$ = - $\frac{1}{2}$ (1 + D.F) x C/O

Step 4. Add both adjustments to span moment to obtain maximum moment at span.

The results of maximum moments at supports and spans are shown in Figure 1.

## MINIMUM MOMENT AT SPAN

Span BC is shorter than the adjacent spans. It is possible that negative moment may extend across the shortest span. It is therefore necessary to calculate the minimum moment at mid span of span BC. It can be total loads on the adjacent spans obtained by allowing dead load on span BC. The procedure of calculating maximum and minimum moment at span is the same. The minimum moment at midspan is -7.06.

**Legend**
D.F – Distribution Factor
$M_{D.L}$ – Fixed-End Moment due to Dead Load
$M_{T.L}$ – Fixed-End Moment due to Total Load
C/O – Carry-Over Moment

**Sign Convention**
+VE for Sagging Moment
−VE for Hogging Moment

Beam−600x230, D.L=1.4G =15 KN/m , T.L=1.4G+1.6Q =22.5 KN/m




| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| D.F | 1 | | 3/5 | 3/5 | 4/9 | 4/9 | 5/11 | 0 |
| $M_{D.L}$ | −45 | −45 | −20 | −20 | −31.25 | −31.25 | −45 | −45 |
| $M_{T.L}$ | −67.5 | −67.5 | −30 | −30 | −46.88 | −46.88 | −67.5 | −67.5 |
| C/O | (a) −9.5 | (b) −33.75 | (c) +0.35 | (d) +4.5 | (e) −0.52 | (f) −5.97 | 0 | (g) −8.24 |
| ΣM | −77.0 | −101.25 | −29.65 | −25.5 | −47.40 | −52.85 | −67.5 | −75.74 |
| Bal. M | (q) +77.0 | (r) +28.64 | (s) −42.96 | (t) −12.17 | (u) +9.73 | (v) −7.99 | (w) +6.66 | (x) 0 |
| Max Supp M | 0 | −72.61 | −72.61 | −37.67 | −37.67 | −60.84 | −60.84 | −75.74 |
| Midspan $M_{T.L}$ | +33.75 | | +15.0 | | +23.44 | | +33.75 | |
| Adj. $M_1$ | (h) +9.5 | | (j) −0.28 | | (l) +0.38 | | (n) 0 | |
| Adj. $M_r$ | (i) +23.65 | | (k) −3.50 | | (m) +4.61 | | (o) +4.12 | |
| Max Span M | +66.90 | | +11.22 | | +28.43 | | +37.87 | |

c/o = $\frac{1}{2}$ x D.F x ($M_{T.L}$-$M_{D.L}$)

(a) $\frac{1}{2}$ x $\frac{3}{5}$ x (−67.5+20) = −9.5
(b) $\frac{1}{2}$ x 1 x (−67.5−0) = −33.75
(c) $\frac{1}{2}$ x $\frac{5}{9}$ x (−30+31.25) = +0.35
(d) $\frac{1}{2}$ x $\frac{3}{5}$ x (−30+45) = +4.5
(e) $\frac{1}{2}$ x $\frac{9}{11}$ x (−46.88+45) = −0.52
(f) $\frac{1}{2}$ x $\frac{4}{9}$ x (−46.88+20) = −5.97
(g) $\frac{1}{2}$ x $\frac{5}{11}$ x (−67.5+31.25) = −8.24

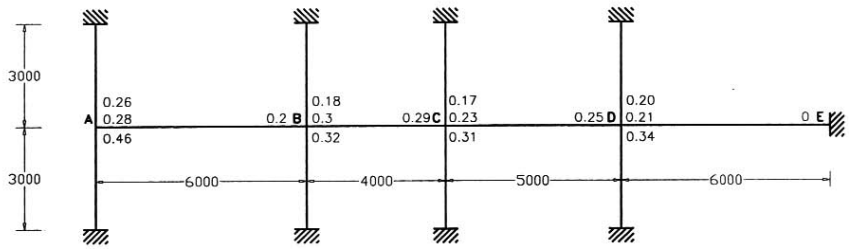
Adjustments due to supports:
−$\frac{1}{2}$(1+D.F) c/o

(h) −$\frac{1}{2}$ (1+1) x (−9.5) = +9.5
(i) −$\frac{1}{2}$ (1+$\frac{3}{5}$) x (−33.75) = +23.63
(j) −$\frac{1}{2}$ (1+0.6) x (+0.35) = −0.28
(k) −$\frac{1}{2}$ (1+$\frac{5}{9}$) x (+4.5) = −3.50
(l) −$\frac{1}{2}$ (1+$\frac{4}{9}$) x (−0.52) = +0.38
(m) −$\frac{1}{2}$ (1+$\frac{9}{11}$) x (−5.97) = +4.61
(n) −$\frac{1}{2}$ (1+$\frac{5}{11}$) x (0) = 0
(o) −$\frac{1}{2}$ (1+0) x (−8.24) = +4.12

Balancing Moments are of opposite sign to reduce larger moment

(q) = −(−77.0−0) x 1 = +77.0
(r) = +(101.25−29.65) x $\frac{2}{5}$ = +28.64
(s) = −(101.25−29.65) x $\frac{3}{5}$ = −42.96
(t) = +(25.5−47.40) x $\frac{5}{9}$ = −12.17
(u) = −(25.5−47.40) x $\frac{4}{9}$ = +9.73
(v) = +(52.85−67.5) x $\frac{9}{11}$ = −7.99
(w) = −(52.85−67.5) x $\frac{5}{11}$ = +6.66
(x) = +(75.74−0) x (0) = 0

*Figure 1 : Max. M (Support & Span)*
*for a continuous beam over supports providing no restraint to rotation.*




**Load Pattern A**

| | | A | T.L. | B | D.L. | C | T.L. | D | D.L. | E |
|---|---|---|---|---|---|---|---|---|---|---|
| D.F | Upper col | 0.26 | | 0.18 | | 0.17 | | 0.2 | | |
| | Lower col | 0.46 | | 0.32 | | 0.31 | | 0.34 | | |
| | Beam | 0.28 | | 0.2 | 0.3 | 0.29 | 0.23 | 0.25 | 0.21 | 0 |
| | $M_{D.L}$ | | | | −20 | −20 | | | −45 | −45 |
| | $M_{T.L}$ | −67.5 | | −67.5 | | | −46.88 | −46.88 | | |
| | C/O | −4.75 | | −9.45 | +3.90 | +7.13 | −0.24 | −3.09 | 0 | −0.20 |
| | ΣM | −72.25 | | −76.95 | −16.10 | −12.87 | −47.12 | −49.97 | −45 | −45.20 |
| M | Upper col | +18.79 (72.25x0.26) | | +10.95 (76.95−16.10)x0.18 | | | +5.82 (47.12−12.87)x0.17 | +0.99 (49.97−45)x0.2 | | |
| | Lower col | +33.24 (72.25x0.46) | | +19.47 (76.95−16.10)x0.32 | | | +10.62 (47.12−12.87)x0.31 | +1.69 (49.97−45)x0.34 | | |

**Load Pattern B**

| | | A | D.L. | B | T.L. | C | D.L. | D | T.L. | E |
|---|---|---|---|---|---|---|---|---|---|---|
| D.F | Upper col | 0.26 | | 0.18 | | 0.17 | | 0.2 | | |
| | Lower col | 0.46 | | 0.32 | | 0.31 | | 0.34 | | |
| | Beam | 0.28 | | 0.2 | 0.3 | 0.29 | 0.23 | 0.25 | 0.21 | 0 |
| | $M_{D.L}$ | −45 | | −45 | | | −31.25 | −31.25 | | |
| | $M_{T.L}$ | | | | −30 | −30 | | | −67.5 | −67.5 |
| | C/O | −1.5 | | −6.3 | +0.18 | +2.25 | +4.53 | −0.14 | 0 | −3.81 |
| | ΣM | −46.5 | | −51.3 | −29.82 | −27.75 | −31 | −31.39 | −67.5 | |
| M | Upper col | +12.09 (46.5x0.26) | | +3.87 (51.3−29.82)x0.18 | | +0.55 (31−27.75)x0.17 | | +7.22 (67.5−31.39)x0.2 | | |
| | Lower col | +21.39 (46.5x0.46) | | +6.87 (51.3−29.82)x0.32 | | +1.01 (31−27.75)x0.31 | | +12.28 (67.5−31.39)x0.34 | | |

*Figure 2 : For Max M in col*

## DETERMINATION OF COLUMN MOMENTS

For multi storey buildings, it is considered satisfactory to compute column moments under the same assumption used for beam moments, i.e. far lends of columns are fixed above and below the floor at which moments are to be determined. Column moments are computed for unbalanced floor loading, that is line load on one side only.

Figure 2 is a sub-frame of a multi-storey structure; live load is placed on the alternate spans as shown on load pattern A and load pattern B.

The method of calculating the maximum moments in columns is:

Step 1. Write down the Distribution Factors for the columns and for the beams and the $M_{D.L}$ and $M_{T.L}$ according to the load pattern.

Step 2. Calculate and write down the carry-over moment (C/O) and C/O = ½ x D.F x ($M_{T.L}$ - $M_{D.L}$ )

Step 3. Obtain Total Unbalanced Moment (∑M) by adding $M_{T.L}$ to C/O

Step 4. Maximum moments in column are obtained by multiplying the difference of the beam moments at the joint by the distribution factors of the columns.

The sign of column moments should be opposite to the beam unbalanced moments at the joint. The results of the column moments are shown in Figure 2.

It can be seen that the maximum moments in columns A, B and C are obtained from load pattern A, whereas load pattern B gives maximum moments in column D. ■

## CONCLUSIONS

1. Moment coefficients may be used only if loads and spans meet the code requirement.
2. The Hardy Cross Method is too time consuming.
3. The 2-Cycle Method is simpler and faster. Not only support moment but also span moment and column moment can be obtained fairly quickly using this method.
4. A structure basically consists of beams and columns, the 2-Cycle Method helps us to understand structures better and thus gain confidence. Hence, we can feel and appreciate them better.
5. It can be used to counter check computer software. No structural engineer should ever use unfamiliar software without applying some verification.
6. It helps us to be a computer-aided design engineer and not just a computer operator!

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# UKM Chemical Engineering Students Win IEM's 1st Malaysian Chem-E-Car Competition 2004

*Reported by: Prof. Dr Asbi bin Ali and Dr Law Chung Lim, Chemical Engineering Technical Division*

On 12 January 2005, the Chemical Engineering Technical Division organised the 1st Malaysian Chem-E-Car 2004 Competition. Universiti Kebangsaan Malaysia is the co-organiser of this event. The competition was officially opened by Ir. Prof. Abang Abdullah bin Abang Ali, President of The Institution of Engineers, Malaysia. Ir. Prof. Abang Abdullah was pleased to see participating students who will be young engineers in the future being very creative and innovative in making their own Chem-E-Car. The Organising Chair of Asia Pacific Confederation on Chemical Engineering Congress 2006 (APCChE 2006) announced that a regional Chem-E-Car Competition will be organised by the Organising Committee in conjunction with APCChE 2006. He was confident that participating students in this national competition will have gained experience and will be able to compete very well with teams from other countries during the regional competition.

The competition consisted of two sessions. The first session was a poster presentation. Participants were given 10 minutes to present their model car and describe the propulsion system as well as the innovative and creative ideas they have made in areas such as propulsion system, safety, environmental issues, efficiency, etc. It was then followed by the model car competition where each team was given four attempts. The team whose model car ended nearest to the end line wins the competition.

A Chem-E-Car is a model car whose propulsion system is either a chemical cell or a fuel cell. The power that is required to drive the model car must be generated or converted from chemical energy. Of course, commercial batteries and fuel cells were not allowed in the competition.


*"Fuel Cell" from UKM won the poster presentation*


*Winner for Car Model presentation*

*Organising Committee with the car models of the teams*

Seven teams from Universiti Kebangsaan Malaysia (UKM), Universiti Malaya (UM) and Universiti Putra Malaysia (UPM) participated in the competition. The participating teams were: Pro-A, Chem-X, Funny Car, Avicenna and Fuel Cell from UKM, Crest from UM and Phoenix from UPM. On competition day, the participating teams were notified that the distance to be traveled was 15m and the


*Participating Teams in the 1st Malaysian Chem-E-Car Competition 2004*

additional load to be carried by the model car was null.

The team of judges for the competition consisted of Ir. Johan Alimin bin Abdul Samad, Ir. Ahmad Nordeen bin Mohd Salleh and Ir. Chen Yew Seong. Rules Coordinator was Dr Law Chung Lim.

Fuel Cell from UKM won the competition. The team scored 346cm from the finish line. The next closest competitor was ProA from UKM at 393cm, and third place went to Avicenna from UKM at about 468cm. The first prize is a cheque for RM1500.00 and certificates.

In addition to doing well in the model car competition, the winning team also won the first place in the poster competition. Other winners in the poster competition were Phoenix from UPM (second place) and Funny Car from UKM (third place).

The Chemical Engineering Technical Division is excited about the success of the Chem-E-Car competition which produced a winning team this year and looks forward to the opportunity of having this team to compete at the international level in Glasgow in July 2005 to represent IEM and Malaysia. The 2nd IEM Chem-E-Car Competition is being organised for this year and an announcement will be made soon. ■

# Visit to Open University Malaysia

*Reported by: Ir. Assoc. Prof. Megat Johari bin Megat Mohd. Noor, Engineering Education Technical Division*

As part of the programme for the half-day seminar on Trends and Issues in Engineering Education, the Division organised a visit to the Universiti Terbuka Malaysia on 23 March 2005. The university, better known as Open University of Malaysia (OUM), was officially established on 10 August 2000. The university is located in the heart of Kuala Lumpur in Jalan Tun Ismail, within walking distance from a mass transit railway interchange station and is readily accessible from all parts of the city.

After the initial briefing with a multimedia presentation by Ir. Prof. Madya Dr. Rosli bin Hamir, the Dean of the Faculty of Engineering and Technical Studies, the misconception that members of the entourage had that the programmes conducted by OUM were all virtual was quickly eliminated. The OUM adopts a multi-mode learning approach where learning takes place through real and virtual interaction between learners and tutors via the following: self-managed learning, online learning and face-to-face interaction.

A tour of the CIDT (Centre for Instructional Design and Technology) where open and distance learning (ODL) materials that are used in the various programmes offered by OUM are developed was an eye-opener for the participants of the visit. The materials include printed modules, online content and multimedia content. CIDT uses proven instructional design, strategies and methods together with the latest in communications technology to perform its functions effectively.

The Tan Sri Dr. Abdullah Sanusi Digital Library comprises a wide range of resources in print and online formats in support of the virtual and open distance learning concept. The online databases consist of Electronic Books (e-books) and Electronic Journals (e-journals). The availability of "MY Library (OPAC)" also enables users to search the library collection. Self-service features including loan renewals, reservation of items on loan to other users and checking of items on loan are also available.

Despite the short period of the visit, the participants felt that OUM has a great potential in ensuring university education reaching the masses and that the multimedia and distance contents developed specifically for the respective courses are invaluable and could be shared with other institutions of higher learning. ■

# Visit To New Straits Times Press (NSTP)

*Reported by: Ir. Mah Soo, Standing Committee on Publications*

On 27 July 2004, a visit to the New Straits Times Press at 31, Jalan Riong, Bangsar, Kuala Lumpur was organised by the IEM Secretariat for the IEM Publishing Book Project Sub-Committee to gain insight on the mechanisms of publishing books.

The IEM participants on this visit comprised of Y. Bhg. Dato' Ir. Pang Leong Hoon, Ir. Chin Mee Poon, Ir. Mah Soo, Puan Nurul Aida and Puan Abriza.

The participants were received by Y. Bhg. Datuk Ahmad A. Talib, who is the Group General Manager for Communications & Editorial Marketing in NSTP. He gave the participants some insight on the following topics:

1. the process and stages in getting a book published;
2. what type of books NSTP had supported;
3. what ways NSTP could work with IEM on the Book Project;
4. some examples of book formats with regards to contents, size and thickness, and the charges involved; and
5. the sources of potential contributors such as writers, editorial staff and publishers.

He stressed that the objective of the Book Project should influence the book features as well as the distribution methods. To give an impressive corporate image, the book should be printed on good paper with beautifully coloured photographs. It should appeal to the engineering fraternity as well as be interesting to the general public for information. A coffee table type of book would suit the Book Project well.

He cited books published by various corporate and professional bodies for use as corporate gifts as well as for sale to the general public and their respective professional fraternities. The book could be printed in hard-cover binding for corporate use or as a collector's item and in soft cover binding which is affordable to the general public.

He showed examples of books produced in collaboration with some corporations and professional institutions that were published by NSTP. They were professionally done and portrayed an excellent corporate image.

As for the text, information and photographs, NSTP has an archive of press releases on the engineering profession and could offer its resources for a fee. NSTP also could offer its professional services from concept to final publication of the book with certain agreed financial terms.

Finally, the visit was concluded with the presentation of an IEM souvenir to Y. Bhg. Datuk Ahmad A. Talib, as an appreciation for his generosity in his time and sharing of experience with the participants. ■

# MMU Cyberjaya Membership Drive

***Reported by: Sdri. Heah Hooi Kiang***

"Close your eyes and imagine…" a hypnosis class? No, it was a membership talk by the IEM G&S. Dear Ivan and Bernard had kicked off the talk in an interesting way, which is out of the audiences' expectation. In a more relaxing circumstance instead of the formal and serious typical engineering talk, they successfully warmed up the floor and had flawless interaction with the participants.

Held on 3 March 2005, the one and a half hour talk in MMU Cyberjaya was divided into two sessions. Students were introduced to the IEM G&S in the first session. The roles of each portfolio, as well as the activities held throughout the year and the benefits of joining as a student member were clearly explained. Besides, with the sharing of experiences and stories by both young engineers, the audience had a chance to think about their future. Hence, the determination to become a Professional Engineer (PE) and to get an Ir. title positively increased among the crowd.

Specially-designed IEM G&S t-shirts and caps were given out during the Q&A session. Questions asked by members of the audience were answered in a professional way by both of the speakers. With the talk, students have managed to get a clearer picture of the role that IEM G&S can play in their student life. All of the uncertainties and doubts were dispelled by the end of the day. ■

# G&S Bowling Competition

*Date* : **21 February 2005**
*Venue* : **Endah Parade Bowling Alley**
*Participants* : **IEM G&S, SSP, SMHB, BENAIM**

Shalin Zulklifi wannabes from SMHB, SSP, BENAIM and IEM G&S Section showed up at Endah Parade on the evening of 21 February 2005 for a showdown of bowling prowess. From the number of participants that turned up and with some bringing their own shoes and balls, the evening looked promising and it sure was.

The total of 43 participants was separated into groups of 4 with members from different companies to allow participants to get to know other better. Feelings of awkwardness soon faded when the games started. Members of each group pushed and encouraged each other to bowl better. Throughout the evening, shouts of delight when a member hit a strike and groans of agony when a pin was missed could be heard from the lanes we occupied. The lanes were certainly scorched that night and presumably 'square' engineers can sure roll!

The night concluded around 10 p.m. with the following participants walking away with the prizes:

**TEAM EVENT**
***Champion:*** Group 7 (Jaafar, Chua MF, Choo Ah Min)
***1st Runner Up:*** Group 4 (Rafidin, Husaini, Chen L.S, Suresh)
***2nd Runner Up:*** Group 5 (Samsuar, Tan Loo Shyang, Daniel Sek, Ivan Tan)

**MEN**
***Champion:*** En. Jaafar (SMHB)
***1st Runner Up:*** Tan Loo Shyang (SMHB)
***2nd Runner Up:*** Chua MF (SMHB)

**WOMEN**
***Champions:*** Loo A.C (SMHB)
***1st Runner Up:*** Peggy Yeo (SMHB)
***2nd Runner Up:*** Leong LY (SSP)

**BEST EFFORT:**
***Men:*** Wong Chee Fui (SSP)
***Women:*** Rozila (SMHB)

# The Trip Down To MMU Melaka

*Reported by: Sdri. Eunice Lim Hui Lyn*

On 22 March 2005, two young engineers (Sdr. Yau Chau Fong and Sdr. Ivan Tan) from IEM G&S and two student volunteers (Sdri. Heah Hooi Kiang and me) from MMU Cyberjaya traveled from KL down to Melaka for a membership talk held in the Multimedia University Melaka campus. Our team of four started the journey early in the morning and reached Melaka by 12:30 p.m., the right time for lunch. We had lunch, followed by a short tour around the historical city.

In the evening, after a light dinner, we drove to MMU Melaka, the main purpose of the trip. Around 20 students attended the talk presented by the two young engineers. The purpose of the talk was to introduce IEM to the students. Both speakers explained about IEM, the activities held throughout the year and the ten benefits of joining IEM. They also explained about the procedure to be a Professional Engineer (PE) and the Ir. title. Finally, after the presentation, there was a Q&A session where the students asked questions regarding IEM and aspects of the engineering world. The questions were dutifully answered by the speakers. Some refreshments were provided to the students and the guests of the day. After the talk, we packed up and drove back to the city. It was a great trip, tiring, but fun. ■