# KEYNOTE ADDRESS
# "COASTAL RECLAMATION IN MALAYSIA"

REGIONAL SEMINAR ON LAND RECLAMATION FOR URBAN DEVELOPMENT
UNIVERSITY MALAYA,
KUALA LUMPUR 10 – 11 AUGUST 1992

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1997

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# COASTAL RECLAMATION IN MALAYSIA

by

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**ABSTRACT**

In the past two decades or so, there has been an increase in the number of coastal land reclamation projects for residential, commercial and industrial development in many of the more developed coastal cities of Malaysia. The success of any coastal reclamation project is strongly dependent on sound planning and design practices, covering both the engineering and non-engineering aspects. Engineering considerations in the planning and design of coastal reclamation projects are discussed while potential environmental impacts are elaborated based on local and overseas experience. Some of the negative impacts include coastal erosion, loss of mangroves/wetlands, impedance of natural drainage and damage to marine eco-system. Recent advances in mathematical modelling have contributed greatly to the improvement of planning and design practices for such projects as well as in the assessment and quantification of potential environmental impacts.

The Environmental Quality (Amendment) Act (1985), Environmental Impact Assessment Order (1987) and General Circular 5/1987 issued by the Prime Minister's Department constitute the main legal and administrative instruments of the Government to control and regulate the planning approval of coastal reclamation projects in this country. There is a need to strengthen or improve the administrative and enforcement efficiency of the present mechanism and to develop comprehensive information data base and state-of-the-art technology to assist in the screening and planning approval of specific reclamation projects. The preparation of integrated coastal zone management plans for all coastal areas is also strongly recommended as a positive step towards sustainable and balanced use of the land, water and biological resources of the coastal zones with due consideration to the tradeoff between economic development and environmental conservation.

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## 1. INTRODUCTION

Malaysia has a total land area of 329,750 $km^2$, comprising the mainland of Peninsular Malaysia (131,590 $km^2$) and the states of Sarawak (124,449 $km^2$) and Sabah (73,711 $km^2$). The corresponding lengths of shoreline for the three regions are 1970 km, 1040 km and 1800 km respectively. Physiographically, the coastlines of Malaysia are of varied character and configuration. The east coast of Peninsular Malaysia comprises mainly sandy beaches while the west coast is made up of low elevation coastal plains formed from marine clay, occasionally interspersed by sandy pocket beaches hemmed in between rocky headlands. The coastlines of Sabah and Sarawak comprise roughly equal proportion of sandy and muddy formations.

The coastal zones of Malaysia support a major portion (70 %) of the population, is rich with natural resources, and is the center of economic activities: urbanisation, agriculture, fisheries, aquaculture, oil and gas exploitation, transportation and communication, recreation, etc. Of the coastal regions, the west coast of Peninsular Malaysia is most developed socio-economically, with 57 percent of its length under agriculture and 21% under housing, transportation and recreation facilities.

The population of Malaysia in 1990 was 17.8 million, expanding at an annual growth rate of 2.6%. At this rate, the population is expected to reach 33.6 million by the year 2020. In 1970, urban areas accounted for 27% of the total population but this has increased to about 40% in 1990. The urban population is expanding at a rate of 4.2%. One would expect more than 50% of the population to be resident in urban centers by the year 2020. Many of the large population centers are located in coastal areas, typical examples are Penang, Melaka, Johor Bahru, Kuantan, Klang, Kuala Terengganu, Kota Bahru, etc.

On the economic front, the structure of the Malaysian economy is also undergoing rapid transformation. In 1980, the manufacturing sector accounted for 20.5% of the Gross Domestic Product (GDP) but this has increased to 27% by the year 1990. With an estimated growth rate of about 10% per annum, the manufacturing factor is expected to account for 37% of GDP by the year 2020. Many of the industries are located in coastal cities to facilitate export and to tap the labour pool in these urban centers.

Population expansion and industrialisation are the two main factors that have contributed to the rapid growth of many coastal cities, resulting in an escalating demand for prime land. The wide shallow waters that abut the coastline become the prime target for reclamation. The financial advantage of coastal land reclamation is easily demonstrated considering the current market value of prime land in coastal cities and the construction cost for coastal reclamation. It is also due to the same reason that coastal cities such as Penang, Melaka, Labuan became the pioneers of coastal land reclamation projects.

## 2. CURRENT PROGRESS IN COASTAL LAND RECLAMATION

Coastal land reclamation for urban use is a relatively new development in this country. Prior to the 1970's, there was hardly any work on coastal reclamation other than some small scale reclamation work in conjunction with the construction or expansion of port facilities. Reclamation of coastal waters for housing and industrial uses came into significance after 1970's as a result of accelerated urban development and the rising cost of land in some major coastal cities. To date, Penang, Melaka, Port Dickson, Kota Kinabalu are towns or municipalities that have successfully implemented coastal land reclamation works, either as public sector or private sector projects. In Penang Island, the Penang Development Corporation has to date reclaimed about 500 ha of coastal areas for housing and industrial development, located mainly in the Bayan Lepas area. In Melaka, about 100 ha of land had been reclaimed for residential and industrial use in the Kota Laksamana area. In Port Dickson, about 60 ha of coastal land was reclaimed for coastal resort development. In Pulau Langkawi, a rapidly developing international tourist resort, about 20 ha. of coastal land reclamation work are nearing completion. In Kota Kinabalu, sizeable coastal reclamation works (acreage cannot be confirmed) have also been carried out (the Hyatt Hotel and its vicinity).

There are also a number of other coastal land reclamation projects in the planning and design stage. These include reclamation works on the coast of Perlis, Central District Development Project in Penang Island, Telok Sisek in Kuantan and Rancha-Rancha area in Labuan Island. Details of these projects, unfortunately are not available at this stage. One could expect an increase in coastal land reclamation projects in the future as more coastal towns embark on similar venture, building on the experience and success of others.

The scale of coastal reclamation in Malaysia is small by comparison with the neighbouring country of Singapore. Pui (1991) reported that over the last 100 years, Singapore has reclaimed some 53 $km^2$ (5300 ha) of land from its coastline involving 165 million cubic meter of earth and 120 million cubic meter of seabed sand. The reclaimed land accounts for about 8% of the present land area of Singapore.

## 3. ENGINEERING CONSIDERATIONS IN THE PLANNING AND DESIGN

Coastal land reclamation projects are major engineering undertakings, involving substantial capital cost outlay and long term impact on the natural environment. A good knowledge or understanding of coastal processes and the related marine eco-system is therefore required in order to arrive at the most cost effective and environmentally friendly solution, assuming that such a project is economically justified and socially acceptable

in the first instance. Some of the engineering considerations in the planning and design of such projects are discussed below :-

(a) The layout planning of any coastal reclamation project should give full considerations to coastal and hydraulic characteristics of the area. For this purpose, observations of offshore and nearshore wave conditions, bathymetric information, tides, etc are required. The correct siting of platform level is crucial to the functional performance of the reclamation works as well as its financial viability. Properly conducted engineering study by qualified and experienced specialists is the only proven and trusted approach of developing project layout and dimensions that fulfil the functional requirements of a particular project.

(b) There should be adequate protection against erosion of the reclamation area. Ideally, the reclaimed land should be bordered by stable sandy beaches but this is only possible under highly favourable wave climate or conditions. Erosion protection works can be costly and hence must be accounted for in the capital cost outlay. There are many forms of erosion protection measures such as revetment, articulated concrete slab/ mattress, sea wall, etc. Seawall and other structures with vertical faces are generally not preferred because of the likely occurrence of excessive toe scour and lowering of the foreshore leading to structural collapse. This is evident in some of the beach front protection works constructed by local authorities and municipalities in the past. Another important consideration in the design of protection works is that it should not result in the transferring of the erosion hazard to neighbouring shoreline, a classic example is that of groyne construction.

(c) Where the reclamation work is carried out over clayey foundation (marine clay in particular), adequate considerations must be given to the likely problems of construction difficulties and excessive settlement. Marine clay found on the west coast of Malaysia is characterised by low shear strength and high compressivity. Some of the engineering problems that could be encountered are sand penetration or loss of fill material, slip failure and excessive post-construction settlement. In particular, consolidation settlement in marine clay can extend up to 30 to 50 years. To overcome or minimise these problems, the designer should consider various ways of improving the engineering properties of the foundation soil such as preloading, soil removal and sand drain techniques. Most of these techniques, however, have only demonstrated marginal success or cost-effectiveness when applied to marine clay. More local effort in innovative and adaptive research are therefore strongly advocated.

(d) Typical coastal reclamation projects require large quantities of sand fill of the right type and quality. For such projects, offshore sand source is perhaps the only feasible and financially viable option. The issues of location of borrow site, quantitative availability, material suitability, abstraction and handling procedures must be suitably addressed. To avoid damaging impact on the adjacent shore and reclaimed area, the borrow site must be located sufficiently far from the shore. Under the South Johor Coastal Resources Management Study (1991), it was recommended that the borrow site must be 1.5 km offshore or at a depth greater than 10 m, whichever the further. Sand sourcing investigation is also advised at the time of planning and design and the results should be made available to all contractors participating in tender bidding.

(e) In recent years, the scientific community is increasingly convinced of the threat and potential impact of sea level rise resulting from the greenhouse or global warming effects. It is therefore prudent that coastal reclamation project, characterised by long service life, should provide adequate safeguard against anticipated sea level rise. Such protection could be in the form of higher platform level or the construction of flood barriers or bunds. At this stage, there is still considerable disagreement on the likely magnitude of future sea level rise. For preliminary planning purpose, it may be appropriate to base on the studies by the United Nations Environment Program (UNEP, 1988) which suggested allowing for a sea level rise of 20 cm by the year 2025 and 100 cm by the year 2090.

(f) The planning of infrastructural facilities on the reclaimed land must give adequate consideration to the problems of local drainage and control of pollution resulting from human settlement and industrial activities. The sea should not be regarded as an unlimited dumping site for unwanted matters and pollutants. Storm discharge system, solid waste disposal and sewerage treatment facilities are essential infrastructures that should be provided as part of the coastal reclamation development.

## 4. ENVIRONMENTAL CONSIDERATIONS

By far, the greatest concern on coastal land reclamation project is its possible impact on the natural environment. Experienced engineers have no difficulty in designing and constructing coastal land reclamation works but few can claim of offering complete mitigative solutions, let alone ensuring that there is no impact on the environment. The alteration of coastal

land form invariably leads to a disturbance on the hydrodynamic regime and the marine eco-system, the magnitude of which is hard to predict or quantify. Based on reported experiences locally and overseas, some of the pertinent environmental impacts are :

- Loss of mangrove/ wetlands
- Damage to sensitive marine habitat
- Impact on coastal processes/ coastal erosion
- Impedance of natural drainage

(a) Loss of Mangrove/ wetlands

There is an increasing appreciation by scientists as well as the general public that mangroves and wetlands are valuable resources for their ecological and geomorphic roles. Mangroves help in creating new land, combating erosion and is the breeding ground, nursery and habitat of various fishes, prawns and crabs. Mangrove and other wetlands (eg. mudflats, freshwater swamps, peat swamps, marshes) also form the feeding/ breeding sites of many types of wildlife, endangered mammals, migratory and resident water birds. Coastal reclamation over existing mangrove and coastal wetlands invariably leads to the loss of such habitat, causing a disruption to the survival and welfare of these species and also the equilibrium of nature. In addition to the direct losses over the area of reclamation, heavy silt content in coastal waters, disruption of equilibrium of fresh/ saline water, changes of current flows, etc can also affect the growth or survival of mangrove and other coastal vegetation in adjacent coastline or wetlands, thus extending the area of potential damage. The expert advice of marine biologist/ ecologist should therefore be solicited as part of a comprehensive EIA assessment for any major coastal reclamation project.

(b) Damage to Sensitive Marine Habitat

Most coastal reclamation works involve pumping material from offshore seabed into the area to be reclaimed using dredger and pipeline system. Such operations can result in high concentration of sediment in coastal waters both at the site of reclamation and in the vicinity of the borrow site. This can affect water quality, especially turbidity. Increase in turbidity reduces light penetration into sea water and can result in irreversible damage to marine vegetation, fisheries and coral reefs. To minimise such effects, it is recommended that suction dredger be preferred over mechanical dredger during construction. For the same reason, a plain suction dredger is a better choice as compared to a cutter suction dredger.

(c) Impact on Coastal Processes/ Coastal Erosion

Coastal reclamation changes the planform of the existing coast. Such changes will affect coastal processes by interfering with the natural flow of littoral drifts and tidal currents. The seaward protrusion of the reclamation will result in a groyne-like effect on the coastline. Sediments that are usually carried by the littoral currents will be deposited on the updrift side of the reclamation area. On the downdrift side, the coastline will erode as the littoral currents start to pick up sediments again.

Coastal reclamation at headlands can change the effective length of the headlands. This can affect the stability of hooked shaped bays resulting in possible initiation of new erosion areas in an existing stable coastline.

Tidal currents can also be affected by changes in planform of the shoreline. This is especially the case in lagoons and estuaries. Reclamation of lagoons reduces the volume of water exchanged due to tidal effects and can cause closure of outlets that are maintained by this tidal flux. Changes in tidal currents in estuaries can effect navigation, water quality and erosion and sediment patterns in river mouths and adjacent areas.

(d) Impact on hinterland drainage

Drainage of coastal areas depends on the distance of the point to be drained from the sea and the elevation difference between them. This determines the hydraulic gradient of the water flowing in the drains. Coastal reclamation extends the distance and therefore reduces the hydraulic gradient. This can result in reduction of flood discharge through the drains and can cause flooding in the hinterland.

## 5. NUMERICAL MODELLING - STATE-OF-THE-ART TECHNOLOGY

Coastal planners and engineers have longed for predictive tools to forecast the response of engineering or natural system due to changes in system design, layout configuration and boundary forces. Until the 1970's, physical modelling is perhaps the only proven technique for this type of investigation. However, the main limitation of physical modelling is that it is expensive and time consuming and besides, it can only provide a qualitative assessment of sediment movement or response. Despite many research effort aimed at perfecting the art of mobile bed modelling, it is fair to say that there is as yet no major or significant breakthrough.

In the past decade, tremendous progress has been made in the field of numerical modelling. Increasingly, numerical model has conquered new frontiers and has earned itself a respectable position in the engineering world as the modern day tool for the analysis and design of complex hydraulic and coastal engineering works. The impact of land reclamation on the coastal processes such as currents, waves, sediment transport, etc are now readily predictable or quantifiable using state-of-the-art computer models, typical examples of which are MIKE 21 and LITPACK by the Danish Hydraulic Institute. Similar advances have also been made in the prediction of water quality changes and marine eco-system response. Such modern tools necessarily require greater expertise and experience for their usage. This has given rise to the development and expansion of hydraulic research institutes which offer specialist services on the application of such models to support practical engineering analysis and design. Appendix 1 lists some examples of numerical models that are useful for coastal engineering applications.

## 6. INSTITUTIONAL FRAMEWORK, LEGAL AND OTHER PROVISIONS

The political and administrative jurisdiction of the State Government on coastal waters extends to a distance of 3 nautical miles (or 5.5 km) from the shoreline (Mean High Water Spring). Coastal reclamation projects therefore usually fall on state land and hence require the approval of State Government before they can be implemented. An application for land reclamation, complete with layout is submitted to the Land Office which then seeks and consolidates the views and comments of the various government agencies before submitting it to the State Director of Land and Mines. The State EXCO is the final approving authority acting on the advice and recommendations of the Department of Land and Mines and with due consideration to the socio-economic desirability of the proposed project.

For the larger reclamation projects (defined as exceeding 50 ha), the developer is also required to comply with a federal law known as the Environmental Quality (Amendment) Act (1985). Any development activity affected by the Environmental Impact Assessment Order 1987 (Prescribed Activities) requires the submission of an EIA Report to the Department of Environment and no physical works are allowed to commence until approval/ clearance is obtained from this Department.

Another Federal Government Circular, No. 5/1987 issued by the Prime Minister's Department requires all development proposals in the coastal zone to be referred to the Coastal Engineering Technical Center (resident in Department of Irrigation and Drainage) for comment. This circular is intended at instituting preventive measures or regulatory control on development activities which could lead to the initiation or aggravation of coastal erosion problem in the country. From the environment control viewpoint, this circular is not as comprehensive as the EIA Act since it only deals with the problem

of coastal erosion and besides, it is an administrative circular without the backing of legislation. The state authorities responsible for approval of development application is therefore not bound to follow the recommendations of the Coastal Engineering Technical Center.

From the above discussions, there is sufficient regulatory control on the planning approval of large reclamation projects. A review may be warranted to extend the EIA control to cover smaller reclamation projects by including other criteria such as location, proximity to existing urban development, existing physical condition and sensitivity of the marine environment, etc. Similarly, some rethinking may be required on measures to bring about greater voluntary compliance with General Circular 5/1987 as well as to streamline the administrative and enforcement efficiency of this Circular.

The realistic assessment of environmental impact of any coastal reclamation projects, however, requires a full complement of data and information on the coastal environment, as well as knowledge of the potential development or future land use in the coastal belt. While an individual project may result in insignificant impact to the environment, the same may be not true of a cluster of projects to be implemented in the same locality. Similarly, the quality and validity of findings by EIA Consultants are also heavily dependent on the amount of data available and the time and financial resources available for new data collection and study. To overcome the above difficulties, there is a need to carry out integrated coastal zone management for all coastal regions, to be discussed next.

## 7. COASTAL ZONE MANAGEMENT

As coastal development intensifies, environmental stresses increase proportionately. As a result, coastal pollution, resource degradation or depletion, and resource use conflicts are on the rise in Malaysia. At the macro-planning level, it is therefore necessary to carry out long term developing planning based on strategies that will ensure the sustainable and balance use of land, water and biological resources in the coastal zone. In practical terms, this means the preparation and implementation of integrated coastal zone management policies and plans on a nationwide basis.

The development of a coastal zone management plan involves a multi-disciplinary approach. It should address issues such as the physical environment, resource inventory, environmental sensitivity, demand or landuse projection, socio-economic setting and other factors which are of importance in arriving at the optimal land and resources utilisation plan for a region. The need and desirability of coastal reclamation projects can be a subject of deliberation in the formulation of a coastal zone management plan.

A good example of coastal zone planning study is the South Johor Coastal Resources Management Plan Study (Ch'ng, 1991). This study which started in late 1987 is aimed at formulating a

comprehensive coastal resources management plan for the South Johor region to achieve the twin goals of economic development and coastal resource conservation. The management plan examines a host of coastal concerns such as mangrove and coral ecosystems, fisheries resources, coastal pollution, coastal erosion, coastal sand mining and resource use conflicts. The findings of the Study are currently under consideration by the Johor State Government for implementation under the Sixth Malaysia Plan. It is hoped that the success of this pilot project will spearhead similar planning efforts in other parts of the country.

## 8. CONCLUSIONS

Coastal land reclamation to yield valuable land space for a variety of uses has been carried out for some time in Malaysia and is expected to be on the upward trend. The success of such projects depends on sound engineering practices and adequate attention to potential environmental impacts. Engineering considerations for the planning and design of coastal reclamation projects include layout planning, simulation studies, protection against erosion, geotechnical considerations, sand sourcing, allowance for sea level rise, etc. Greater efforts are required in the field of adaptive and basic research to upgrade local skill and technology for the planning and design of coastal reclamation works. Modern technique such as numerical modelling holds great promise for future applications.

Coastal land reclamation projects can result in significant impact on the coastal environment such as loss of mangrove and wetlands, damage to sensitive marine habitat, coastal erosion and impedance of hinterland drainage. Planners and designers should give adequate consideration to avoid or minimise such potential impacts and implement the necessary mitigative measures, where required in a proactive manner.

The current legislation and institution mechanism for regulation and control of coastal reclamation activities are adequate. The existing mechanism can be further strengthened by establishing the necessary information and planning data base to enhance decision making capability. Realistic assessment of impact of development activities in the coastal zone requires a total, integrated approach with due consideration to resource availability, system limitation and realistic projection of future demand or landuse. For this purpose, it is recommended that comprehensive coastal zone management plans be formulated for all coastal areas in the interest of sustainable economic development and environmental preservation.

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## Numerical Models for Coastal Engineering

| Type of Models | Name | Developed by |
|---|---|---|
| Two dimensional depth integrated hydrodynamic model | MIKE21HD | DHI |
| | TRISULA | DHL |
| | TIDEFLOW-2D | HRL |
| Wave propagation model | MIKE20NS | DHI |
| | ENDEC | DHL |
| | HISWA | DHL |
| | JONSEY | HRL |
| | OUTRAY | HRL |
| | INRAY | HRL |
| | PORTRAY | HRL |
| Add on modules for sediment transport and pollution study. | M21AD | DHI |
| | M21ST | DHI |
| | PARTICLE | DHI |
| | SUSTIM | DHL |
| | SUTRENCH | DHL |
| | DELWAQ | DHL |
| | POLLFLOW-2D | HRL |
| | MUDFLOW-2D | HRL |
| One-line shoreline evolution model | LITOT/LITLIN | DHI |
| | UNIBEST-CL | DHL |
| | BEACH-PLAN | HRL |
| Two Dimensional vertical cross shore profile change model | LITCROSS/ LITPROF | DHI |
| | UNIBEST-TC | DHL |
| | NEARSHORE | HRL |
| Random plume dispersion model | PLUME-RW | HRL |

DHI - Danish Hydraulic Institute, Denmark
DHL - Delft Hydraulic Laboratory, Netherlands
HR - Hydraulic Research Limited, United Kingdom.