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SMALL STATES CONFERENCE ON SEA LEVEL RISE
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COASTAL MANAGEMENT

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Summary Notes.

1. Introduction

These notes are a brief summary of the concepts presented in a "poster paper" at the "SMALL LOW-LYING ISLAND NATIONS' CONFERENCE ON SEA LEVEL RISE" held in Male, Maldives in November 1989.

They present an engineering view of the cause and effect of coastal erosion and flooding by the sea, together with a possible structure by which the problems faced by small low-lying island nations can be approached in a coherent and integrated form.

2. Context

An essential feature in solving the problems of sea level rise is that several key professional inputs will, without doubt, be involved in any coherent programme. In general terms these are politicians, who carry the social responsibilities for the well-being of their countries, leaders of financial institutions who will take decisions on the provision of financial resources, scientists who will define the key environmental factor which constrain possible physical solutions, and engineers who will design and construct such protective structures that are required to mitigate or remove the consequences of sea level rise.

These groups will need to inform each other of their objectives, constraints, modes of working and a wide range of additional factors.

It is therefore essential that the development of a COASTAL MANAGEMENT STRATEGY must be based on an INTER-PROFESSIONAL STRATEGY MANAGEMENT TEAM, calling on the multi-discipline inputs needed to carry out a programme of work.

It is also essential that professional people from the regions at risk should take the lead in this management team.

3. The Problem

Coastal flooding and damage is not caused directly by variations in the long-term sea level. It is almost always the combination of high tides, storm surges and wave action which result in damage.

This is clearly illustrated in the method adopted in all coastal engineering design, namely that the CRITICAL DESIGN WATER LEVEL is calculated as the basic design criterion onto which the action of waves is added.

Tidal fluctuations are deterministic - they can be predicted for many years ahead to provide a MAXIMUM HIGH TIDE LEVEL, to within ten or twenty millimeters accuracy.

In extreme storm conditions the action of the wind blowing over the ocean surface results in a rise in the water level at a downwind coastline. This rise can be as much as two meters. However, this introduces a complexity to the problem because higher winds create higher storm surges and extreme winds occur randomly. It is therefore the practice to use a concept of "return period" which might be 100 years for example. Calculations

are then carried out, based on measured wind data or storm surge data, to predict the magnitude of the 100-year return period event. Clearly, if a longer return period is selected the magnitude of the variable will be higher. There is therefore an inevitable RISK associated with the selection of a return period for a given site.

Adding the STORM SURGE to the MAXIMUM HIGH TIDE LEVEL gives the CRITICAL DESIGN WATER LEVEL.

Wave action is also governed by the wind and therefore carries the same "return period" concept. Again from measured data, wave conditions with a selected return period, typically 100 years, are estimated. The action of these waves, with an extreme water level defined as described above, is the major physical process causing coastal flooding and erosion.

4. Solutions

In general terms two types of solution are used for coastal protection - Coastline structures and Offshore structures. It must, however, be noted that one solution is to do nothing, that is, to sacrifice a section of a coastal region.

The objective of these structures is to destroy wave energy by causing the waves to break or to expand their power in flowing into and out of porous coastal slopes.

It should also be noted that one of the best forms of coastal defence is a substantial beach which may be moved offshore in extreme storms but has the potential of re-building itself. Nowadays such beaches can be created by importing sand from a nearby source and creating an artificial beach.

Obviously any coast protection system has to comply with strict criteria of environmental acceptance. The latter includes not only visual and aesthetic factors but also marine and land-based natural environment considerations. For example, it would be unacceptable to invade the visual attraction of a tourist beach area with man-made structures - submerged artificial reefs would be possible. Equally it would be wrong to use rocks in a coastal structure which could change the mineral content of the local waters by solution.

5. Major Factors

Coastal protection structures are expensive. Designs are always based on minimum cost solutions, usually justified by careful cost/benefit analysis. In some areas of the global coastal domain the "benefit" is very difficult to identify in monetary terms and this might apply to some small low-lying States.

The justification and provision of financial resources is therefore a major factor in a COASTAL MANAGEMENT STRATEGY. It is unlikely that funding agencies, national or international, will be prepared to support coast protection work in a piecemeal fashion. They will undoubtedly wish to see an integrated, coherent and fully-justified strategy for a coastal region or even an entire State.

Those in positions of responsibility will have to make very difficult priority decisions on which sectors of the coastline to protect first, including the "do nothing" option. It is therefore essential to establish a framework which allows these and many other decisions to be taken in the full knowledge and understanding of the factors involved.

6. Training

In many coastal areas of the World there are few appropriately trained people available to undertake the management, scientific and engineering tasks involved in the implementation of a coastal management strategy. Training must therefore be an integral part of the programme, because it is essential that the "centre of gravity" of any programme should be locally based.

7. A Possible Framework

It is helpful to suggest a possible framework which will allow a sensible coastal management strategy to be developed and implemented, recognising that the form and priorities of that framework will change with time.

The following is an initial suggestion for a framework - to provide a basis for discussion.

OVERALL OBJECTIVE

COASTAL FUNCTIONS DATA BASE

COASTAL ENVIRONMENT DATA BASE

COASTAL PROCESS APPRECIATION

DESIGN OPTIONS AND COSTS

FINANCIAL RESOURCES COST/BENEFIT

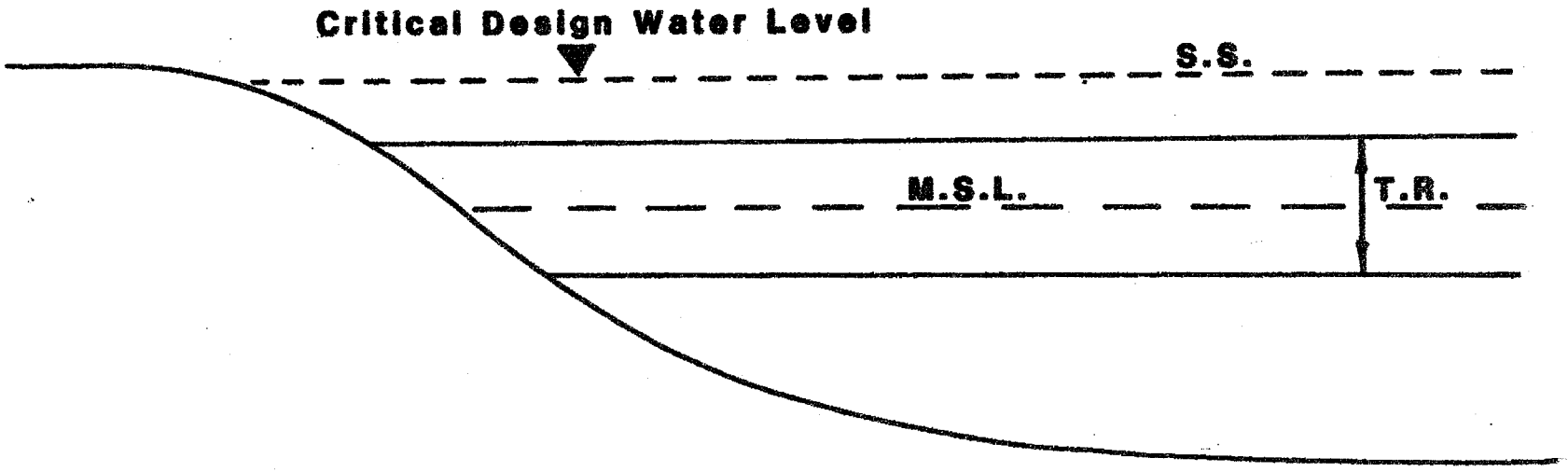
STRATEGY MANAGEMENT TEAM

PROTECTIVE WORK PROGRAMME

8. Summary

There exists a real threat to coastal communities from the predicted rise in mean sea level. This demands an integrated, coherent strategy to tackle the wide range of problems involved and an essential part of that strategy is a focus for the proper interactions between the various professions involved. A possible framework of an organisation to develop that strategy is proposed. It is by no means final but is put forward as a basis for discussion and evolution.

It is essential to at least identify the next steps in the process and to initate actions because time is not on our side.

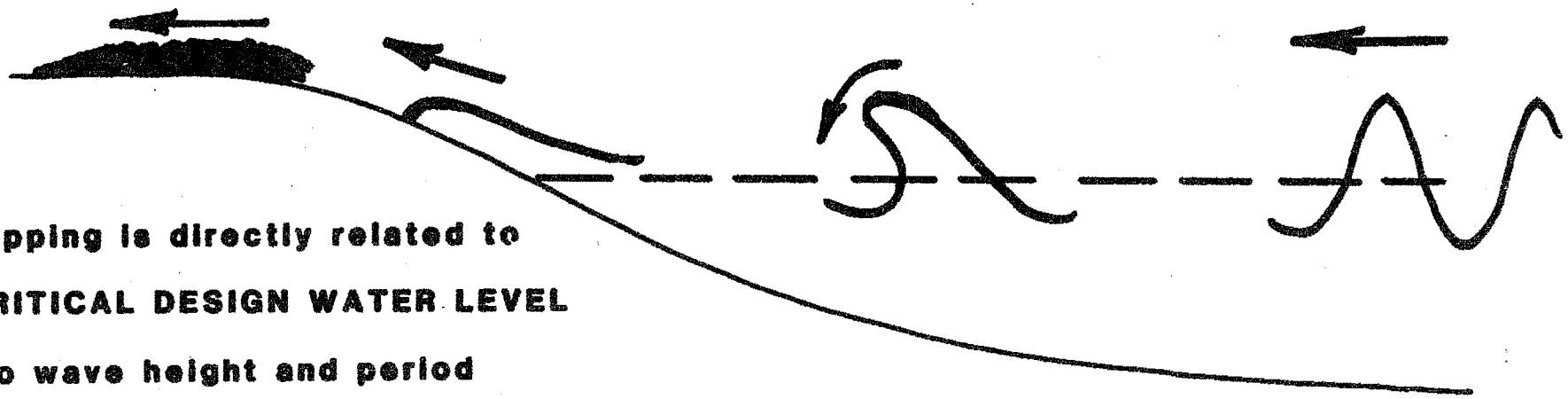


Mean Sea Level (M.S.L.)

Tidal Range (T.R.)

Storm Surge (S.S.) (water level rise due to wind action)

1 WATER LEVELS FOR DESIGN

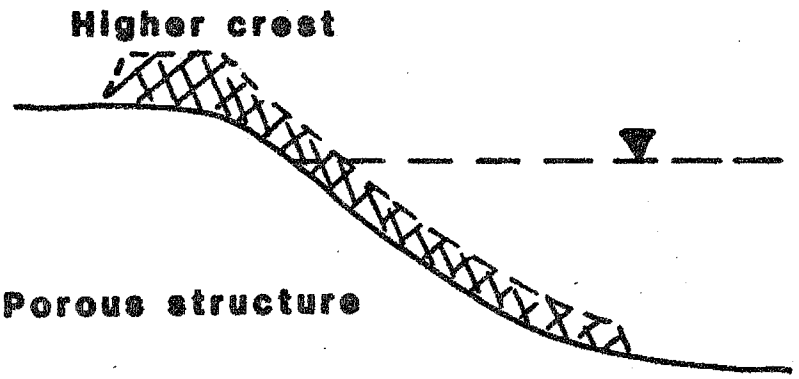


Overtopping is directly related to
the CRITICAL DESIGN WATER LEVEL
and to wave height and period

Waves overtop and cause flooding	Waves run up beach or coastal structure	Waves break in shallow water or on a reef	Incident waves from deep ocean

2 INFLUENCE OF WAVE ACTION ON COASTAL FLOODING

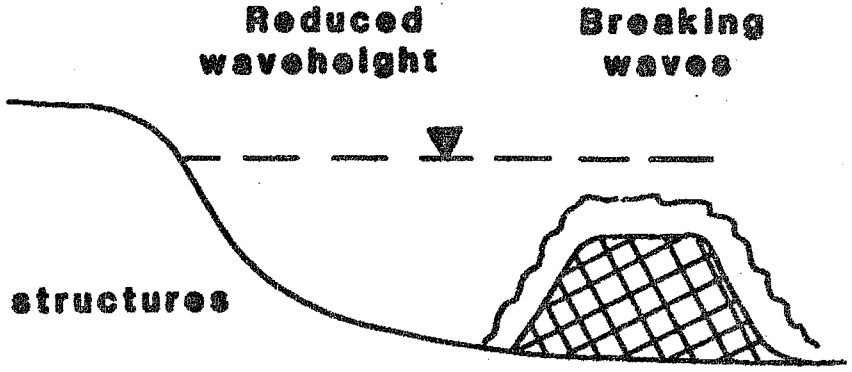
COAST-LINE SOLUTIONS



Reduced runup

Reduced overtopping

OFFSHORE SOLUTIONS

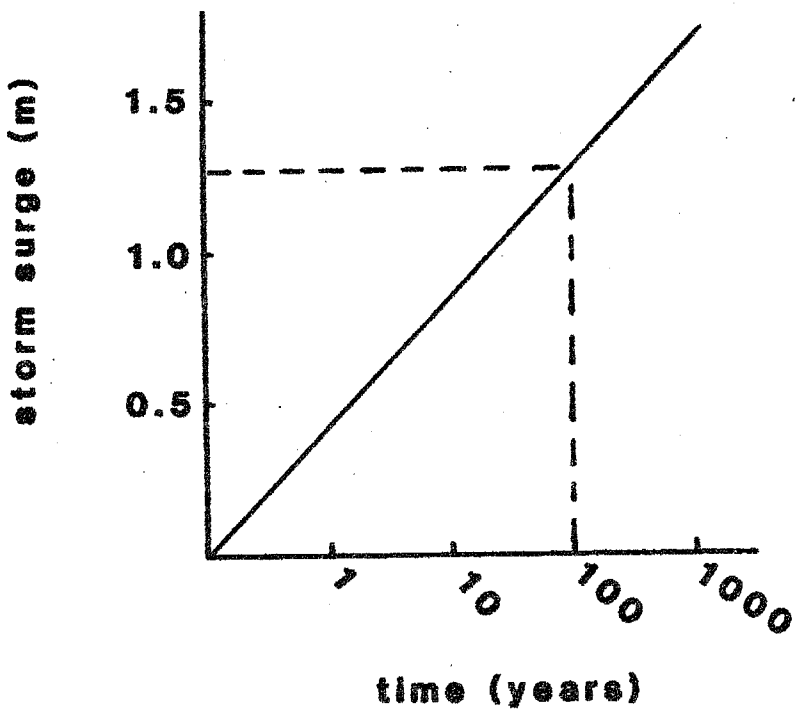


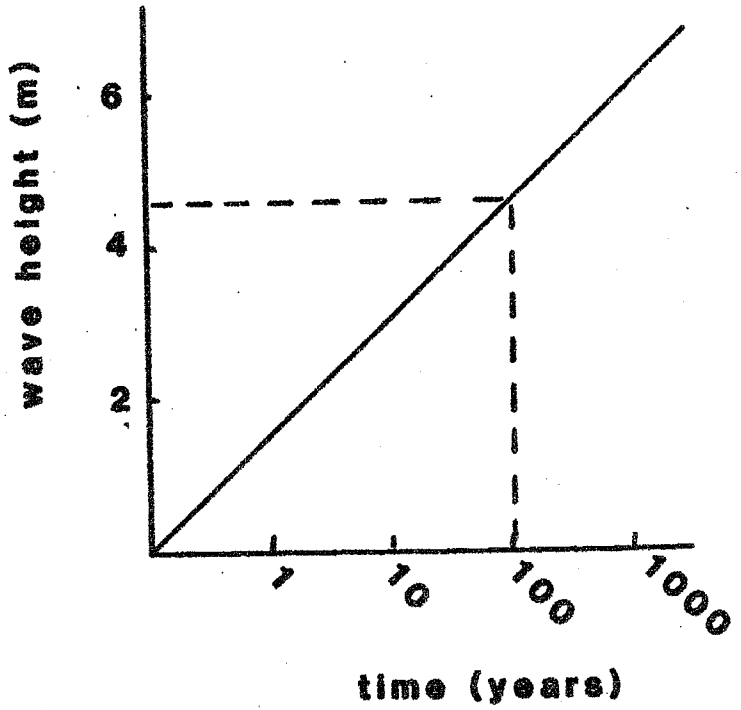
Artificial core

Coral cover

Foundation conditions : coral/sands/clays/salt marsh

3 TYPES OF COAST PROTECTIVE STRUCTURE





The "100-year event" as a design basis:

"100-year storm surge" : 1.25 m

"100-year wave height" : 4.50 m

There is a 10% chance that the "100-year event" will occur in the next 10 years.

There is always RISK in design for natural processes

4. EXTREME VALUES IN COASTAL ENGINEERING

A COASTAL MANAGEMENT STRATEGY

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COASTAL MANAGEMENT OBJECTIVES

COASTAL FUNCTIONS - DATA BASE

COASTAL ENVIRONMENT - DATA BASE

COASTAL PROCESS APPRECIATION

COASTAL ENGINEERING OPTIONS AND COSTS

FINANCIAL RESOURCES COST/BENEFIT

STRATEGY MANAGEMENT TEAM

PROTECTIVE WORKS PROGRAMME

COASTAL FUNCTION - DATA BASE

OBJECTIVES: To provide a coherent and unified information source as a basis for priority decisions on coast protection.

CONTENT: LOCATION, SIZE, FINANCIAL IMPORTANCE, SOCIAL INFLUENCE, COMMERCIAL RELEVANCE

CATEGORIES:
Transportation - sea borne
Property - private, public, commercial
Tourist regions
Infrastructure - power, water, communications
Coastal agriculture
Fisheries
Aquaculture
Forestry - mangrove
Historical, religious sites of importance
Marine environment - preservation, improvement

COASTAL ENVIRONMENT - DATA BASE

OBJECTIVE: To provide essential data for engineering design and criteria for natural environment preservation.

CONTENT: LOCATION, MAGNITUDES,
HISTORICAL CHANGES
NEW DATA COLLECTION

PHYSICAL FACTORS: Tides
Storm surges
Winds
Waves
Currents

TOPOGRAPHY: Sea-bed contours
Beach profiles
Land levels
Flooding areas

MATERIALS: Sands, silts, suspended sediments
Rock, coral
Sources and destinations
General geology

NATURAL ENVIRONMENT FACTORS: Water Quality
Temperatures, Salinity
Turbidity
Marine life categories

COASTAL PROCESS APPRECIATION

OBJECTIVE: To develop an understanding of the physical and biological dynamics of coastal regions as a basis for engineering solutions.

CONTENT: ANALYSIS OF COASTAL ENVIRONMENT DATA BASE
NUMERICAL MODELLING OF COASTAL PROCESSES
VALIDATION OF NUMERICAL MODEL PREDICTIONS

OUTPUT: Reports on data base analysis, implications and restrictions on engineering solutions.
Reports on existing marine environment and potential changes – again providing controls for engineering solutions.
Provides a basis for solution options
Coupled with priorities determined from COASTAL FUNCTIONS DATA BASE.

COASTAL ENGINEERING OPTIONS AND COSTS

OBJECTIVE: To develop designs and construction time-table based on coastal process appreciation and location priorities.
To evaluate cost estimates as a basis for approaches to international and national funding agencies.

OUTPUT: Design options and specifications
Cost estimates, resources and man-power
Priorities and timetable for construction

FINANCIAL RESOURCES COST/BENEFIT

OBJECTIVE: Based on COASTAL ENGINEERING OPTIONS AND COSTS to develop a case for financial investment justified by associated benefits.

OUTPUT: Present financially, environmentally and technically sound proposals for submission to international and national funding agencies.
A coherent, co-ordinated COASTAL MANAGEMENT STRATEGY.

STRATEGY MANAGEMENT TEAM

OBJECTIVE: To provide control, co-ordination and appropriate expertise for management of a COASTAL STRATEGY.

FUNCTION: To provide the essential focus for COASTAL MANAGEMENT.
To integrate political, financial, engineering and environmental activities within a coherent programme of coast protection and flood prevention.
To provide a communication centre for the varied elements of the programme.
To determine and arrange appropriate training for the man-power required in the programme.

REASONING: A coastal management strategy requires education and communication as top priorities. The political, financial, engineering and environmental responsibilities rest with different groups of people who need, importantly, to appreciate each other's objectives and limiting factors.
A strategy involves complex interactions for which a STRATEGY MANAGEMENT TEAM provides the focus.
IT IS ESSENTIAL THAT THE TEAM MUST BE BASED LOCALLY TO THE COASTAL REGIONS UNDER THREAT.