12h January 2019

Faculty of Engineering
University of Peradeniya

Coastal Land Reclamation & City Development

Civil Engineering Society

Annual Seminar 2018

Proceedings

CES Annual Seminar 2018

Coastal Land Reclamation and City Development

Proceedings of CES Annual Seminar 2018

Sponsored by

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மாநகர மற்றும் மேல்மாகாண அபிவிருத்தி அமைச்சு
Ministry of Megapolis & Western Development

CHEC PORT CITY COLOMBO (PVT) LTD.

Organized by

Civil Engineering Society
University of Peradeniya

Civil Engineering Society
Department of Civil Engineering
University of Peradeniya

CES Annual Seminar
on

Coastal Land Reclamation & City Development

12th January 2019
E.O.E. Pereira Theatre
Faculty of Engineering
University of Peradeniya

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Agenda

Inaugural Session

8.00 - 9.00 am	Registration
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9.20 - 9.30 am	Address by Dr. A.G.H.J. Edirisinghe Head, Department of Civil Engineering
9.30 - 9.40 am	Address by Prof. G.B.B. Herath Dean, Faculty of Engineering
9.40 - 9.50 am	Address by Eng. Nihal Rupasinghe Secretary to the Ministry of Megapolis and Western Development
9.50 - 10.30 am	Introduction to Coastal Land Reclamation and Port City Development by Mr. Thulci Aluwihare, Head, Strategy & Business Development, CHEC Port City Colombo (Pvt) Ltd
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Session 1 (Chair: Prof. S.B. Weerakoon)

11.00 - 11.40 am	Hydrodynamic and Coastal Engineering Considerations of Port City Development by Eng. (Mrs.) Manori Fernando, Consultant - CPCC EIA Team (Civil & Coastal Engineer) / Coastal Engineer and Engineering Manager, Lanka Hydraulic Institute
11.40 - 12.20 pm	Geotechnical Consideration of Coastal Land Reclamation Projects by Eng. Bimal Prabhath Gonaduwage Deputy Project Director (Reclamation), Port City Development Project, Ministry of Megapolis and Western Development
12.20 - 12.40 pm	Discussion
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Session 2 (Chair: Prof. K.P.P. Pathirana)

1.30 - 2.10 pm	Breakwater and other Marine Structures Construction of Coastal Land Reclamation Projects by Eng. Lalith Wijeratne Deputy Project Director (Structures), Port City Development Project, Ministry of Megapolis and Western Development
2.10 - 2.50 pm	Environmental Considerations of Coastal Land Reclamation Projects by Mrs. Anoja Herath, Director (Environment), Ministry of Megapolis and Western Development
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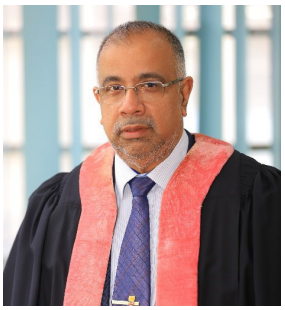
3.30 - 3.40 pm	Vote of Thanks by Mr. A.R. Prabhash Gunasinghe, Vice-President, Civil Engineering Society (CES)
3.40 pm	Refreshments

Message from the Dean, Faculty of Engineering



I am happy to learn that the Department of Civil Engineering is organizing its annual seminar on 12th January 2019 and that a proceeding is being published on this occasion too. The theme chosen for this years' seminar the 'Coastal Land Reclamation and City Development' is a timely topic for the civil engineering profession in Sri Lanka.

Today with limited land availability, city planners are looking for alternative forms of additional space for city development. Coastal land reclamation is one such alternative many countries have already embarked on. Sri Lanka being an island, with plenty of coastal area, the coastal land reclamation is very viable alternative. However, any type of reclamation including the coastal land reclamation can lead to both positive and negative impacts. With no past experience, many people including professionals have raised concerns over the development of the so called 'Colombo Port City' project. Anyhow time has come to us the Sri Lankans too to venture in to such new development methods which other countries have initiated successfully to make cities more comfortable for living. So I feel this seminar will be a good forum for both our engineering professionals and the future engineers to clarify any issues they have on this theme. I congratulate the organizers for providing a platform for a discussion to a timely topic through the seminar. Finally, I wish the seminar a great success.

Prof. G.B.B. Herath
Dean, Faculty of Engineering
University of Peradeniya

Message from the Head, Department of Civil Engineering

I am pleased and honoured to write this message at the time of organizing the annual seminar of the Civil Engineering Society (CES). Annual seminar is one of the major events in the calendar of activities of CES. As one of the oldest student centered societies in the faculty, CES always pay attention to develop the academic knowledge and other skills of students.

This year, deciding to select the topic of Coastal Land Reclamation & City Development is a winning point for students. The port city project under Western Development is going to be the centre of focus in this seminar and it is a good example of integration of different engineering disciplines. While changing the shape of the island, this project will address few other challenges for professionals to address to maintain the livelihood of the economic capital of Sri Lanka.

While congratulating the organizing committee for timely selection of the topic and excellent planning and organizing, I wish all the stakeholders a fruitful seminar day.

Dr. A.G.H.J. Edirisinghe
Head, Department of Civil Engineering
Faculty of Engineering
University of Peradeniya

Message from the President, Civil Engineering Society

The Department of Civil Engineering, University of Peradeniya, the working committee of Civil Engineering Society (CES) - 2018 and the CES Annual Seminar 2018 sub-committees take this opportunity to thank the Ministry of Megapolis and Western Development (MMWD) and CHEC Port City Colombo (Pvt) Ltd. for their contribution and sponsorship on organising this prestigious annual event of CES Annual Seminar 2018 on "Coastal Land Reclamation and City Development" at the E.O.E. Pereira Theatre, Faculty of Engineering, University of Peradeniya.

World's major port cities are growing faster than inland cities. Port City Colombo is a brand new city development built as an extension of the Central Business District of Sri Lanka's vibrant commercial capital, Colombo. Spanning 269 ha of reclaimed land from the sea, Port City Colombo will be South Asia's premier residential, retail and business destination. In the fast few years, the Sri Lankan and the world media has been talking about this Colombo Port City Project. Therefore, our annual seminar on "Coastal Land Reclamation and City Development" is a pertinent and a timely topic for the civil engineering professionals and especially for the undergraduate and postgraduate civil engineering students some of who may end up practicing at the Colombo Port City Project in the near future.

The speakers of the technical seminar Mr. Thulci Aluwihare (CHEC), Eng. Bimal Prabhath Gonaduwage (MMWD), Eng. Lalith Wijeratne (MMWD), Mrs. Anoja Herath (MMWD), and Eng. (Mrs.) Manori Fernando (LHI), should be commended for giving us candid picture of the current Port City development and the technical aspects on geotechnical, structural, environmental and hydrological considerations of the coastal land reclamation projects.

I am glad to see the active and enthusiastic participation of members of the Department of Civil Engineering in this annual seminar event. It is a strong indication of the commitment of staff members & students, and the importance of these types of event to Civil Engineering Societies. Together we hope we can bring a successful CES Annual Seminar 2018.

Dr. S.K. Navaratnarajah
President, Civil Engineering Society
Department of Civil Engineering
University of Peradeniya

Message from the Secretary, Ministry of Megapolis and Western Development

The Vision for Port City is: "Building a World Class City for South Asia"; and the Mission is: "To develop the most livable city in South Asia. Built on sustainable values, a healthy environment with future ready infrastructure to enhance living convenience. An exemplar city providing the highest quality commercial, entertainment, medical, education and lifestyle opportunities. The catalyst for growth, a place that fuses the culture and energy of a nation with international best practice."

The location of Port City takes advantage of twin attractions of proximity to the Colombo CBD and oceanfront vistas. This is a tried and tested formula by city centres that aspire to position themselves as destinations for finance, tourism, residential living, working, shopping and entertainment, while providing required amenities and facilities within walking distance. Also, the Colombo CBD has limited oceanfront lands available for development, especially in view of the land area facing Galle Face, formerly occupied by the Defence forces, now being allocated to Shangri-La and ITC Hotels. Globally, ocean-front urban lands fetch the highest real estate prices, especially if such lands are adjacent to a CBD or commercial capital.

Presently, Colombo is not a "Destination", but primarily a transit point for tourists. The average stay by tourists is roughly 1.7 nights for Colombo, which is too low by international norms (in comparison to the 5.5 night's average stay at a beach location by a typical tourist to Sri Lanka). The lack of vibrancy of Colombo in terms of multiple shopping, recreation and entertainment choices is a significant deterrent to attracting South and East Asian tourists. Sri Lanka's tourist arrivals being impacted by cyclicality (with higher arrivals being recorded during the traditional winter season) can be attributed to Colombo not being a sought-after tourist destination. In an international context, with strong sustainability awareness trends and competition among sustainable urban development projects, Colombo Port City is taking form. It is a project of major importance for people and cities around the world and will become a reference and benchmark. By applying sustainable planning principles the overall objectives can be met and the project will become successful.

Therefore, at this juncture, it seems vital importance of this kind of seminar organize by Civil Engineering Society (CES) of Faculty of Engineering, University of Peradeniya which produce pioneers in engineering not only for Sri Lanka but also for the global.

Ministry of Megapolis and Western Development on behalf of the government of Sri Lanka consider selecting of Port City Development Project for the CES annual seminar is a great patronage for the Ministry. In addition to that, as an Engineer produced by University of Peradeniya it is inevitable for me as the Secretary of Megapolis today to contribute this prestige event. I consider this event organize by the University of Peradeniya is a great service and timely importance subject for development of the country and engineering industry. Further, it will be definitely beneficial for the future leaders, engineers, and entrepreneurs who are going to take the batten of Sri Lanka in next era.

Ministry of Megapolis and Western Development would like to take this opportunity to pay sincere gratitude to Department of Civil Engineering, Faculty of Engineering of University of Peradeniya for selecting Port City Project for the annual CES seminar. Further, I personally give my tribute to Faculty of Engineering, University of Peradeniya as my alma-mater of engineering for organizing this value event.
Ministry of Megapolis and Western Development wishes all the success for Civil Engineering Society (CES).

Eng. Nihal Rupasinghe
Secretary
Ministry of Megapolis and Western Development

About the Civil Engineering Society

Among many societies which are acting lively throughout the Peradeniya University, the Civil Engineering Society (CES) holds a major position. The CES is a prominent society in the Faculty of Engineering of the University of Peradeniya, which provides a common platform through various activities for the Civil Engineering students, staff, and the industry to interact, and thereby, enrich their academic and professional skills. Being one of the longest-serving organizations within the university system in Sri Lanka, the CES has survived and thrived through over 40 years of its history.

The history of the CES goes back to 1973. The inaugural President of the society was Dr. K. Shanmuganthan when Prof A.Thurairajah was the head of the Department of Civil Engineering while Prof H.B De Silva was the Dean of the faculty. The first event organized was a talk delivered by Mr. D.G.L Ranathunge of the Irrigation Department, which was held on February 15, 1973. The annual seminar of the CES was also initiated in the year 1973. Due to the tireless efforts and commitments of all members, society managed to get a growing appreciation. The vision and mission of Civil Engineering Society are stated below;

Vision
The Civil Engineering Society will be a significant contributor to the Faculty of Engineering in achieving its vision of becoming the centre of excellence in engineering education and research in South Asia.

Mission
The mission of the Civil Engineering Society is to provide a common platform, through various activities, for the civil engineering students, the staff and the industry to interact and thereby, enrich their academic and professional lives.

Activities of the Civil Engineering Society

- CES talk series is organized twice a month under the patronage of resource persons from the industry and higher education institutes to share their experiences.
- CES annual seminar links, industry and the faculty.
- CES soft skills workshops provides an opportunity to improve soft skills of the students.
- Civil Engineering field trips provide budding engineers the way theory is in practice.
- Civil Engineering Project Symposium is a stage for final year engineering students to exhibit their research potentials.

- Spaghetti bridge competition paves a path for students to apply the theoretical knowledge in to practical application.
- CES quiz competition assesses practical knowledge in Civil Engineering applications.
- CES visual production competition helps to understand the linkage of theoretical and practical applications within the industry.
- CES concrete mix design competition exposures the undergraduate to the practical applications on concrete mix designs.
- Career fair brings the job opportunities to the doorstep of the faculty, for fresh engineers yet to graduate.
- Vortex is the annual get together of the CES and it is the concluding event of an official year.

Themes of CES Annual Seminars in recent years

2017 Civil Engineering for Urban Resilience
2016 Applications of Computational Methods in Civil Engineering
2015 High-rise Buildings
2014 Highway planning and Design, Construction and Maintenance
2013 The Challenges of Urban Development, Sri Lankan Perspectives
2012 Transport Sector Challenges and Role of Expressways
2011 Urban Environmental Challenges

CES Executive Committee Members

Academic year 2018

Head of the Department	: Dr. A.G.H.J. Edirisinghe	
President	: Dr. S.K. Navaratnarajah	
Secretary	: Dr. M.C.M. Nasvi	
Treasurer	: Dr. A.M.R.G. Athapaththu	
Vice President	: Mr. A.R.P. Gunasinghe	
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Joint Secretary	: Mr. K. Gajanan	
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Joint Treasurer	: Mr. B.U. Kaushalya	
Field Representatives	: E 13 Batch	Mr. M.P. Wattegedara
	E 14 Batch	Mr. W.A.P.C.P. Gunawardhana
	E 15 Batch	Mr. A.I. Thamarasinghe

CES Annual Seminar 2018
Coastal Land Reclamation and City Development

Invited Presentation #1

Introduction to Coastal Land Reclamation and Port City Development

By

Mr. Thulci Aluwihare
Head, Strategy & Business Development
CHEC Port City Colombo (Pvt) Ltd.

Mr. Thulci Aluwihare

Head of Strategy and Business Development
CHEC Port City Colombo (Pvt) Ltd

A reputed Financial Advisor with International experience in corporate wealth creation through investment, divestiture, capital raising and restructuring. Thulci was a member of the Colombo International Financial Centre (CIFC) Steering Committee Task Force to set up a Special Economic Zone (SEZ) within Port City to attract FDIs, promote export of services and ease of doing business. Prior to joining CHEC Port City Colombo Pvt Ltd, Thulci headed the Mergers & Acquisions practice at PwC Sri Lanka and Maldives. With over 14 years of experience at PwC Colombo and Melbourne, he was involved in large cross boarder MNC transactions. As one of the top performers, Thulci was selected to the global PwC panel of trainers for Mergers & Acquisions and successfully conducted training for newly promoted Managers in the Advisory University Program held in Warsaw, Rome, Copenhagen, Stockholm, Dublin and Abu Dhabi. Thulci is an Economics graduate from the University of West London, UK and has read for a Masters in Financial Economics from the University of Colombo.

Introduction to Coastal Land Reclamation and Port City Development

Mr. Thulci Aluwihare
Head, Strategy & Business Development,
CHEC Port City Colombo (Pvt) Ltd

1. Background of the Project

The Colombo Port City project is a Public-Private-Partnership (PPP) between the Government of Sri Lanka (GOSL) and CHEC Port City Colombo (Pvt) Ltd (Project Company). The salient features of the PPP arrangement are captured in the Tripartite Agreement (TPA) signed on 12th August 2016.

2. Key Responsibilities of the Project Company:

Undertaking a Foreign Direct Investment (FDI) of no less than US$ 1.4 billion to create the land fill and internal infrastructure according to the standards in the TPA.

a. Create 269 ha of land and protective structures.
b. Construct all required infrastructure within the reclamation area such as roads, utility lines, water supply, sewerage, electricity, solid waste disposal, storm water drainage etc.
c. Incur commercial risks associated with marketing of developable parcels of real estate allocated to the Project Company to prospective investors on a 99-year lease.
d. Maintenance of reclaimed area via an Estate Management Company, to be set up as a joint venture with the Government of Sri Lanka (GOSL).

3. Commercial Arrangement with GoSL

The GOSL will hold freehold title to all 269 ha of reclaimed land and the Project Company will not receive any freehold land of the 269 ha of reclaimed land. The GOSL will grant the Project Company a 99-year lease over 116.1 ha (marketable) of the reclaimed land (i.e. 43%). The GoSL will have 62 ha of Marketable land for development and the remaining 90.9 ha will be common areas such as beaches, road, parks, etc.

Description of the Proposed Project

Nature and Scope of the Project

The project aims to establish a new world-class city development based on best international experience, especially adapted to the Sri Lankan context and the site-specific conditions. The new city will tap into the intrinsic values of the region and environment to create an ideal modern community for business, tourism, living and leisure.

Major components of Port City at a glance are:

1. Total land area reclaimed: 269 ha.
2. Total marketable land: 178 ha.
3. Total public lands (parks, roads, public areas, utility areas etc.): 91 ha.
4. Total public beach of 1.5 km.
5. Total protected water area for recreation and water sports (canal and area protected by breakwater): 125 ha.
6. Total open spaces (not occupied by buildings): approximately 60% of reclaimed land.
7. Total gross floor area (GFA) planned over 25 years: 5.65 million m^2 (excluding parking).
8. Total resident population envisaged over 25-30 years: 75,000.
9. Total resident and transient population over 25-30 years: 250,000.

4. Project Details

Proposed Developments within the 269 reclaimed land area will be in keeping with Sri Lanka's planning and building regulations and on the basis of the reclaimed land being gazetted under the Sri Lanka Lands Ordinance and subsequently as an Area of Authority under the UDA Act. No industrial activities will be allowed within Port City.

- Commercial : Banks, Offices and retail, hotels and restaurants.
- Residential: Dwelling houses/ units, apartment building, serviced apartments.
- Institutions: Healthcare, educational and R&D institutions, diplomatic embassies.
- Small businesses and services and allied activities :associated with the mixed development activities.
- Entertainment: Indoor amusement and entertainment establishments, outdoor recreational spaces.
- Community : Art galleries , socio- cultural establishments /community centers
- Other : Marina and related facilities , tourism business , convention and event facilities, cultural events and festivals.

5. Outline of the Development Plan: Vision and Concept

The Vision:
"Building a World Class City for South Asia"

The diagram below provides a breakdown of the colour-coding adopted in the master plan, of permissible developments within Port City.

6. Master plan

Fig 1: Master Plan

Master Plan Principles and Objectives

The Colombo Port City master plan has been developed based on the following:

a. Overall Vision: Colombo Port City shall be a sustainable addition to Colombo's Central Business, District generating business, tourism and a high quality of life – the most livable city in South Asia.

b. Master Plan Concept Objectives:

- To create a sustainable and attractive urban district well connected to and integrated with the existing city.
- To create a tourism hub with unique character that reflects the distinctive local culture and existing urban fabric.
- To create a regional financial and business hub, a city district brand with high quality public spaces and residential environments attractive to local and international developers and investors.
- To create sustainable urban districts that adapt to local climate, micro climate and make efficient use of energy resources.

c. Urban Sustainability Objectives: In the context of global competition of emerging sustainable cities, the overarching goal is to create a mixed-use area that is livable and accessible with reduced urban heat island effect and becomes a resource that is efficient on energy demand. This is done by the following sustainability guiding principles:

- Urban pattern: Orientation, shape and dimension taking local climate conditions into consideration and promoting a resource efficient and convenient micro-climate.
- Urban design principles: Promoting an open city with continuous green - blue and open spaces, accessible and attractive for all people.
- Land-use, traffic and transport: Promoting accessibility through walking, bicycling and high class public transportation system minimizing car dependency.

By visualizing and unlocking the synergies between urban sub-systems, the Master-plan identifies the links between urban and landscape planning, public and social spaces, storm water management, architecture, real estate development, urban functions, enterprises and buildings, energy, waste management, traffic and transport, water supply and sanitation.

7. Planning Principles and Design Guidelines

The Development Control Regulations for Port City, will give all stakeholders complete and thorough information and guidelines to be followed within the Colombo Port City Development Project. It will be applicable for all developments going forward.

Users and stakeholders for the DCR will include:

- Government authorities
- The Master developer
- Potential investors
- Third party developers
- Design and development consultants
- Others

The Development Control Regulations (DCR) will consist of 4 volumes (Urban Design, Utilities, Landscaping and Sustainability) which will include guidelines for all stakeholders in the Development.

Volume 1 – Urban Design

Plot sizes, plot ratio, building height, land use, setback, vehicular and pedestrian access, etc.

Volume 2 – Utilities

General electrical system, water supply system, waste water system, sewerage system, storm water system, fire hydrant system, irrigation system, communication system, gas corridors, solid waste system, etc.

Volume 3 – Landscaping

Green plot ratio/minimum green area, planting setbacks, plant diversity guidelines, streetscape integration, planting installation, pathways, trails, pavements, protection of trees and vegetation, native and indigenous planting, water sensitive urban design, etc.

Volume 4 – Sustainability

Management commitment from third party developers, heat island effect, air quality, green living, noise pollution, light pollution, solid waste management, water management, energy management, green certifications, etc.

8. The Smart City Concept

The sustainability aspect of the DCR covers concepts such as Smart buildings with smart metering for energy and water consumption. The smart metering will enable digital feedback for energy and water consumption. Daylight/ motion detectors will be fitted in common places to reduce energy and the use of artificial lightening. The DCR requires Sustainability awareness in buildings that will display information on sustainability awareness and provide guidance to building users.

9. The Green City Concept

The green structure has 3 tiers:

- Primary green structure - Linear parks support green corridors and the central park
- Secondary green structure - Tree lined streets help bird movement though the city
- Tertiary green structure- Private green areas mitigate urban heat island effects

10. Green Structure Concepts: Parks and Open Spaces of Port City

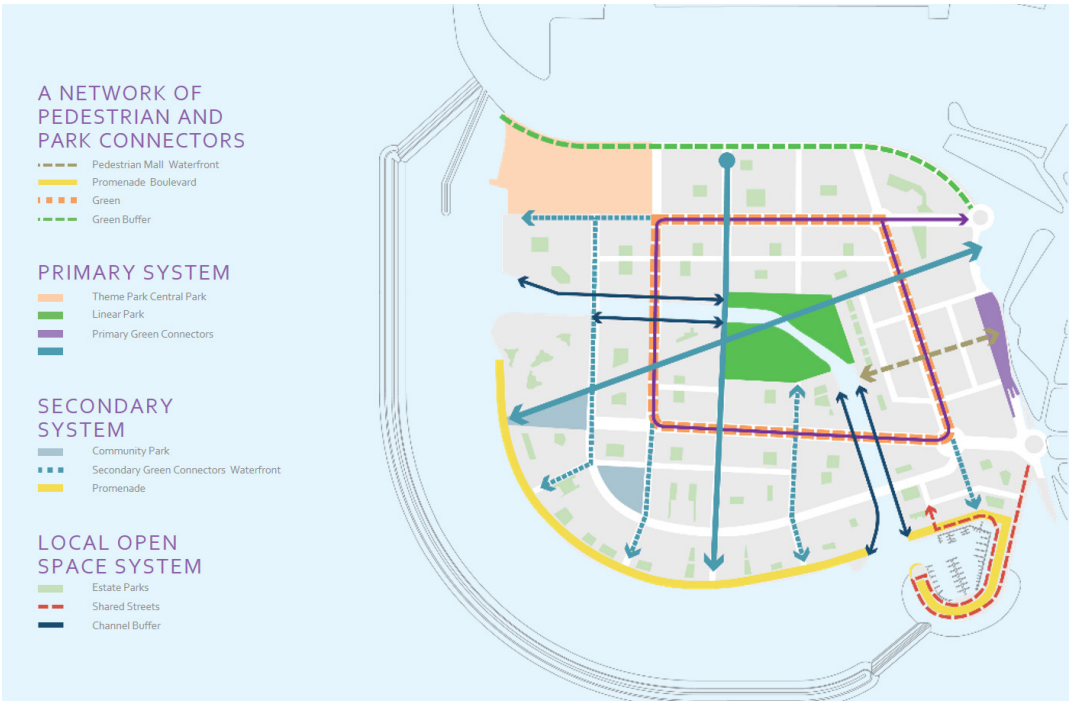


Fig 2: Parks and Open Spaces of Port City

CES Annual Seminar 2018
Coastal Land Reclamation and City Development

Invited Presentation #2

Hydrodynamic and Coastal Engineering Considerations of Port City Development

By

Eng. (Mrs.) Manori Fernando
Consultant - CPCC EIA Team (Civil & Coastal Engineer) /
Coastal Engineer and Engineering Manager
Lanka Hydraulic Institute

Eng. (Mrs.) Manori Fernando

Consultant - CPCC EIA Team (Civil & Coastal Engineer)/ Coastal Engineer and Engineering Manager
Lanka Hydraulic Institute

Eng. Manori Fernando is a Civil Engineering professional specialized in Coastal Engineering, with more than 15 years of experience in the industry. She has completed her primary education in Devi Balika Vidyalaya, Colombo and got entered to the University of Moratuwa in 1998. In 2002, she graduated as a civil engineer with a First Class Honours degree. Soon after graduation she resumed work as a research assistant in the Department of Civil Engineering at University of Moratuwa in the field of hydraulic and coastal engineering and got involved in several research projects conducted under the department. Further she has served the university as a teaching assistant during that period. While serving at the university she has completed her Maters degree in the field of Coastal Engineering. Her master thesis is more focused to identification of the behaviour of waves and their effects on porous coastal structures via physical modelling techniques.

In 2010 she has joined with Lanka Hydraulic Institute (LHI), a leading research and consultancy organization in Sri Lanka and currently working as an Engineering Manager. Under LHI, she served as a project manager for several local and international projects in the field of coastal and harbour engineering and conducted feasibility studies, detailed designs, coastal and hydrodynamic studies and environmental impact assessments and gained a sound knowledge on field investigations, numerical and physical modelling techniques, coastal processes, coastal structures and impact assessments. At LHI she was involved numerical modelling and hydrodynamic studies for Colombo Port City Development project and then she was invited to work for the project by the Colombo Port City Company Ltd (CPCC) as a consultant. From 2017 to date she is engaging with the environmental team of the port city development project and provides her assistance in the field of coastal and environmental activities of the project.

Hydrodynamic and Coastal Engineering Considerations of Port City Development

Eng. (Mrs.) Manori Fernando
Consultant - CPCC EIA Team (Civil & Coastal Engineer) /
Coastal Engineer and Engineering Manager
Lanka Hydraulic Institute

1. Introduction

Coastal land reclamation by means of expanding the boundary and widening the territory provides good opportunities to the small state or countries that are facing problems specially increasing in population and high demand for residential area. Coastal land reclamation is a method used to create a new landform ocean into a state which it can be useful for human benefits. Many cities are now viewing reclaiming land from the sea as the answer to increased urbanization. In particular, port cities and other coastal areas are centers of economic activity and act as catalysts for national prosperity.

Due to rapid development and urbanization, Colombo Central Business District (CBD) has to be expanded and due to its orientation the only possible way of expansion is reclaiming the adjacent sea. According to the idea of the development of Sri Lanka's Urban Development Authority (UDA) and the Sri Lanka Ports Authority (SLPA), the new development plan of land reclamation should be combined with construction of the Colombo South Port. After developing the Colombo South Port breakwater, Sri Lanka Ports Authority (SLPA) was instructed by the Government of Sri Lanka to design and implement a reclamation project covering sufficient land area between the Colombo Port Expansion Project (CPEP) site and the Galle Face Green to create a port city. Colombo Port City (CPC) is the Sri Lanka's first and the biggest coastal land reclamation project.

Initial Technical Feasibility Study of the CPC project was carried out in 2010 considering 200 ha of land and the Environmental Impact Assessment was done in 2011 and preliminary approval was granted by CCCRMD to develop 200 ha of proposed reclamation land. An addendum to the EIA was prepared in for the new proposal of the 233 ha of the reclaimed land. Sand required for the proposed development was proposed to extract from the offshore sand reserves and separate IEE was done for the targeted sand extraction sites.

After amending the previous agreement, the project company delivered the final design of the CPC development which contains the 269 ha of land fill. Therefore a Supplementary Environmental Impact Assessment (SEIA) was carried out in 2015 in order to cover the additional features of the development. As per the TOR issued by CCCRMD, impacts of sand extraction, coastal reclamation, construction of offshore breakwater and other protective structures were addressed under the SEIA. Master plan implementation on the reclaimed land is considered as the second phase of EIA conducted separately during 2017.

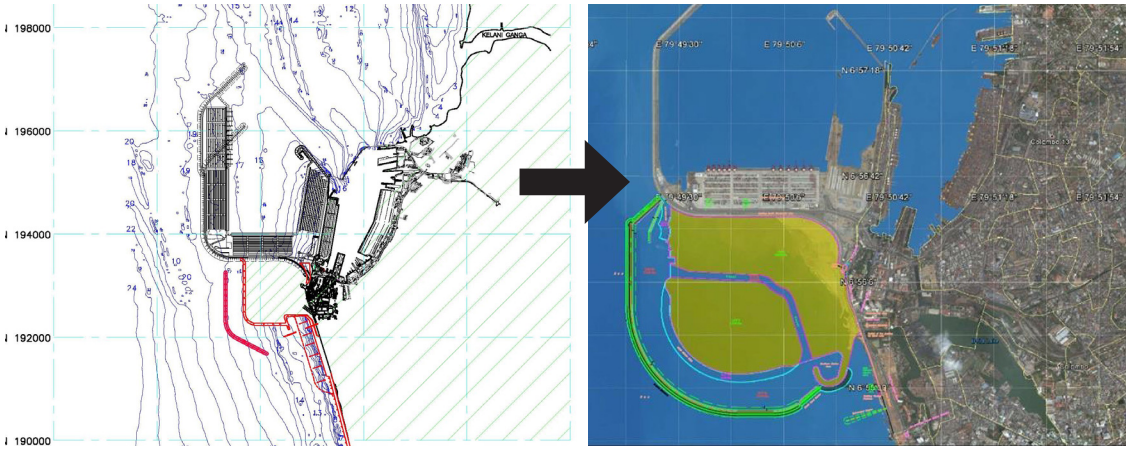


Fig 1: Development of Port city from 200 ha to 269 ha

As mentioned the reclaimed area is finally designed as 269 ha which covers the total project foot print area of 446.6 ha including beaches, water area, canals, and the seabed area occupied by protection structures. The evolution of the Project Area from the time of the original EIA to the latest SEIA is summarized in Table below.

Major Elements of Project (in Ha)	EIA* 2011	Addendum** 2013	SEIA** 2015
Reclaimed land area	200	233.5	269
Beach area	Not specified	Not specified	19.79
Canal area	None	23.7	15.24
Water area between landfill & breakwater	-	161.8	113
Seabed area occupied by protective structures	-	67.3	29.58
Total Project Area	351.0	486.3	446.61

Note: * Based on designs commissioned by SLPA
** Based on designs of the investor, CCCC

The Colombo Port City master plan has been developed based on its overall vision, ie. "Colombo Port City shall be a sustainable addition to Colombo's Central Business District generating business, tourism and a high quality of life - the most liveable city in South Asia". Therefore following objectives were considered during the preparation of master plan;

- To create a sustainable and attractive urban district well connected to and integrated with the existing city.
- To create a tourism hub with unique character that reflects the distinctive local culture and existing urban fabric.
- To create a regional financial and business hub, a city district brand with high quality public spaces and residential environments attractive to local and international developers and investors.
- To create sustainable urban districts that adapt to local climate, micro climate and make efficient use of energy resources.

In keeping with the above vision and objectives, SWECO of Sweden, Atkins of UK and Surbana Jurong of Singapore, the world-renowned specialists in sustainable urban planning and design have been responsible for the master plan for Port City together with the local specialists and advisers. Using worldwide best practice, the Master Planning consultants have developed a customized phased approach for development of Colombo Port City.

Fig 2: Visual Rendering of the Proposed Port City Development (Showing Maximum Permissible Building Height, Green Spaces and Marina)

The new city will tap into the intrinsic values of the region and environment to create an ideal modern community for business, tourism, living and leisure. Colombo Port City is also focused on creating a safe and delightful public environment for recreation, gathering and resting. 91 ha of public lands (parks, roads, public areas, utility areas etc.), 1.5 km long public beach and 125 ha of protected water area for recreation and water sports will facilitate with the design.

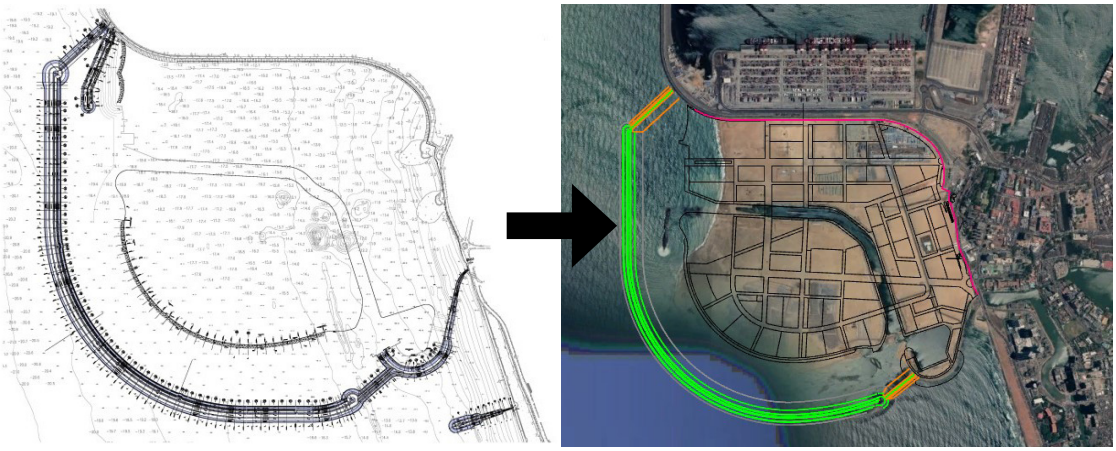


Fig 3: Concept to Implementation

It is emphasized that the project has two important phases, namely

1. Overall layout preparation, coastal structure design, reclamation of land, construction of breakwaters other coast protection structures, extraction of sand and supply of quarry material required for reclamation and protection works for proposed Colombo Port City Development Project.
2. Development activities and infrastructure facilities (buildings, utilities, procedures for disposal of waste water and solid waste, transport and traffic, landscaping and aesthetics, storm water management etc.) within the reclaimed land area of Colombo Port City. Colombo Port City will be implemented over a 25-year period.

The most critical component of the project is the first phase of the development since it proposed to change the sea environment to a land which a challenge. A number of methods have been adopted to assess the environmental impacts of the proposed development.

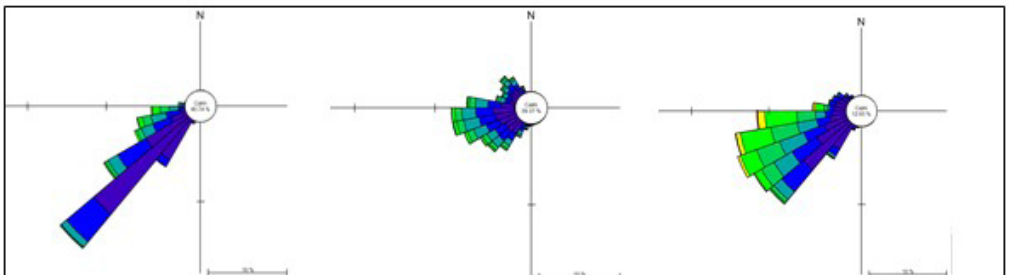
A comprehensive set of studies were carried out from 2010 to date paying attention to the coastal and hydrodynamic considerations of the proposed development. The objective of this study is to obtain the design criteria of the layout and the protection structures and to ensure that any environmental consequences due to reclamation and sand extraction from the proposed project are recognized early in the project cycle and taken into account in project design and implementation.

2. Studies carried out during Initial technical feasibility study and initial EIA 2011

Initial study (during 2010) mainly focused on carrying out required numerical model studies to facilitate the assessment of technical feasibility of the project 'Development of Modern city at Southern Border of the Colombo Port' which provides the valuable information for the Environmental Impact Assessment study.

Under initial study wave climate in the vicinity of proposed city area was studied. In order to examine the marine environment it is important to obtain site specific met ocean data. For the Colombo Port Expansion Project, LHI has undertaken directional wave measurements in the vicinity of Colombo Port from 1998 to 2015 and those 3 hr records were used for the wave climate modelling and analysis.

The wave climate is characterized by two simultaneous wave systems. Long periods swell with a southerly direction in deep water that becomes more westerly as it approaches the coast. This exhibits only small differences of height during the year. The other system is the shorter period sea waves which are generated by the local (monsoon) winds but are influenced to a certain degree by local sea breezes.

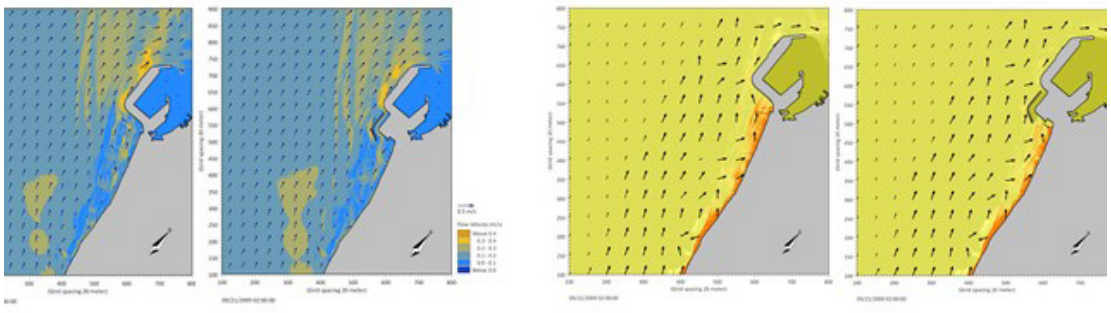


(a). Swell waves (b). Sea Waves (c). Overall Waves

Fig 4: Annual variation of Waves (1998 - 2015) _ Swell, Sea & Overall Waves

Design wave parameters for the offshore breakwater were obtained using MIKE 21 NSW modelling and in accordance to the extreme wave conditions. MIKE 21 BW modelling was carried out to optimize the layout of offshore breakwater and to observe the wave disturbance in and around the proposed city area. Further studies were done to obtain the design wave height for the revetment of the proposed modern city area using MIKE 21 PMS modelling.

Further the impact on hydrodynamics of the area of interest, with the presence of proposed modern city was assessed using MIKE 21 HD modelling incorporating both wind and wave climate in the vicinity. Sediment transport patterns of the proposed development area were studied and the influence of proposed city development was examined by comparing the behaviour with and without port city reclamation.



(a). Current Field (b). Sediment Transport Pattern

Fig 5: Current & Sediment Transport Rate Comparison during Spring Tide

3. Studies Carried Out During Detailed Design

Design of the coastal structures is based on the Serviceability Limit State (SLS) and Ultimate Limit State (ULS). The SLS refers to the structure performance under normal/more regular conditions and ULS refer to the performance of the structure under extreme (design) conditions. In the SLS, no damage to the structures should be allowed as maintenance is to be avoided. Met ocean data collection, data analysis and extreme data prediction was carried out to obtain the normal and extreme parameters for the design. Design philosophy mentioned in the standard codes and coastal theories were used for that purpose.

In the ULS, which represents the design condition (200 yr), slight damage (movement of rock) is allowed. For the overload condition (200+20%) which is used to ensure the stability of the structure, the construction may never fail.

The design wave conditions for the structures are based on a high-detail wave study of the Marina Area using the state of art model software with diffraction compensation. This model is setup using some conservative assumptions and computed results have been compared with results from the 3D physical wave model.

According to the requirement of the Designer CCCC FHDI Engineering Co Ltd, Tianjin Research Institute of Water Transport Engineering (TIWTE) and Nanjing Hydraulic Research Institute (NHRI) performed certain field investigation, numerical modelling and physical modelling studies during 2013 / 2015 for the modified layout. These reports include:

- Final report on Hydrographical Survey.

- 2-D Stability Physical Model Test on the offshore breakwater and revetment for marina.
- 3-D Physical model test south part and 3-D physical model test North part Analysis (numerical modelling) of coastal evolution and siltation.
- Analysis (numerical modelling) of water exchange.
- Wave physical Model Test of the Stability of Beach Profile.
- Analysis (numerical modelling) of Water Exchange Supplementary Report for the effect of Port City on Beira Lake outfall.
- Ground investigation preliminary report.
- 3-D Physical model test on the Southern Part of Colombo Port City project .
- 2-D Physical Model Test on the Offshore Breakwater of Colombo Port City Development Project.
- Value engineering of marine structures and reclamation Layout and Structural design Optimization studies.

A range of peak wave periods is given, which can be applied in the structural design study to determine the required armour protection for the governing wave condition. It should be noted that these design wave conditions are considered conservative, which thus provides an additional factor of safety in the design.

Table 2-3 – Design wave conditions (200a) for the various marine structures in the CPC Development

Structure	H_s [m]	T_p [s]	Direction [°]
Offshore Breakwater	6.4	12-16	225-285
North Sand Barrier	6.4	12-16	-
Inner Breakwater			
Upper section, 0-250m	5.8	12-16	250-300
Lower section, 250-375m	5.0	12-16	250-300
Tip of Inner Breakwater, 375-500m	3.0	12-16	250-300
Inner Revetments			
North Canal Entrance	2.0	9-15	-
Canal Revetment	1.3	9-15	-
Start of main beach North	1.5	9-15	-
South Canal Entrance West	2.1	9-15	-
South Canal Entrance East	1.5	9-15	-
Start of main beach Southeast	2.1	9-15	-
Inner Marina, vertical wall	1.2	9-15	-
South Sand Barrier	4.5	12-16	195-225
Sea-side Marina Revetment			
Northeast part (sheltered)	2.4	12-16	-
Main Revetment (most exposed)	4.6	12-16	200-225
Western part	3.0-3.5	12-16	-

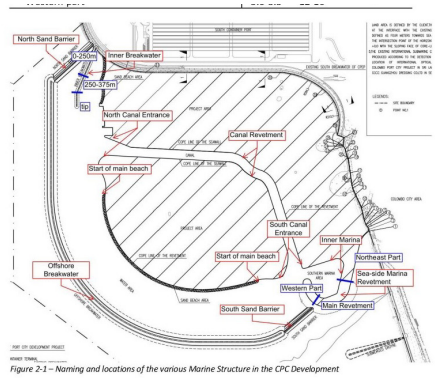


Figure 2-1 – Naming and locations of the various Marine Structure in the CPC Development

Port City Development Project 11 Part E – Layout and Structural Design

Fig 6: Design Wave Conditions for Marine Structures

Derived extreme wave parameters were used as the design parameters of the offshore breakwater and as input wave conditions for the wave disturbance studies carried out and design wave conditions for all other structures were obtained using wave disturbance study.

The design water levels were selected as -0 m CD for low water and +1.2 m CD for high water, in combination with extreme wave conditions. Future water level rise, storm surge levels were considered while selecting the design high water level.

Current flow conditions may reach up to 0.8 m/s for extreme conditions (200 yr wind condition) near the sand barriers and at the southwest side of the offshore breakwater it can be up to 1.25 m/s. For all other locations current conditions are relatively mild and will not be governing for design of rock and armour units.

Further layout and structural optimization was done by using wave disturbance modelling and via physical modelling of the structures.

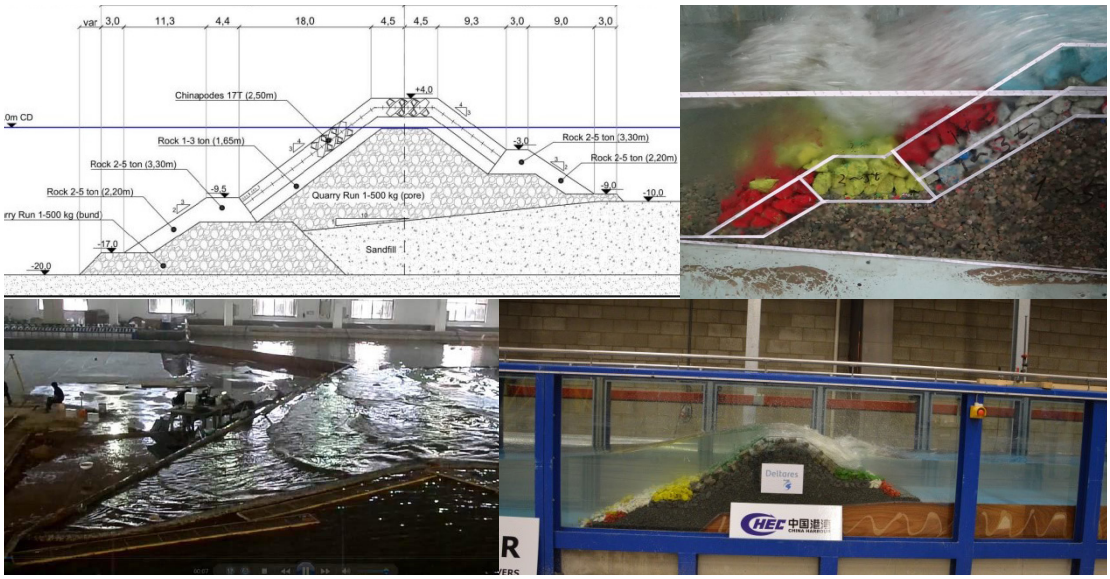


Fig 7: 2D and 3D Physical Model Studies

4. Studies carried out during SEIA stage (2015/ 2016)

The overall scope of the study is to contribute to the SEIA study based on the TOR issued by CCCRMD which includes studying of exiting marine environment, identification of environmental impacts (if any) based on the proposed construction activities & formulation of mitigatory measures in order to mitigate or minimize the impacts.

A comprehensive set of modelling on coastal environment were undertaken during the preparation of this SEIA. This includes wave climate modelling, wave disturbance modelling, hydrodynamic modelling and sediment transport and sediment dispersal modelling incorporating dredging and dumping activities in order to assess the excess turbidity levels in the vicinity of the area. In addition to that comprehensive 2D and 3D physical model test studies and numerical modelling studies which conducted during the design stage also considered for the study.

Impacts on Beria Lake outfall and storm water drain outlets impacts due to the proposed development were studied separately via numerical model. In addition, ground investigations have been carried out over a period of more than two years to better understand the technical requirements that would need to be taken into account in the implementation of the project.

In summary, the following engineering studies have been carried out and reports compiled during the feasibility and environmental study phase of this project using the services of local and international experts/organizations:

- Wave climate modelling (LHI)
- Hydrodynamic modelling (LHI)
- Wave disturbance modelling (LHI)
- Sediment transport modelling (LHI)
- Sediment dispersal modelling (LHI)
- Shore profile survey (LHI)
- 2-D Stability physical model Test on Offshore Breakwater and Revetment for Marina – Tianjin Research Institute of Water Transport Engineering (TRIWTE)
- 3-D Physical Model study Test - South Part and North Part – Nanjing Hydraulic Research Institute (NHRI)
- Analysis (numerical modelling) of Coastal Evolution and Siltation – TRIWTE
- Numerical modelling of Water Exchange – TRIWTE and LHI
- Ground Investigations – Forth Harbour Design Institute
- Water quality sampling and analysis (NARA)
- Assessment of inland quarry material availability, permits, transportation routes, impacts etc. (GSMB Technical Services)
- Model and ecological studies at reclamation area (University of Moratuwa)
- Impacts on Beria Lake outfall and storm water drain outlets impacts due to the proposed development, including 3D numerical model (CDR International, Netherlands)

To the maximum possible extent, environmental considerations have governed the planning and layout of Port City and incorporated into the design process from its inception. This has allowed the early identification of any environmental issues, which may impose constrains on the design. This approach of "Mitigation by Design" has reduced the need for a range of specific mitigation measures.

Physical parameters of the area are assessed initially since it plays a vital role in formulation of impacts. The existing environmental with respect to physical environment, was established through the primary data generated during previous EIA studies and data collected from recent surveys.

Several numerical model studies were performed to facilitate the assessment of the proposed port city with respect to the coastal environment. State of art modelling techniques was incorporated to establish wave climate, tidal variations, current flow conditions and sediment movement in the vicinity of the proposed site based on the actual measured data. Impact of proposed land reclamation on coastal environment was accessed by comparing the existing and proposed conditions via state of art modelling techniques.

Numerical modelling studies and physical model test studies have led to the development of a hydraulically efficient layout with respect to overall impacts on the coastal regime. Hydrodynamic and wave disturbance modelling studies have been carried out to investigate the impact of the overall layout on the coastal regime and to ensure satisfactory levels of wave disturbance are maintained at the water area within Port City.

In order to find out the anticipated impacts of the coastal land project comprehensive analysis of each and every activity is required. With respect to the sand extraction investigations such as; geotechnical investigations, assessment of sediment quality and quantity, type of extraction method, type of dredges and quantity of dredgers to be utilized etc. were carried out to examine the behaviour of the sand pit.

In general sediment movement is taken place in nearshore dynamic areas where the waves have an influence on sea bed and current flow is high. Therefore any activity causing the loss of sediments will directly influence the sediment unbalance in the dynamic zone and thereby causing erosion. In view point of above it is important to select a dredging site away from this dynamic coastal zone and the proposed dredging sites are well away from the shore ensuring this criterion.

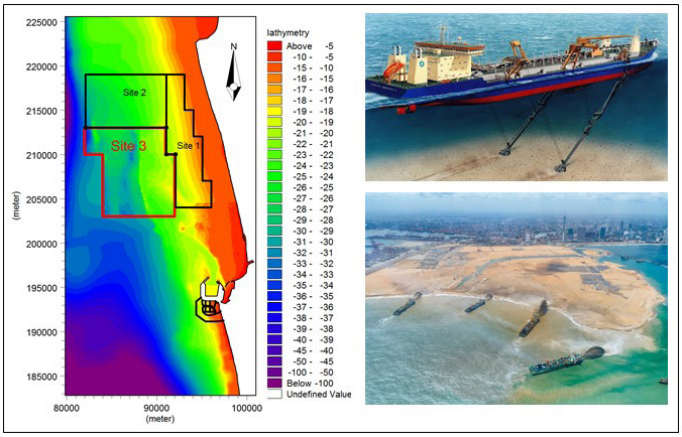


Fig 8: Dredging and Reclamation Process

All possible impacts were assessed during the studies and mitigatory measures are proposed in order to minimize the impacts on the marine environment. Further detailed monitoring plan is developed for each monitoring activity for implementation.

CES Annual Seminar 2018
Coastal Land Reclamation and City Development

Invited Presentation #3

Geotechnical Considerations of Coastal Land Reclamation Projects

By

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Eng. Bimal Prabhath Gonaduwage is a Civil Engineering professional with Chartered Engineering status, with more than 18 years of experience in Civil Engineering industry.

He got his college education from Bandarawela Central College. From there, he was eligible to enter to the Faculty of Engineering, University of Peradeniya, Sri Lanka and graduated as a Civil Engineer. Then, Eng. Gonaduwage strengthened his academic back ground by obtaining post graduate degree in Master of Science Degree in Construction Project Management (MSc.CPM) from University of Moratuwa, Sri Lanka. He was awarded scholarship from Joint Japan/World Bank Graduate Scholarship Program (JJ/WBGSP) to study in Unesco-IHE, Institute of water Education, Delft, The Netherlands. He obtained post graduate in Master of Science Degree in Coastal Engineering and Port Development (MSc.CEPD) from Unesco-IHE. In addition to that, Eng. Gonaduwage qualified as a Chartered Engineer and obtained corporate membership from the Institute of Engineers Sri Lanka (IESL).

Eng. Gonaduwage has conducted master thesis in following areas.

- Masterplan for the Development of Container Terminals in Ports
- Rules & Regulations of Regulatory Authorities and Effects on Foreign Funded Port Construction Project in Sri Lanka

Eng. Gonaduwage started his carrier as a Civil Engineer from Central Engineering Consultancy Bureau (CECB) which most reputed and well known Engineering Organisation in Sri Lanka from 2000 to 2008. He gained valued experience in construction, contract management, consultancy and design and planning from CECB. Then he joined to Sri Lanka Ports Authority due to the interest of working as a Port and Coastal Engineer. He engaged full time in Oluvil Port Development Project (46 Million Euro) which constructed by MTHojgard, The Denmark and then he had engaged with Colombo Port Development work since 2008 to 2014. With the strength of above eminent experience and academic background, he has been working as a Deputy Project Director in Colombo Port City Project (1.3 Billion US$) under the Ministry of Megapolis and Western Development (MM&WD) to date.

In addition to that, Eng. Gonaduwage has contributed for many activities conduct by Civil Engineering Sectional Committee and actively participate several other activities organised by IESL.

Geotechnical Consideration of Coastal Land Reclamation Projects

Eng. Bimal Prabhath Gonaduwage
Deputy Project Director (Reclamation)
Port City Development Project
Ministry of Megapolis and Western Development

Reclamation Work of the Port City Project

1. Introduction

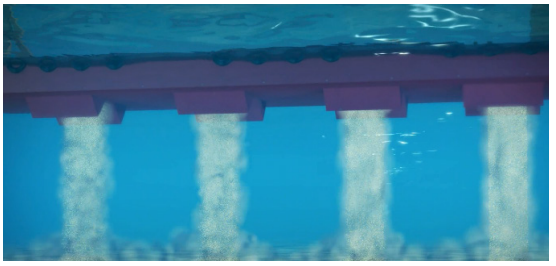
The Colombo Port City Development Project includes a reclamation works which is required to provide a stable platform for the development of the port city and the associated infrastructure. The reclamation area is 268.9 ha according to the EPC Contract.

The land shall be formed by reclamation with dredged sand materials from sand borrow area. Ground improvement shall be carried out to reduce residual settlement, to provide adequate stability against the applied load. Depending on the service purpose of the formed land and considering the site planning, land reclamation materials, geological condition and construction condition, ground improvement methods of dynamic compaction, vibro-flotation and roller compaction are proposed to meet the requirement of intended land.

1.1 Dredging and Reclamation

Filling Methods use at Reclamation Project

Rainbow Method



Bottom Dumping Method

Piping Method

Using Ground Machinery

Compaction Methods use at Reclamation Project

Dynamic Compaction Method

Dynamic Compaction Method

Dynamic Compaction Method

2. Design Methodology

2.1 Scope of Design

Scope of ground improvement design report comprise of:

a. Improvement methods selection and the methods suitability justification
b. Suitable detection tests designed to verify the effect of ground improvement.
c. The calculation of settlements to verify the fulfilling of the required improvement technical objectives, and the summary of settlement show that it satisfies the design criteria
d. The calculation of liquefaction potential to verify the fulfilling of the required improvement technical objectives, and the summary of liquefaction potential show that it satisfies the design criteria

2.2 Codes and Standards

The latest edition of the following standards governing, as referenced herein shall be applicable:

- BS EN 1997-1:2004: Eurocode 7-Geotechnical Design-Part 1: General Rules
- BS EN 1997-2:2007: Eurocode 7-Geotechnical Design-Part 2: Ground investigation and Testing
- BS 6349-5: Maritime Structure. Part 5. Code of Practice for Dredging and Land Reclamation
- BS 1377: Methods of test of soils for civil engineering purposes Design Condition

2.3 Soil Parameters of Reclaimed Area

Unit No.	Name	Geology
2-1	Very Soft CLAY	Quaternary Marine/Continental Deposit
2-2	Very Soft Sandy CLAY	
2-3	Soft Sandy CLAY	
2-4	Very Soft CLAY/SILT	
2-5	Firm to Stiff Sandy CLAY	
2-6A	Mixtures of silty CLAY/clayey SILT/silty SAND/sandy SILT	
2-6B	Very loose to loose silty SAND	
2-7	Medium Dense Gravelly SAND	
2-8	Dense Gravelly SAND	
3-1	Firm to Stiff Sandy CLAY (Residual Soil)	Quaternary Residual Soil
3-2	Very Stiff Sandy CLAY (Residual Soil)	
4-1	Completely Weathered GNEISS	Precambrian Bedrock
4-2	Highly Weathered GNEISS	
4-3	Moderately Weathered GNEISS	
4-4	Slightly Weathered GNEISS	

2.4 Fill Material

Filling material shall comply with the following requirements

- Maximum particle size: 100 mm
- Average silt content of the sand filled in the breakwater shall less than 5%
- Maximum silt content dispersed in the granular material (other area, except top layer of artificial beach): 10%

2.5 Reclamation Level

Generally the initial fill level (i.e. construction level) of the reclaimed land shall take into account of the effect due to ground improvement if ground improvement is found to be necessary. In consideration of the settlements caused by ground improvement and consolidation of original soil layers, the initial fill level shall be higher. In accordance with the construction experience of adjacent projects, the settlements caused by ground improvement is estimated to be about 0.6 m and should be adjusted according to the in-site ground improvement trials.

3. Design Criteria

1. The allowable bearing capacity: no less than 120 kPa.
2. Residual Settlement: The total post-construction residual settlement occurring at the reclamation surface anywhere within the site from the delivery date(s) to the end of the 50-year design life of the reclamation shall not exceed 300 mm in general, and 100 mm for specific areas planned for development of low rise villas in the Port City Master Plan. Low rise villas shall be defined as individual houses, for residential use, with less than three stories (ground floor, first floor, second floor and roof). Settlement calculations shall be based on an assumed long-term loading equivalent uniformly distributed load of 20 kPa in addition to the pavement dead load applied above the finished reclamation surface.

3. Compaction

The compaction criteria are only relevant for the area with ground improvement as the values are too high to achieve for areas without ground improvement.

a. The Road Area

- For the road area, the top 0.8 m fill material shall be compacted to at least 96% of the maximum dry density determined in accordance with BS 1377: Part 4. The in-situ density of fill within 1.5 m of the earthwork final surface shall be not less than 95%. The fill material from 1.5 m down to the mean water level shall be compacted to at least 93% of the maximum dry density determined in accordance with BS 1377: Part 4.
- The top 6 m from the final finish level shall achieve relative density of at least 50%. And the remaining fill material from 6 m down shall achieve relative density of 40% or more and as verified by appropriate in situ testing methodology.
- The in situ density shall be determined in accordance with BS1377: Part 9.

b. The Other Areas

- For the other areas, the top 1.5 m fill material shall be compacted to at least 95% of the maximum dry density. The fill material from 1.5 m down to 3 m shall be compacted to at least 90% of the maximum dry density. The fill material from 3 m down to the mean water level shall be compacted to at least 75% of the maximum dry density.
- The top 6 m from the final finish level shall achieve relative density of at least 50%. And the remaining fill material from 6 m down shall achieve relative density of 40% or more and as verified by appropriate in situ testing methodology.

4. Differential Settlement

- Post-construction differential settlement occurring at the reclamation surface within the road network area from the delivery date(s) to the end of the 50-year design life of the reclamation shall be limited so that the slope between any two points resulting from differential settlement is no steeper than 1/300 over a 20m base length at any time.

5. Liquefaction

- The reclamation fill shall be placed and treated in a suitable manner in order to prevent the occurrence of liquefaction under the specified design seismic event loading, of 0.05%g for 1second period and 0.20%g for 0.1 second period with 5% damping based on BS EN ISO 19901-2 Seismic design procedure 2004.

4. Design Calculations

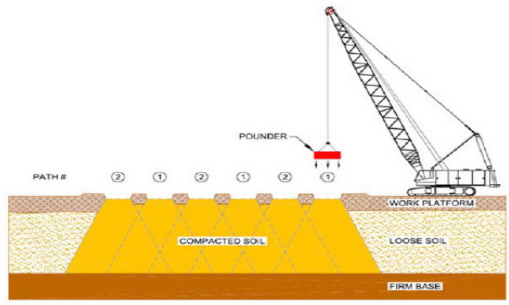
Selection of Improvement Method
Zones division and Improvement Method

List of Ground Improvement

No.	Zone		Methods of Ground Improvement	Expected Penetration Depth	Remarks
1	A	Revetment Area	Vibroflotation	Existing Seabed	Revetment along canal
2	B	Revetment Area	Dynamic Compaction(2000kN.m)	5.0~6.0m	Revetment along beach
3	C	Road Area	Dynamic Compaction(4000kN.m)	7.0~8.0m	
4	D	Development Area	Dynamic Compaction(2000kN.m)	5.0~6.0m	
5	E	Drainage Area Near Existing Road	Full Tamping (1000kN.m)	4.0~5.0m	
6	F	Drainage Ditch Area	Vibroflotation	Existing Seabed	Near Existing South Breakwater of CPEP

4.1.1 Dynamic Compaction Method

Dynamic compaction is a maturing method of ground improvement. A sufficient amount of energy must be applied during dynamic compaction to cause ground compression to reach the requirements for relative density.



Dynamic Compaction Method

The applied energy is generally given as the average energy given at the entire area, and can be calculated as following:
Where:

$$AE = \frac{(N)(W)(H)(P)}{(grid\ spacing)^2}$$

AE = average applied energy
N = number of drops at each specific drop location
W = mass of tamper in tons
H = drop height in meters
P = number of passes, equal to 2

The depth to which compaction is effective can be estimated at the following formula (Menard):

$$D = WH$$

Where,

D = The depth of compaction and height of fall in meters

H = Height of fall in meters

W = The mass in tonnes

4.1.2 Vibro-flotation

Since there are marine structures in Revetment area and existing South Breakwater of Port of Colombo, dynamic compaction is not suitable for these areas. The reclamation material is the dredged sand which is medium to coarse. The silt content of the fill sand is required to be less than 10%. So vibro-flotation is recommended as ground improvement method.

Mitchell (1970) has defined 3 zones to justify the suitability of vibro-flotation. The sand whose grain-size distribution fall in zone B (in Fig.3.2) is most suitable for compaction by vibro-flotation. So the method of vibro-flotation is suitable.

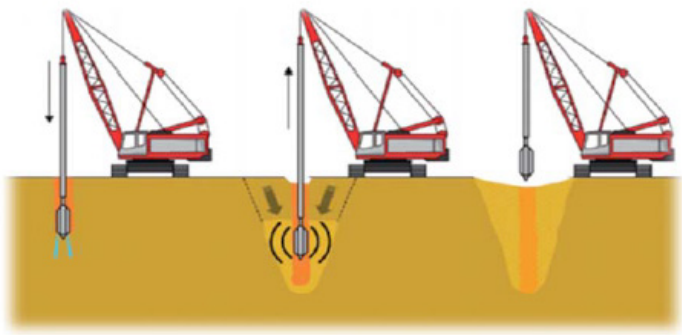


Fig 3.1 Vibro-flotation Method

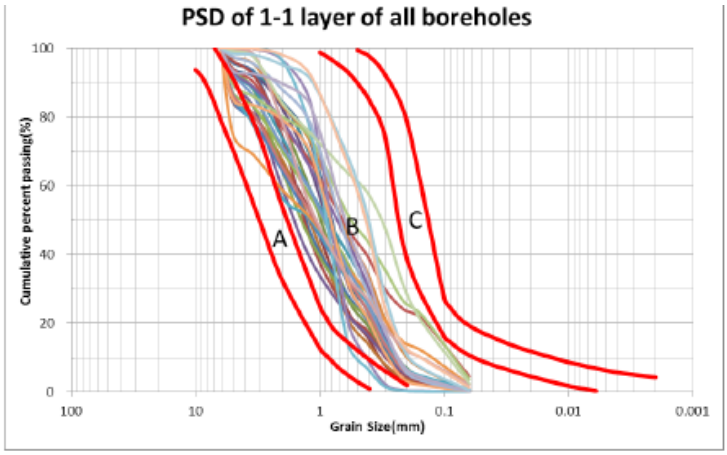


Fig 3.2 Particle Size Distribution – (PSD)

$$S_N = 1.7 \times \sqrt{\frac{3}{(D_{50})^2} + \frac{1}{(D_{20})^2} + \frac{1}{(D_{10})^2}}$$

Where D50, D20 and D10, are the diameters (in mm) through which respectively, 50%, 20% and 10% of the material passes.
The smaller the value of SN, the more desirable the backfill material is. Following is backfill rating system proposed by Brown (1977).

Range of S_N	Rating as Backfill
0-10	Excellent
10-20	Good
20-30	Fair
30-50	Poor
>50	Unsuitable

S_N values calculated for Port City Project

	D_{50}	D_{20}	D_{10}	S_N
Max	2.080	0.425	0.30	7.1
Min	0.239	0.122	0.076	29.1

Table 7.2 shows, values of S_N ranges from 7.1 to 29.1, rating as "Excellent"~"Fair", mainly "Good", So the method of vibro-flotation is suitable.

4.1.3 Roller compaction

After dynamic compaction and vibro-flotation roller compaction is adopted to compact the surface sand. Before regular construction, trials of roller compaction shall be carried out respectively according to the backfilling materials variety on trial section to determine the roller compaction parameters of compaction thickness for the largest dry density, type of compaction machines, compaction velocity, compaction passes, and so on.

Trials of roller compaction to comprise rolling passes of a vibratory roller excited force not less than 300 kN and dead weight not less than 18 tons or such other means as the Engineer may approve. The final specifications of vibratory roller shall be confirmed based on the results to trails. The vibratory roller shall be a smooth wheeled vibrating roller with a drum.

4.2 Settlement calculation

4.2.1 Calculation Method for Residual Settlement

Residual Settlement included three parts, creep settlement of sand, primary consolidation settlement and secondary consolidation settlement of clayey soil. The residual settlement can be expressed with the following formula:

The residual settlement can be expressed with the following formula:

$$S_{residual} = \triangle S_{creep} + \triangle S_{pri} + \triangle S_{sec}$$

Where

$\triangle S_{creep}$—Residual settlements of creep deformation settlement for sand layers (include layers of 2-6A, 2-6B, 2-7, 2-8 and fill sand)

$\triangle S_{pri}$—Residual settlements of primary consolidation settlement for clayey layers and fill sand (include layers of 2-1, 2-2, 2-3, 2-4, 2-5,3-1, 3-2 and fill sand)

$\triangle S_{sec}$—Residual settlements of secondary settlement for clayey layers (include layers of 2-1, 2-2, 2-3, 2-4, 2-5,3-1 and 3-2)

Summary of Settlement Calculation

Boreholes	Primary settlement			Secondary settlement $\triangle S_{sec}$ /Creep settlement of sand $\triangle S_{creep}$ (m)	Total Residual Settlement $S_{residual}$= $\triangle S_{creep}+\triangle S_{pri}+\triangle S_{sec}$ (m)
	Primary settlement in operation S_{ope} (m)	Primary settlement in construction S_{con} (m)	Residual of Primary settlement $S_{pri}=S_{ope}$-Utc*S_{con} (m)		
RA04	0.085	0.047	0.038	0.042	0.079
RA05	0.396	0.280	0.115	0.074	0.190
RA06	0.673	0.540	0.133	0.079	0.213
RA07	0.196	0.144	0.052	0.053	0.105
RA08	0.050	0.020	0.030	0.036	0.066
RA09	0.254	0.203	0.051	0.054	0.105
RA10	0.240	0.150	0.089	0.068	0.157

4.2.2 Calculation Method for Differential Settlement

The differential settlement can be calculated by the following formula:

$$Ration = \frac{S_{residual1} - S_{residual2}}{L}$$

Where

$S_{residual1}$, $S_{residual2}$ — Residual settlements of adjacent boreholes;

L —Distance between the two adjacent boreholes

Summary of Differential Settlement

No.	Adjacent Borehole	Adjacent Borehole	Distance (m)	Differential Settlements (cm)	Slope Ration ‰	Differential Settlements of Employer's requirement
1	RA35	RA36	132	3.4	0.3	≤3.3‰
2	YBH01	RA10	268	3.3	0.1	≤3.3‰
3	RA04	RA08	229	1.3	0.1	≤3.3‰
4	YBH04	RA09	227	4.3	0.2	≤3.3‰
5	RA36	RA10	136	0.3	0.0	≤3.3‰
6	RA10	YBH05	183	5.3	0.3	≤3.3‰
7	RA05	RA11	250	0.9	0.0	≤3.3‰
8	RA06	RA12	248	11.3	0.5	≤3.3‰

4.3 Liquefaction calculation

The liquefaction potential is assessed following the procedures as described in En 1998-5:2004.
The following equation is formulated for calculation of seismic shear stress τe:

$$\tau_e = 0.65\alpha S\sigma_{v0}$$

Where:

α —Ration of the design ground acceleration on type A ground, a_g, to the acceleration of gravity g;
σ_{v0} —Total vertical overburden stress;
S —Soil factor;

Calculation Results of Liquefaction Assessment (Road Areas)

(Land Reclamation Level +3.5m)

Depth (m)	Elevation (m)	σ_{V0} (kPa)	σ'_{V0} (kPa)	$(N_1)_{60}$	τ_e (kPa)	$\frac{\tau'_e}{\sigma'_{V0}}$	τ'_e (kPa)	FS	Liquefiable (Yes/No)
1	2.5	18	18	24.5	1.3	0.29	5.2	9.02	No
2	1.5	36	36	18.4	2.5	0.21	7.5	6.55	No
3	0.5	54	54	18.4	3.8	0.21	11.3	6.55	No
4	-0.5	72	63	10.9	5.1	0.12	7.8	3.38	No
5	-1.5	90	72	10.9	6.3	0.12	8.8	3.06	No

4.4 Design Verification

Trial construction shall be carried out to verify the suitability of the adopted methods prior to large scale construction. And the Cone Penetration Test or Standard Penetration Test, Plate Load Test, and In-situ density test shall be conducted for verifying the effect of the ground improvement.

4.5 Tolerance

4.5.1 For land area:

The permitted tolerance of average reclamation level within 1 hectare before ground improvement is -50 mm~+200 mm and the maximum tolerance of reclamation level is ±700 mm. The final reclamation level of rough grading shall be subject to permitted tolerances of +/-0.25 m and an average level of -0.05 / + 0.10 cm within 1 hectare.

4.5.2 For water area, the tolerance refer to following items:

- Behind quarry run berm, the top level of the sand core shall not higher or lower 0.5m than design level, for marina works such as north sand barrier, offshore breakwater, and marina revetment.
- The bottom level of inner breakwater shall not higher or lower 0.5 m than design level, within 50 m zone at seaside and leeside of center line of inner breakwater.
- The permitted tolerance of bottom level is -300 mm~0 within 20 m zone from seawall of canal and marina.

At rest area, the permitted tolerance is -600 mm~0 above the elevation of -5.0m, and -900 mm~+900 mm below the elevation of -5.0 m.

5. Tests and Frequency

5.1 The test frequency for trial construction is as follows:

- Standard Penetration Test (SPT) or Cone Penetration Test (CPT) : 3 points for each trial area of dynamic compaction or vibroflotation trial
- Plate Load Test (PLT)
- 2 points for each trial area of dynamic compaction or vibroflotation trial
- In situ density test on ground surface: 3 points for each trial area of dynamic compaction, vibro-flotation, or roller compaction trial

5.2 The test frequency for large scale construction is as follows:

- Standard Penetration Test (SPT) or
  Cone Penetration Test (CPT) : >1 test/4000 m^2
- Plate Load Test (PLT)
- 1 test/100000 m^2
- In situ density test on ground surface (Road Area): 1 test/1000 m^2
- In situ density test on ground surface (Other Area): 1 test/4000 m^2

6. Monitor

The monitoring frequency is two to three times per week during reclamation period and two to three times per month after reclamation. And the monitoring frequency should be adjusted according to the site conditions and construction situation. If monitoring data has been proved to be stabilized for a period of time with enough evidence, the contractor can properly adjust their monitoring frequency and inform the employer and designer in time.

6.1 Settlement Monitoring Plate

At a rate of at least 1 per every 20000 m^2 of ground improvement, on completion of filling surface settlement plates shall be installed to allow the surface settlement to be monitored throughout the Contract Period. The settlement plate is to be placed on the ground and filling progressively raised around the pipes. Whether the settlement performance criteria is met can be confirmed by the monitoring results.

CES Annual Seminar 2018
Coastal Land Reclamation and City Development

Invited Presentation #4

Breakwater and other Marine Structures Construction of Coastal Land Reclamation Projects

By

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Port City Development Project
Ministry of Megapolis and Western Development

Eng. Lalith Wijeratne

Deputy Project Director (Structures),
Port City Development Project,
Ministry of Megapolis and Western Development

Eng. Lalith Damsiri Wijeratne is a Civil Engineering professional with Chartered Engineering status, with more than 30 years of experience in Civil Engineering industry.

He got his college education from Bandarawela Central College and he was eligible to enter to the Faculty of Engineering, University of Peradeniya, Sri Lanka and graduated as a Civil Engineer. Then, Eng. Wijeratne strengthened his academic back ground by obtaining Diploma in Information Technology - ITMIN, Diploma in Occupational Safety & Heath-NIOSH, Diploma Construction Management - ITMIN and Diploma in Project Management -IPM. In addition to that, Eng. Wijeratne qualified as a Chartered Engineer and obtained corporate membership from the Institute of Engineers Sri Lanka (IESL).

Eng. Wijeratne has followed foreign training on Port Construction & Management Training in Philippines and contributed his knowledge to developed Master plan for the Development Landing Sites and Anchorages for Development in Sri Lanka under FAO UN.

Eng. Wijeratne started his carrier as a Civil Engineer in a private organization and gained construction experience in Mahaweli areas System 'C' and 'B' from 1986 to 1995. Then he joined to Government Corporation Ceylon Fishery Harbour Corporation and worked as Senior Construction Engineer on developing new/ rehabilitation Fishery Harbours from 1996 to 2004. 2005 He joint with United Nations organisations; United Nations Development Programme (UNDP) and Food and Agriculture Organization of the United Nations (FAO) as Project Manager on costal Tsunami rehabilitation projects.

From 2011 he serves as Project Manager – (International capacity) Ministry of Housing, Road and Urban Development - Republic of Maldives.

He has been working as a Deputy Project Director in Colombo Port City Project under the Ministry of Megapolis and Western Development (MM&WD) since 2016 to date.

Breakwater and Other Marine Structures Construction of Coastal Land Reclamation Projects

Eng. Lalith Wijeratne
Deputy Project Director (Structures)
Port City Development Project
Ministry of Megapolis and Western Development

1. General Introduction

The breakwater of this project is an offshore structure which has total length of 3245 m. The south head and north head of the Offshore Breakwater connect to the southern and northern sand barriers respectively. The general view after completion is shown in Fig I.

The top level of the offshore breakwater is at +4.0 m and the width of the crest is 9 m.

Fig 1 : Breakwater general view after completion

2. Scope of Works

The scope of works consists construction of the following works activities:

- Trench excavation and filling (if necessary, as per geotechnical information)
- Placement of Quarry Run toe bund on top of the seabed level
- Placement of 1-50 kg filter rock behind the Quarry Run toe bund

- Placement of sand fill material in the Breakwater core within the design envelop
- Placement of Quarry Run C material in the centre of the core
- Placement of Quarry Run A material in the core of the structure
- Placement of Rubble Stone material as filter rock
- Placement of 300-500 kg scour protection
- Placement of Underlayer rock on top of the core of the structure
- Placement of 2-5 ton and 2-3 ton toe rock material at sea-side and lee-side respectively
- Placement of Chinese pods on the slopes

3. Construction Methodology

Two distinctive construction methodologies will be used in the construction works:

Construction using a temporary road & using Marine Equipment
Construction of the Quarry Run up to -4.0 m CD is the same for both construction methodologies and is performed using Marine Equipment.

Construction using mainly by a temporary road

1. Trench Excavation & sand filling
2. Quarry run toe bund rock filling
3. 1~50 kg rock filling
4. Sand core filling behind 1-50 kg filter rock
5. Quarry run core material filling below -4 m
6. Rubble stone filling below -4 m
7. Quarry Run Core above -4.0 m CD and lee-side Quarry Run overfilling for temporary road Up to +2.0m & protection layer rock filling
8. Seaside under layer rock filling
9. First part of 2~5 ton toe rock placement to form the V-notch
10. Under layer and first part of 2~5 ton toe rock profiling
11. Chinese pods installation at seaside
12. Balanced 2~5 ton toe rock placement
13. Lee-side excavation & quarry run core trimming and profiling
14. Under layer rock placing
15. 2~3 ton toe rock placing
16. Chinese pods installation
17. 300~500 kg rock filling at lee side

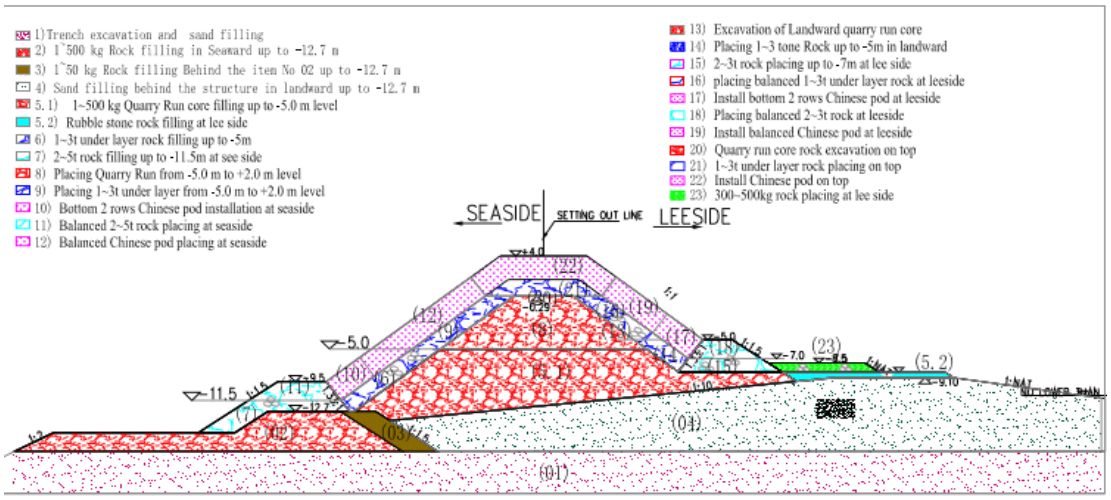


Fig 2 : The typical sectional layout of offshore breakwater

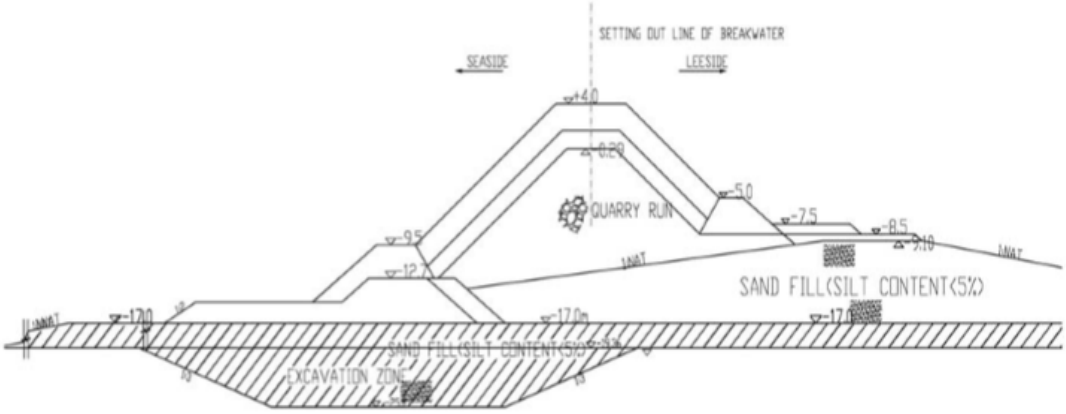


Fig 3 : Trench Excavation and Sand Filling

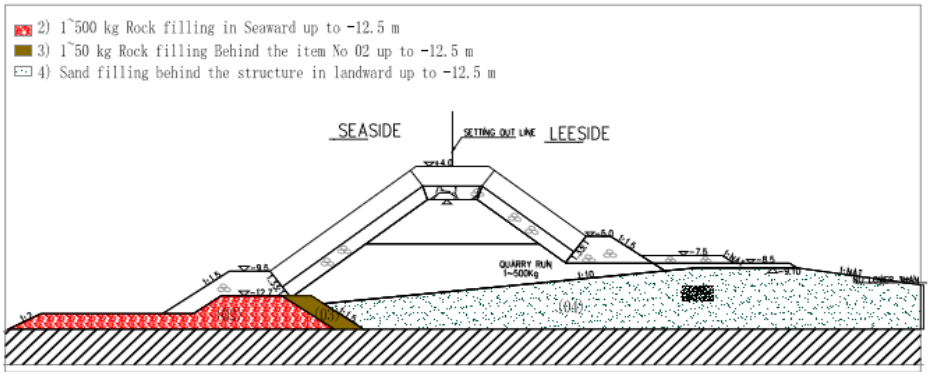


Fig 4 : Bottom rock and backfilling sand filling

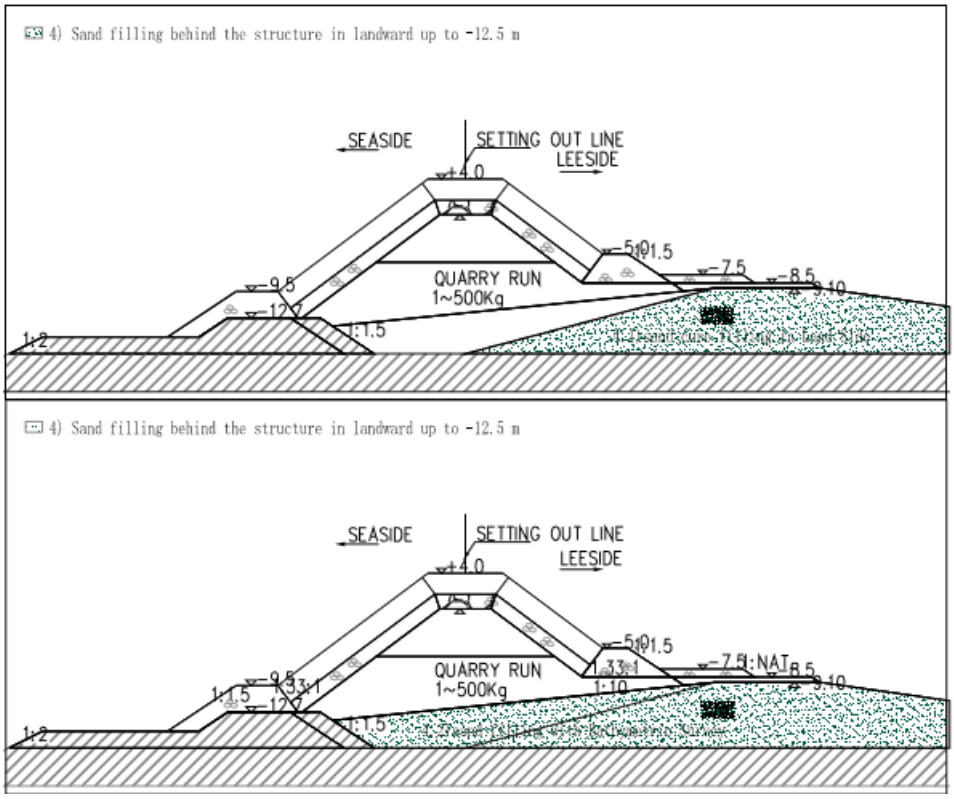


Fig 5 : Sand filling steps

Final Bathymetric Survey will be conducted to prove the top of the quarry run core is free of sand before placing 2~5 ton rock on seaward face. If there is sand on top of the quarry run core, it will be removed by suction boat and it will be again surveyed to ensure that surface is free from sand.

Rock filling below -5 m

As it described above, after the sand core filling, 1-500 kg rock will be placed up to -5 m, and rubble stone will be placed at lee side. For these two type of rocks placing, kinds of method will be used, such as rock filled by 55 m^3 split barge , by short arm excavator on deck cargo ship, by 1000 m^3 split barge.

Fig 6 : Rock filling by 1000 m^3 split barge

The 1~3 ton under layer rock

The 1~3 ton under layer rock will be filled up to -5 m, by short arm excavator on deck cargo ship and then long arm excavator will be used for the under-layer slope making. The 'V 'shape area for Chinese pod installation is difficult to construct. For this issue, the 2~5 ton rock will be placed in two steps. Placing sequences will be followed the construction Fig: 7.

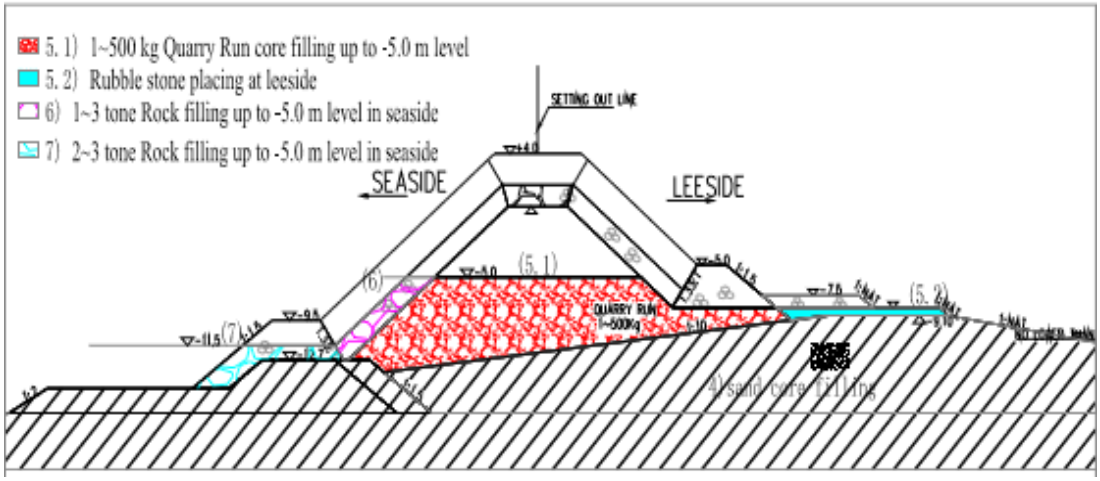


Fig. 7 : The bottom amour rock & Quarry run filling

Quarry run core rock and under layer rock filling from -5 m to +2 m Details are shown in fig 8.

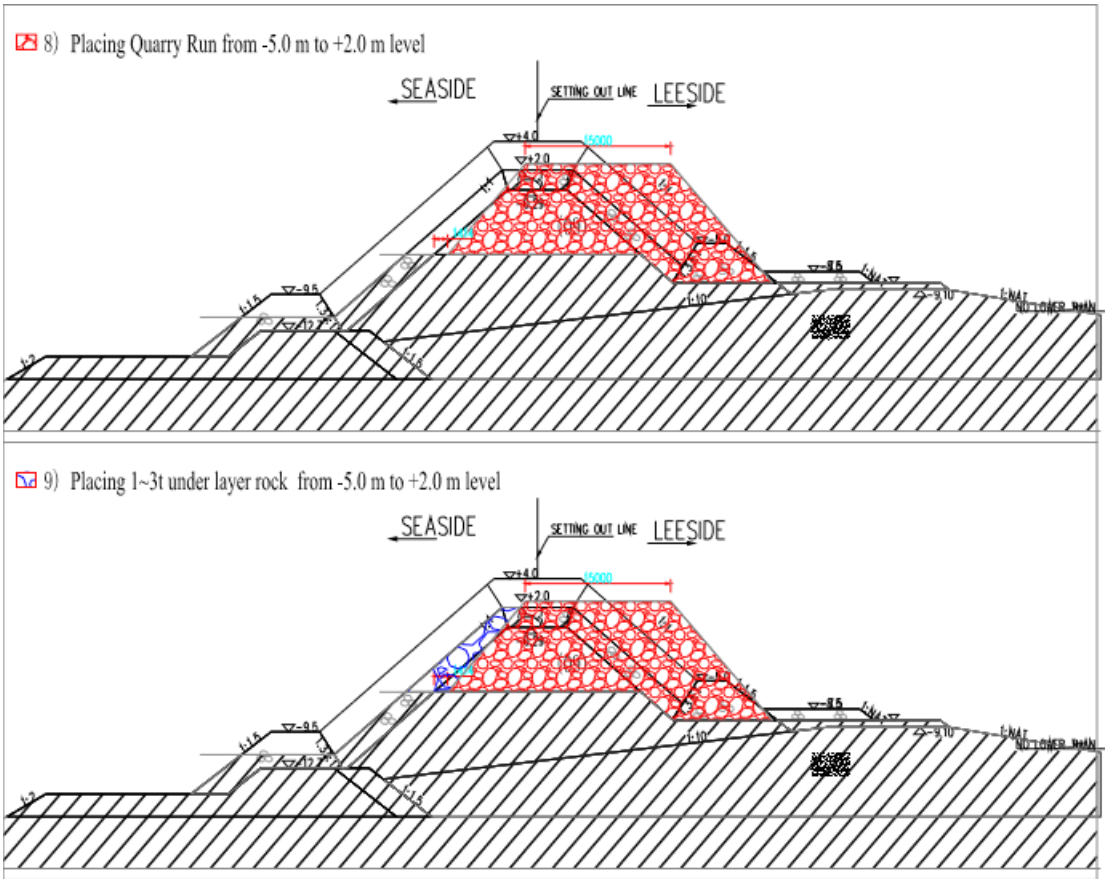


Fig 8 : The quarry run core and 1~3 ton under layer rock filling up to +2.0 m Level

With the slope, the profile of the quarry run can be checked easily from the alignment onshore by GPS. 1~3 ton under layer rock will be used to fill the empty area of quarry run core, thus the thickness of under layer will be maintained.

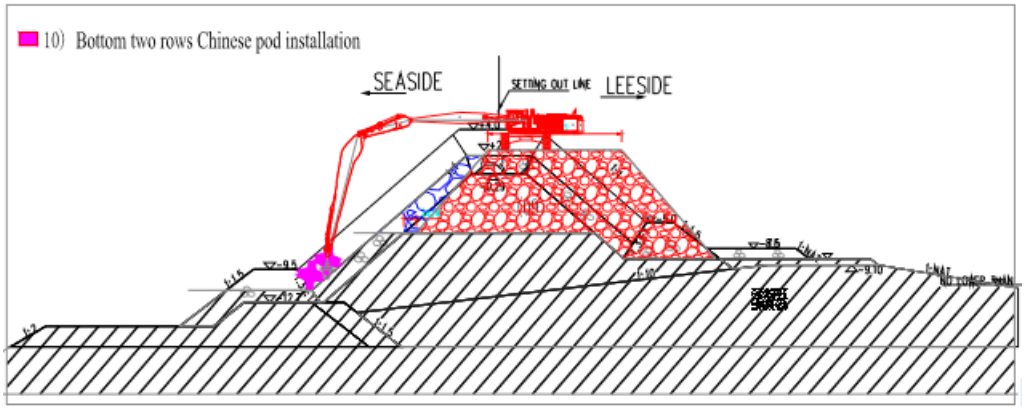


Fig. 9 : The seaside Chinese pod installation

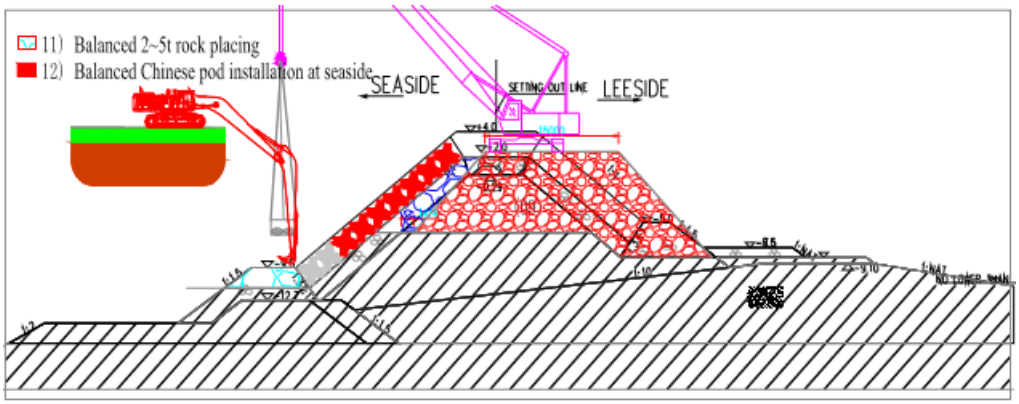


Fig 10 : Balanced 2~5 ton rock placing and Chinese pod installation at seaside

4. Selection of Rock

Rock Handling, Stockpiling and Testing

1) Selection of Rock Sources & Suppliers.
2) Handling, stockpiling and testing of rock material on site to be used in permanent work.

Selection of Rock Sources & Suppliers

1st selection stage:

1) Environmental protection licenses (EPL) issued by the central environmental authority
2) Industrial Mining License (IML) issued by the Geological surveying & Mining Bureau (GSMB)
3) Trade License issued by the local authority where the quarry is located.
4) Location map of the quarry

After the above required documentation is confirmed, the supplier will be eligible to supply 2nd selection stage:

1) Apparent relative density (BS 812: Part 2) >2,600 Kg/m^3
2) Water absorption of rock source; (BS 812: Part 2) <5%
3) LAAV; (ASTM C-535) <25%, Either: Aggregate Abrasion (BS 812: Part 113) <15%
4) Weathering ($MgSO_4$ and MBA); (BS 812: Part 121) $MgS0_4$ <18%
5) Point load strength. ISRM 1986 recommended method, shall be not less than 4.0 MPa

Handling, stockpiling and testing of rock material on site to be used in permanent work.

Main Rock Categories

Rock material are divided in 3 main categories:

1. Quarry Run material
2. Light Grading
3. Heavy Grading

Table 4-2: Specifications for Quarry Run material

Quarry run	Rock Weight (kg)					Remark
		NLL	W50	NUL	EUL	
	<5%	<10%	<50%	>70%	>97%	
A	1.6	3	-	250	500	(i.e. M_{15}=6kg)
B	0.1	0.5	20	250	500	(i.e. M_{15}=1.6kg)
C	0.01(20mm)	0.05(32mm)	5	100	300	M85/M15=20~1000

Note: No stone shall have a weight greater than 1000kg, the content of mud and sand should be less than 5%.

Table 4-3: Specifications for Heavy Grading

Layer Type (kg)	Rock Quality	Rock Weight (kg)						Nominal size(mm) Dn_{50}[2)]
		ELL[1)] <2% or <5%	NLL <10%	NUL >70%	EUL >97%	W50		
						Lower Limit	Upper Limit	
3000-5000	A	2100	3000	5000	7500	3700	4300	1154
2000-5000	A	1400	2000	5000	7500	3200	3800	1097
2000-3000	A	1400	2000	3000	4500	2200	2800	980
1000-3000	A	700	1000	3000	4500	1700	2100	910
800-2000	A	560	800	2000	3000	1200	1600	810
700-1400	A	500	700	1400	2000	800	1200	735
300-500	A	200	300	500	750	350	450	532
100-200	A	70	100	200	300	130	170	385
10-100	A	7	10	100	150	40	80	275

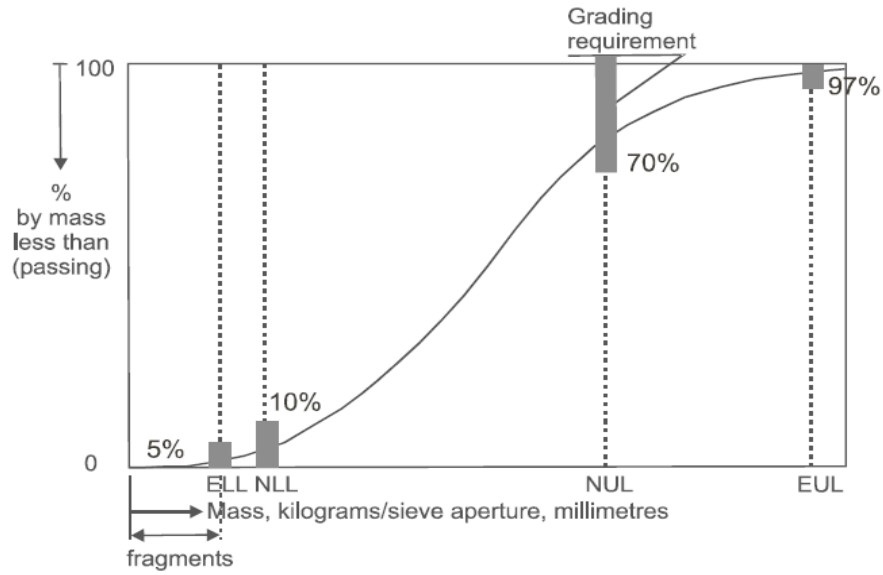
Note:

1) For a light grading (NLL<300kg) the mass indicated is limited to 2%, otherwise the limit is <5%.

2) "Rock sizes" are calculated on the basis of specific gravity of 2.65t/m^3 for Quality A, where "Dn50" refers to the face dimensions of a notional cube.

Table 4-4: Specifications for Light Grading

Layer Type	Rock Quality	Size of stone(mm)				Nominal size(mm) Dn_{50}
		ELL <5%	NLL <15%	NUL >90%	EUL >98%	
1-50kg	A	45	70	265	360	170
Rubble stone	A	50	100	200	320	150
Inverted filter layer	A	1	5	100	180	52



Testing Frequencies

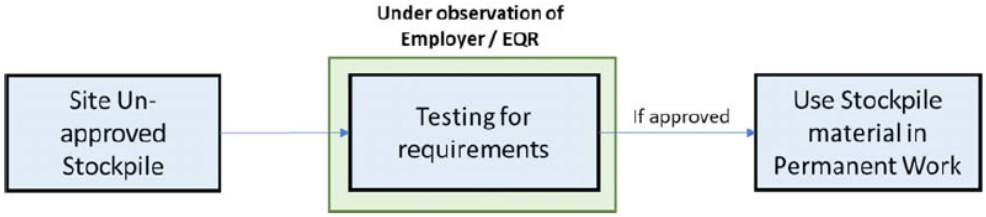
Grading (per class)	25,000t
Shape (per class)	10,000t
Apparent relative density	25,000t
Water Absorption	50,000t
Weathering ($MgSO_4$ and MBA)	50,000t
Abrasion	25,000t
Strength	50,000t

Drop tests shall be carried out to determine the drop test breakage index ID in accordance with clause 3.8.5.2 in CIRIA Publication C683- The Rock Manual, and Annex B of BS EN 13383. The frequency of testing and the samples selected for testing shall be determined by the employer.

Drop test is conducting for specially armour rocks (Heavy Grading)

Grading test for armour rock

Sample for rock property test



Invited Presentation #5

Environmental Considerations of Coastal Land Reclamation Projects

By

Mrs. Anoja Herath
Director (Environment)
Ministry of Megapolis and Western Development

Mrs. Anoja Herath
Director (Environment)
Ministry of Megapolis and Western Development

Mrs. Anoja Herath is an officer of the Sri Lanka Administrative service with more than 15 years of experience. Currently she works as a Director at the Ministry of Megapolis and Western Development and responsible for monitoring the implementation of the environmental impacts mitigation activities of the projects, carried out by the Ministry, including the Ports City Development Project.

She worked as a Director at the Ministry of Agriculture and the Ministry of Science and Technology. She served as a member of Board of Directress in the Ceylon Fertilizer Company from 2015 to 2017. Mrs Anoja Herath's longest career spell was at the Ministry of Environment for 10 years as the Assistant Director in the areas of Air Pollution and Climate Change. She has participated in many global forums representing Sri Lanka as Government Delegate for the United Nations Framework Convention on Climate Change and Kyoto Protocol.

She obtained her first degree in the field of Agriculture from University of Peradeniya and obtained her Master of Arts in Sociology at the University of Kelaniya.

Environmental Considerations of Coastal Land Reclamation Projects

Mrs. Anoja Herath
Director (Environment)
Ministry of Megapolis and Western Development

1. Introduction

Colombo Port City Development project is one of the best examples in Sri Lanka to study the environmental issues of coastal land reclamation project. Initial Technical feasibility study of this project was carried out in 2010 and the Environmental Impact Assessment was done in 2011 for reclamation of 200 ha land. However, Supplementary Environmental Impact Assessment (SEIA) was carried out in 2015 to capture the design changes of EIA carried out in 2011and to subject to public scrutiny the aspects covered in the addendum to the EIA of 2013 and subsequent changes. SEIA was carried to an altered design comprising of an area of 269 ha, together with the impacts of extraction of sand from the identified borrow areas and quarry material required for the entire landfill and protective works. SEIA study covers the entire reclamation footprint and the extraction of quarry material and sand for the entire project.

According to the terms of the project agreement, the Colombo Port City will be developed in two distinct phases, with required environmental approvals obtained in two phases as well as follows:

Phase 1 EIA: For reclamation, sand extraction and construction of coastal structures to protect the landfill and landscaping aesthetics for the proposed Colombo Port city.

Phase 2 EIA: Construction of the buildings and infrastructure of the port city. This EIA will be based on the concept master plan and infrastructure requirements submitted to the UDA. The construction of permanent structures/ built environment on the landfill will take place only upon receiving necessary approvals for the Phase 2 EIA study.

1.1 Terms of Reference (TOR) for the SEIA

Coast Conservation and Coastal Resources Management Department is the project approving agency of the project and decided the scope of the environmental studies and issued the Terms of Reference (TOR) for the SEIA (Phase 1) of the reclamation, dredging, Construction of protection Structures such as Breakwaters and Revetments and extraction of sand and quarry material required for reclamation and protection works for proposed Colombo Port City Development Project. The Project proponent for this SEIA the Ministry of Megapolis and Western Development appointed Central Engineering Consultancy Bureau as the lead consultant to execute this SEIA study. Main components of the TOR were as follows:

1. Introduction
2. Description of the project and reasonable alternatives
3. Description of existing environment
4. Anticipated Environmental Impacts of the project
5. Proposed mitigation measures
6. Environmental Management Programme
7. Conclusions and recommendations

Environmental considerations were asses based on the above components in the Port City Development Project.

1.2 Outline of the Studies Carried Out

A comprehensive review of the modelling work and preliminary designed carried out for the feasibility study included the comprehensive 2D and 3D physical model test, interpretation of coastal evolution and siltation, sediment transport modelling considering dredging and reclaiming and interpretation of contaminant concentration at the Beira lake outfall with proposed mitigation measures. In addition, following engineering studies have been carried out during feasibility and environmental study phase.

- Wave climate modelling
- Hydrodynamic modelling
- Sediment dispersal modelling
- Shore profile survey
- Numerical modelling of water exchange
- Ground investigations
- Water quality sampling and analysis
- Assessment of inland quarry material availability, permits, transportation routes, impacts etc.
- Model and ecological studies at reclamation area

1.3 Material Requirements for Port City Development

To complete the Port City Development Project, a total of 2.83 million cubic m^3 of quarry material and 65 million cubic m^3 of dredged sand will be required. Port city obtain quarry material from independent licensed quarry supplier who will individually obtain required local authority, environmental and transport permits. A total of 11 different quarry sites with required approvals have been surveyed and Geological Surveys and Mines Bureau Technical Services estimates, the required quantity of port city works out to around 43% of the quarry material available at these sites. Furthermore, 11 quarry sites represent around 7-9% of the total registered quarries in the Colombo and Gampaha districts. Consequently, the impact of this project on the national quarry material requirement would be negligible and therefore no price impact to the construction industry according to the GSMB Technical Services.

Around 300 six-wheeler trucks and 38 ten wheelers are to be used for transportation from the quarry sites to the project site.

Sand is to be extracted from two areas initially designated by GSMB with exploration licenses issued to the SLPA. Under this SEIA, environmental impacts have been ascertained for these sites, which comprise a combined area of 100 sq. km (46 sq. km for Site 1 and 54 sq. km for Site 2) and a dredge-able/available sand quantity estimated at 112 million cubic m^3 (44 million cubic m^3 for Site 1 and 68 million cubic m^3 for Site 2) or almost double the sand requirement for completion of Port City.

2. Potential Environmental Impacts

2.1 Dreading of the Seabed for Extraction of Sand

- Impact on sensitive habitats reefs and sea grass beds
- Softbottom microzoobenthos and endangered species
- Impact of breeding grounds /spawning grounds
- Increase in the suspended solid and turbidity impacting phytoplankton and other aquatic plants and animals
- Impacts on fishing grounds and fishing community
- Impacts on the fishing community

2.2 Reclamation

- Coastal effects
- Sediment plumes
- Impeding /silting up of the outlet location, obstructing the discharge from the Beira lake
- Impact on water quality of the adjoining coastal area with regard to beira lake outlet
- Impacts of coastal water quality with regard drainage outlets
- Marine pollution by sewage and waste water and solid waste generation from workers quarters

2.3 Construction of Breakwater and Other Relevant Structures

- Increase in noise and vibration
- Damages to roads due to vehicles transporting heavy loads
- Impacts of quarry sites
- Oil spills

3. Proposed Mitigation Measures

SEIA identified the potential environmental impacts and the mitigation measures in order to avoid or minimize any such adverse impacts in different stages of the project development.

1. Mitigatory Measures adopted in Design Phase
2. Mitigation measures identified in construction and operational stages
3. Risk Management and Disaster Mitigation

3.1 Mitigatory Measures Adopted in Design Phase

Site selection, the geographical positioning of the reclamation and its layout and proposed protection has been carried out to minimize the impact on environment and minimum exposure to hazards.

The northern boundary of the project is the existing breakwater of the Colombo port expansion project and the design will influence only the southern coastline side, which is anyway expected to naturally accumulate with sand over time as a result of the Colombo South Port breakwater.

The selected location for reclamation therefore mitigates a number of potential impacts, which may have arisen if such reclamation was to be undertaken on a separate site.

3.2 Mitigation Measures Identified in Construction and Operational Stages

3.2.1 Dredging Site

NARA, who was commissioned by the Project Proponent to carry out the marine ecological studies and socio-economic impacts, and LHI, who carried out studies on shoreline/coastal impacts, have recommended following guidelines for dredging that are designed to minimize impacts on the coastal area, ecology and income from fisheries.

- Any additional amount of sand reclamation should be obtained from the proposed sand extraction site allocated to the Sri Lanka Land Reclamation and Development Corporation (SLLRDC) as proposed and identified by the Project Proponent. Separate approval should be obtaining from the Central Environment Authority for dredging sand from the site allocated to the Sri Lanka Land Reclamation and Development Corporation (SLLRDC).
- Dredging of sand for reclamation should be carried out 03 km away from the shoreline and in depths more than 15 m. Dredging depth to be limited to 03 m from the surface of sea bed and at least 0.5 m of thick layer of sediment should be maintained during extraction.
- Mining license should be obtained from Geological Survey and Mines Bureau for required deposits of borrow pits prior to the commencement of dredging activities.
- The route of the dredger should be selected to minimize the impacts on fishing in the area and general navigation routs.
- All GPS track records of dredger movement shall be provided on request by CC&CRMD.
- All the barges should be equipped with navigational light and signals as applicable to sea going vessels and the barge operators should be educated on the existing fishing activities and dredging area should be marked using buoys. In the event of an accident to the fishermen, vessels, fishing gear or equipment due to project activities, Coast Conservation and Coastal Resource Management Department should be duly informed and the Environment Monitoring Committee will decide on compensation to be paid by the PP.
- Modern dredging methods should be applied to minimize the amount of suspended sediment release to sensitive marine environment such as reefs, hard bottom area located in the vicinity of the dredging site as indicated in the SEIA report.

- All precautionary measures should be taken to minimize overflow of the extracted sand and other contaminant from machinery and vessels.
- Sand dredging activities should be avoided in the area which are closer to the reef habitats, spawning areas, breeding areas, and more sensitive and high productive areas, sites having unique habitats or other values including habitats of threatened or endangered species.
- Proper extraction methods and technology to prevent or minimize any potential damage during the extraction period shall be maintained and extend support to carry out research in relation to fishing impacts, biological impacts due to sand extraction in collaboration with National Aquatic Resource Research and Development Agency (NARA) and any damages or changes on fishery resources, other aquatic resources and marine environment due to project activities should be restores.
- All measures should be taken to maintain turbidity level at the boundary of the study area below the standard level and use silt screen as required, if the turbidity level at the boundary of the study area exceed the standard level, the project proponent must have sufficient silt curtain ready or should be able to mobilize such measures within 24 hours if an unforeseen plume of sediment develop.

3.2.2 Reclamation Site

3.2.2.1 Mitigation on Coastal Environment

Recommended that baseline measurements of beach profiles be under taken prior to project commencement and thereafter monitoring be carried out at prescribe time intervals. Accordingly, yearly survey of the beach profiles is carrying out.

3.2.2.2 Mitigation of Sediment Plumes

As and when necessary, silt curtain will be installed to prevent silt migration. The silt curtain will be formed by polyester-fibre textile sheets to be hanged from buoys and be weighed down by steel chains. An opening will be provided to allow for navigation of TSHDs and other construction vessels in and out of the reclamation site.

3.2.2.3 Mitigation on Impacts on Road Surface due to Transportation of Material

It was recommended to use only the vehicles, which are authorize to transport goods on Sri Lankan roads and not to exceed the recommended axel loads. (for transportation of quarry material only six-wheeler trucks and ten-wheeler trucks will be used).

Overload controlling system has to be implemented. Transportation shall be done through two sessions, avoiding peak hours, and via six different routes to minimize traffic congestion.

The trucks shall be covered to avoid any spilling of transported material or release of dust to the environment. Dust generation during the transportation via unpaved internal roads shall be controlled by sprinkling water along the roads at regular intervals. Sprinkling water to wash quarry materials loaded in trucks before unloading them at the stockpiling site shall minimize dust generation during the unloading. The movements of the wet returning trucks may cause Spitting mud along the road surfaces outside the project site. Washing the tires of the trucks, before they are moving out of the project site shall control this impact.

3.2.2.4 Noise and Vibration Control Measures

Noise levels at the boundaries of the project site will be maintained during construction phase to the levels stipulated in the National Environmental (Noise control) Regulations by applying appropriate mitigatory measures.

Interim standards on vibration for blasting activities and interim standard on vibration for the operation of Machinery, Construction Activities and vehicle movement proposed by the central environmental authority will be strictly adhered to during project construction and operation phases.

3.2.2.5 Sewage and Wastewater Treatment Systems, Solid waste Disposal Method

Adequate sanitary facilities and waste management facilities should be provided.

3.2.2.6 Mitigation of the Impacts on Beira Lake

A numerical model was built specifically for assessing the impact of Port City on the discharge from the Beira Lake outfall. This assumed the elimination of current sewerage discharge into the Lake will not be finalized by the Government prior to completion of reclamation work of Port City. The final engineering design adopted at the Beira lake outfall will not block the outlet but will streamline the continuity of the discharge and bring water further to the sea, improving dispersion and preventing any obstruction to the Beira outlet. The approach proposed in this SEIA has the additional advantage as it allows for the formation of a beach close to Galle Face Green without obstructing the outlet.

3.2.2.7 Income Support and Benefit Programme for Fisherman

This SEIA concludes that sand dredging is expected cause local and temporary impacts on the biological environment due to the removal of benthic fauna and increasing turbidity as a result of an increase in suspended particles in water columns. Hence it is proposed that the income support and benefits programme will be worked out in detail by the relevant Ministries and organizations / departments involved, with the inputs of community-based organizations (CBOs) such as the fishermen's societies, churches, etc.

Accordingly, a sum of Rs. 500 million allocated to the Ministry of Fisheries and Aquatic Resources Development via the Ministry of Megapolis and Western Development to meet the requirements of the proposed fisher community income support and benefits program.

4. Environmental Management Plan (EMP)

An Environmental Management Plan has been prepared based on the SEIA approval conditions. EMP lays the framework for continued assessment of potential impacts through the application of monitoring and auditing.

4.1 Monitoring of Implementation of Mitigation Activities

Periodic monitoring through reporting and frequent meetings are carried out to overcome any adverse impacts. Regular environmental monitoring reports, monthly environmental meetings, regular site environmental audits, Ad Hoc inspections were carried out. During the past two years no major environmental issues were reported. However, there were complains on increase of ground water table, complains from fishing communities, complains on exceeding the vibrations levels were there. Ministry of Megapolis and Western Development with the project company take immediate actions to resolve those issues.

According to the EMP following assessments are carried out periodically and submitted to the project approving agency.

Parameter	Frequency	Monitoring locations	Done
Water quality	Monthly	Dreading site, Kelani River mouth, Channel mouth, Reclamation site, B, Lake outfall	NARA
Fecal Coliform	Monthly	Beira Lake, Beira Lake out fall and adjacent coastal waters (Distance between two sample points was 500 meters or more)	NARA
Nutrient	Bi-annually	Sand extraction site 3	NARA
Air Quality	Bi-annually	6 Locations	NBRO
Noise	Bi-annually	5 Locations	ITI
Vibration	Bi-annually	5 Locations	ITI
Fish catch and fishing locations	Monthly	12 coastal fisheries inspector divisions, from Wattala to Kammalthurai in Negombo Fisheries District.	NARA
Photographic Survey	Quarterly		Sab
Density of mature/ running fish – Spawning biomass Site 2 & site 3	Quarterly	Site 2 & 3	NARA
Current measurements	Quarterly	Beira Lake outfall, Reclamation site, Cannel mouth, Kelani River Mouth, Dredging site	NARA
Species Diversity and Species Density Underwater visual survey Thambagala - site 3	Annually	Site 3	NARA
Species Diversity by Grab Sampling (Benthic grab sampling)	Annually	Site 3	NARA

Notes

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