Surveys for Shoreline Monitoring Programme

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SUMMARY

Malaysia has a shoreline of over 4,000 kilometres and certain portions of this shoreline that are being eroded needed engineering measures to protect the shoreline and in certain instances these measures included beach nourishment works. Effective engineering measures require careful study including hydraulic studies of the coastal regime and engineering design alternatives. In certain instances, environmental impact assessment is also required. Invariably the need to identify this land/sea interface is crucial. Such studies and assessment must be based on a proper spatial dataset for the targeted coastal areas. The provision of this dataset for initial studies, assessment and design is the role and responsibility of Surveyors.

However, the Surveyors role does not end with the provision of the initial spatial dataset. One of the measures to monitor the impact of such coastal engineering works is the implementation of a shoreline-monitoring programme for each coastal engineering works. This programme included initial or baseline survey, shoreline monitoring survey during construction works and thereafter for a further period of at least two years. Typically, the Surveyors involvement in projects of this nature could span three to five years. This presentation will discuss the typical scope for the topographic and bathymetric profiling for shoreline monitoring programme for a typical coastal engineering works, the basic instrumentation and methodology employed to ensure that the survey is “fit-for-purpose” as implementers of these works have to be cost conscious.

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PREAMBLE

Malaysia has a shoreline of over 4,300 kilometres and certain stretches of this shoreline are being eroded over time. Stretches that are more severely eroded needed engineering measures to protect the shoreline and in certain instances these measures included restoration works such as beach nourishment, shoreline revetments works.

For such coastal engineering measures to be effective, careful engineering studies including hydraulic studies of the coastal regime are crucial to better understand the physical environment and the engineering design alternatives available. In certain instances, environmental impact assessment is also required for the proposed coastal engineering works.

The effectiveness of any engineering measures implemented can only be known years after the completion of the associated construction works. Malaysia has implemented shoreline monitoring programme for certain coastal engineering works to better understand the impacts of these works on adjacent coastline as well as the effectiveness of these measures. After all, almost all coastal engineering works can be considered costly.

INTRODUCTION

Appropriate coastal engineering measures depend on proper and studied evaluation of the coastal zone involved and such evaluation will invariably require an appropriate spatial data set for the targeted coastal areas. This would include the identification of the land sea interface in addition to the understanding of the physical regime within the coastal area. The provision of this spatial data set for initial studies, assessment and design is the role and responsibility of Surveyors. However, the Surveyors role does not end with the provision of the initial spatial dataset.

One of the measures to monitor the impact of coastal engineering works is the implementation of shoreline monitoring programme for certain coastal engineering projects. This programme included initial or baseline survey, shoreline monitoring survey during the construction works period and thereafter for a further post construction period.

SHORELINE MONITORING PROGRAMME

The shoreline monitoring programme are normally stipulated by the Client Agency, a government department having responsibility over the affected coastline, as part of its requirement for the implementation of the coastal engineering works. This programme includes -

- Initial or Baseline Survey;
- Shoreline Monitoring Surveys during construction; and
- Shoreline Monitoring Surveys after completion of the construction works.

A comprehensive land and hydrographic survey is undertaken for the designated coastline and the results of the survey forming the initial or baseline survey, is normally utilized for initial engineering and hydraulic studies, assessment of design alternatives as well as detail engineering design. Hence the scope of work has to be carefully determined to ensure "fit-for-purpose". The survey will cover both the land and the adjacent sea.

During the implementation period or construction stage, shoreline monitoring surveys over a selected section of the designated coastline are carried out, normally at three or four monthly intervals, hence three to four surveys per annum. The results of the survey are compiled and the impact of the ongoing of construction works on the adjacent coastline monitored by the Design Engineer and the Client Agency.

After the completion of the engineering works, shoreline monitoring continues during this post construction stage for up to three years and surveys are carried out at six monthly intervals. The results of the survey are compiled and continue to be monitored by the Design Engineer and the Client Agency.

TECHNICAL REQUIREMENTS

The technical requirement for a Shoreline Monitoring Programme typically implemented included –

Pre-mobilization Preparation

The Surveyor is required to procure all relevant survey information including cadastral maps necessary to provide relevant survey information and survey control along the length of the survey area within the designated coastline. In addition, the Surveyor is to ascertain the datum (horizontal and vertical) to be adopted for the Shoreline Monitoring Programme.

Prior to mobilising to site and the commencement of fieldwork, there will be the usual survey pre-planning and preparation and a kick-off meeting where matters necessary for the successful implementation of the programme are ascertained and if there be any issues, resolved.

Planimetric and Height Controls

(a) Monumenting

The monuments are established on suitable existing permanent structures. Where existing permanent structures are not available, the Surveyor shall construct at the required positions. The ground markers are usually constructed out of a 1000 mm

length (minimum) of 50 mm diameter galvanised iron pipe in concrete of dimensions 300 mm x 300 mm x 300 mm. The pipes are filled with concrete or cement-sand mortar. The monument reference number and the traverse reference for the ground marker are usually written on the concrete.

(b) Planimetric Control

Planimetric control survey are usually by method of traversing from the existing survey control points in the vicinity of the project area to the monumented survey reference marks and for the establishment of the D-GPS Reference Stations. Traverses normally close to better than 1: 10,000. It is not unusual for survey controls to be established by GPS these days.

(c) Height Control

Height control survey is normally by method of leveling or edm heighting or a combination of these methods to the monumented survey reference marks. The levels are referenced to the nearest pair of acceptable Government Benchmarks. Maximum misclosure does not exceed $0.020 \sqrt{k}$ m where k is the length leveled within a level loop in kilometres.

The planimetric and height control survey is to establish primary survey (horizontal and vertical) control for the shoreline profiles along the length of the designated coastline that is to be surveyed, the establishment of survey reference stations, the establishment of the real-time D-GPS reference stations and tidal observation stations.

Topographic and Bathymetric Profiling

The shoreline profiles shall extend –

- to at least 100 metres landward of the high water line or erosion scarp depending on the Site; and
- to at least 1000 metres seaward of the low water line.

The onshore section of the profile can be surveyed by traditional land survey techniques with spot levels are taken at 10 metres intervals or closer if there is rapid/change in the profile and where features such as bund, road, scarp, drain etc.

The offshore portion of the survey should be surveyed utilising precision echo sounder (single beam single frequency echo sounder) and navigation and positioning of the survey vessel by real-time DPGS. Along the beach and the shallow areas where the use of an echo-sounder will result in an error in excess of ± 0.3m, echo-sounders will not be used and the Survey are continued using total survey stations or theodolite and leveling staves.

These shoreline profiles are obtained by a combination of land-based survey taken during low tide to wading depth and seabed survey taken during high tide, with the aim to always ensure, when ever feasible, sufficient overlap to render the profile continuous.

Soundings are recorded as continuous echo sounding profiles. All echo sounding equipment is calibrated before and after each day sounding operations by means of a 'bar check'. The intervals between survey points along the lines shall not be greater than 10 metres.

A tide pole is normally established within the survey area onto a suitable marine structure. The tide pole are tied to the survey reference stations established to ascertain its relationship to adopted Datum. Tidal observations are carried out at 10 or 15 minutes interval whenever sounding work is being carried out and soundings is reduced to the adopted Datum from observed tides.

Topographic and Planimetric Site Survey

A site survey along the entire coastal strip within the designated coastlines are carried out and all significant planimetric features such as rock dumps, jetties, drains, roads, tracts, culverts, river mouths, or other hydraulic structures, buildings, electric/telephone poles, fencings, big trees (diameter more than 0.3m), rock out-crops, beach scarp, offshore sandbars, etc. are surveyed so that these features can be plotted on the survey plans.

Water Level Measurement

Continuous water level measurement with the water levels recorded at an interval of not more15 minutes for a minimum of 30 continuous days, usually at two suitable locations using a self-recording water level recorder. The water level recorder is to be established with reference to the adopted Vertical. The accuracy required for the water level records are not more than ±25 mm. Water level records are presented in suitable tabular form (in MS-Excel format) in CDROM.

Self-Recording Current Measurement

(a) Measurement Period

Current velocity measurements are carried out within the period of Water Level Observation. The measurements are carried out continuously for 14 days simultaneously, usually at two locations, covering spring and neap tide period.

(b) Instrument Type

The instruments are of self-recording and shall record the speed and directions as functions of time, usually at 30 minutes interval. The instrument records the readings automatically. It is no longer unusual for specifications to require instrument that is

capable of measuring the current throughout the entire water column at predetermined intervals.

Proofs of calibration of the current meters that are to be used in the current measurement are to be submitted. The instruments shall as far as possible, be insensitive to clogging, biofouling, silting, wave induced water particle velocities and normal mechanical shock and assure reliable and accurate reading during the deployment period without the need for servicing and maintenance. The sub-surface float, wire and anchor system are designed to withstand the maximum current velocity. It is recommended that acoustic doppler current profilers be used for measurement of current velocity profiles.

The Surveyor is responsible to provide adequate security to avoid lost of instrument and ensure data delivery. In addition, the Surveyor shall also ensure during deployment that the instrument are sitting vertically by visual inspection where possible.

In-situ Measurements

(a) Currents

Current speed and direction can also be directly observed using a direct reading current meter at the designated locations. Observations are carried out generally at one metre below water surface, at mid-depth and one metre above seabed within the water column. The current speed and direction are observed at half-hourly interval over a-25 hour duration coinciding with a spring and a neap tidal season. Apart from the flow speed and direction, the date and time of measurement are recorded together with the location and depth along the profile. The observed data are processed to produce tabulation of observed current speed and direction and accessible in MS-Excel format.

(b) Temperature and Salinity

Temperature and salinity observations are carried out at the same locations as current observation and along the same points within the water column. The observation is normally made with a temperature and salinity bridge at 4 hours interval over a 25-hour period coinciding with a spring and neap tide. The results are tabulated and accessible in MS-Excel format.

Sampling

(a) Water Sampling

Water sampling for total suspended solids analysis using water pump sampler are normally carried out at the same locations as the current observation, usually at the

same points within the water column. At times, the Design Engineer may just specify that water sampling be carried out at 0.2 and 0.8 depth of the water column at the time of sampling. Sampling are normally carried out at 4 hourly intervals over a 25 hour duration coinciding with a spring and a neap tidal season, generally at the approximately the same time as the in-situ temperature and salinity observation. The water samples collect by using the water pump type water sampler are stored in the approved 500ml HDPE bottles, which will be capped and labelled accordingly. Water samples are sent to laboratory for total suspended solids analysis.

(b) Seabed/Sediment Sampling

Along each of the designated shoreline profiles, up to five (5) sediment samples are collected at sea using van der veen type of grab sampler and on land (using a shovel) at the following positions along each of the profiles –

(i) at the sand dune/along the beach;
(ii) at Mean Sea Level; and
(iii) at three more points in the watered portion of the profile

In situation where the profiles extend across a sand bar, an additional 2 or 3 samples could be collected on the sand bar (top and a few meters deeper on either side) and another 1 or 2 samples in deeper water seaward of the sand bar.

The samples are normally sent to a laboratory for particle size distribution (including hydrometer test where required) in accordance with BS.1377 Part 2: 1990.

PLANS AND RECORDS TO BE SUBMITTED

(a) Records

During the progress of the Survey, the Surveyor shall keep continuous and accurate records of the Survey and of any other data (including the variation in water levels). The Surveyor is to make available the above records for examination and recording when requested. The records can include the following:

(i) Dates started and completed.
(ii) Make, model number, and type of equipments used.
(iii) Benchmark used for establishing elevation including description of its location and datum.
(iv) Location, ground elevation and identification number of the base stations.
(v) Shoreline Profiling records
(vi) Daily “bar check” records
(vii) Daily tidal records

(b) Preparation of Survey Plans

All results of the Survey are fair drawn using AutoCAD. The plans are prepared on standard A1 size format plan form. The title block of the drawings will normally conform to the standard format used by the Client Agency.

The plans prepared and submitted generally comprise of at least the following:

(i) General Layout Plan

The General Layout Plan contains at least the following details:

- All boundary marks and lot numbers of the land fronting the entire length of shoreline compiled from the cadastral maps for the coastline;
- The base line, traverse lines, and positions of temporary benchmarks, if any, and all survey reference stations;
- The position of tidal and current measurement stations;
- Position of latitude and longitude within 20 second grid spacing;
- A key plan of the survey locality (scale l: 50,000) to be indicated at the top right-hand corner.

(ii) Topographic and Bathymetric Survey Plans

Plans showing all spot levels and sounding depths along the surveyed profiles are plotted at an appropriate horizontal scale, usually 1: 1000. All existing significant planimetric features such as existing structures, rock revetment, seawalls, gabion, roads, drains, offshore bar, beach scarp etc, are indicated in the profiles.

(iii) Shoreline Profiles

Plans showing the profiles of the survey lines are plotted at appropriate horizontal scale, usually 1: 1000 and vertical scale of l: 100. All existing significant planimetric features traversed by the profiles such as existing buildings, roads, drains, rock revetment, seawalls, gabion, beach scarp etc, are indicated in the profiles.

(c) Submission of Records, Plans and Report

Upon completion of the Survey, the surveyor shall submit the following records, plans and reports to the Client Agency and the Design Engineer –

(ii) Original copies of all relevant survey records (data, field books, calculation sheets, tide/water level records etc.) duly certified by the Surveyor.

(iii) Required (complete) sets of prints of the survey drawings which have been duly certified by the Surveyor;

(iv) One complete set of CD's containing, on each CD, the plotted survey drawings (in AutoCAD format), water level records and current measurement records respectively;

(v) One CD containing the digital topographic and bathymetry survey data in ASCII Format; and

(vi) Required copies of neatly-bound survey report, incorporating description of work, personnel and equipment employed, method of survey and tabulation of results of all survey controls, water level observations, current measurements and in-situ observations, temperature and salinity in-situ observations, sampling locations and records and results of laboratory analysis.

FREQUENCY OF SURVEY

The frequency of the survey is usually of the following -

a) Initial or baseline survey before the commencement of the coastal engineering works and in many instances, this survey is also utilized for detail design;

b) At three or four-monthly interval during the duration of the construction works; and

c) At half-yearly interval for an additional period of two to three years after the completion of construction works.

Typically, for a coastal engineering works of this nature where shoreline-monitoring programme is mandated, the role of the surveyor begins during the project inception stage and continues for up to three years after the completion of the construction works on site. The involvement of surveyors in such projects could span, depending on the size of the project, four to seven years. Though the surveyor is almost normally amongst the first to work on-site, with shoreline monitoring programme, the surveyor is also just about the last the leave the site.

CONCLUSION

Shoreline monitoring allows Surveyors to play its role and contribute towards an effective assessment by the Client Agency on the success and sustainability of coastal development works. Such assessment is welcomed as project normally cost millions of dollars to implement and brings into play a continuing learning regime within the Client Agency, the engineering and surveying fraternity on the effectiveness and sustainability of the costal engineering measures designed and implemented in an otherwise dynamic environment.

It brings to the fore the role and essentiality of spatial dataset. A surveyor's involvement begins at the study, assessment and design stage but do not need to end there, as it was in previous occasions. The surveyor's involvement and contribution continues for a few more years after the end of the construction works, after all the construction plants and machineries have long being demobilized from site.

In addition, the surveyor is called upon to review the results of its survey, to compute quantities and volumes and to provide hard facts of the physical situation at site. This allows planners, engineers and decision makers' data to access the coastal works in an objective

manner, to ascertain whether project objectives and intent has been met and whether the project provides the necessary returns.
The surveyor has a role albeit an important one, as the surveyor is called upon to be an independent consultant, working with the project implementation agency, design engineers, turnkey contractors.

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