SURVEYING FOR PORT FACILITIES AND MARINE STRUCTURES

Hong Kong Harbour

The products produced by advanced multi-beam bathymetry, Universal Reference Station DGPS Correction Technology, digital photogrammetry, 3D visualisation and fly-through videotography are definitely not just pretty pictures or animations but extremely useful for end-users: the designer, engineer, planner and port administrator.

Hong Kong (HK) was founded as a port for China some 160 years ago and has flourished as an â€˜entreportâ€™ since then. Substantial development of HK Harbour is one indispensable milestone in maintaining the position of HK as the main gateway to China and premier business areas of Asia.
Development and reclamation works for HK Harbour can be traced back to 1887. Coping with rising growth in the economy, construction works for marine structures have never stopped. The requisites necessary for being one of the busiest international ports are thus constantly ensured.
We consider that survey activities play an important role in the reclamation and construction of port facilities and marine structures. The results of such surveys always provide the crucial basis for spatial, hydrological, geological, geophysical, port operational and hydrographical analysis in coastal engineering works. Moreover, port administrators can even make use of such valuable data as background information for design, construction and maintenance purposes.
This article will focus on some survey activities for port facilities and marine structures in the HK harbour area.

Port Facilities and Marine Structures

One of the principal functions of the HK port administrator, in common with most ports world-wide, is to ensure the safe operation of the port and all its waters and to promote excellence in marine services. The Civil Engineering Department (CED) of the Government of the Hong Kong Special Administrative Region has played a key role in the upkeep of the port of HK. It not only serves as the Authority for civil engineering marine works, such as reclamation and seawall construction, but also provides regular maintenance services for public and government marine facilities. These include typhoon shelters, cargo working areas, breakwaters, seawalls, landing steps, piers, dolphins, fairways and approaches to berths, anchorage areas, navigation aids and some major river channels.

Technology and Equipment

To align with engineering work requirements, the Survey Division of CED is actively engaged in collecting and presenting spatial, hydrological and geophysical information for preliminary study, recording, measurement and maintenance purposes. The efficiency and effectiveness with which the above are fulfilled rely not only on the manpower and talent in survey operations but also the competence of survey equipment.
Beyond traditional tools like wire, sextant, chain, polar-fix, mini-ranger, Total Station and single beam echosounder, surveyors in HK have been adapting to the IT (Information Technology) age and use the modern devices available to the survey profession today. Advanced multibeam bathymetry, Universal Reference Station DGPS Correction technology, digital photogrammetry, 3D visualisation and fly-through videotography are all being implemented. These products are definitely not just pretty pictures or animations but extremely useful for end-users: the designer, engineer, planner and port administrator whose tasks are to convey project aims, ensure specified requirements and workmanship tolerances, define the milestones and maintain progress.
Two surveying tasks are specially selected in the following sections to illustrate the way that the advanced surveying technology is being applied.

Monitoring Marine Rubble Structures

To ensure rubble breakwaters, seawalls and river-walls remain in a sound condition to protect the harbour, and typhoon shelters and coastal infrastructures remain intact, regular inspection and maintenance of these structures are necessary. Conventionally, visual inspection and ground survey are the common methods used here. Visual inspection involves walking or making observations from a vessel, taking notes of observed defects and their severity. The results are to a certain extent subjective and dependent on the skills of the inspector and his previous knowledge of the site. It is almost impossible for inspectors to identify underwater structure movements or uniform deformation in rubble structures simply from visual inspection. The advantage of a ground survey is that it is systematic and scientific and does not depend on the skill of individual inspectors, as does visual inspection. Results are in general accurate to the centimetre and quantitative comparison with last survey results is straightforward.
However, a ground survey is labour intensive. It takes a long time and significant resources if a long length of rubble structure is to be covered in detail. Apart from being labour and resources intensive, there are other areas of deficiency in ground survey. Access to tidal areas is difficult and hazardous because of waves and slippery surfaces. Large armour rock or concrete units are difficult to survey because of their irregular shape.
Recently, the CED has applied a new monitoring method combining low altitude photogrammetry and multi-beam bathymetry in the surveying of marine structure deformation monitoring. The structural health of some of the breakwaters in HK is regularly monitored at half-yearly intervals by integrating low altitude photogrammetry data with hydrographic data. Low altitude photos offer a very valuable source of

quantitative information at high resolution and accuracy. They provide full and detailed coverage of the rubble structures. Small armour movements, settlements and changes in the slope profile can be readily detected using various photogrammetric techniques and procedures. The planimetric and vertical accuracy are about Â±0.2m at 90 per cent confidence level, which satisfies the engineering requirement of Â±0.3m in the monitoring of rubble structures. However, some factors such as flying height, flying speed, time of taking photos and location of photo control points should be carefully considered to achieve the highest possible quality of aerial photography. While the aerial photos provide comprehensive coverage of the above-water portion of rubble structure, a high-resolution multi-beam bathymetric system is being used for the underwater portion of the survey. Coupled with the high accuracy of local DGPS correction technology, the method provides essentially 100 per cent accurate coverage of the seabed in a width two to seven times the water depth in one swath. The survey data can be readily processed to give a digital representation of the seabed. Planimetric and sounding accuracy are estimated to be 0.21m and 0.25m respectively, which are of the same order as for photogrammetric measurements.
Integrating photogrammetric data and hydrographic data provides a complete picture of the rubble structure. It permits a thorough evaluation of the condition of the structure on both the above water and underwater portions. Scouring at the foundation or the toe of structures, which may lead to rapid disintegration of the armour layer, can be identified at an early stage.

Hydrographic Survey of Artificial Reefs

Artificial reefs are very effective devices for attracting and supporting large populations of fish. They can provide complex, hard surface habitats in areas where only soft bottoms occur, which includes much of HK waters. Large artificial reef structures also provide improved feeding opportunities for many fish by changing water flow patterns. Localised areas of high flow are created as moving water passes over and around large artificial reef structures and low flows are established in sheltered areas inside the structure and at the downstream side. A combination of multi-beam bathymetry, 3D visualisation and fly-through videotography can provide ecologists with the full picture and information regarding the working mechanism within the artificial reefs. Artificial reefs mainly consist of submersed steel, vessels or old tyres set in a particular form. 3D visualisation models, and even fly-through video, can help to form a picture of the artificial reefs as situated on the seabed and thus invisible to humans on land.

Conclusions

The externally oriented economy of Hong Kong depends greatly on efficient communications, including marine transport. There are ever-increasing demands and public concern over port and marine facilities. The demand for survey activities for construction, monitoring and analysis of data is tremendous. Such survey activities include collection and presentation of spatial, geophysical and geological information, determination of sub-aqueous filling and dredging quantities and monitoring marine structures. The resultant survey records also provide valuable information for end-users in carrying out their relevant studies. Amid all these on-going activities in CED, there is a need for the Survey Division to continually explore different survey techniques and expand the scope of services to serve the community in port development and administration.