# Reference Notes on Land Surveying — Control & Mapping

**Second Edition 1994**


## Acknowledgement

Special thanks are due to the Survey and Mapping Office, Lands Department of Hong Kong Government for their supply of figures and helpful hints in the compilation of this booklet.

# 1. INTRODUCTION

This reference guide has been prepared to provide information covering some of the more important aspects of geodetic control and mapping in Hong Kong. It will serve as an everyday source of reference not only for Land Surveyors, Land Survey technicians and trainees, but also for those concerned with construction industry who will need to have an understanding of the processes involved, even when these are undertaken by specialists.

# 2. DATUM, ORIGIN AND PROJECTION

## 2.1 Geodetic Datum

There are two geodetic datum currently in use for horizontal control in Hong Kong. They are the local datum – Hong Kong 1980 Geodetic Datum (HK80), and the global datum – the World Geodetic System (WGS84).

HK80, the most commonly used, is based on the Gauss Conformal (Traverse Mercator) Projection to determine the territorial grid in Hong Kong.

WGS84 provides better locational reference in terms of absolute position on earth. It can be transformed to the Gauss Conformal Projection by a four-parameter similarity transformation.

The Datum Parameters are as follows:

| | Hong Kong 1980 Geodetic Datum (HK80) |
|---|---|
| Origin Point: | Old Trig "Zero" at Royal Observatory, Kowloon with the following astronomic latitude and longitude.<br>Latitude 22°18'12.82" N<br>Longitude 114°10'18.75" E |
| Azimuth: | Trig. 67.2 to Trig 94 (292°59'46.5") |
| Ellipsoid:<br>Semi-major axis<br>Flattening | International (Hayford)<br>a = 6378388 meters<br>f = 1/297.0 |

| | World Geodetic System (WGS84) |
|---|---|
| Origin Point: | Centre of mass of Earth |
| Azimuth: | — |
| Ellipsoid:<br>Semi-major axis<br>Flattening | WGS84<br>a = 6378137 meters<br>f ≡ 1/298.2572235634 |



## 2.2 Projection (Grid) Systems

There are two projection (grid) systems being used in Hong Kong They are the HK80 Grid and UTM Grid Systems. The HK80 Grid is a local grid system for surveying and large scale mapping in Hong Kong. UTM Grid is an universal referencing system and is used as locational referenc for the 1:20000 map series and other mapping products at a smalle scale in Hong Kong.

The Projection Parameters are as follows:

| | Hong Kong 1980 Grid System (HK80 Grid) |
|---|---|
| Projection | Transverse Mercator |
| Reference Ellipsoid: | International (Hayford) |
| Origin of Projection: | Central Meridian of the projection passing through the old Trig 2 "Patridge Hill" with the following geodetic coordinates<br>Latitude 22°18'43.68" N<br>Longitude 114°10'42.80" E |
| Grid Coord. of Origin: | 819069.80 mN<br>836694.05 mE |
| Scale Factor: | Unity (1.0) along the central meridian |

| | Universal Transverse Mercator Grid (UTM Grid) | |
|---|---|---|
| Projection: | Transverse Mercator | |
| Reference Ellipsoid: | International (Hayford) – for HK80<br>WGS84 Ellipsoid – for WGS84 | |
| Origin of Projection: | Zone 49<br>Latitude Equator<br>Longitude 111° E | Zone 50<br>Equator<br>117° E |
| Grid Coord. of Origin: | 0 mN<br>500000 mE | 0 mN<br>500000 mE |
| Scale Factor: | 0.9996 at the central meridian | |

## 2.3 Vertical Datum

All elevations are related to a reference plane as the level datum. Figure 1 is a diagram showing the relationship between the various datums used in Hong Kong. A brief description of the level datums are given as follows:-

### 2.3.1 New Rifleman's Bolt

The original levelling monument was a copper bolt fixed in the Hong Kong Naval Dockyard by H.M. Surveying Vessel "Rifleman" in 1866 for the soundings of the foreshore of Victoria Harbour. Later it was relocated and re-fixed on the eastern wall of Blake Block in H.M.S. TAMAR. The level of the monument was found in May 1984 to be 5.420 metre above Principal Datum. The monument is not now used as a bench mark and is being preserved for its historical value only.

### 2.3.2 Mean Sea Level

The Mean Sea Level is 1.38m above Chart Datum or 1.23m above Principal Datum. It was determined by the Royal Observatory and derived using 19 years of observation records from the Automatic Tide Gauge at Quarry Bay.

### 2.3.3 Principal Datum

Principal Datum, formerly known as Ordnance Datum, is used as the reference datum for all heights and levels on land. It is 0.146m above Chart Datum or 1.23m below Mean Sea Level.

### 2.3.4 Chart Datum

Chart Datum, formerly known as Admiralty Datum, has been adopted as zero point for Tide Tables since 1917. It is used as the reference datum for all soundings and submarine contours.

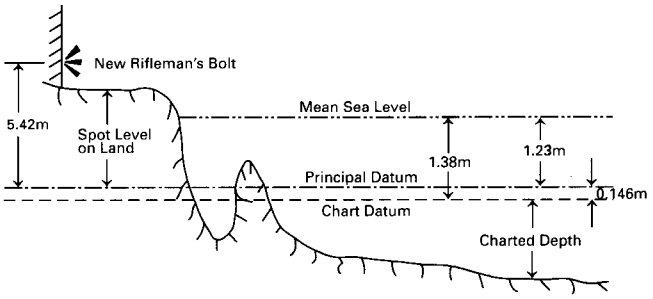


FIGURE 1. DIAGRAM SHOWING THE RELATIONSHIP BETWEEN VARIOUS VERTICAL DATUMS.



# 3. GEODETIC SURVEY

## 3.1 Horizontal Control

Table 1 shows the general guidelines for standards of horizont control surveys which include main and minor triangulation and variou types of traverses.

| | Main Triangulation | Minor Triangulation |
|---|---|---|
| Accuracy | 1:120 000 | 1:60 000 |
| Average side length | Over 6 km | 3 – 6 km |
| Triangle closure | 3.5" | 6" |

| | Main Traverse | Minor Traverse | Title Traverse |
|---|---|---|---|
| Accuracy | 1:30 000 | 1:15 000 | 1:7 500 |
| Maximum angular misclosure (second) | $5\sqrt{n}$ | $10\sqrt{n}$ | $30\sqrt{n}$ |
| Linear misclosure (mm) | 20 + s/30 | 10 + s/12 | 10 + 2s/15 |
| Maximum length | 5 km | 2 km | 1 km |

where "n" is the total number of traverse stations
"s" is the traverse length in metre

TABLE 1. GENERAL STANDARD OF HORIZONTAL CONTROL SURVE

## 3.2 Beacons or Survey Marks

Geodetic Survey Marks are specially designed monuments t accurately and prominently identify the physical position of a contr point on the ground. They vary from stainless steel discs to concre pillars on concrete platforms for horizontal control, and to round heade stainless steel rods embedded in walls or bedrocks for vertical contr

## 3.3 Baselines

A Baseline is a standard base for the calibration of a distan measuring instrument such as steel tape or an Electromagnetic Distan Measurer (E.D.M.)

### 3.3.1 Steel Tape Standard Base

The minimum length of a standard steel tape base is 10m. The base length is measured with invar tape and determined to an accuracy of ±0.2mm. There are three standard bases established at various locations in the territory. They are calibrated annually by the Survey and Mapping Office, Lands Department of Hong Kong Government. Table 2 is a summary of the most up-to-date steel tape base calibration records.

| Locality | Marks | Base Length (m) (to the nearest 0.5 mm) | |
|---|---|---|---|
| | | A – B | A – C |
| Legislative Council Building, H.K. | Square brass plate with cross scribed on each | 9.9995 | 29.9980 |
| Fanling Swimming Pool, N.T. | Cross mark engraved on a square brass plate | 9.9990 | 29.9990 |
| San Po Kong Magistracy Building Porch, Kowloon | Cross mark engraved on a circular brass plate | 10.0015 | 30.0015 |

TABLE 2. STEEL TAPE BASE CALIBRATION RECORDS

### 3.3.2 Plover Cove Baseline

This Baseline is used for the checking of E.D.M. equipment. The location of the baseline is on the main dam of the Plover Cove Reservoir. The accuracy of an individual section is ±1mm. It is calibrated annually by the Survey and Mapping Office, Lands Department of Hong Kong Government. The most up-to-date record of the baseline is shown in Table 3.

| Section | length (m) |
|---|---|
| 0 - 1 | 29.991 |
| 0 - 2 | 99.979 |
| 0 - 3 | 179.980 |
| 0 - 4 | 300.003 |
| 0 - 5 | 470.022 |
| 0 - 6 | 520.018 |
| 0 - 7 | 1000.069 |

TABLE 3. PLOVER COVE BASELINE RECORD



## 3.4 Vertical Control

Table 4 gives general guidelines for the standard required for precis and ordinary levelling.

| | Precise Levelling | | Ordinary Levelling |
|---|---|---|---|
| | 1st Order | 2nd Order | |
| Closure between forward and backward run | 4 $\sqrt{k}$ mm | 8 $\sqrt{k}$ mm | 12 $\sqrt{k}$ mm |
| Density of Bench Marks along the route | 500 m | 500 m | 500 m |

where "k" is the total distance run in km

TABLE 4. GENERAL STANDARD OF PRECISE AND ORDINARY LEVELLIN

# 4. AERIAL SURVEY & PHOTOGRAMMETRY

Photogrammetric survey includes three distinct stages namel photography or data acquisition, measurement, and data reduction.

In the first stage, consideration is given to the required accuracy the final product, the type of photography to be taken, (i.e. vertic photograph, low oblique, high oblique) and the scale of the photograp which is a function of the flying height, the camera focal length and th elevation of the ground. When an aerial photograph is used for mappin flight lines are laid out on a flight map such that photographs on fligl strips will normally have a 25% side overlap and each photograph in th line of flight will normally have 60% overlap.

In the second stage, the measurements are made with an instrume selected to give the desired accuracy in the most economical manne Such instruments may include linear comparators, x-y comparator stereo-comparators, parallax bars, and stereoscopic plotting instrument

In the third stage, the measured data is reduced to the desired fin form such as a machine plot, digital terrain data for earthworks or ro excavation quantities or a series of profiles.

Aerial photographs at various altitude, covering the whole territor are available from the Survey & Mapping Office, Lands Department Hong Kong Government.