# Chart Datum Establishment for Mandaitivu Island

***Abstract***— *Mandaitivu is an island situated near Jaffna which has only the land surveying datum. The purpose of this study was to establish an accurate tidal datum for Mandaitivu Island to be used for hydrographic surveying. This research evaluated three methods of establishing tidal datum. First method was transferring datum by running a level line from a known station. As the second method, the datum was established by considering the tidal pattern in Mandaitivu Island against the nearby standard port at Kankesanturai harbour. The third method was by analysing long term observed tide data at the island itself. Mean Sea Level (MSL), Indian Spring Low Water (ISLW) and Lowest Astronomical Tide (LAT) datums were derived at the new tidal station at Mandaitivu. The MSL was used as the common datum for all three methods. Here, the levelling transfer method is only valid as there was no difference in tidal pattern between the two stations. However in the real world, the tidal pattern differs due to local characteristics. Therefore the results from the simultaneous tidal observation method and tidal analysis method were more appropriate. The differences between the computed datums were around +/- 5 cm for all the methods and are within the International Hydrographic Organization (IHO) standards. Finally, the LAT was established as the chart datum for Mandaitivu with the analysis results of 10 months tidal data and it is 0.47m bellow the MSL.*

***Keywords***- **Chart Datum, Tide, Hydrography, Datum Transfer**

## I. INTRODUCTION

Tides are the periodic rise and fall of sea level responded by the combined effects of the gravitational forces generated by the Moon and the Sun, and the rotation of the Earth. Tides are so reliable because their movements are based on the positioning of the moon and sun in relation to the earth. Tides are observed from tide gauge of tidal station. A tide gauge is a device for measuring the change in sea level relative to a vertical datum (tidal datum) establishing correct tidal datum for a tide gauge is very important because all the tide observation and prediction also related to tidal datum. A tidal datum is a standard elevation defined by a certain phase of the tide. There are several tidal datums which are commonly used for tidal observation and used as vertical datums in various applications. Tidal datums are various water level datum obtained by long term observations at various tide gauge stations. There are several tidal datum such as Mean Sea Level (MSL), Lowest Astronomical Tide (LAT), Indian Spring Low Water (ISLW), HAT (Highest Astronomical Tide) Mean Low Low Water (MLLW) , etc. Different countries use different tidal datum depend on their purpose of application. There are several methods that can be used in establishing tidal datum for a new tide gauge.

Tidal datum transfer using levelling methods is adopted where a close by tide gauge benchmark (TGBM) is available in the vicinity. This must be established from a previously known tidal station. Here, the accuracy depends on the distance between the new station and the existing TGBM. Here, the local effects cannot be estimated. However, in the datum establishment by adopting a secondary port and the tidal analysis method, the local effects can be estimated. Secondary port means it has the complete tidal information including the datum information. Here, simultaneous tidal observations were considered in computing the datum at the unknown location. Respective high and low water levels were compared and datum levels can be calculated with respect to whatever datum considering at the secondary port. Though, this is a quick method. In the tidal analysis process, the datums can be accurately computed based on the derived MSL and the tidal constituents. However, a continuous data should be available for a considerable period for better accuracy. The length of the tidal data observation depending on the accuracy requirements e.g. one to three months of data for engineering projects and 19 years of long-term observations for the establishment of a stable national vertical reference.

Mandaitivu is an island which located close to Jaffna peninsula in Sri Lanka (Figure1). A proper tidal datum has not been established for this island. Recently, a requirement came from the industry to firmly establish the chart datum for national charting program. The main datums required were MSL and LAT.

## II. METHODOLOGY

All the three methods were used to compute the tidal datum for Mandaitivu. Here, a new tide gauge was established to be used in the second and third methods.

MSL was transferred to the new station by levelling using the survey department bench marks (MB) located within the island.

Simultaneous high and low waters were obtained from the Kankesenturai harbour tidal station and the MSL and chart datum (LAT) were computed. Then, tidal data were collected at the Mandaitivu island for 10 months and they were analysed using the TOTIS tidal analysing software. From this, the actual MSL and the chart datum (LAT) levels were computed for the site.


Figure 1. Mandaitivu and Kankesanturai

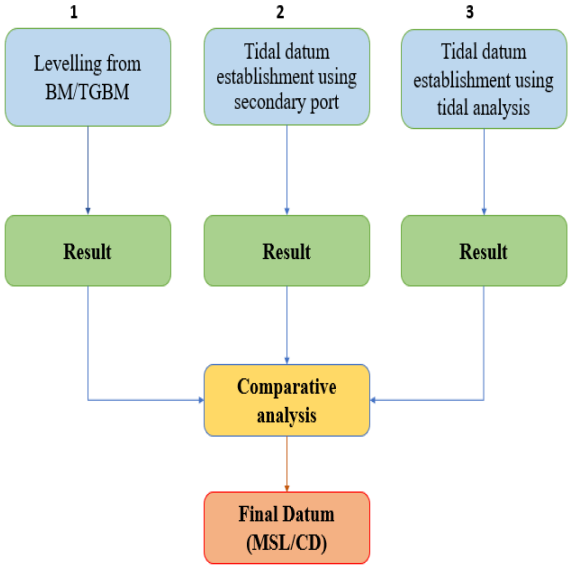


Figure 2. Conceptual methodology

## III. Results

The obtained value for the MSL from levelling at the station was 0.637m above the zero tide gauge (Figure 3). Since, no other datum information was not available for the island, this was the only datum to be computed using the levelling method. However, this is not the observed site MSL of the island; instead it is from the land surveying levelling datum.

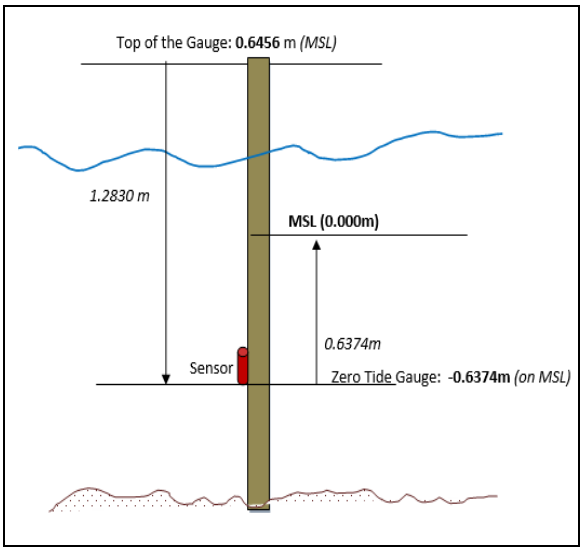


Figure 3. Mandaitivu MSL value at the station after levelling transfer.

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Two days simultaneous tidal data were collected during the spring period at Kankesenturai and Mandaitivu tidal stations. The following datums (Figure 4) were successfully derived from this method. LAT and ISLW datums were established in addition to the MSL. Here, the MSL is 0.690m above the zero tide gauge.

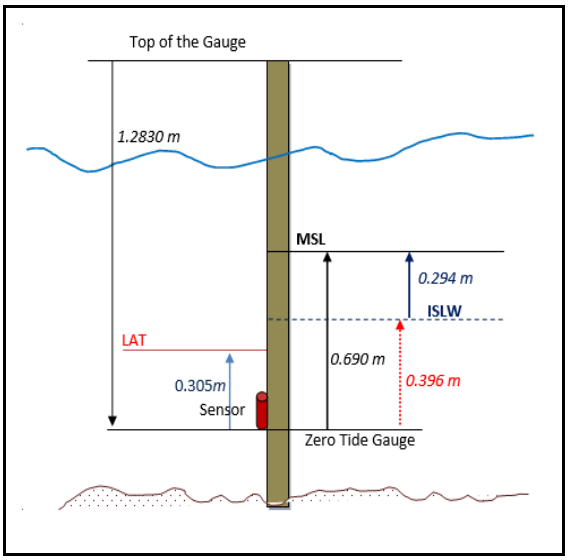


Figure 4. Mandaitivu tidal datums by considering secondary port at Kankesenturai harbour.

Continuous tidal data at 15 minute interval from April 2018 to January 2019 were collected and analysed using TOTIS software. Here, 54 major tidal constituents were

successfully resolved using harmonic analysis method. The obtained datums are shown in Figure 5. Here, the MSL is 0.731m above the zero level of the gauge. The standard deviation of the result was 0.06m.

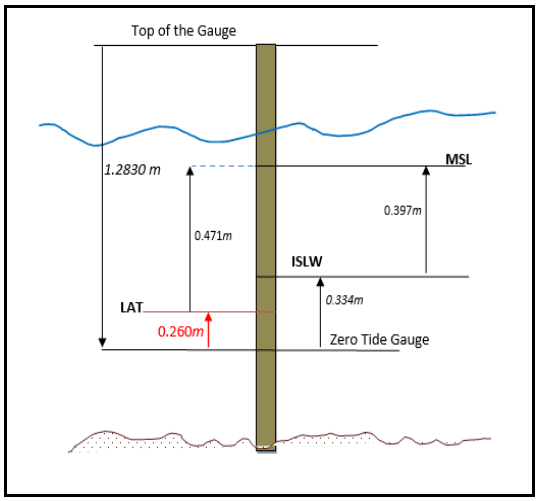


Figure 5. Mandaitivu tidal datums by tidal analysis.

Finally, comparisons of the datum levels were shown in the Table 1. Here, the comparison was only made between the second and the third methods as in the levelling method could only transfer land survey MSL. The MSL difference was about 0.04m and ISLW difference was 0.06m, while LAT has given 0.04m difference.

Table 1. Datum comparison (from zero gauge)

| **Datum** | **Secondary Port Method** | **Tidal Analysis Method** | **Difference** |
|---|---|---|---|
| MSL | 0.69 m | 0.73 m | 0.04 m |
| ISLW | 0.39 m | 0.33 m | 0.06 m |
| LAT | 0.31 m | 0.26 m | 0.04 m |

## IV. CONCLUSION

It is obvious that the differences were less than 0.1m and all the results can be accepted within the IHO orders. However, the tidal analysis method was more scientific and based on long term observed data. Therefore, the tidal analysis method is the most accepted method among the professional community in establishing tidal datums. However, when the datum information is urgent and need to be established immediately, then the levelling and secondary port methods is more suitable. However, there could be some doubts in the levelling method as it does not consider the local tidal dynamics. Finally, the datum transferring from secondary port and tidal analysis is more suitable for isolated islands as no previous datum information is not available.

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