

TIDES AND TIDAL HARMONICS AT UMBHARAT, GUJARAT

A. SURYANARAYANA AND G. NARAYANA SWAMY
National Institute of Oceanography, Dona Paula, Goa 403 004.

ABSTRACT

A part of the data on tides recorded at Machiwada near Umbharat, Gulf of Cambay during April 1978 was subjected to harmonic analysis following the Admiralty procedure. The general tidal characteristics and the value of four major harmonic constituents are reported.

Key-words : Tides, Tidal Harmonics, Umbharat, Gulf of Cambay.

At the instance of the Oil and Natural Gas Commission (ONGC), a comprehensive study of the nearshore waters at various land approaches of the proposed submarine pipeline between Tarapur and Hajira was conducted for over a year from January, 1978 (Anon. 1979). Tide was one of the parameters studied in detail and the present paper deals with the description of the tides and their harmonics at Umbharat (Gujarat) during this period.

Umbharat is situated close to the river Purna (Fig. 1). Some physical characteristics of the coastal waters of this region have been described earlier (Swamy, Sarma & Suryanarayana, 1982). The study area is under the influence of semi-diurnal tides with significant diurnal inequality. The range of the tides is large and particularly so in the northern parts of the coastline. The tidal streams generally set northward during the flood, and southward during the ebb of the tidal cycle.

The water level variations were obtained by visual observations using graduated poles erected across the beach within the intertidal zone at Machiwada (Umbharat) (Fig. 1). The intertidal area was extensively muddy and had a width of about 0.5 km at this station. This caused many operational problems. The zeros of the poles were inter-related and were again related to the bench mark nearby, by levelling and theodolite surveying. Ultimately the observed water levels were reduced to the Chart Datum. The observed tide data were plotted (Fig. 2) along with the predicted tides (only high and low) at Vansi Borsi (near Umbharat) (ONGC, personal communication) and at Bhavnagar (nearest standard tidal station) (Anon. 1977). The general characteristics of tides in this area were thus obtained (Table I).

The tides at Machiwada lead over the tides at Bhavnagar by nearly 2 hr. 30 min. However it may be noted that at Vansi Borsi, which is situated at the mouth of Purna river, the tides lag behind the Machiwada tides, particularly the low tide (Table I). With reference to the tides at Bhavnagar, the tidal range at Machiwada was smaller by a factor of 0.63 as observed.

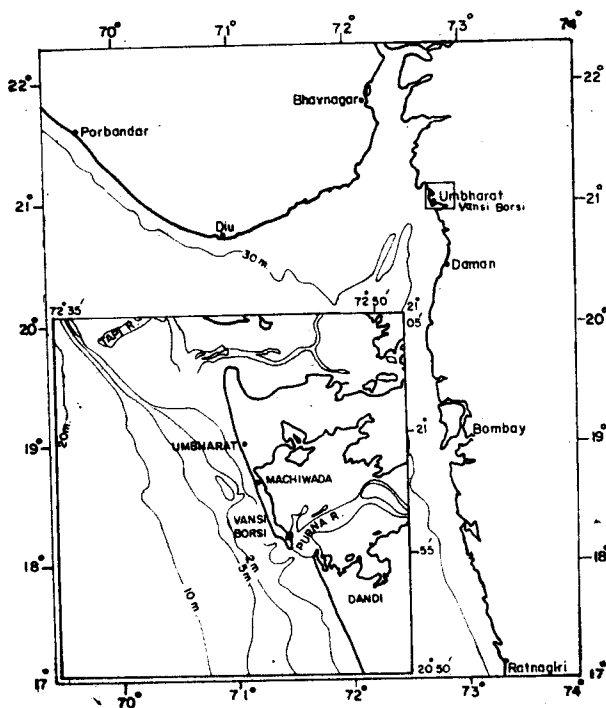


Fig. 1. Location Map.

A part of the observed tidal data viz., the data on water level variations for the period 1-16 April, 1978 was subjected to harmonic analysis following the Admiralty method (Anon. 1964). This method has found wide application and it was chosen here owing mainly to its simplicity and immediate applicability. The theory of the semi-graphic method of tidal analysis has been detailed in Admiralty Handbook (Anon. 1959) and by Dronkers (1964).

The most important constituents analysed for, were M_2 , S_2 , K_1 and O_1 , where M_2 and S_2 are in the semi-diurnal species and K_1 and O_1 are in the diurnal species, as per the conventional notations (Anon. 1959).

Table I. Characteristics of tides at Machiwada, Umbarhat.

Time difference(*) (min)		Observed tidal range (m)		Average ratio of tidal range(*)			
High tide	Low tide	Spring Neap		O	P		
O	P	O	P				
-145	-111	-147	-63	6.7	2.5	0.63	0.57

* W.r.t. Bhavnagar; O Observed (Machiwada); P Predicted (Vansi Borsi)

Any particular constituent of the actual tide as produced in the ocean usually lags behind the constituent of the corresponding tide-raising force. A further lag is introduced in the response of the water at a particular place, to the tide-raising force constituent which produces it. The lag of the tidal constituent at a given place, behind the corresponding tide-raising force constituent at Greenwich is a constant for the place and constituent and is denoted by g , measured in degrees. Hence, the phase of a tidal constituent at a particular place is the phase of the corresponding tide-raising force constituent at Greenwich, minus g . The lag g is a constant angle for a given place and constituent. The amplitude of a particular tidal constituent on a

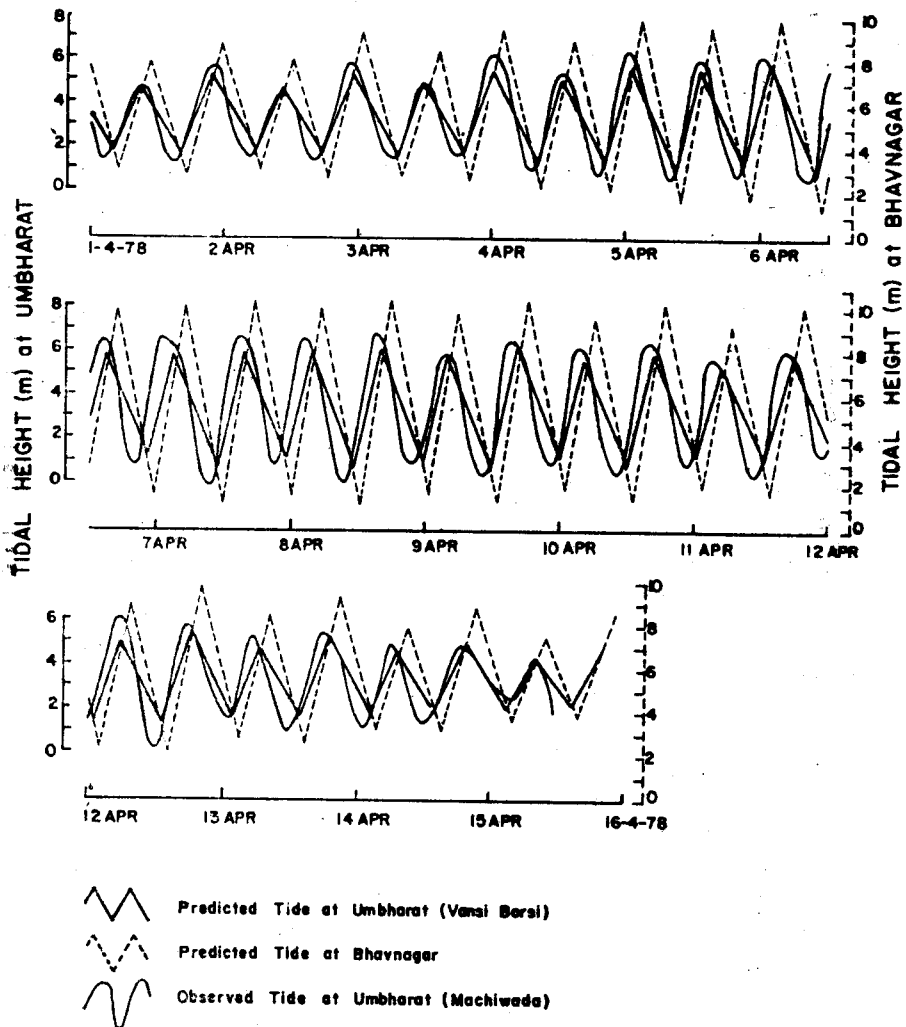


Fig. 2. Tides at Umbharat.

date when its nodal correction factor (f) (Anon. 1959) is unity is a constant for the constituent at that place. It is denoted by H . The amplitude of the same constituent on any other date at the same place will be fH .

These two quantities H and g for every constituent collectively form the harmonic tidal constants for the place. The height of tide at the place can be found as the sum of the values of $fH \cos(E + u - g)$ of each constituent. Here E is the phase of a constituent of the tide-raising force at Greenwich in combination with u which is the phase correction (Anon. 1959). The variations of f and $(E + u)$ are precisely known (Anon. 1978).

The harmonic constants of the four major constituents of the tide at Machiwada (Umbharat) determined for each day are given in Table II. For the calculation of the harmonic constants, the angles and factors of the tides for each day were taken from Admiralty (Anon. 1978). The nearest standard port considered was Bhavnagar for the purpose of the calculation.

Table II. Harmonic constants of tides at Umbharat.

Date	M_2		S_2		K_1		O_1	
	g°	H(m)	g°	H(m)	g°	H(m)	g°	H(m)
Apr. 1978								
4	075	2.2	122	0.67	078	1.05	061	0.50
6	062	2.5	109	0.80	132	0.91	115	0.41
8	179	2.2	226	0.67	088	0.53	071	0.24
10	238	2.1	285	0.63	145	0.67	128	0.30
12	223	2.2	270	0.67	080	0.78	063	0.35
14	180	3.4	227	1.06	142	0.80	125	0.36
Mean	160	2.4	207	0.75	111	0.79	094	0.36

With the determination of these main constituents, approximate tidal predictions can be made for many practical purposes in this area.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Dr. S.Z. Qasim, former Director and Dr. V.V.R. Varadachari, Director, National Institute of Oceanography, for their interest in these studies. The guidance rendered by Dr. B. N. Desai, Deputy Director, NIO is gratefully acknowledged. Thanks are due to Sri L.V. Gangadhara Rao for going through the manuscript critically, and to the Oil and Natural Gas Commission (Bombay Offshore Project) for financial support.

REFERENCES

- Anonymous, 1959, *The Admiralty Semi-graphic Method of Harmonic Tidal Analysis over a Period of One Month, Admiralty Tidal Handbook No. 1*, Hydrographic Department, London, p 2-14.

- Anonymous, 1964, *Harmonic Tidal Analysis for Short Period Observations*, Admiralty Tidal Handbook No. 3, Hydrographic Department, London, p. 14-20.
- Anonymous, 1977, *The Indian Tide Tables for the year 1978*, Survey of India, Dehra Dun.
- Anonymous, 1978, *Admiralty Tide Tables, Vol. 2, Atlantic and Indian Oceans*, Hydrographer of the Navy, Hydrographic Department, London.
- Anonymous, 1979, *Report on the Proposed Submarine Pipeline Route from Bombay High/Bassein to Tarapur/Hajira: Physical, Chemical and Biological Characteristics of the Waters*, National Institute of Oceanography, Goa.
- Dronkers J.J., 1964, *Tidal Computations in Rivers & Coastal Waters*, North-Holland Pub., Amsterdam, 518 pp.
- Swamy, G.N., R.V. Sarma and A. Suryanarayana, 1982, *Physical Characteristics of the Coastal Waters between Navapur and Umbharat, West Coast of India. Part I: Current Pattern*. Mahasagar—Bulletin of the National Institute of Oceanography, **15**: 67-83.