Sedimentation Rate in Waters around Iran

Hamid Reza Boveiri[1] and Seyyed Majid Musaddad[2]
[1]Corresponding Author: Faculty member, Sama Technical and Vocational Training College, Islamic Azad University, Shoushtar Branch, Shoushtar, Iran.
E-mail:boveiri@shoushtar-samacollege.ir, Phone: +989163073004, Fax: +986126238811
[2]Faculty member, Islamic Azad University, Shoushtar Branch, Shoushtar, Iran

Abstract
Sediment transport in the surf zone has two components, long shore and cross shore. Usually long shore dominates cross shore sediment transport. Since waves reach the beach from different quadrants, transport may be interpreted to the right hand Q_{lR} or to the left hand Q_{lL}. Net annual transport is defined as $Q_{lNET} = Q_{lR}+Q_{lL}$ and utilizes to predict the deposition and erosion rates of beaches on opposite sides of jetties or breakwaters. One of the most common prediction methods is the energy flux method that is used in this paper. Calculating long shore sediment transport rate utilizing energy flux method in southern Caspian Sea manifests that transport rate in warm and cold seasons are different. Transport rate in cold seasons is more than in warm ones. The highest transport rate is 3927.4557m³/day during cold season in BANDAR-ANZALI and the lowest transport rate is 122.5276m³/day during warm season in BANDAR-NOSHAHR.

Keywords: Sediment transport, Southern Caspian Sea, Energy flux method, Long shore, CERC.

1. Introduction

Sediment transport (and resulted erosion) in surf zone is one of the interesting topics that must be investigated in marine science since it causes some phenomena such as changing the shore line, scour (the localized removal of bed material below its natural elevation) usually occurs near (and usually caused by) marine structures such as jetties, seawalls, bridge pilings. Sediment transport has significant effect on offshore pipelines (scour could damage pipelines or collapse oil platforms). Recently, environmental problems associated with the handling and deposition of Sediments have been attended a lot. These concerns most frequently arise from dredging operations, but sedimentation can occur wherever sediment is introduced into the marine environment. Turbidity of the water

depends on the fall velocity of the sediment particles, which is a strong function of the grain size. Turbid waters can be carried by currents away from the project site, blocking the light to organisms over a wide area as the sediments settle out. Fine sediments (silts and clays) get greater salinity under environmental regulation because they produce greater and longer-lasting turbidity, which impact larger areas of the seafloor than coarser ones by sand grains. Nowadays it is necessary to obtain accurate data on sediment size, composition and toxicity.
To predict sediment transport rate in surf zone, several expressions exist so that the energy flux method is of great application in sediment transport prediction. Sediment transport rate in the southern Caspian Sea is obtained using this method.

2. Energy flux method

The long shore sediment transport rate depending on an available quantity of littoral material is most commonly correlated with the so-called long shore component of wave energy flux as in following relation.

$$P_l=(EC_g)_b \sin \alpha_b \cos \alpha_b \quad (1)$$

Where E_b is the wave energy evaluated at the breaker line,

$$E_b=(\rho g H_b)^2/8 \quad (2)$$

C_{gb} is the wave group speed at the breaker line,

$$C_{gb} = \sqrt{g d_b} = \left(g \frac{H_b}{k} \right)^{\frac{1}{2}} \quad (3)$$

Where ê is the breaker index H_b / d_b . The term $(EC_g)_b$ is the "wave energy flux" evaluated at the breaker zone, and α_b is the wave breaker angle relative to the shoreline. The immersed weight transport rate *I*R has the same units as *P*R (i.e., N/sec or lbf/sec), so that the relationship is homogeneous, that is, the empirical proportionality coefficient *K* is dimensionless.

$$I_l = KP_l \quad (4)$$

This is another advantage in using *I*R rather than the *Q*R volume transport rate. Equation (4) is commonly referred to as the "CERC formula."

Equation (4) may be written as below.

$$I_l = KP_l = K(EC_g)_b \sin\alpha_b \cos\alpha_b \quad (5)$$

Assuming shallow water breaking, the following relations are resulted.

$$I_l = K\left(\frac{\rho g H_b^2}{8}\right)\left(\frac{gH_b}{K}\right)^{\frac{1}{2}} \sin\alpha_b \cos\alpha_b \quad (6)$$

$$I_l = K\left(\frac{\rho g^{\frac{3}{2}}}{8K^{\frac{1}{2}}}\right) H_b^{\frac{5}{2}} \sin\alpha_b \cos\alpha_b \quad (7)$$

$$I_l = K\left(\frac{\rho g^{\frac{3}{2}}}{16K^{\frac{1}{2}}}\right) H_b^{\frac{5}{2}} \sin(2\alpha_b) \quad (8)$$

The relationships for *I*R can be converted to a volume transport rate:

$$Q_l = \frac{k}{(\rho_s - \rho) g (1-n)} P_l \quad (9)$$

$$Q_l = K\left(\frac{\rho\sqrt{g}}{16K^{\frac{1}{2}}(\rho_s - \rho)(1-n)}\right) H_b^{\frac{5}{2}} \sin(2\alpha_b) \quad (10)$$

Field data relating I*L* and *PL* are plotted in Figure (1), for which the calculations of the wave power are based on the root-mean-square (rms) wave height at breaking *Hb rms*. Figure (1) includes the Data measured by:

(1) Sand accumulation at jetties and breakwaters (South Lake Worth Inlet, Florida (Watts 1953a); Anaheim Bay (Caldwell 1956), Santa Barbara (Dean et al. 1987), and Channel Islands (Bruno et al. 1981, Walton and Bruno 1989), California; Rudee Inlet, Virginia (Dean et al. 1987); Cape Thompson,Alaska (Moore and Cole 1960) ; and Point Sapin, Canada (Kamphuis 1991)) ;

(2) sand tracer at Silver Strand,California (Komar and Inman 1970); El Moreno, Mexico (Komar and Inman 1970); Torrey Pines, California (Inman et al. 1980); and Ajiguara, Japan (Kraus et al. 1982));

And (3) sediment traps at Kewaunee County, Wisconsin (Lee 1975); and Duck, North Carolina (Kana and Ward 1980)). Because of questions in methodologies and trapping efficiencies, these data may be the most appropriate ones for engineering applications which are based upon the category 1 defined in the above.

The *K* coefficient defined here is based on the utilization of the rms breaking wave height (*Hb rms*). The *Shore Protection Manual* (1984) presented a dimensionless coefficient *KSPM sig* = (0.39) based on computations by utilizing the significant wave height. The value of this SPM

coefficient corresponding to the rms wave height *Hb rms* is *KSPM rms* = 0.92 which is indicated in Figure (1) with a dashed line for reference.
An early design for value of the *K* coefficient was introduced for using with rms breaking wave height by Komar and Inman (1970); *KK&I rms* = 0.77. This value can commonly be seen in many long shore transport rate computations.

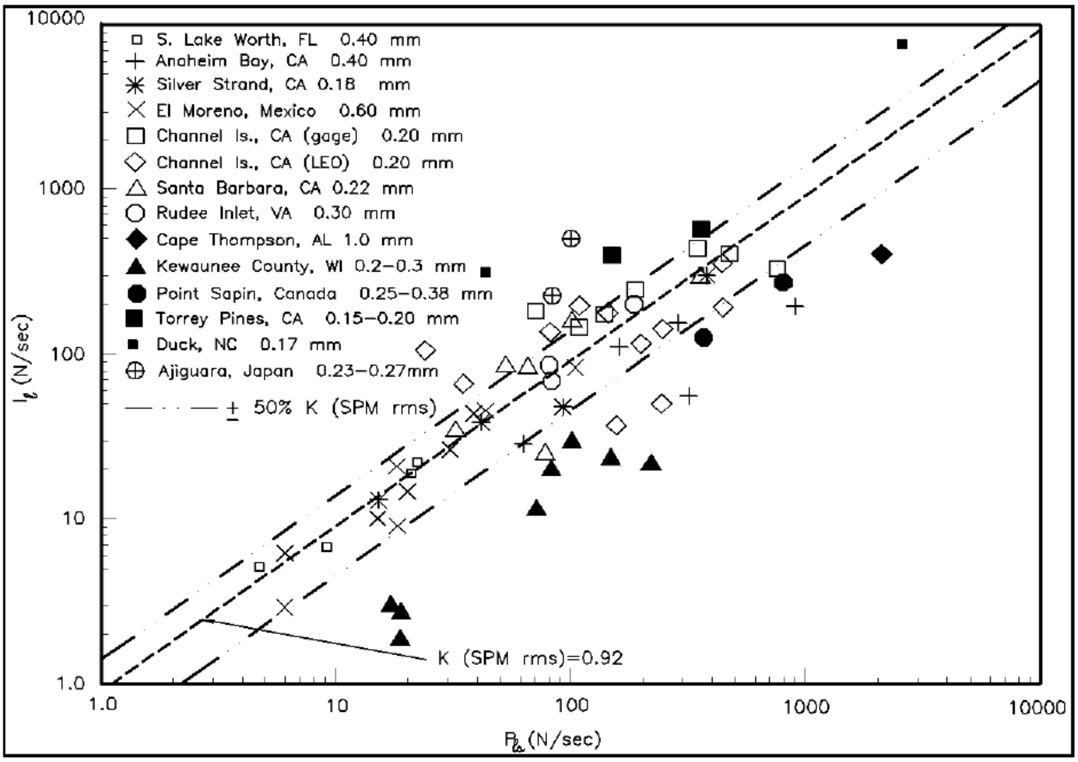


Figure (1): Field data relating IR and PR (CERC, 2003)

Values of the other parameters to be used in the sediment transport equations are:

ρ_s = 2,650 kg/m3 for quartz-density sand

ρ = 1,025 kg/m3 for 33 parts per thousand (PPT) of salt water

ρ = 1,000 kg/m3 for fresh water

g = 9.81 m/sec2

n = 0.4

The breaker index (K) is 0.78 for flat beaches and increases to more than 1.0 depending on beach slope (Weggel, 1972).In most researches it has been mentioned that K depends on beach slop. Data set used for comparison between represented grain sizes in the range from 0.15 to 0.25 mm and K have values close to the values obtained by Komar and Inman . Figure (2) illustrate K dependence on median grain size.

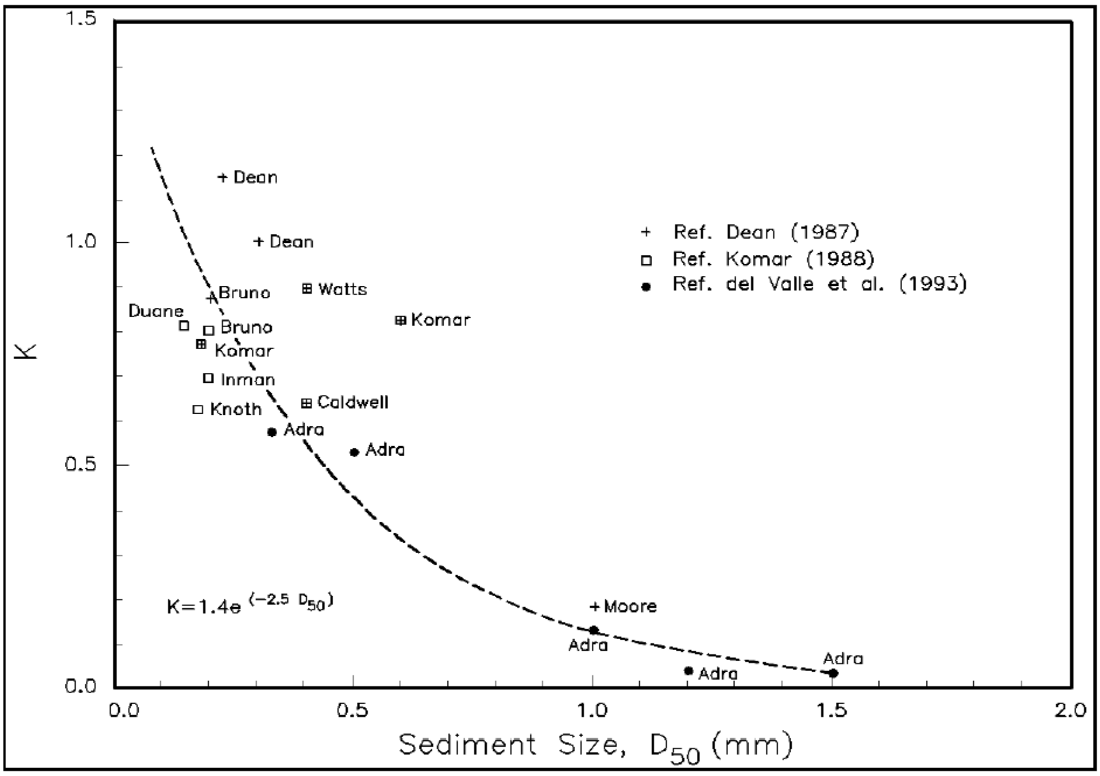


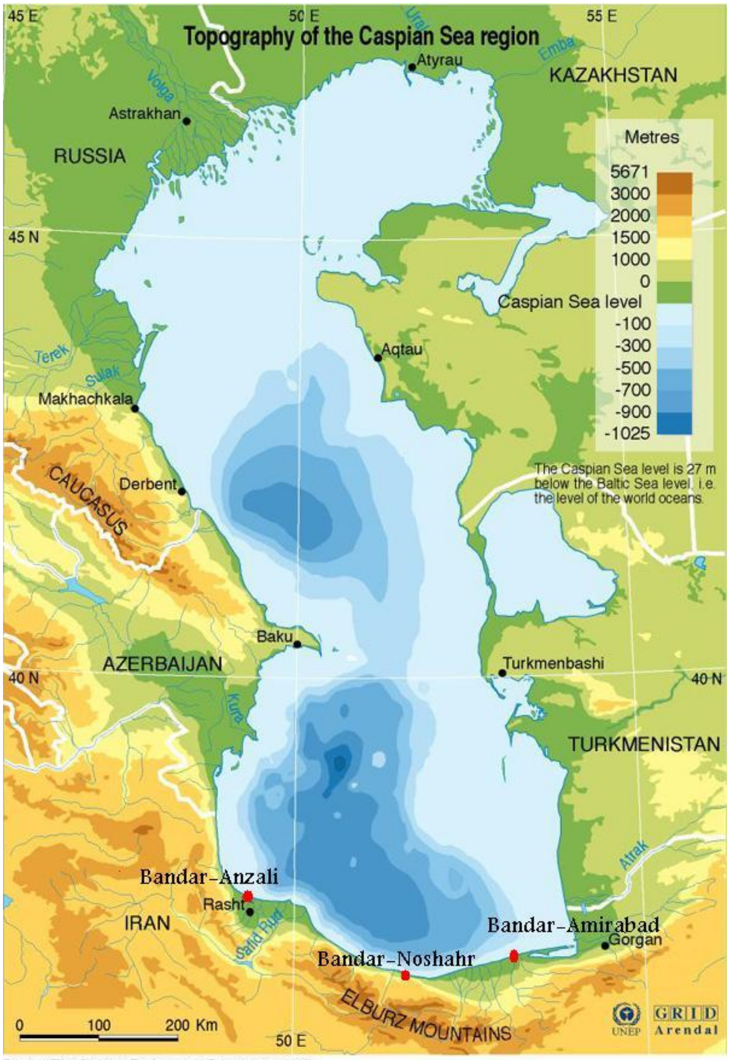
Figure (2): Coefficient *K* versus median grain size *D*50 (CERC, 2003)

3. Calculating sediment transport rates in the southern Caspian Sea

To calculate sediment transport rate in the southern Caspian Sea three stations were chosen; BANDAR-E-ANZALI as western station, BANDAR-E-NOSHAHR as central station and BANDAR-E-AMIRABAD in GOLESTAN province as eastern station.

Sediment transport rate is obtained by utilizing CERC (CERC, 1998) common formula. For calculation, wave data include wave direction, wave height in deep water, wave breaking height, breaking depth and sediment density. To find wave breaker angle relative to the shoreline, utilized data and are in basis of topographical surveys. Calculating sediment transport rate manifests that littoral sediment transport rate in cold season and warm season does not have the same value and transport rate in cold season.
In the western station (BANDAR-E-ANZALI), in cold season, sediment transport rate, width of the surf zone, beach slop, mean relative grain density and wave breaking high are calculated as 308.548m³/day, 110m, 0.007, 2.61 and 1.01m respectively. While in warm season those are 1414.9430m³/day, 74m, 0.007, 2.61 and 0.74m respectively. In this station, the highest transport rate is 3927.4557m³/day which obtained during

cold season and the lowest rate is 607.7472m³/day obtained during warm season.



Source: The Caspian Environment Programme, 2002.

Figure (3): The situation of stations in the south cost of the Caspian Sea

In the central station (BANDAR-E-NOSHAHR) in cold season, sediment transport rate, width of the surf zone, beach slop, mean relative grain density and wave breaking high are calculated as 1993.5749m³/day, 79m, 0.01, 2.61 and 0.52m. While in warm season those are 272.7703m³/day, 52m, 0.007, 2.61 and 0.52m. In this station, the highest transport rate is 2157.8613m³/day which is obtained during cold season and the lowest rate is 122.5276m³/day obtained during warm season.

In the eastern station (BANDAR-E-AMIRABAD) in cold season, sediment transport rate, width of the surf zone, beach slop, mean relative grain density and wave breaking high are calculated as 1853.4687m³/day, xxxm, 0.007, 2.61 and 0.8m. While in warm season those are 471.6550m³/day, 78.6m, 0.007, 2.61 and 0.55m. In this station, the highest transport rate is calculated as 2206.7559m³day obtained during cold season and the lowest is 227.6545m³/day obtained during warm season [3].

4. Discussion and conclusion

Sediment transport rate in the southern Caspian Sea is more than open seas. Littoral transport rate in south of Caspian sea is in order of 10^7, while transport rate is in order of 10^6. Transport rates obtained in ANZALI, NOSHAHR and AMIRABAD stations manifest that during cold season, transport rate in ANZALI is more than other stations. Figure (4) illustrates sediment transport rate in ANZALI, NOSHAHR and AMIRABAD stations.

Seasonal changes in sediment transport rate in ANZALI are more than in the other stations (figure (5)).

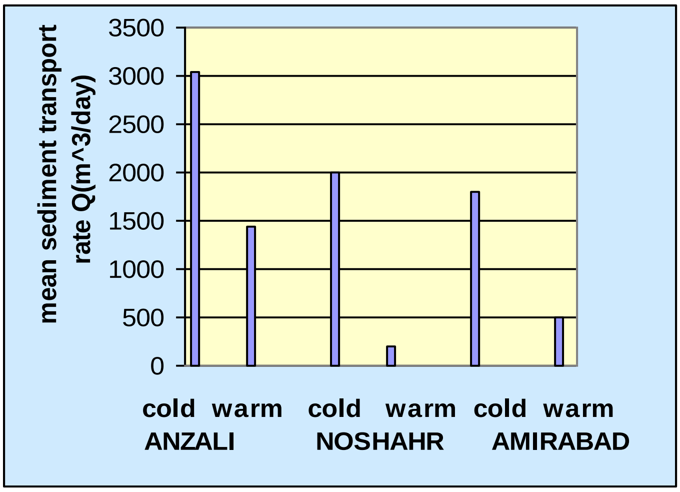


Figure (4): Mean sediment transport rate in cold and warm season (jafari, 2004)

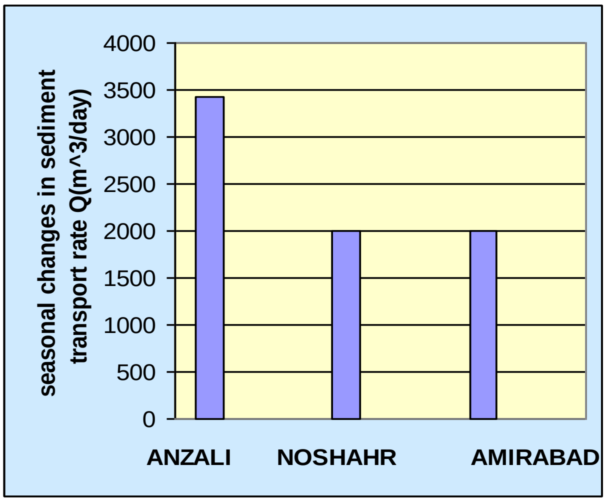


Figure (5): Seasonal changes in sediment transport rate in ANZALI, NOSHAHR and AMIRABAD.

Mean sediment transport rate in BANDAR-ANZALI is more than the other stations, and it is not in response to fetch length and duration. It could be because of sediment sources in this area.
Energy flux method is a good expression to predict littoral transport rate in the south of Caspian Sea. To obtain actual transport rate in the south of Caspian Sea, utilizing traps is recommended.

Acknowledgement

This research has been financially supported by the office of vice chancellor for research of Sama College of Islamic Azad University, Shoushtar Branch.

References

[1] Masselink G. and Pattiaratchi C.B.2001, "Seasonal changes in beach morphology along the sheltered coastline of perth, Western Australia",J.Marine Geology 172,pp 243-263.
[2] Coastal Engineering Research Center (CERC), 2003, "Coastal Engineering Manual U.S. Army Corps of Engineers".
[3] Jafari .M, 2007, ”Evaluation of morphodynamic effects of sea walls on surrounding coast” ,thesis of M.Sc., a faculty member of natural resources and marine science, TARBIAT MODARES university.