# CONTRIBUTIONS TO THE STUDY OF WAVE ACTION ON THE HETEROGENEOUS MARINE MOBILE BOTTOM ON THE ROMANIAN SEASIDE COSTAL AREA ASSOCIATED TO THE DANUBE DELTA

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***Abstract***
*The Romanian seaside related to the Danube Delta is the result of sedimentation and alluvial processes of fluvial deposits at the mouth of the Danube flowing through its three channels in the Black Sea. It is well-known that the total amount of sediment which supplies the Romanian coast, approximately 7.34% (A.Spataru), is coarse silt composed of fine sands.*
*Research and studies have been conducted on the distribution of marine silt along the seaside belt by NIMH Bucharest, showing that near shore coastal seabed area is mainly occupied by particles with a mostly larger diameter than 0.050 mm to 0.200 mm. Size sorting of marine silt on seabed in the coastal area of the Romanian seaside north of Midia Cape is naturally processed due to wave action and marine currents. In the last period of time due to the Black Sea level fluctuations, particularly shown through Black Sea level rise superimposed with the action of the waves, the Romanian seaside near the Danube Delta is permanently under a complex and continuous process of erosion.*
*The present research attempts to determine what diametres sand particles should have on the mobile bottom of the Romanian seaside related to Danube Delta, which may constitute a stable bed for coastal wave action.*
*Depending on the size of sand particles and the flow regime in the coastal zone, marine erosion occurs. In this work it was considered that for the two types of sand A and B, the fluid movement in the coastal zone is in laminar field, the sizes of movement results from Froude and Reznolds references. In times of storm at the wave elevation in the coastal zone, lower costal coordinates as the one related to the hidrotehnical system of Razelm - Sinoe, are outweighed by high waves which involve the majority of particles, creating gaps (closure )in the seaside belt section determining water saturation in the hidrotehnical system Razim - Sinoe. The hidrotehnical system Razelm - Sinoe is a freshwater ecosystem that has many functions, the most important being that of water transiting from St. George brace into the Black Sea and to irrigate about 120,000 ha located in Dobrogea plateau in Constanta and Tulcea counties (N.Petrescu, 1998) .*

Keywords: marine erosion, coastal belt, laminar movement, turbulent motion, wave action.

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## 1. INTRODUCTION

Scientific work shows that at present for a fairly complex area such as that of marine hydraulics, there are experimental and theoretical methods that can reveal marine erosion of the bed of sand in the coastal zone.

The working method was to combine experimental research with theoretical mathematical methods based on calculation relationships of the wave action on coastal belt related to the Danube Delta.

For testing was considered that fluid movement occurs in laminar field so that we could calculate the number of mathematical relations of Froude and Reynolds, compared with Schields valid criteria for continuous movement (Yalin and Russel, 1987).

The scientific paper highlights the importance of material heterogeneity existing on the mobile bed on the Romanian seaside coast area related to Danube Delta, to the action of the waves (ICIM, 1993).

## 2. MATERIAL AND METHOD

The experimental research has been made between 2010-2011 on the Romanian seaside area pertaining to Razelm - Sinoe water system. Effects of wave motion on the bottom in the coastal zone for the Romanian seaside pertaining to Danube Delta, are expressed by the following sizes:

D, w, γ, δ, σ, β,V*, T, where :

- D - specific particle diameter in the coastal mobile bed
- W - speed drive sand particles
- Γ - kinematic viscosity
- Δ - density of water
- Σ - standard dispersion of sandy material
- B - form factor / form coefficient
- V * - speed friction
- T - period wave generation

The mathematic relations for the above sizes, regarding the base relations of dimensional analysis, will be:

$$\gamma\left(\frac{wd}{v};\frac{V*}{w};\frac{d}{\sqrt{VT}};\frac{d}{\tau};\beta\right)=0 \qquad (1)$$

It is known that in such cases the following applies to Schields for Reynolds number equal to R * = w. d / γ and Froude number equal to F * = V * / w and

When V*= $\sqrt{\tau/\delta}$, where τ is average tangential tension of friction of several spatial and temporal cycles of movement of the waves at the lower part of the bottom cell of the Romanian seaside coastline.

To calculate the value of τ is considered that the fluid is viscous, and movement occurs in a deep water, the motion being harmonic undulatory.

The level of free moving particles located on the surface is expressed by the relationshi (Jakobsen 1970):

$$\eta(x,t)=H+A_1\cos(m_0x-kt)+$$
$$+A_1^2\frac{m_0^2g}{4K^2}\left(3\frac{m_0^2g^2}{K^4}-1\right)\cos^2(m_0x-Kt) \qquad (2)$$

Tangential friction tension in the mobile bottom area of the Romanian seaside is expressed by the relation:

$$\tau=A_1\frac{\delta K\sqrt{\lambda K}}{Shm_0H}\cos\left(m_0x-kt-\frac{\pi}{4}\right)+$$
$$+A_1^2\frac{\delta k\sqrt{\lambda K}}{\sqrt{2}Sh^2m_0H}\left(1-\sqrt{2}+\frac{3}{2Sh^2m_0H}\right)\cdot$$
$$\cdot\cos 2\left(m_0x-kt-\frac{\pi}{8}\right) \qquad (3)$$

Where: $k=\frac{2\pi}{T}$ and $m_0=\frac{2\pi}{\lambda}$

T – the period of wave generation
λ – wavelength
sh – hyperbolic sine
H – wave height in coastal area
g – acceleration of gravity

Calculation of friction tangential tension expressed by computing the relationship (3) can be made because the movement boundary layer at the bottom of the bed of sand in the coastal zone remains laminar, meaning it is checked for particles with small diameter compared to the length wave $\sqrt{\gamma T}$ (Seabergh, 1983).

At larger diameters of the sand particles, moving boundary layer at the bottom of the bed of sand in the coastal zone becomes turbulent, and computing relationships of the movement are based on Froude and Reynolds equations and compared with the values in the graph of Schields.

Regarding the number $\frac{d}{\sqrt{\lambda T}}$ it still has not been established so far what are its links with numbers R * and F *.

The report d/ σ has a particular importance on the erosion of sand particles due to wave action. For each particle of D diameter, on their passage through a mesh with a sieve diameter ≤ D, is determined the percentage weight of particles sifted passing through the sieve mesh eye. For screened particles of diameter D, it is chosen the value of diameter d that defines the weight of studied material that passed through the sieve mesh (ICIM,1992).

The diameter d is very important for determining the value R *, either F * and the speed drive of w sand particles which in turn depends on the diameter.

So for particles with diameter $d = D_{50}$, their speed drive is W50, so that the value of Re * coincides with a specific amount of sand that has a monogranular diameter of $D_{50.}$

If $\sigma = D_{84,\,1} - D_{50} = D_{50} - D_{15,\,9}$, resulting geometrical dispersion value $\sigma g = D_{50}/D_{15,\,9} = D_{84,\,1}$. Given Gauss's law:

$$f(x) = \frac{1}{\tau\sqrt{2\pi}} e^{-(x-m)^2 \cdot 2\tau^2} \qquad (4)$$

where σ is the approximate dispersion expressed in a probabilistic mathematical diagram that shows generally for five natural sands, as in Fig. 1a, 1b,1c,1d,1e.

If we assume that R * is the value of monogranular material for $\tau_g = 1$, with $d = D_{50}$, then this corresponds to a number $F_0$ *, for $\tau_g > 1$, and R * remains the same, then values are obtained $F^* \neq F_0$

Generally the mixing area was found to be more compact, more homogeneous for $F^*>F_0^*$, so there may be a relationship of determination between F * and $\tau_g$.

The obtained expressed points are few regarding the relationship between F* and $\tau_g$, but there are many other studies that have shown that σg influences the initial movement in the mobile bed of seaside belt.

Regarding β, it is noted that for sand this value can be considered constant.

Experiments were performed on a section related to the seaside belt in the area of the engineering system Razelm - Sinoe, using five types of sand that have geotechnical characteristics known from previous studies.

For each type of mobile seabed two samples of sand were collected from the two varieties with known geotechnical characteristics (Bijkel 1982 ).

Measurements were made at various times of the calendar year on the -H wave depth in the coastal area, wave generation period -T and wave generation frequency-ν.

It was intended specifically that for each set of T values corresponding to waves with water depth H to record production of sand entrainment phenomenon located at the mobile bottom of the costal belt.

They found that baseline from which erosion has occurred was that when after wave action, the back and forth entrainment of the sand began, creating small isolated islands, considering that water movement was uniformly distributed on the mobile sea bed of the coastline.

You can also say that for lower values of the wave amplitude in the coastal zone from the initial process leading to erosion, water separation from the sand is generated at low tide, meaning we have a stable equilibrium configuration.

At higher wave amplitudes, greater depths and greater wave production periods, the erosion phenomena are stronger and are produced faster due to Ep potential energy of breaking the wave in the coastal zone, the motion being turbulent (Sabation, 1972).

## 3. RESULTS AND DISCUSION

For the formation of mobile seabed of the coastal belt related to the Danube Delta, there have been used five grades of sand type 1, 2, 3, 4 and 5 with known geotechnical characteristics.

$D_{50}$ , σ and σg values given to the five grades of sand, for which the geotechnical characteristics have been reported depending on their granulometric curves (fig. 1 a, b, c, d, e).

In preparing these data, the average temperature recorded during the making of experience and also kinematic viscosity of water were taken into account

For a sequence of values of T period, corresponding to H water depths in coastal areas were determined values of K = 2л / T and m0 in the the relationship:

$$m_0 g \cdot tgh \cdot m_0 H = K^2$$

Determining value for A1 and A2, was made for the action situation of large amplitude waves with T period of great production, great water depth and also for wave action situation with low amplitude with T period of small production, low water depth. The calculus relation is:

$$A_2 = A_1^2 \frac{m_0^2 g}{4K^2}\left(\frac{3m_0^2 g^2}{K^4} - 1\right) \quad (5)$$

Determination of F* was made by replacing A2 in relations (2) and (3), where K= 2л/T şi $m_0 = 2\pi / \lambda$, $\lambda = \sqrt{vT}$ .

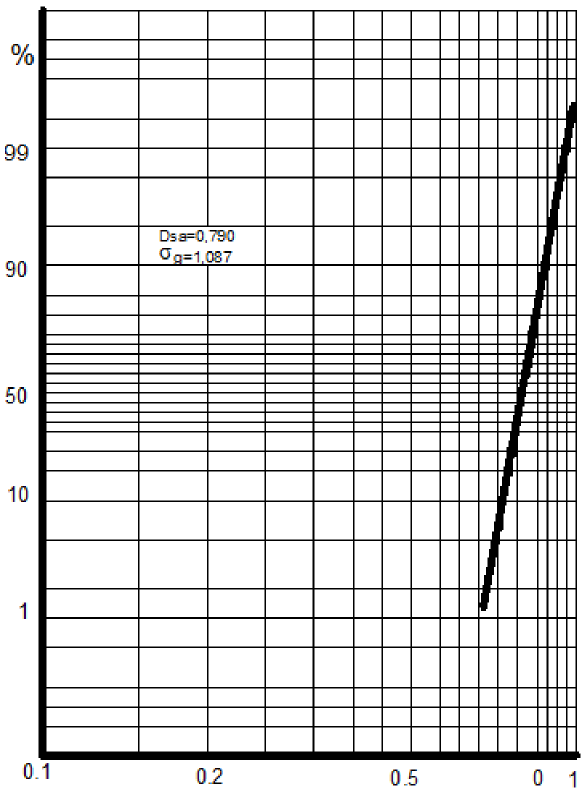


**Figure 1. a: Report σg/Dsa-sand1**

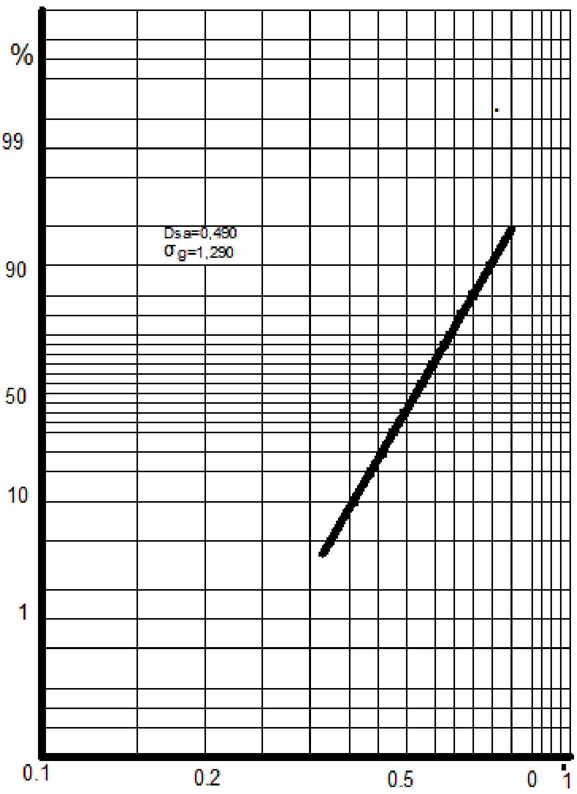


**Figure 1. b: Report σg/Dsa-sand2**

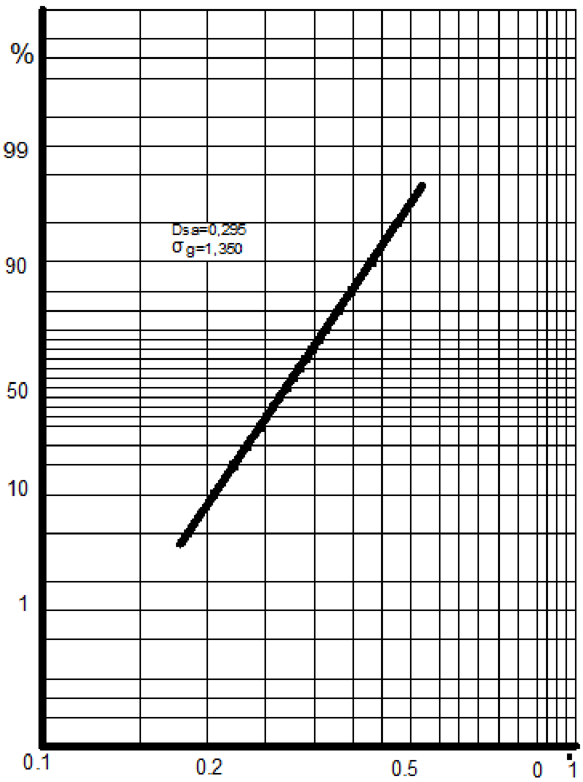


**Figure 1. c: Report σg/Dsa-sand3**

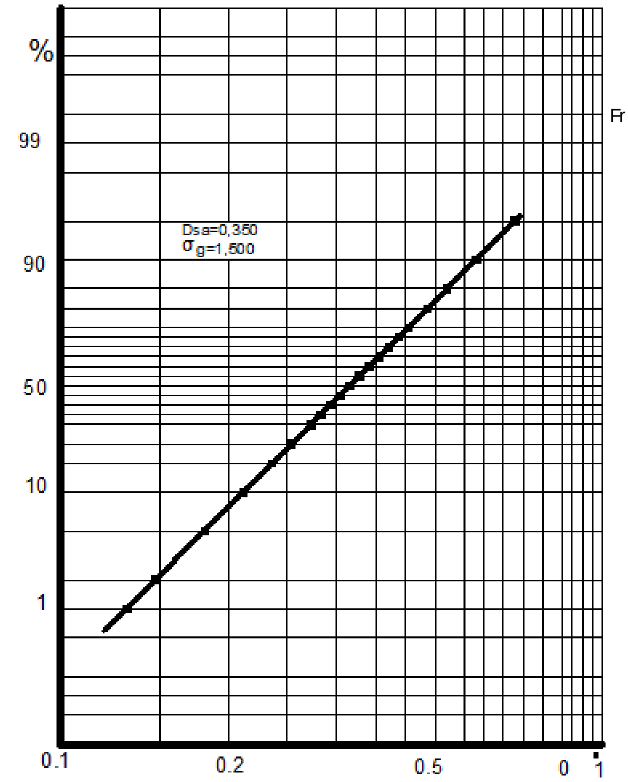


Figure 1. d: Report σg/Dsa-sand4

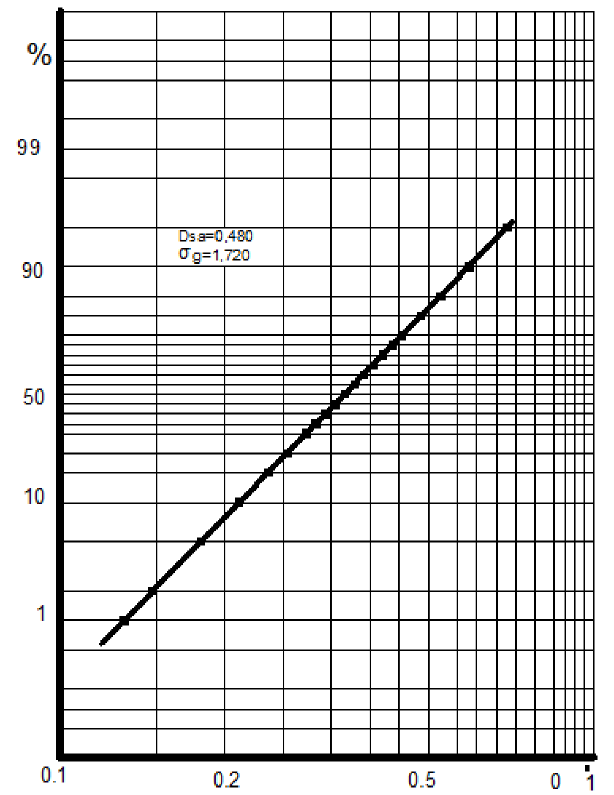


Figure 1. e: Report σg/Dsa-sand5

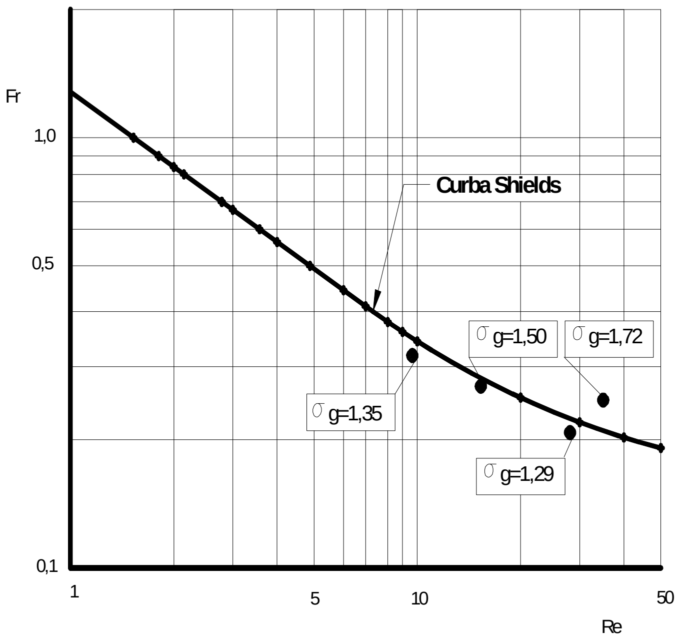


**Figure 2: $\sigma_g$ dispersion in relation with F and R**

Average values of Froude number and the corresponding obtained Reynolds numbers, as shown in Figure 2 are close to the Schields curve, except value σg = 1.72.

It was also found that the parameter $d/_{\gamma T}$ has no influence on the entrainment movement of sand particles.

## 4. CONCLUSION

Sand particles on the bottom of mobile seabed related to hydrotechnical system Razelm - Sinoe, was studied for the case of constant motion and undulatory motion for which relations F * and R * of Schields type were determined.

Variations of σg values for β = constant and β values for $\tau_g$ = constant, generates a lot of curves that are parallel in the field of experiments conducted.

Experiences of Schields type do not represent a particular curve which belongs to a certain family of curves, but corresponds to β and $\tau_g$ values and they are specific for medium sand as values for diameter d. So for any comprehensive study is necessary to have a basic curve for $\tau_g = 1$ for spherical particles. So for a large number of experiments we obtain

$\tau_g$ and β values which influence the entrainment of particles phenomenon to wave action.

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