CHAPTER 316

Studies on the Suspended Concentration in the Surf Zone

Ching-Her Hwang[1] Li-Hung Tsai[2] Po-Ching Lin[2] Chin-Chi Tsai[3]

Abstract

This study is to carry out the field measurements of the suspended concentration by using MTB-16K turbidity records in the surf zone of mild sloping beach (1/144). Then the vertical concentration distributions of the suspended sediment at different water depth d/L_0 and the longitudal concentration distributions of the suspended sediment across the surf zone are analyzed and discussed respectively in this paper.

Indroduction

In order to understand the phenomena of sediment transport in the near shore, it is necessary to investigate the problems of the sediment suspension mechanism induced by waves. Earlier there are many scholars and experts, such as Farichild (1959), Homa and Horikawa (1962), Noda (1967) etc., who had been studied this problems by using siphon, pumped sampler and suspend sampler respectively. In fact, it is difficult to obtain the exact records of suspended sediment variations. Lately there are other researchers such as Homa (1965), Sleath (1974, 1982), Wrigh (1982), Deigaard (1986), Makoto Ifuku (1988), Gotoh (1994), Nielson (1994), Ono (1994) and authors (1993-1995) etc. had also been studied this problems in the laboratory and in the field respectively. And this study is to carry out field measurement of the suspended concentration in the surf zone of mild sloping beach (S=1/144) located at the mid-west coast of Taiwan, R.O.C. under the sponsor of the National Science Council for the integrated research program "Coastal Space Utilities".

[1] Chief, the Coastal Engineering Division, Institute of Harbor & Marine Technology, No.83, Lin-Hai Rd., Wuchi, Taichung District, Taiwan, R.O.C.

[2] Assistant researcher, the Coastal Engineering Division, IHMT.

[3] Assist, the Coastal Engineering Division, IHMT.

Field Measurement

Four sets of memory MTB-16K turbidity recorder which set up above the sea-bed 6.5cm, 22cm, 35cm and 76cm etc. near the low water level at the tidal zone are used to measure the vertical concentration distribution of the suspended sediment. Also there are three sets of memory MTB-16K turbidity recorder which set up at a distance of 50m each other and above the sea-bed 6.5cm are used to measure the longitudinal concentration distribution of the suspended sediment across the surf zone. The maximum tidal range is about 5m in this area, hence their concentration distributions of the suspended sediment at different water depth can be measured by the tidal variations. Concurrently a DNW-5M pressure sensor and a UCM 40 Type MKII were also set up respectively near the sea-bed around the low water level and a waverider was set up outside the surf zone to record the oceanography conditions. The schematic diagrams are shown as Fig. 1.

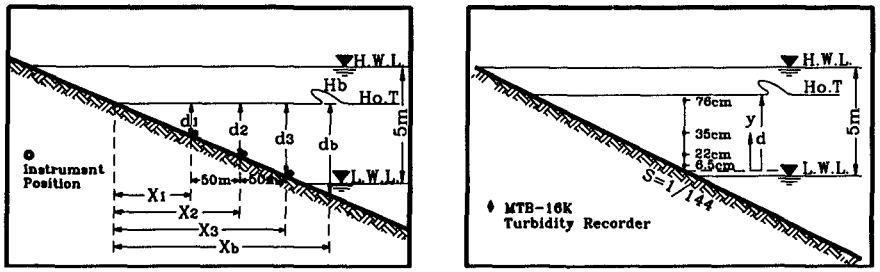

Figure 1 The schematic diagrams of parameters and memory MTB-16K recorders mounted on sea-bed

Field data of wave, water level and suspended concentration are recorded respectively every one hour interval by using the DNW-5M pressure sensor and the MTB-16K turbidity recorder from PM 7, 14 March, 1995 to AM 7, 16 March, 1995. The recorded periods of field data are continuous 10 minutes every times and data is adopted by one second interval.

Data Analysis and Discussions

3.1 The distributions of wave height across the surf zone

Figure 2 shows the parts of time histogram of the wave height and water level field measured data taken from the DNW-5M pressure sensor in the near shore on 14 March, 1995.

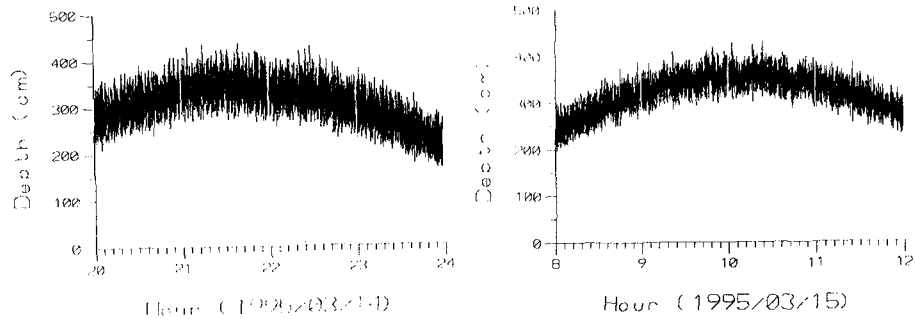

Figure 2 Time series of wave height and water level in the near shore

And the coresponding time series of wave height and wave period taken from the waverider at -20m water depth outside the surf zone are shown as Figure 3.

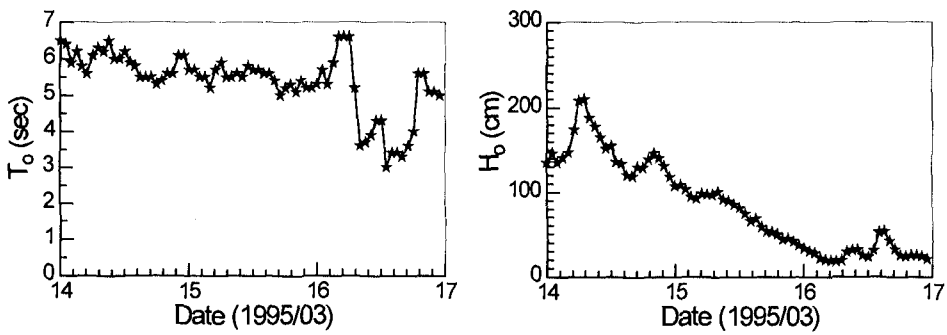

Figure 3 Time series of wave period and wave height at -20m water depth

Results indicate that the distributions of wave height are gradually decreasing from the largest H_0=2.2m occurred at AM 6, 14 March to the smallest H_0=0.20m occurred at AM 7, 16 March and its corresponding distributions of wave period are decreasing from 6~7 secs to 3~4 secs during wholly observing periods.

Figure 4 shows the relationship diagram between the local wave height H and its corresponding water depth d by analyzing the field measured data in the surf zone. Various legends such as "□" and "+" etc. represent the results in the flood or in the ebb. Results also indicate that the local wave height is linearly decreasing with water depth when the H/d value is equal to 0.4. If we convert this relationship with the form H=r(d+H), then the empirical constant is r ≒ 0.3. This means that the distribution of wave height can be expressed as the following empirical form in the surf zone.

$$H = r(d+H) \qquad S = \frac{1}{144} \qquad (1)$$

$$H_0 < 2.2m$$

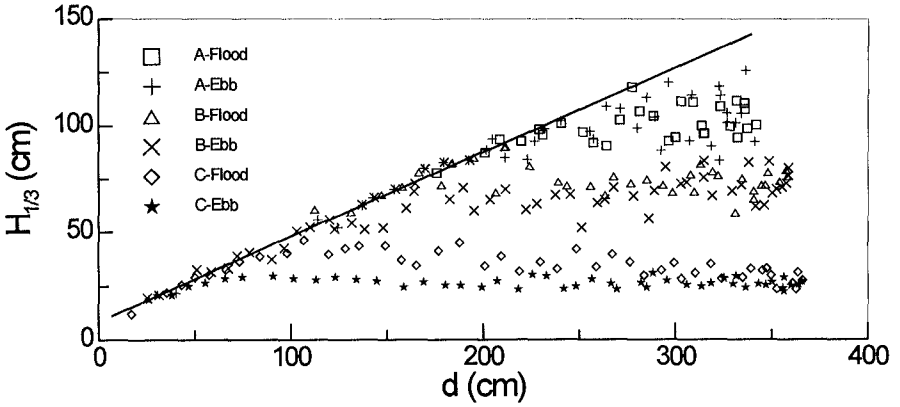

Figure 4 The relationship diagram between wave height and water depth in the surf zone

3.2 The distributions of suspended concentration in the surf zone

3.2.1 The vertical distributions of suspended concentration

Parts of the time series of suspended concentration measured at various positions and its corresponding water level are shown as Figure 5 and Figure 6 respectively.

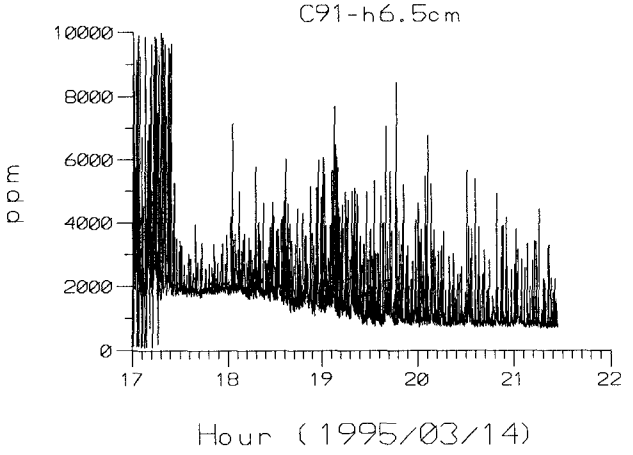

Figure 5 Time series of suspended concentration at various position

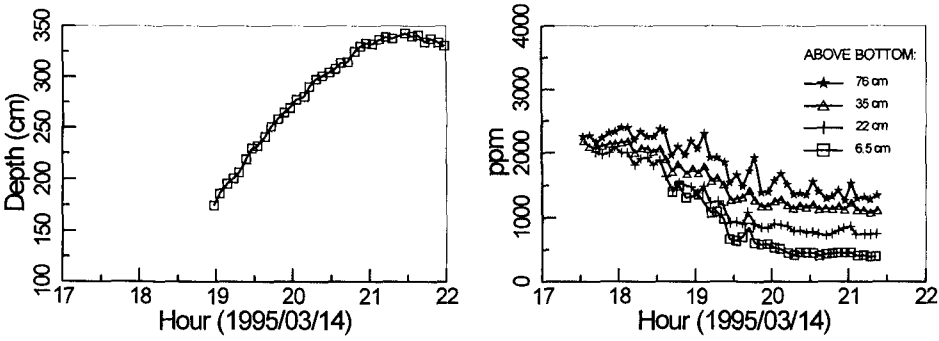

Figure 6 Time series of the water level and its corresponding suspended concentration

Results indicate that the tendency of suspended concentration is decreasing with increasing the water depth. And the higher water depth is, the discrepancy of suspended concentration measured at different height is smaller.

By using the concept of Figure 1 schematic diagram, the concentration distributions of the suspended sediment at different relative water depth d/L_0 can be measured by the tidal variations. Figure 7(a)~(d) shows the vertical distributions of suspended concentration at different relative water depth d/L_0. The dots and solid line in the Figure 7 represent respectively the field measured data and a regressive curve in this study. Results indicate that the vertical distribution of suspended concentration is more uniform for the smaller relative water depth d/L_0.

And results also show that the maximum suspended concentration mostly occurs at the bottom for different relative water depth under the same wave conditions. Figure 8(a)~(d) shows the dimensionless relationship between measured relative suspended concentration (C/C_{max}) and different relative water depth d/L_0.

Then, we can summarize the analyzed results in different way to express the vertical distributions of suspended concentration under various relative water depth d/L_0 as shown in Figure 9.

Moreover, the relationship diagram between the vertical suspended concentration at any relative depth y/d and the relative water depth d/L_0 can be also shown as Figure 10(a)~(c).

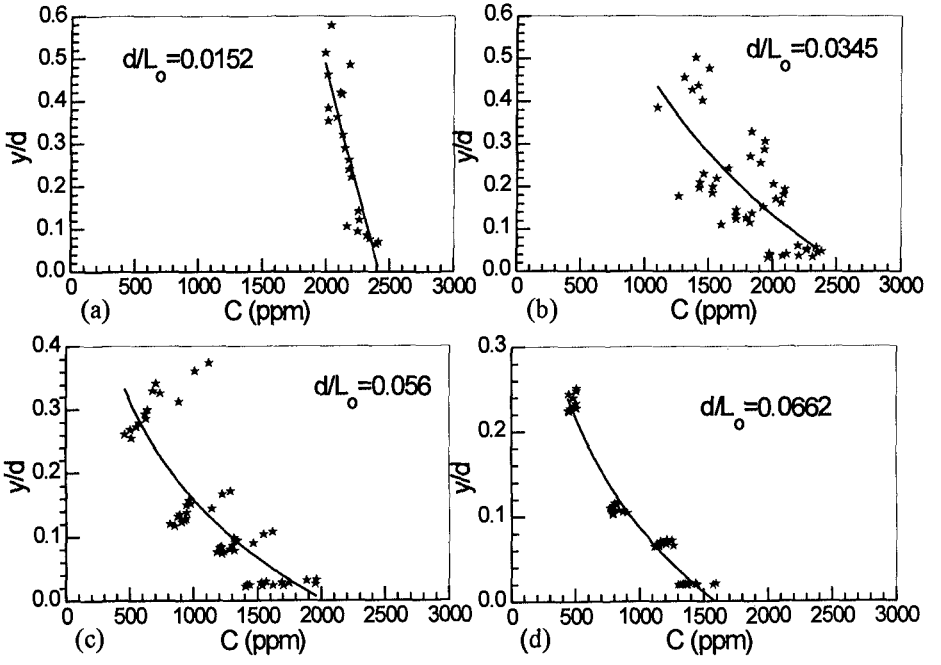

Figure 7 The vertical concentration distribution for the different relative water depth

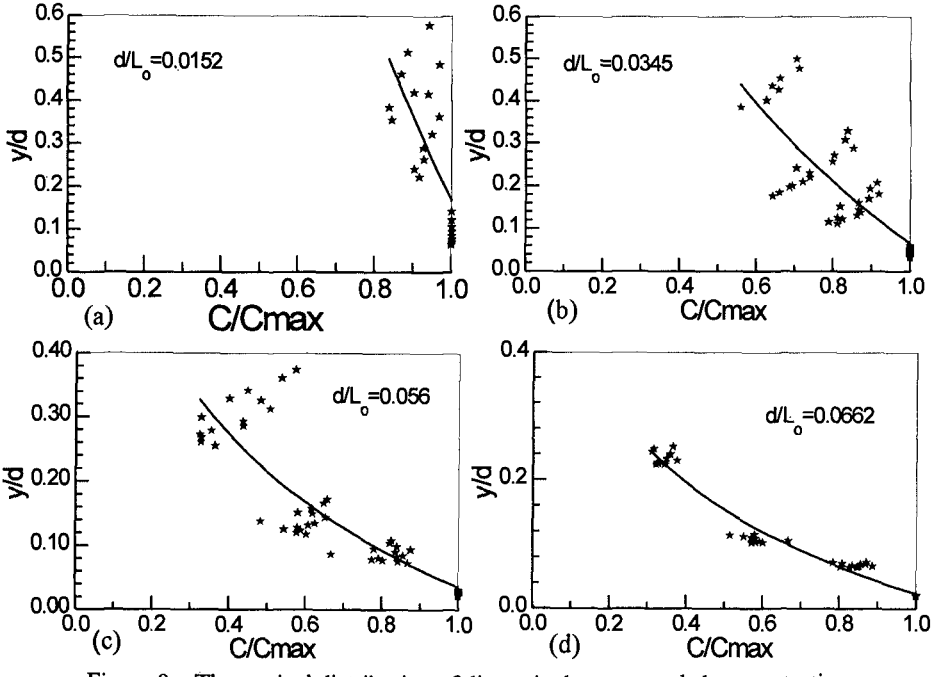

Figure 8 The vertical distribution of dimensionless suspended concentration

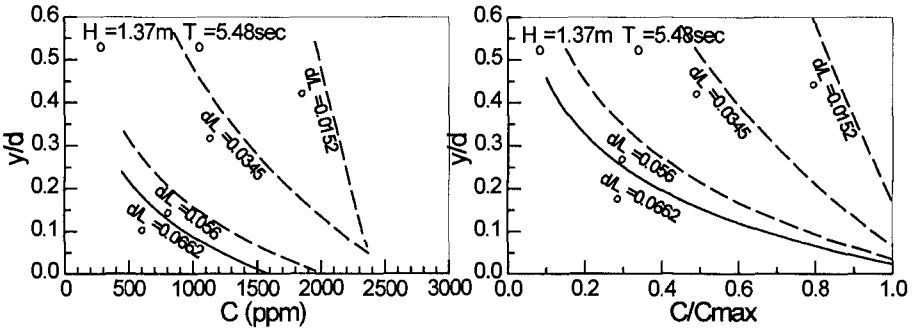

Figure 9 The vertical distributions of suspended concentration under the same wave condition

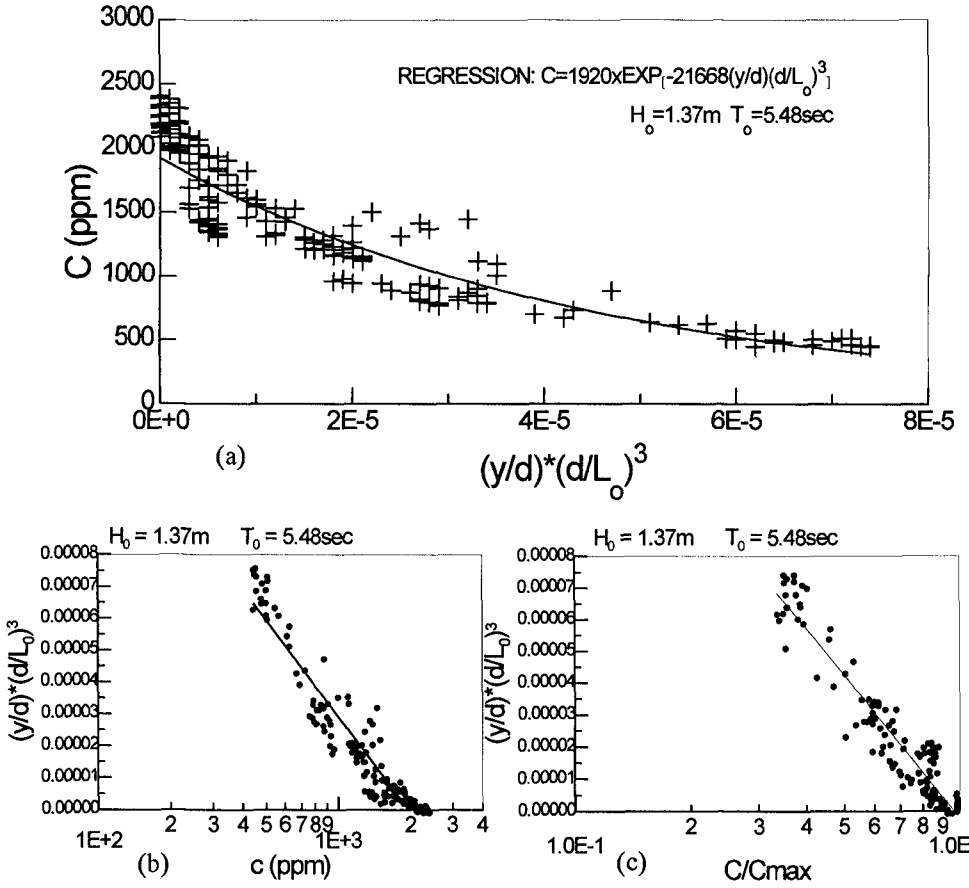

Figure 10 The relationship between suspended concentration C and $(y/d)\cdot(d/L_0)^3$

It means if the water depth d is given, then the suspended concentration at any depth y can be obtained by following regressive formulus.

$$C = 1920 \cdot e^{-21668\left(\frac{y}{d}\right)\cdot\left(\frac{d}{L_o}\right)^3} \tag{2}$$

where d : water depth
y : height from the seabed
C : suspended concentration, its unit is ppm

3.2.2 Suspended concentration near the seabed across the surf zone

Figure 11(a)~(d) shows the concentration distributions measured near the seabed across the surf zone under various wave steepness H_o/L_0. The definitions of parameter X and X_b are shown as Figure 1. The width of the surf zone, X_b, is computed by wave theory here. In general, results indicate the maximum values of suspended concentration usually occur around the breaking point for the same wave condition.

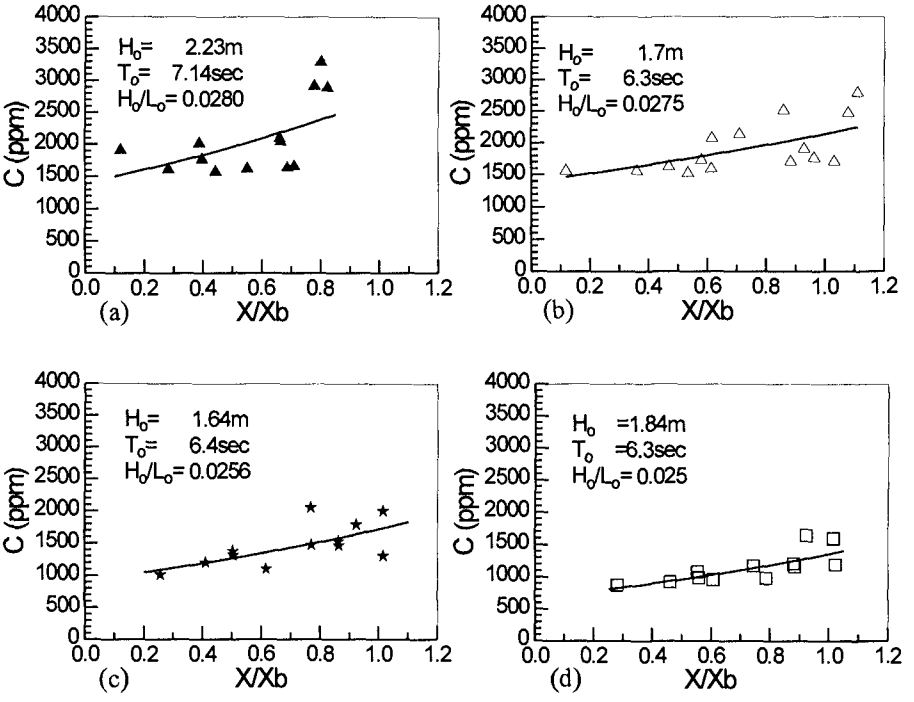

Figure 11 The distributions of concentration near the seabed across the surf zone

We can also summarize above results as Figure 12 under various wave steepness H_o/L_o. It means that the suspended concentration near the seabed will be decreasing with decreasing the depth. But it will be increasing when the incident wave steepness H_0/L_0 is increasing for the same depth.

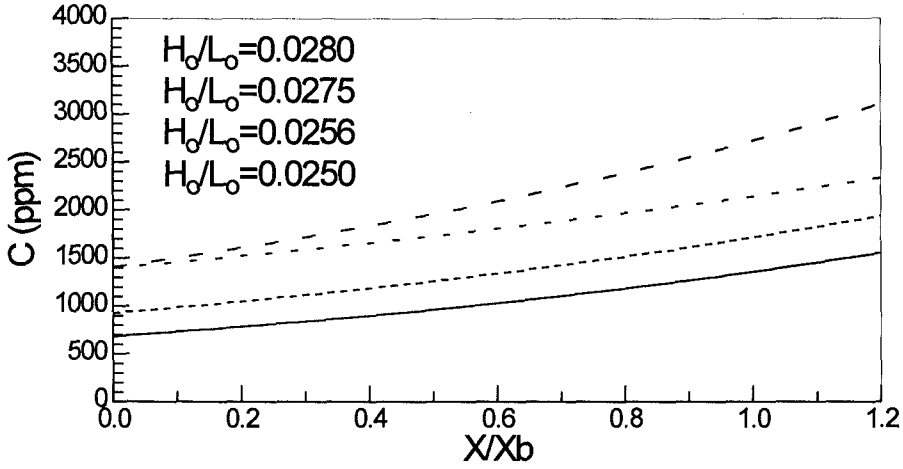

Figure 12 The concentration distributions near the seabed across the surf zone

Conclusions

Summarize above field data analysis and discussions, we can obtain some conclusions as following :

1. All measured field data can be provided as the quantitative basis of the numerical analysis in this study.

2. The local wave height H will be linearly decreasing onshore with depth d when the incoming wave is broken. Its relationship can be expressed as H=r(d+H) when the beach is a mild slop S=1/144 and incident wave height H_0 is smaller than 2.2m, then the coefficient is r ≒ 0.3.

3. The vertical distribution of the suspended concentration C can be computed by equation $C = 1920 \cdot e^{-21668\left(y/d\right)\cdot\left(d/L_o\right)^3}$ if depth d is known.

4. The distributions of the suspended concentration across the surf zone are related with the incoming wave steepness H_0/L_0. In general, its maximum value usually occurs around the breaking point.

Acknowledgement

This paper is part of the research projects, which is funded by the National Science Council for the integrated research program "Coastal Space Utilities", under contact NSC 84-2611-E-124-002. Authors also deeply appreciate to Miss Chien, E. J. for typing this manuscript.

References

1. Fairchild, J. C. (1959) : Suspended sediment sampling in oscillatory wave action, Beach Erosion Board, Tech. Memo 115 P.
2. Homma, M. and K. Horikawa (1962) : Suspended sediment due to wave action, proc. 8th coastal Eng. Conf. PP.168-193.
3. Sleath, J. F. A. (1982) : The suspension of sand by waves, J. Hydraul Res., Vol.19, PP.439-452.
4. Makoto Ifuku and Tadao Kakinuma (1988) : Suspended sediment concentration in the surf zone, 21th ICCE, Chap.23, PP.1661-1675, ASCE.
5. P. Nielsen (1994) : Suspended sediment particle motion in coastal flows, Proceedings of 24 ICCE, Chap.174, ASCE.
6. Onoetl (1994) : Suspended sediment concentration profiles under Non-breaking and breaking waves, Proceedings of 24 ICCE, Chap.203, ASCE.
7. C. K. Chang and C. H. Hwang (1995) : Studies on Wave, Current and Suspended Sediment Characteristics at the Surf Zone, Coastal Dynamics'95, ASCE, PP.728-738.