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Wave Breaking Co-efficient and Digha Coastal Beach Profile

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Abstract**-- Wave properties are important influencer to tune the beach profile. And also beach profile controls the wave nature such as breaker type. Both wave properties and beach longitudinal profile organize each other through a balance. The said research paper is traced this incidents with evidence in Digha coastal beach. Through this paper, longitudinal beach profile and breaker type and their relationship have been sketched. To analyse the breaker type several parameters have been used, viz. beach slope (β), depth of water (d), wave period (T), Breaker height (H_b) and time between two successive waves (Δt). Breaker type configurations may vary between offshore (B_0) and onshore (B_b) beach platform. Offshore breaker type is important for beach surfing zone.**

Keywords**-- Breaker Type, Longitudinal Beach Profile, Beach Slope, Offshore Beach Platform, Onshore Beach Platform.**

I. INTRODUCTION

The wave form appears as a periodic undulation of the water surface above and below the still-water level (swl) - the level the water surface would assume in the absence of waves (Robin Davidson-Arnott 2010, p.78). Water waves propagate on the ocean surface as a result of a generating force (Dean and Dalrymple 1991). Wave is an undulation on the surface of water which is occurred due to wind (Dey and Shukla March 2019b). The most common generating force for water waves is the moving air or wind (Faizal et al. 2011). Energy is transferred from the wind to the water by the frictional drag of the air on the ocean surface, thus creating waves (Janssen 2004). The driving force behind almost all coastal process is the waves (Pethick, 1984). As waves approach a beach; they deform and usually break (Galvin June 1968). According to Wiegel (1964), waves break was classified based on the wave steepness and beach slope, into three, viz. spilling, plunging, or surging. Being the transition zone between land and sea, beach is a coastal landform facing the open sea which is a gently sloping flat plain between low water line of spring tide to the upper limit of wave action (Dey and Shukla March 2019a).

Thus, the profile describes the littoral zone that may stretch from the landward limit of wave action (considerably higher than high tide level) to water depths of 10m to 20m at low tide (Komar, 1976). Wave height during breaking is an important factor that shapes the beach profile (Dey and Shukla March 2019a). The qualitative dependence of breaker type on wave steepness and beach slope is generally recognized (for example, U.S. Navy Hydrographic Office, 1944), but the only data supporting these conclusion appear in a generalized graph for laboratory oscillatory waves (Iiversen, 1953; Patrick and Wiegel, 1954) and a somewhat analogous graph for laboratory solitary waves (Iippen and Kulin, 1955; Street and Camfield, 1966; Galvin June 1968).The aforesaid paper is evacuated the nature of breaker type and its relations to longitudinal beach profile of Digha coast.

II. STUDY AREA

Digha is an important tourist hub of West Bengal which belongs to the Contai or Kanthi sub-division, Purba Medinipur (Dey and Shukla March 2019a). The 7 km long beach stretches from the mouth of the tidal river Champa in the east to West Bengal - Odisha Border (Dey and Shukla March 2019b). The younger Digha coast is the part of the Bengal Basin. The sedimentary geology of the great Bengal basin has been totally controlled by regional tectonic activities, quaternary as well as Holocene sea-level fluctuation and sedimentation history (Banerji 1984; Hutchison 1989; Achharyya et al. 2000; Goodbred and Kuehl 2000; Morley 2002; Alam et al. 2003; Sikder et al. 2003; Mukharjee, et al. 2009; Jana, et al. 2018). Digha coastal beach is also divided into 15 beaches, viz. from west, beaches are Udaypur (80.32m), Jatranala (1632.9m), Police Holiday Home (304.73m), Larika (656.42m), Hospital (368.90m), Jagannath Temple (170.00m), Aparajita Cottage (342.00m), Blue View (161.60m), 1st Gate (260.30m), Saikatabas (154.51m), Hotel (362.57), Breack (260.00m), Digha Mohana (1662.60m) (Dey and Shukla 2017; Mondal and Dey 2018; Dey and Shukla February 2019).

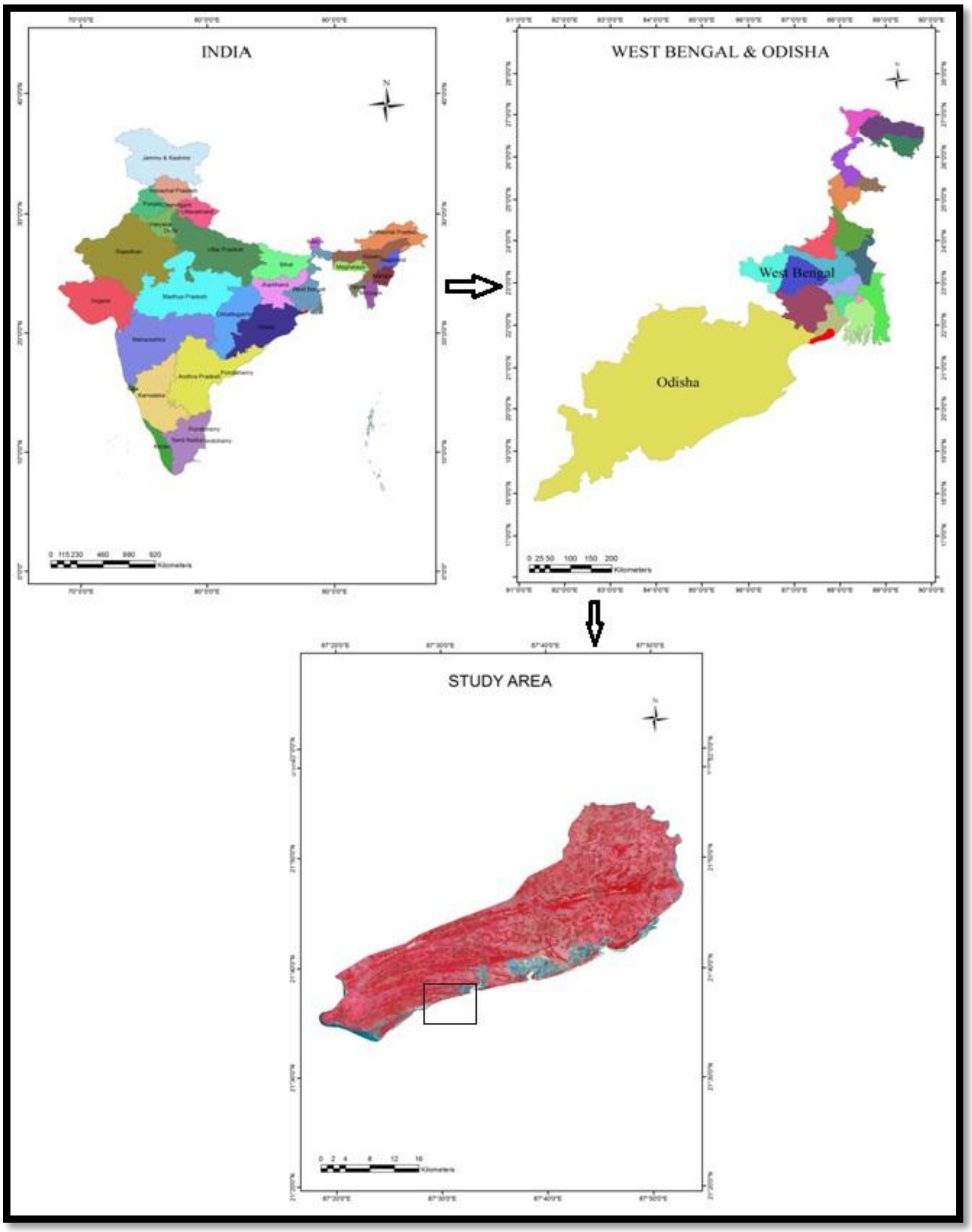

Fig. 1 Location Map

III. METHODOLOGY

The research work has two aspects, viz. (a) quantifying the wave breaking type (b) and its relation to longitudinal beach profile.

Primary data has been used to evacuate the aforesaid objectives. Conventional instruments e.g. Garmin GPS, Dumpy level etc have been used to collect the primary data during field work.

To quantify the breaker type on onshore at Digha coast breaking Co-efficient (B_b) after Galvin (1968) method has been used. In addition, Surf Scalling Factor (ϵ) after Guza and Bowen (1975), Phase of Differences (P) after Kemp (1975) and Breaker Point after Huntley and Bowmen (1975) are used to analyse the interrelationship between beach longitudinal profile and breaker type.

IV. Result And Discussion

1. Wave Breaking

As the wave progresses into shallow water (towards the coast), the various wave parameters, e.g. wave height and wave length become more pronounced until at the critical point the wave breaks or collapses (Dey and Shukla March 2019a).

As waves move toward shallow water, its height increases with decreasing wave length. The ratio between wave height (H) and wave length (L) is quantified as steepness (H / L) (Dey and Shukla March 2019a); when it reaches a critical point, the wave breaks down. Stokes' 'wave theory' predicts that when the angle at the wave crest reaches 120, the wave form becomes unstable and it breaks (Pethick, 1984).

1.1. Breaker variable

Wave Breaking is several physical features, viz. Beach Slope (β), Depth of water (d), Wave Period (T), Breaker height (Hb) and time between two successive wave (Δt), which also known as breaker variable.

Table 1:-
Experimental Condition of Breaker Variable to Various Breaker Type (After Galvin, 1968)

Breaker Type	Breaker Variable					
	Beach Slope	Water Depth (cm)	Period (sec.)	Breaker Height (cm)	Breaker Position (m)	Δt (sec)
Spilling	0.05	38.1	1.00	7.9	5.60	0.00
Plunging	0.10	30.5	7.00	11.6	2.32	0.06
Collapsing	0.20	38.1	4.00	14.9	1.31	0.06
Surging	0.10	30.5	5.00	7.0	2.35	0.15

1.1.1. Beach Slope (β)

Wave steepness controlled the wave breaking. Wave steepness is a ratio between wave height (H) and wave length (L) (Dey and Shukla March 2019b). If the value of wave steepness reaches its critical point at (H/L = 1/7 = 0.147), it breaks down (Dey and Shukla March 2019a). Wave length, wave height, water depth, wind velocity are directly influenced to wave steepness. All the aforesaid wave properties are controlled by the beach slope. Average beach slope of Digha coast is $1^0 51' 0.21''$ (1.85).

1.1.2. Water depth

According to Airy's wave theory (1845) depth of water (d) is measured by a holding staff. About 0.66 m water depth has observed.

$$\text{Depth of water } (d) = \frac{(\bar{C} - \bar{T})}{2} \quad \text{---------} \ (1)$$

Where,

$\bar{C}$ = Wave crests height

$\bar{T}$ = Wave troughs height

1.1.3. Period

The period indicates the time, to complete a wave cycle until it breaks down. Generally, small wave such as spilling type breaker takes a short time to break down after wave formation and also large plunging wave takes more time to complete the wave cycle than spilling type breaker.

1.1.4. Breaker Height

Ocean wave propagates on a sloping beach begin to slow down and during this time wave height increases to maintain a constant energy flux until breaking occurs (Dey and Shukla March 2019b). According to Stokes' Wave theory predicts that when the angle at the wave crest reaches 120 the wave form becomes unstable and it breaks (Pethick 1984 p.26). The top of the wave then overturns and falls onto the front face of the wave and during this process a large portion of the wave energy is converted into currents and turbulent kinetic energy (Mukaro et al. June 2013). The breaking process generates eddies while a large amount of air bubbles is entrained into water downstream of the breaking point (Hoque 2008). Average wave height during breaking (Hb) is quantified as 0.755 m by the following formula (2).

Wave Height during Breaking $(Hb) = \bar{C}b - \bar{T}b$ ------- (2)

Where,

$\bar{C}b$ = Wave crests height during breaking.

$\bar{T}b$ = Wave troughs height during breaking.

1.1.5. Time between two successive wave

The wave period (T) is defined as a time between two successive wave crests to pass a fixed point (Dey and Shukla March 2019b) which is controlled by depth of water. The relation between wave period, wave velocity and wave length is proportional but the relation between wave period and wave height is inversely proportional (Dey and Shukla March 2019b). Through the following formula (3) period between two successive waves at Digha coast is being measured which is 8.11 seconds.

Wave Period $(T) = 2\Pi$ --------- (3)

1.2. Type of Breaking

The breaker type classification is relevant to wave hydrodynamics. Carrier (1966) and Peregrine (1967) were grouped the wave breaking on the basis of approach of their breaking. But in 1968 Glavin gave the proper wave breaking group on the basis of their configuration.

1.2.1. Classification

Glavin (1968) on the basis of breaking variables classed and grouped in four main sections, but after critical analyzing nine breaker type was concluded.

Sl. No.	Type of Breaking	Description
1.	Spilling	Wave crest spill down as Bubbles and turbulent at the front face of a wave. Before breaking, the wave crests may steepen about 25% of the front face.
2.	Well-developed Plunging	Crest curls over a large air pocket and occurs a considerable smooth splash-up usually follows.
3.	Plunging	Crest curls over a smaller air pocket than in Well-developed Plunging.
4.	Collapsing	Breaking occurs over at minimal air pocket at the lower half of wave amplitude without any wave generating splash. Bubbles and foam occur after wave breaking.
5.	Surging	Low wave slides or slips up rapidly towards base of a wave with little or without bubble formation. Seawater surface usually planes except on ripples which may be produced on the beach face during runback the water or during seaward movement.
6.	Plunging Altered by Reflected Wave	Small waves reflected from the preceding wave (which is returned from the beach obstruction) peak up the breaking crest. Otherwise, wave Breaking is not affected.
7.	Plunging Altered by Secondary Wave	Primary wave may ride immediately before on secondary wave or secondary wave rides immediately behind the primary wave in front. First kind is very difficult to distinguish from surging altered by secondary wave.
8.	Surging Altered by Secondary Wave	Plunging secondary wave may break down just in front of surging primary wave. It’s very difficult to trace and distinguish from plunging altered by secondary wave.
9.	Secondary Wave Washed Out	Previous primary wave may break out on the field which may be viewed or just disappear when it carries the secondary wave offshore during runback.

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1.2.2. Characteristics of Breaker Variable

Table No. 2

Characteristics of Breaker Variable of Different Breaker Type (After Patrick and Wiegel 1954; Wiegel, 1964; Galvin 1968)

Type of Breaker	Variable		
	Beach Slope	Depth to Height Ratio	Breaker Tilt
Spilling	Flat	1.2	<30°
Plunging	Medium	0.9	30° to 45°
Collapsing	Steep	0.8	>45°
Surging	Steep	0.0	Near 90°

1.2.3. Breaker Chart

According to Galvin (1968), forty three condition of breaker variables are summarized in Table number 3. The following chart concluded the dominant breaker type as per various breaker type conditions.

Table No. 3:-

Breaker Chart for Dominant Breaker Type (After Galvin1968)

Slope	Depth (cm)	Stroke (cm)	Period (Sec)	Breaker Height (cm)	Dominant Breaker Type
0.05	30.5	4.9	1.00	7.2	1
		9.8	2.00	9.4	3
		19.5	4.00	11.3	2
		24.4	5.00	11.9	2
0.05	38.1	4.9	1.00	7.8	1
		14.6	2.00	13.0	1
		29.3	4.00	17.7	2
		29.3	5.00	15.9	3 and 2
		29.3	6.00	13.6	2 and 3
0.10	22.9	4.9	1.00	6.5	2
		4.9	2.00	6.9	3
		29.3	5.00	11.3	3 and 2
		29.3	6.00	10.1	3
		48.8	6.00	10.1	4
		48.8	7.00	9.7	4
		48.8	8.00	5.7	5
0.10	30.5	4.9	1.00	7.2	3
		4.9	2.00	4.3	3
		14.6	2.00	11.8	2
		29.3	4.00	16.4	6
		29.3	5.00	6.9	5
		48.8	5.00	15.0	3
		48.8	6.00	7.8	5
		48.8	7.00	15.0	4
		48.8	8.00	7.2	5
0.10	38.1	4.9	1.00	7.0	1
		4.9	2.00	4.5	3
		14.6	2.00	9.4	2
		29.3	4.00	14.5	2
0.20	22.9	4.9	1.00	6.2	6
		4.9	2.00	1.5	4
		29.3	6.00	7.9	5
		48.8	6.00	10.7	4
		48.8	8.00	5.7	4
0.20	30.5	4.9	1.00	9.1	6
		4.9	2.00	6.4	4
		29.3	4.00	6.2	5
		29.3	5.00	8.7	5
		48.8	7.00	6.4	5
0.20	38.1	4.9	1.00	9.0	6
		4.9	2.00	6.9	3
		29.3	4.00	14.8	4
		29.3	5.00	14.0	3

***Note:** 1= Spilling; 2 and 3 = Plunging; 4 = Collapsing; 5 = Surging; 6 = Plunging altered by reflected wave (As per serial number of breaking type classification)*

2. Breaker Point (Huntley and Bowmen 1975)

A critical ratio Wave height and water depth is called gamma (γ) which could be quantified by the following formula (4).

Critical Value (γ) $= \frac{H}{d}$ (After Galvin 1972)--------- (4)

Where,
H = Wave Height
d = Depth of water

The Critical Value (γ) varies from 0.6 to 1.2 which related to beach slope (β). According to Huntley and Bowmen (1975), high critical value (γ = 1.2) indicates steep beach and low Critical Value (γ = 0.6) indicates flat beach. In addition, Mean Critical Value (γ = 0.78) associated moderately sloppy beach. Critical value of Digha coast is 1.14 which indicates Digha coast is associated with moderate to steep beach.

3. Breaker Co-efficient (Galvin 1968)

Wave breaking is a dynamic phenomenon. According to Galvin (1968) breaker is depends on the breaking co-efficient and which is affected by the different characteristics of wave. Galvin propose a breaker co-efficient formula (5) which entertained the entire variables on onshore.

Breaking Co – efficient $(B_b) = \frac{Hb}{g\,ST^2}$ (After Galvin 1968)--------- (5)

Where,
B_b= Breaking Co-efficient on onshore
Hb= Wave height during breaking
g= Gravitational acceleration
S= Beach Slope
T= Wave period

If the breaking co-efficient is >4.8, then it is considered as spilling breaker and most of the wave induced energy dissipated and depositional beach formed. And also if the breaker co-efficient is varies between 4.8 to 0.09 and the plunging breaker formed, beach has become eroded. Breaking co-efficient of Digha coast is 0.00098, breaker type is more surging than plunging.

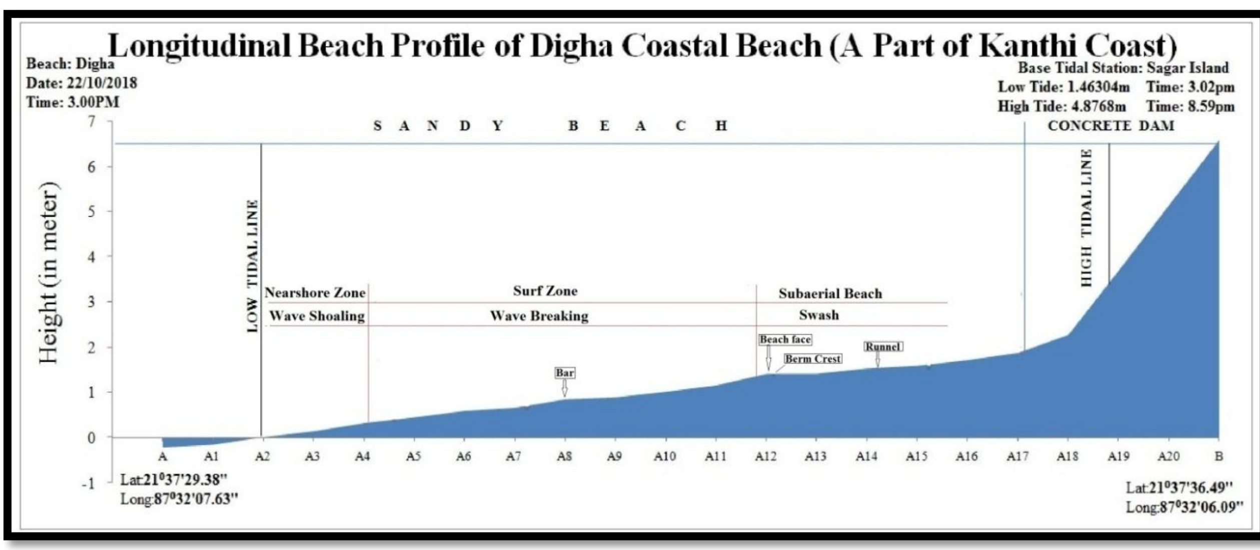

Figure 2 Longitudinal Beach Profile of Digha Coast (A Part of Kanthi Coast) (Dey and Shukla, February 2019)

4. Longitudinal beach Profile Digha

Energy moves towards coastal beach via wave without displacement of water particles. After collapsing of wave, energy flux on beach. Some energy also reflect back to sea on the basis of beach slope after dissipate.

Small gentle waves and swell tend to build up beaches, whereas storm waves tear them down (Paul 2002, p.85). Digha, the open coast receives high proportion of long swell wave (Dey and Shukla 2019b).

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Wave approaching the shore in the southerly and easterly wind, have longer fetch (500-900 km) than the approaching waves in the southwesterly wind, which have comparatively a shorter fetch (250-400 km) in the coast of West Bengal (Paul 2002, p.86). It has been generally recognized that Breaker type depends on wave steepness and beach slope (Galvin 1968). Thus, the beach longitudinal profile (Figure No. 2) is very important to quantify the breaker type.

5. Relation between Wave Breaker Type and Longitudinal Beach Profile

The location and consequences of wave breaking is controlled initially by the incident wave height and length, but it is also affected by the form and slope of the nearshore and beach foreshore (Robin Davidson-Arnott 2010, p.92). Three beach conditions have been recognized.

Table No. 4
Relation between Wave Breaker Type and Longitudinal Beach Profile

Sl. No.	Type of Beach	Beach Slope	Breaker Type	Beach Characteristics	Wave Breaking Characteristics
1.	Dissipative Beach	Gently Slopping Beach	Spilling Breaker	i. Wave energy level is usually high. ii. Sediments are fine. iii. Surf zone is wide. iv. Subdued bar morphology may be present but rips are not found.	i. Wave breaking occurs from some distance of the offshore. ii. Breaker zone and the surf zone are situated between the line of first breaking and the beach. iii. Wave energy is dissipated during the initial breaking phase or in turbulence at the crest of surf bores progressing through the surf zone. Further dissipation of wave energy takes place during run-up on the beach tract.
2.	Intermediate Beach	Moderately Slopping Beach	Plunging Breaker	i. Bar and Rip morphology consist. ii. Four different intermediate beach states are determined and with increasing Ω. these are – a. Low Tide Terrace (LTT) b. Transverse Bar and Rip (TBR) c. Rhythmic Bar and Beach (RBB) d. Longshore Bar Trough (LBT)	i. Low to moderate waves breaking on the steep swash slope and berm. ii. Wave breaking occurs at the toe of the beach. iii. Wave energy is dissipated in turbulence.
3.	Reflective Beach	Very Steep Shoreline	Plunging to Surging Breaker	i. Beachface is steep. ii. Beach cusped found. iii. The pronounced step is a presence at the base of the Swash Zone. iv. Wave height is small. v. Nearshore deep water. vi. Beach sediment relatively coarse.	i. Waves are reflected without breaking from the cliff shore. ii. Wave energy may be dissipated, if the wave breaks. iii. Due to wave breaking, splash and spray occurs and reaching high into the air.

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5.1. Surf Scalling Factor (Guza and Bowen 1975)

Surf scalling factor indicates a relationship between beach and wave energy. Although, quantifying the wave energy dissipation or reflection from the beach under different breaker type. According to Guza and Bowen (1975), the surf scalling factor has been measured by the following formula (6).

Surf Scalling Factor (ϵ) $= \frac{a\,2\Pi}{g\,T\,tan^2\,\beta}$ (After Guza and Bowen 1975)--------- (6)

Where,
a = Wave Amplitude
Π = 3.14
g = Gravitational acceleration
T = Wave period
β = Beach Slope

Table No. 5
Ranges of Surf Scalling Factor

Sl. No.	Breaker Type	Surf Scalling Factor	Wave Energy
1.	Plunging to Surging Breaker or Surging Breaker	<2.5	Large proportion of incident wave energy is reflected from the beach.
2.	Plunging Breaker	2.5 - 33	Wave break down on steep swash slope.
3.	Spilling Breaker	>33	Most of the wave energy dissipated at the surf zone.

Surf Scalling Factor of Digha coast is 28.56 which concluded that the wave break down on steep swash slope as plunging breaker.

5.2. Phase of Differences (Kemp 1975)

Kemp (1975) researched on the interaction between breakers and the shorewards of the break-point flow which may predicts the breaker type. This duration of onshore water movement caused by a single wave, lasting from the moment of breaking until the furthest point that the water moves up-beach, Kemp called the run-up (Pethick 1984 p.29).

The phase of difference (P) is the ratio of run-up duration to wave period.

Phase of Differences (P) $= \frac{t}{T}$ (After Kemp 1975)--- -- (7)

Where,
t = Duration of the onshore water movement
T = Wave period

Table No. 6
Ranges of Phase of Difference

Sl. No.	Breaker Type	Phase of Difference	No. of Wave Contain
1	Plunging to Surging Breaker or Surging Breaker	<0.5	One breaker
2	Plunging Breaker	0.5 -1.0	Below 10 breaker
3	Spilling Breaker	>1.0	10 to 20 surfing breaker

Wave period of Digha coast is 8.11 second and duration of the onshore water movement is 10.46 seconds. Thus, the phase of difference of Digha coast is quantified as 0.78 which indicates to Plunging type breaker.

5.3. Breaker Type Transition

Comparison between measures to evacuate the breaker type and indicates the transitional values between each other in table number 7.

Table No. 7
Comparison of Breaker Co-efficient on Onshore

Theory	Breaker Type Transition on Onshore (H_b)	
	Surging to Plunging	Plunging to Spilling
Breaker Coefficient	0.003	0.068
Surf Scalling Factor	2.5	33
Phase Difference	0.5	1.0

V. Conclusion

Beach slope of Digha coast is moderate. It is concave and planar in outline and geometry (Dey and Shukla March 2019a). Beachface is s moderate top steep. Based on the ratio between RTR and dimensionless fall velocity, the Digha coastal beach is considered as 'low tide bar/rip intermediate type' (Dey and Shukla March 2019a). From the above discussion it has been revealed that in Digha wave breaker type is considered as surging to plunging. As the energy of both tide and wave is high, the coastal beach is highly unstable (Dey and Shukla March 2019a). During high tide waves are reflected without breaking from the concrete embankment. Wave energy may be dissipated, if the wave breaks during low tide of sand coastal beach. Due to wave breaking, splash and spray occurs and reaching high into the air near the concrete embankment.

REFERENCES

[1] Acharyya, S.K., et al., (2000): Arsenic toxicity of ground water in parts of the Bengal basin in India and Bangladesh: the role of Quaternary Stratigraphy and Holocene sea-level fluctuation, Environmental Geology, vol. 39, Iss. 10, 1127-1137.

[2] Alam, M., et al., (2003): An overview of the sedimentary geology of the Bengal basin in relation to the regional tectonic framework and basin-fill history, Sedimentary Geology, vol. 155, Iss.3, 179-208.

[3] Banerji, R.K., (1984): Post-Eocene biofacies, palaeoenvironments and palaeogeography of the Bengal basin, India; Palaeogeography, Palaeoclimatology, Palaeocology, vol. 45, Iss. 1, 49-73.

[4] Davidson-Arnott, R. (2010): Introduction to Coastal Processes and Geomorphology; Cambridge University press; New York.

[5] Dean, R. G. and Dalrymple, R. A., (1991): Water Wave Mechanics for Engineers and Scientists, World Scientific Publishing Co., Singapore.

[6] Dey, N. and Shukla, P. (February 2019): Sedimentary textural characteristics of Digha coastal beach, a part of Kanthi coast, W.B., India; International Journal of Recent Development in Engineering and Technology, vol. 8, Iss. 2, pp. 1-8.

[7] Dey, N., Shukla, P. (March 2019a): Effects of Tidal Range on the Digha Coast: A Geomorphological Investigation, Indian Journal of Spatial Science, Vol. 10, Issue. 1, pp. 79-86.

[8] Dey, N., Shukla, P. (March 2019b): Wave Statistics of Digha Coast and Beach Profile, West Bengal, India; International Journal of Recent Development in Engineering and Technology, Vol. 8, Issue. 3, pp. 1-7.

[9] Dey, N., Shukla, P., (2017): Physical carrying capacity assessment in coastal tourist destination – a case study in igha, West Bengal; Economic Development & Environment (Edited book Volume), Vasundhara Publication, Gorakhpur, 102-106.

[10] Faizal, M. et al. (2011): Experimental Investigation of Water Wave Characteristics in a Wave Channel, International Journal of Fluid Mechanics Research

[11] Galvin, C.J. Jr. (1968): Breaker Type Classification on Three Laboratory Beaches, Journal of Geophysical Research, vol. 73, Iss. 12, pp. 3651-3659.

[12] Goodbred, S.L., Kuehl, S.A., (2000): The significance of large sediment supply, active tectonism, and eustasy on margin sequence development: Late Quaternary stratigraphy and evolution of the Ganges-Brahmaputra delta, Sedimentary Geology, vol. 133, Iss. 3, 227-248.

[13] Hutchison, C.S., (1989): Geological Evolution of South-east Asia; Oxford: Clarendon Press, vol. 13, p. 368.

[14] Ippen, A. T., and Kulin, G. (1955): Shoaling and breaking characteristics of the solitary wave, MIT Hydrodyn. Lab. Tech. Rept. vol. 15.

[15] Iversen, H. W., (1953): Waves and breakers in shoaling water, Proc. 3rd Con/. Coastal Eng., vol. 1.

[16] Jana, S., Paul, A.K., (2018): Genetical Classification of Deltaic and Non Deltaic Sequences of Landforms of Subarnarekha Middle Course and Lower Course Sections in Odisha and Parts of West Bengal with Application of Geospatial Technology, Journal of Coastal Sciences, vol. 5, Iss.1, 16-26.

[17] Janssen, P., (2004): The Interaction of Ocean Waves and Wind, Cambridge Univ. Press, Cambridge, UK.

[18] Komar, P.D. (1976): Beach Processes and Sedimentation, Englewood Cliffs, Nj: Prentice-Hall.

[19] Mondal, C., Dey, N., (2018): Carrying capacity assessment in coastal tourism center: a case study in Digha, West Bengal; Sustainable Development: A Dynamic Perspective (Edited Book Volume), Anjan Publisher, Kolkata, vol. 1, 175-182.

[20] Morley, C.K., (2002): A tectonic model for the Tertiary evolution of strike-slip faults and rift basins in SE Asia, Tectonophysics, vol. 347, Iss.4, 189-215.

[21] Mukherjee, A., et al., (2009): Geologic, geomorphic and hydrologic framework and evolution of Bengal basin, India and Bangladesh; Journal of Asian Earth Sciences, vol. 34, Iss.3, pp. 227-244.

[22] Patrick, D. A., and Wiegel, R. L. (1954): Amphibian tractors in the surf, Con•. Ships Waves, vol. 1, p. 397.
[23] Paul, A., (2002): Coastal Geomorphology and Environment. ACB Publications, Kolkata.
[24] Pethick, J., (1984): An Introduction to Coastal Geomorphology, Edward Arnold, London.
[25] Sikder, A.M., Alam, M.M., (2003): 2-D modelling of the anticlinal structures and structural development of the eastern fold belt of the Bengal Basin, Bangladesh; Sedimentary Geology, vol. 155, Iss.3, 209-226.
[26] Street, 1•. L., and F. E. Camfield, Observations and experiments on solitary wave deformations, Tech. Note 85(1)-66 Stan/ord Univ. Dept. o• Civil Eng., 10 pp., 1966.
[27] U.S. Navy Hydrographic Office, (1944): Breakers and surf: Principlesi n forecasting H . O. Publ. vol. 1, p. 234.
[28] Wiegel, R. L., (1964): Oceanographical Engineering, Prentice-Hall, Englewood Cliffs, N.J., p. 532.