Response to Referee reports for ESurf-2021-71

R#: Referee number (1 or 2); C#: Comment/Response number; A: Authors' response.

Line number in **Original MS** : OL #

Line number in **Marked copy** : ML #

General Comments from Referee 1 and authors' response

This paper attempted an analytical approach to beach flanking, which had many cases of damage in the east coast of Korea. As noted in the general comment on Referee 1, this analytical approach will also benefit the readers of Earth Surface Dynamics and other coastal engineering journals on studying beach erosion at the downdrift side of structures blocking longshore sediment.

In order to improve the readability of the research that has not been tried much, the paper was improved overall based on the comments of referee 1. These include redundant words/phrases, readability and grammar in English, title of the paper, overall re-organization/revision of the contents, sections and sub-sections, as well as limitation of the proposed approach. And the corrected and supplemented details are in the following answers of specific comments from referee 1.

Specific Comments from Referee 1 and authors' response

R1C1) The current title only partially reflects the contents of the paper, and analysis, results and comparison are loosely spread in various sections and sub-sections. Integration should be considered.

AC1) The paper has been revised with the title and contents as recommended.

Revised title: "Analytical approach for beach flanking downdrift of natural groin induced by winter high waves: Case study of Jeongdongjn in Korea"

Revised contents:

1. Introduction

2. Analytical approach

   2.1 Parabolic bay shape model

   2.2 Downdrift control point

   2.3 Maximum indentation point

3. NOAA's wave data for Jeongdongjin Beach

   3.1 NOAA's wave data (1979 – 2018)

   3.2 Seasonal longshore sediment transport

4. Results and comparison

   4.1 Analytical results versus numerical results

   4.2 Analytical results versus shoreline monitoring results

5. Discussions

6. Concluding Remarks

R1C2) Abstract [OL 9–21]: Text written loosely. Please rewrite. Please also provide keywords.

AC2) The abstract of the paper was compactly supplemented, and the contents and limitations of the entire approach were rewritten in the abstract. The amended contents are as follows.

[ML 11–21] Beach erosion at the unprotected downdrift end of a seawall or revetment is common and the same can be found at a groin, when oblique waves approach these structures. This phenomenon, known as beach flanking, has often occurred at downdrift of natural groin on the east coast of South Korea during high waves in winter months. The resulting planform assumes a distinctive crenulate shape with a maximum indentation point within the eroded shoreline. Analytical approach is employed to study the beach erosion at downdrift end of a natural rocky groin on Jeongdongjin Beach in Korea, using mathematical equations derived from the parabolic model for headland-bay beaches in static equilibrium, to predict the downdrift control point and maximum indentation of the eroded shoreline planform. NOAA's wave data over 40 years are used to determine the prevailing wave height, wave angle at breaking, wave direction and longshore sediment transport rate to solve the equations. Location of the calculated maximum indentation is verified using shoreline video monitoring data, and its spatial and temporal change is also compared with the result of one-line numerical model for shoreline change. Limitation of the proposed analytical approach for Jeongdongjin Beach is discussed, as well as the effect of sediment bypassing the groin.

[ML 23] Keywords: Beach flanking, Analytical approach, Parabolic model, Maximum indentation point, Shoreline video monitoring.

R1C3-1) 1. Introduction [OL 23–78]

Please define "beach flanking" at the beginning of the Introduction and describe the effect of groin on sediment transport.

Please describe methods and/or models (numerical etc.) for analyzing beach erosion, and show references.

Please replace "sagging" by an appropriate word throughout.

AC3-1) First of all, I modified the term "beach flanking" rather than "sagging" as a whole. The term "beach flanking" was cited as a term expressed by Balaji et al. (2017), who attempted a similar study. And at the beginning of the introduction, the terminology "beach flanking" was explained, and methods for analyzing beach erosion (include the effect of groin on sediment transport) was also described. The amended contents are as follows.

[ML 25–38] Beach erosion at the downdrift end of a shore-based coastal structure (e.g., seawall and groin) is common, but rarely being taught in the classrooms nor well documented in the literature. This phenomenon is known as beach flanking, which results in localized eroding beach in crenulate shape. Looking at the history of shore protection, seawalls of vertical or sloping (revetments) have been used for many decades as a purported protection in an erosion situation. It is however unfortunate that they have often promoted further erosion, not only the beach in front of them receding to the point of being non-existence, due to partial standing and reflecting waves, but also short-crested system when waves approach obliquely which accelerates sediment removal to downdrift coast. Consequently, immediately at the unprotected downdrift end of seawalls, erosion occurs, promoting by the action of diffraction-refraction and nearshore currents to remove sediment away and produced a seaward-concave shoreline planform (e.g., Kraus and McDougal, 1996). On the other hand, groins have been installed in England since the 16th century. They are structures of moderate dimension which run from the beach into the sea. The structures are generally at right angles to the shoreline, inclined or in complex form in more recent time. The purpose of installing groins is to intercept and accumulate sediment on the updrift side, during periods of oblique persistent swell. Whilst the sediment being accreted, the beach downdrift of these structures will suffer erosion. Only after the updrift shoreline has built up to the tip (head) of a groin, or nearly so, sediment will again be fed to the downdrift side, to recover the receded shoreline.

R1C3-2) [OL 23] "… the eastern coast of …" → "… the east coast of …"?

[OL 31] "… a group of natural (pillar) rocks…" → "…a cluster of natural pillar rocks…"

[OL 44] "…for project planning." → "…for project planning (USACE, 2002)"

[OL 54] "…sagging shape…" → "…crenulate shape…"

AC3-2) We modified it to the term recommended.

[ML 39] "… the east coast of …"?

[ML 46] "…a cluster of natural pillar rocks…"

[ML 77] "…for project planning (USACE, 2002)"

[ML 56] "…crenulate shape…"

R1C3-3) [OL 36] "Many studies….". Please provide references.

AC3-3) References related to the study of the negative effects of beach erosion at downdrift of groins were added.

[ML 48-49] Beach erosion at downdrift of groins (Fig. 2) and their negative impact on downdrift beach has been well understood (Lehnfelt and Svendaen, 1958; Bakker, 1968, Bakker et al., 1970; Price and Tomlinson, 1970; Magoon and Edge, 1978; Headland et al., 2000; USACE, 2002).

R1C3-4) [OL 42] "the LST becomes static to maintain the shoreline planform…". Is "becomes static" correct?

AC3-4) The content that was intended to be delivered was delivered incorrectly. So we modified it as follow.

[ML 74-75] When this condition is reached, LST is not required to maintain the shoreline stability within an embayment under the same predominant wave direction (Hsu et al., 2000).

R1C3-5) [OL 47] "To reproduce the shapes of shorelines in the laboratory," → please revise.

AC3-5) The content that was intended to be delivered was delivered incorrectly. So we modified it as follow.

[ML 50-52] Badei (1994) conducted laboratory experiments to reproduce the shoreline planform and topographic changes, while Wang and Kraus (2004) performed tests on erosion without longshore sediment transport (LST).

R1C3-6) [OL 56] "High resolution numerical models…". High resolution?

AC3-6) The content that was intended to be delivered was delivered incorrectly. So we modified it as follow.

[ML 80-81] … ,supported by numerical models (e.g., Xbeach and Sbeach) that include waves, currents and topographic changes.

R1C3-7) [OL 58–59] "These laboratory experiments … contributed to solving scientific equations about erosion by providing a similar sagging shape." What do you want to say? Please revise.

[L60] "… still lack reliable factor analysis." What is 'factor analysis'? Is this a proper technical term?

AC3-7) The content that was intended to be delivered was delivered incorrectly. So we deleted it.

R1C3-8) [OL 61] “This study developed a theoretical approach, …”. Past tense? ‘develop’?

[OL 61–64] Please use verbs in present tense.

[OL 64–65] “…formed frequently…”?, “…a group of…”?

[OL 61–78] “theoretical approach”, “theoretical analysis” and “theoretical solutions” etc. → Use “analytical approach”, “analysis” and “analytical solutions”?

Please avoid repeating the use of some expressions, such as “Section 2.…” at the beginning of a sentence or “…in Section X.” at the end of a sentence.

[OL 77] “… through a theoretical formula that facilitates factor analysis.”?? Please revise/clarify.

AC3-7) The parts of the introduction were somewhat ambiguous, so it was supplemented as a whole. The amended contents are as follows.

[ML 82-97] The aims of this paper are threefold, (1) to study the beach flanking at Jeongdongjin Beach in Korea (Figs. 1b and 3), (2) to demonstrate the applicability of an analytical approach derived from the parabolic model, and (3) to develop mathematical equations for calculating the most critical point (i.e., maximum indentation) in the eroded crenulate shape. To solve these equations, NOAA’s wave data over 40 years are used to determine the prevailing wave heights and directions in winter months to Jeongdongjin Beach, where a cluster of natural pillar rocks protruding into the sea behaving like a groin. The analytical results calculated are then validated by comparing with the results from the monitoring video images and the numerical model of shoreline change.

In addition to the introduction given in section 1, section 2 in this paper describes the analytical approach using the parabolic bay shape model (Hsu and Evans, 1989) in static equilibrium, from which mathematical equations are derived for the downdrift control point and the maximum indentation of the eroded beach. Analysis of NOAA’s wave data over 40 years is presented in section 3.1 to provide averaged wave heights and wave angles at breaking points as input to the mathematical equations derived in sections 2.2 and 2.3, as well as the seasonal longshore sediment transport rate (section 3.2) for one-line shoreline change model (section 4.1). The analytical results calculated for the maximum indentation point are then compared with the results of numerical method applying one-line shoreline change (section 4.1) and that from shoreline video monitoring program for Jeongdongjin Beach (section 4.2). Finally, discussions on the limitation of the proposed analytical approach and effect of sediment bypassing are given in Section 5. Concluding remark is given in Section 6.

R1C4-1) 2. Analysis of seasonal incidence waves [OL 79] → please change section heading.

AC4-1) The title of the section heading was specifically modified as follow.

Revised contents: “NOAA’s Wave Data for Jeongdongjin Beach”

R1C4-2) 2.1 Analysis of NOAA data [OL 80–99] >>> Relocate this section to new Sect. 3.1?

AC4-2) That section was relocated to new Sect. 3.1.

R1C4-3) [OL 86; OL 97; OL 99] “eastern coast” → “east coast”?

AC4-3) We modified it to the term recommended.

R1C4-4) [OL 88] “…cause by the energy of the oblique high waves.”? Please revise.

AC4-4) The content that was intended to be delivered was delivered incorrectly. So we modified it as follow.

[ML 254-255] The wave data are analyzed and the results used to calculate the change of the eroding shoreline curve at downdrift of the natural rocky groin caused by the oblique high waves in the winter.

R1C4-5) [OL 95–96] "…Average over 10 year-intervals..." → "…Averaged over every 10- year period…"?

[OL 97–98] "…local shoreline orientation in Gangwon-do was approximately N43°E." → "…local shoreline orientation at Jeongdongjin is in WN to SE direction, or N133°E."?

AC4-3) We modified it to the term recommended.

[ML 261-262] … averaged over every 10-year intervals …

[ML 263-264] … and the local shoreline aligns in NW – SE direction (about N133°E).

R1C5-1) 2.2 Analysis of seasonal longshore sediment transport [OL100–160] >>> Relocate entire section to new Sect. 3.2?

AC5-1) That section was relocated to new Sect. 3.2.

R1C5-2) [OL 101–146] All "Q_y", "P_y", "I_y" → "Q_l", "P_l", "I_l"? because subscript "y" is not defined, while subscript "l" is the most used term in textbook.

All the "sin" and "cos" should not be italicized.

[L118] "…the isobath of the seabed…" → "… seabed contours…"?

AC5-2) We modified it to the term recommended.

R1C5-2) [OL 121] How to derive Eq. (5), reference?

AC5-2) Eq. (5) is derived using longshore sediment transport equation (see the book of Dean and Dalrymple (2001) : Coastal Processes with Engineering Applications, "Littoral Drfit Compuations based on Deep Water Data" parts) and is not cited separately.

R1C5-3) [OL133–138] Paragraph and the original Fig. 5 may be deleted?

AC5-3) The content was unnecessary, so we deleted it.

R1C5-4) [OL 151–152] "…high waves in winter… arrives from…N38°E-2.5° to N38°E +7.5°" >> but α_b = 10° is used in Figs. 16 and 20, Why?

AC5-4) The results of wave direction was obtained by analyzing NOAA data. However, in the period of severe erosion damage in Jeongdongjin Beach, waves entering with a larger oblique angle were incidenced so α=10 ° was applied.

R1C6-1) 3. Parabolic bay shape equation [L164–180] >>> Renumbered as new Sect. 2.1?

AC6-1) That section was relocated to new Sect. 2.1.

R1C6-2) [OL 165] "… is provided by…" → "…defines the location of a point P (R, θ) on an embayed beach in static equilibrium by…"

AC6-2) We modified it as follow.

[ML 106-107] The parabolic bay shape equation (PBSE; Hsu and Evans, 1989) defines the location of a point P (θ, R) on an embayed beach in static equilibrium by

R1C6-3) [OL 166–180] All the "sin" and "cos" should not be italicized.

[OL 169] "…between the wave crest line (wave crest base line) and the line that passes through the …parallel to the shore base line" → "… between the wave crest base line (at the focus) and the tangential line at …on the shore base line;"

[OL 173] "…= 0 is satisfied to endure…" → "…= 1.0 (unity) to ensure…"

AC6-3) We modified it to the term recommended (ML 113, 117).

[L180] Eq. (9). Please show key interim steps that lead to this equation.

AC6-4) We modified the equation as follows: $\alpha_b(\theta) = \tan^{-1}\left(\frac{dy}{dx}\right) = \tan^{-1}\left(\frac{\sin\theta - \theta\cos\theta}{\cos\theta + \theta\sin\theta}\right)$

R1C7-1) 4. Analysis of shoreline change caused by oblique waves [L184–242] >>> Please re-number the section and change the heading as new Sect. 2.1 and Sect. 2.2

AC7-1) That section was relocated to new Sect. 2.1 and Sect. 2.2.

R1C7-2) [OL 199] Pease show interim steps leading to Eq. (10).

AC7-2) Eq. (10) was derived by comparing the longshore sediment transport rate and the amount of shoreline change on a surface area. We added the interim step of equation as follows: $\frac{Q_l t}{(h_c + h_B)} = \frac{x_c^2 \tan\alpha_b}{2}$

R1C7-3) [OL 199–237] All the "sin", "cos" and "cot" should not be italicized.

[L200–201] Unit "m3" and "m2" → superscript "m3" and "m2"

[L204] "Additionally, the time to reach static equilibrium, t1/2, when xc= L/2, is provided by" → "When static equilibrium is reached for xc= L/2, the time".

AC7-3) We modified it to the expression recommended (ML 168)

R1C7-4) [OL 206] "… wave power decreases…"??

AC7-4) We modified it to the term as follow: LST (ML 172)

R1C7-5) [OL 210] Please show key interim steps leading to Eq. (13).

AC7-5) We added the interim step of equation as follows: $\frac{y_{\pi/2}}{y_g} \cong \frac{y_g - R(\pi/2)}{y_g} = 1 - \frac{2}{\pi}\frac{\beta}{\sin\beta}$

R1C7-6) [OL 223–224] Please show key interim steps leading to Eqs. (14a) and (14b).

AC7-5) We added the interim step of equation as follows.

$x_E = R(\theta)\sin(\varphi) = R(\theta)\sin\left(\frac{\pi}{2} + \alpha_b - \theta\right)$ / $y_E = y_g - R(\theta)\cos(\varphi) = y_g - R(\theta)\cos\left(\frac{\pi}{2} + \alpha_b - \theta\right)$

R1C7-7) [OL 241–242] Please consider to replot Fig. 14 using "α " values of 0o, 2.5o, 5o, 7.5o, 10o, 15o and 20o, for better viewing and manual application.

AC7-7) We modified the figure as recommended.

R1C8-1) 5. Results of comparison with numerical model [OL 243–272] >>> Re-number section as new Sect. 4 and also change section heading as: Results and comparison

5.1 Shoreline change model [OL 244–256] >>> First part in new Sect. 4.1: Analytical results with numerical results

AC8-1) That section was relocated to new Sect. 4 and Sect. 4.1.

R1C8-2) [OL 245–247] "…for the shoreline change model…sediment transport. It determines the shoreline change due to the difference in the LST along the coast within the active zone between the…" → "… for shoreline change…within a control volume due to the difference in LST across the active beach zone from berm…"

AC8-2) We modified it as follow.

[ML 355-357] The governing equation for shoreline change model (Pelnard–Considère, 1956) is a mass conservation equation of sediment transport. It determines the shoreline change due to the difference in the LST along the coast within the active zone between the berm and the depth of closure,

R1C8-3) [OL 248 Eq. 20; OL 250; OL 253 Eq. 21; OL255] Replace all four "Q_y " by "Q_l", to be consistent with the LST in the existing Sect. 2.2 (or new Sect. 3.2)?

AC8-3) We modified it to the expression recommended.

R1C8-4) [OL255–256] "…, we calculated or assigned the quantity of the LST at each grid. For example, we used Q_y = 0 for the eroding shoreline along the boundary of the groyne." → "…, the quantity of LST at each grid is calculated or assigned. For example, Q" = 0 is assigned along the updrift groin where shoreline is receding."

AC8-4) We modified it as follow.

[ML 369-371] In the numerical calculations, the quantity of the LST at each grid is calculated or assigned. For example, $Q_l = 0$ is used for the eroding shoreline along the boundary of the groin.

R1C9-1) 5.2 Comparison between theoretical and numerical results [OL257–272] >>> Second part in new Sect. 4.1: Analytical results with numerical results

AC9-1) That section was relocated to new Sect. 4.1.

R1C9-2) [OL 269] "…gives x_c= -32.5 m, …" → "… gives y_E= - 32.5 m, …"?

AC9-2) We modified it as y_E= - 32.5 m (ML 387)

R1C9-3) [OL 270–272, Fig. 16] Replace the "Offshore (m)" on the ordinate by "Cross-shore (m)"

AC9-3) We modified the figure as recommended (Fig. 18).

R1C10-1) 6. Results of comparison with Jeongdongjin monitoring data [OL 273–317] >>> Renumber Sect. and heading as in new Sect. 4.2: Analytical results versus shoreline monitoring results

AC10-1) That section was relocated to new Sect. 4.2.

R1C10-2) [OL 274–276] "As shown in Fig. 17, where … to September 27th, 2013 to November 21st, 2016." >>> to be relocated after the new Fig. 10 at the end of new Sect. 3.1, and the two original sentences are revised as "Nearshore wave data were collected by an AWAC wave meter at a depth of 32.4 m to the south of Jeongdongjin Beach. From the data recorded over three years (27 September 2013 to 21 November 2016), the distribution of the annual mean wave direction is plotted (Fig. 11). As shown in Fig. 11, the prevailing wave direction was within -15° and +10° from the normal to the shoreline."

[OL 282–283] Original Fig. 17 to be re-numbered as new Fig. 9 and relocated under new Sect. 3.1.

AC10-2) We relocated the original Fig. 17 to Sect. 3 and Fig. 18 to Sect 3.1. And it has been modified as follows:

[ML 271-272] Nearshore wave data were also collected by an AWAC wave meter (Fig. 10) at a depth of 32.4 m to the south of Jeongdongjin Beach. From the data recorded over three years (27 September 2013 to 21 November 2016), distribution of the annual mean wave direction is plotted (Fig. 12). The results reveal the prevailing wave direction was mostly within -15o to +10o from the normal to the shoreline.

In addition, the relocated figure is attached below.

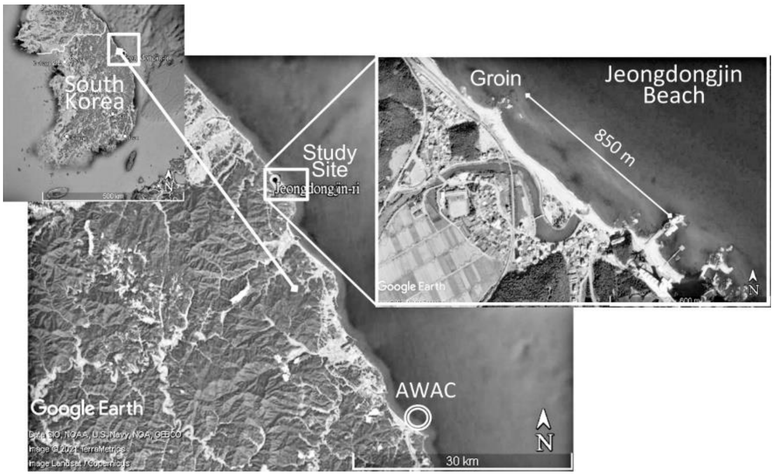

Fig. 10. Location of Jeongdongjin Beach in Gangwon-do on the east coast of South Korea. (Image from Google Earth)

R1C10-3) [OL 276–281] "As the distribution of the annual …obtaining fairly similar results." >> Suggestion: Please delete this part, as it may be irrelevant.

[OL 283–284] Original Fig. 18: The shoreline with gama-groin and legend may be deleted and just retain the little plot (called new Fig. 11) that shows the 'Distribution of the annual mean wave direction'.

[OL 285–286] Figure caption for the original Fig. 18 may be revised as:

"Fig. 11: Distribution of annual mean wave direction obtained from AWAC meter during 2013 – 2016."

AC10-3) We deleted the figure of gamma-groin as recommended. In addition, the relocated and modified figure is attached below.

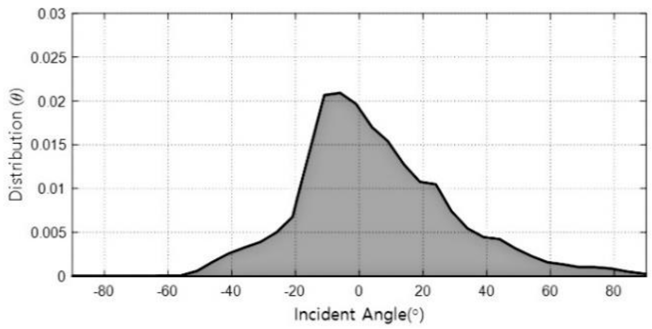

Fig. 12. Distribution of the mean wave direction collected by an AWAC meter near Jeongdongjin Beach.

R1C10-4) [OL 287–290] "Shoreline monitoring in Korea…Project. The survey as also conducted to promote…based on scientific data accumulation and analysis; at Jeongdongjin, a video monitoring program that used four cameras…, covering 3,280 m (97.3%) of the total shoreline within a total of 3,370 m (Fig. 19)" → "Shoreline monitoring in Korea…Project, aiming to promote…, based on data collection and analysis. At Jeongdongjin, a video monitoring program employing four cameras…, which covers 3,280 m (97.3%) of a total of shoreline about 3,370 m (Fig. 18)."

Question: Are the values of "3,280 m" and "3,370 m" correct??

Please double check the correctness of the length of shoreline cited in the original MS [OL290], because the length of Jeongdongjin Beach is only about 800 m (see [OL330] in the original MS).

AC10-4) The total length of the Jeongdongjin's littoral cell is 3,370 m. Among them, 3,270 m of shores are covered by camera monitoring. The length of Jeongdongjin Beach is about 850 m. However, including the natural rocks, the lottoral cell on the north side was also included for monitoring, so it was mentioned to total 3,370 m. The content that was intended to be delivered was delivered incorrectly. So we modified it as follow.

[ML 397-398] At Jeongdongjin, the video monitoring program has commenced since February 2014, by installing four cameras to cover 3,280 m, which is the part (97.3 %) of the total littoral cell of 3,370 m including the northern part of the natural rocks (Fig. 19).

R1C10-5) [OL 293] "the continuously changing shoreline…" → "the spatial and temporal change in shoreline…"

AC10-5) We modified it as follow.

[ML 405] In this study, the variation of shoreline caused by the seasonal waves…

R1C10-6) [OL 295–303] Delete four "we"s in "we divided…", "we determined…", "we applied…" and 'we analyzed…"

[OL 294–296] "images, we divided the accumulative sum…every pixel by the number of captured images, from which we determined the coordinates…and changing shoreline.” → “images, the cumulative sum…of every pixel is divided by the number of the images captured, to determine the coordinates… and changing shoreline.”

[OL 297] “image, we applied the geometric transformation equation of Lippmann and Holman (1989), which transforms…” → “image, the geometric transformation equation given by Lippmann and Holman (1989) is applied to transform…”

AC10-6) We modified it as follow.

[ML 406-408] To extract the average pixel value from the images, the cumulative sum of the attribute values of every pixel is divided by the total number of the images, from which the coordinates of the ground control points and the shoreline changes are assessed. The plane coordinate for the shoreline image is then rectified applying the geometric transformation equation (Lippmann and Holman, 1989), which transforms the image coordinates to ground coordinates as follows,

R1C10-7) [OL 299] The two “tan”s in Eq. (22a) should not be italicized.

AC10-7) We modified it as recommended.

R1C10-8) [OL 303–304] “By using this method, we analyzed the images of critical points taken twice a day from December 6 – 30, 2015, at Jeongdongjin Beach, as shown in Fig. 20, and compared them with the theoretical solution.” → “Images of the critical points that were taken twice daily on Jeongdongjin Beach during December 6 – 30, 2015 are analyzed and compared with the analytical solution, as marked in Fig. 20.”

AC10-8) We modified it as follow.

[ML 417-419] The video images were taken twice a day during December 6 – 30 in 2015, as shown in Fig. 20, and compared with analytical solution.

R1C10-9) [OL 307–308] “…, our results of the video…with those of the theoretical solution for the…) that used the PBSE approximation,…” → “…, the results of video…with that of the analytical solution for the…) predicted by the analytical approach, …”

AC10-9) We modified it as recommended (ML 421-422).

R1C10-10) [OL 309–311] “…video monitoring data… in November and December 2015, while we obtained the theoretical results from the analysis of the NOAA wave data within the same period of time.” → “…video monitoring data … in December 2015, while the analytical results are calculated applying the NOAA wave data within the same period.”

AC10-10) We modified it as follow.

[ML 421-422] In this figure, video monitoring data indicate the location of the critical points caused by seasonal oblique high waves in November and December in 2015, whilst the analytical results are obtained from the analysis of the NOAA wave data within the same period of the time.

R1C11-1) 6. Results of comparison with Jeongdongjin monitoring data [OL 318–333]

[OL 318–333] Please relocate this part to new Sect. 5: Discussions (1)

AC11-1) That section was relocated to new Sect. 5: Discussions (1).

R1C11-2) [OL 318] "Because our results exclude shoreline retreat because of cross-shore sediment transport, the theoretical solution…" → "Due to cross-shore sediment transport is excluded in the present study, the analytical solution…"

AC11-2) We modified it as follow.

[ML 443-444] Because the results presented in this study exclude the shoreline retreat due to cross-shore sediment movement, the analytical results for the maximum indentation from Eqs. (10a) and (10b) with LST might be underestimated.

R1C11-3) [OL 319–320] "…, both theoretical equations neglect…." → "…, the mathematical equations (i.e., Eqs. (22a) –(22b)) neglect…"

[OL 323] Eq. (23): "tan" should not be italicized.

AC11-3) We modified it as recommended (ML 445, 449).

R1C11-4) [OL 324–325] "Here, the subscript 1 denotes the limiting value. Table 2 compares the variables x_c and x_c^l, obtained from …, respectively. If x_c obtained for each α_b is greater than x_c^l obtained a given y_g,"

→ "where subscript l denotes the limiting value. Variables x_c and x_c^l, obtained from …, respectively, are compared in Table 2. If x_c for each α_b is greater than x_c^l for a given y_g,"

AC11-4) We modified it as follow.

[ML 451-452] Here, variables x_c and x_c^l, obtained from Eqs. (10a, 10b) and (23), respectively, are compared in Table 2. If x_c obtained for each α_b is greater than x_c^l for a given y_g,

R1C11-5) [OL 327] "…the theoretical solution that the use of α_b = 10° for…" → "…the analytical solution that uses α_b = 10° for…"

AC11-5) We modified it as recommended (ML 454).

R1C12) 7. Discussions [OL 334–350] >>> Renumber this section as new "5. Discussions" [OL 334–350] Please relocate this part to new Sect. 5: Discussions (2)

• Please expand the Discussion section by including description on the limitations of the analytical approach presented in this study, as compared with other known theoretical methods and/or numerical models for predicting shoreline changes!

AC12) That section was relocated to new Sect. 5: Discussions (2).

Limitations: [443-444] Because the results presented in this study exclude the shoreline retreat due to cross-shore sediment movement, the analytical results for the maximum indentation from Eqs. (10a) and (10b) with LST might be underestimated as compared with methods and/or numerical models for predicting shoreline changes.

R1C13) 8. Conclusions [OL 351–376] >>> Renumber as new "6. Concluding remarks" [L351–376] Please revise.

AC13) That section was relocated and revised to new Sect. 6. Concluding remarks.

R1C14) References [OL 387–444]

Please double check the references, and remove redundant list. >>> Please add the following references:

Bakker, W.T., 1968. The influence of longshore variation of the wave height on the littoral current. Report WWK71-19, Ministry of Public Works, The Netherlands.

Balaji, R., Kumar, S.S., Misra, A., 2017. Understanding the effects of seawall construction using a combination of analytical modelling and remote sensing techniques: Case study of Fansa, Gujarat, India. J. Ocean and Climate Systems 8 (3), 153–160.

Ozasa, H., Brampton, A.H., 1980. Mathematical modeling of beaches backed by seawalls. Coastal Eng. 4 (1), 47 –64.

AC14) We double check the references and removed redundant list. And we added the references.