SURFING ENGINEERED BEACHES

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ABSTRACT

This paper discusses how coastal engineering projects may potentially affect the surfability of sandy beaches. The authors offer unique perspective on this subject as experienced coastal scientists, as well as being life-long surfers. The broad class of coastal engineering projects represents a number of human interventions in the coastal system including beach nourishment and coastal structures such as groins, breakwaters and submerged reefs. Emphasis is given to the differentiation of which types of beach restoration activities can affect surfing, how they may impact or potentially improve it, and what can be done to reduce or eliminate its impacts. To lend the audience a basic understanding of how surfing can be impacted by such activities, a brief description of the surfing activity is initially given. On sandy beaches, the profile shape influences the wave breaking characteristics and is highly related to the sediment grain size. Beach nourishments may cause negative impacts on surfing if they significantly modify the beach morphology to beach types less favorable to surfing, or if they cover features that cause the surf break. Beach nourishment may also enhance surfing by changing the beach type-morphology to one more favorable to surfing. Examples of both positive and negative impacts are given. With increased awareness, education and interaction between user-groups, project designers and environmental agencies, potential conflicts between coastal engineering practices and the growing surfing community may be avoided through pro-active coordination.

INTRODUCTION

The broad class of coastal engineering projects represents a number of human interventions in the coastal system including beach nourishment and coastal structures such as groins, breakwaters and submerged reefs. Projects of this nature may come under scrutiny from the surfing community when they are performed in close proximity to local surfing areas. As the surfing community continues to grow, these two worlds come together as beaches regarded as quality surfing spots are often also areas of high erosion and increased wave energy that require some form of coastal protection. The authors provide an overview of related concepts in this paper and offer additional guidance in a more comprehensive paper recently published in the Journal the American Shore & Beach Preservation (Benedet, Pierro and Henriquez 2007).

Since Captain Cook first arrived in the Hawaiian Islands in the late 1700s and witnessed a man riding a wave while standing on a board, surfing has expanded and evolved tremendously. Nowadays, surfing takes place just about anywhere there is a large body of water with surfable waves and continues to grow as a sport, an art and a way of life. Mostly due to their direct contact with nature's force, surfers tend to be more nature-conscious as a group than the overall population. With little more than a surfboard and a bar of wax, surfers tap directly into the natural energy and forces of the ocean though riding waves. They strive to protect surfing and everything that surrounds it such as beach access, surf-break morphology, beach habitats and water quality. As a result, there is a growing list of surfing advocate organizations that promote the protection of beach-ocean resources and access. Of those, Surfrider Foundation is currently the largest, with more than 50,000 members in the United States alone since its inception in 1984. Surfrider and other surfing interest groups have been taking a bigger role in recent years as advocates in helping the rest of the coastal community to recognize local surf spots as valuable resources, whether natural or man-made.

With increasing sea levels and intense urbanization of the coast, coastal communities are facing many challenges in today's world. Overpopulated coastal cities often suffer from accelerated erosion of sandy beaches, either due to natural or anthropogenic causes. Many of the coastal cities that have an active surfing community also have active beach management programs that attempt to maintain beaches for coastal protection and multiple recreational uses. These beach management programs often employ periodic beach nourishment or coastal structures (or a combination of both) to address beach erosion. Objectives are often to either introduce new sand to a sand-starved system, or to maintain existing sand in a given area. Conflicts between coastal engineering activities and the surfing community may arise when coastal engineering projects affect: (1) the morphology of the seabed (which is responsible for the wave breaking characteristics), (2) the nearshore wave climate, or (3) beach habitats/water quality. In this paper, we focus on morphology and wave climate, which directly affect the surf break.

CHARACTERISTIC SURFING WAVES

Surfing terminology and classification of surfing waves as a function of surfer skill have been discussed by Walker (1974), Dally (1990) and Hutt et al. (2001). The common terminology of the different sections of a wave from the surfer's perspective is shown in Figure 1. Surfers with some level of skill will ride the interface between breaking and non-breaking parts of the wave (the wave face) and in the tube. This transition zone between where the unbroken wave crest turns into a broken crest (white water) is often termed "the pocket." The deep section of the pocket, towards the broken wave crest, may be hollow in the case of plunging waves and form a tube (Figure 1). In "the pocket," the face of a wave is strongly curved with the highest slope gradient. Towards the unbroken wave crest, the wave shape is softer with smaller surface gradients and curvature, this part is called "the shoulder" (Figure 1).

Surfable waves gradually break along the wave crest and thus allow "the pocket" to move along the wave crest. Surfers would say that the waves are "peeling" to the side (right or left as seen from the surfer's point of view). How fast the wave peels along the crest greatly determines the surfability and degree of difficulty. By following the peel of the wave to the right or left of the direction of wave propagation, surfers travel at speeds much faster than the wave forward moving speed.

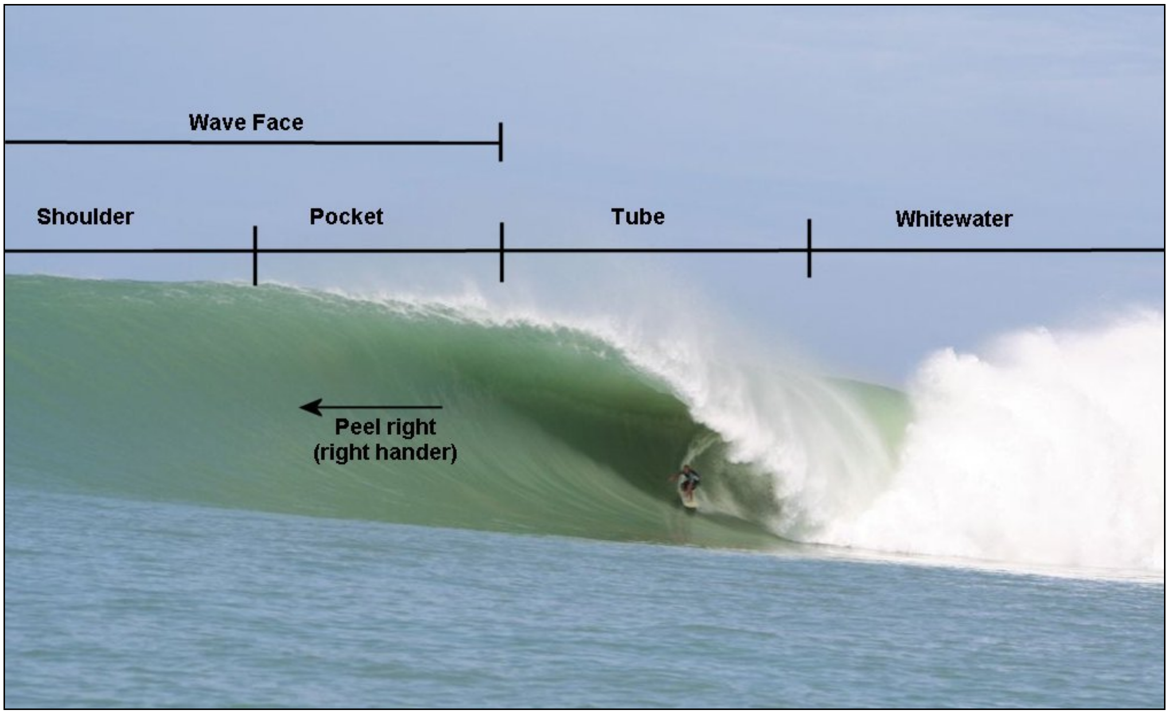

Figure 1. Surfing wave terminology.

The quality of surf breaks within specific regions depends on the seabed slope and morphology, wave height, period and direction, and wind strength and direction. The shape of a breaking wave is of great importance for surfing and breaker type (spilling, plunging, collapsing or surging) is a means of classifying wave shapes during breaking. In addition to breaker type, the main factors used to characterize a surfing wave are breaker height, wave period, peel angle, and to some extent, current velocity. Of course, these parameters are highly influenced by both local and far-field weather conditions, which is why surfers continuously monitor weather conditions, weather maps and global wave model forecasts.

Offshore storms and depressions cause strong winds to blow over a stretch of ocean surface (fetch) for a certain amount of time. Wind energy is transformed into wave energy by the creation of high-frequency waves known as choppy waves. With travel distance, the energy from the high-frequency waves is transferred to lower frequencies, developing swell waves. The combination of these phenomena causes the wave field to "clean-up" as the swells propagate further from the source, which makes for an ideal surfing condition. Clean swell waves that are generated from storms located far offshore travel hundreds to thousands of miles before reaching the local surf break. Waves generated by local winds can also be surfed, which are often referred to "wind-waves" (although the term is employed erroneously because swell waves are also wind waves), or more simply "wind-chop." Examples of sea conditions with swell waves and wind chop are shown in Figure 2.

Figure 2. Low frequency, organized, "clean swell" waves (two images on the top) and high frequency, disorganized "wind chop" waves (lower two images).

The main breaker types are spilling, plunging, collapsing and surging (Galvin 1968). Examples of each type of wave breaker are shown in Figure 3. Spilling breakers occur if the wave crest becomes unstable and flows down the front face of the wave producing a foamy water surface. Surfers would call this condition a "soft" or "mushy" wave. This regime is considered surfable and it is the preferred breaker for beginners. Plunging breakers occur if the crest curls over a steep front face and falls forward into the trough of the wave, resulting in a high splash. Surfers call this a "tubing" or a "hollow" wave. This regime is preferred by most surfers and allows for a range of maneuvers and many styles of surfing. Collapsing breakers occur if the crest remains unbroken and the front face of the wave steepens to the point of collapsing all at once as a very hollow and powerful "close-out" wave that results in an irregular turbulent water surface. Surfers often encounter this regime at reef breaks when the tide is too low and the reef is not submerged enough to produce surfable waves, or at the beach face of very steep beaches. Collapsing breakers are generally not favorable for surfing on surfboards, although some collapsing waves against the beach face are often ridden by bodysurfers and bodyboarders who are able to take advantage of the short ride-length. Surging breakers occur if the crest remains unbroken and the front face of the wave advances up the beach with minor breaking. This regime is unsurfable and occurs at extremely abrupt slopes.

Spilling wave

Plunging wave

Surging/Collapsing wave

Figure 3. Spilling wave (top), plunging wave (middle) and surging/collapsing wave (bottom).

A wide range of wave heights and shapes are suitable for surfing. For a wave to be optimal for surfing, the wave has to break gradually (peel) along the wave crest. When a wave breaks all at once along the crest, the wave is deemed unfavorable for surfing, and is termed a “closeout.” Longboarders (those who ride longer wider boards) can surf spilling waves as small as 0.15 m high, whereas tow-in surfers (those towed into the waves by Personal Water Crafts or PWCs) are able to ride the biggest plunging waves that can be found, some up to 20 m height. In general context, waves between 0.5 m and 10 m are considered surfable. However, most waves surfed in sandy beaches across the U.S. fall within the 0.5 m to 3.0 m range.

BEACH MORPHOLOGY AND SURFABILITY

Surfability of sandy beaches can be directly related to the dominant beach morphological type. Beaches can exhibit a range of morphologies throughout the year given fluctuations in wave conditions and sediment supply. However, most beaches exhibit a dominant beach-bar morphology pattern that makes it more or less favorable to surfing. Beach-bar morphologies influence surf by controlling the wave breaker type and the peel angle, the two most important parameters for surfing.

Wright and Short (1984) and Short (1999) classified different beach types (beach-bar morphologies) in Australia. The Wright and Short (1984) classification system was later applied to beaches in Europe (Short and Aagard 1993), South America (Benedet et al. 2000; Klein and Menezes 2001; Klein et al. 2002) and U.S. (Lipman and Holman 1991; Benedet et al. 2005). Wright and Short (1984) divided beaches into three main morphological types (i.e. reflective, intermediate and dissipative) as a function of beach grain size and wave characteristics. Examples of this classification system are shown below in Table 1.

Beach Type	Breaker Type	Short Description	Surfing Characteristics	Examples
Dissipative	Spilling	Flat beach, wide surf zone, multiple bars, fine sand, hard packed sand	Spilling waves, longboard friendly, wide surf zone means lots of paddling but long rides when waves connect between multiple bar systems	New Smyrna, FL, Pacific Peach, CA, Galveston, Texas
Intermediate (four sub-beach types described as a group)	Plunging	Intermediate slope, one or two bars, medium sand, beach cusps and other shore indentations, rip currents,	Plunging waves, barrels are common occurrence, often the best beach breaks, bar and beach indentations can form excellent temporary breaks	Hossegor, Fr, Sebastian Inlet, FL, Moss-Landing, Monterey, CA
Reflective	Surging/ Collapsing	Steep beaches, no bars, waves collapsing on the beachface with all their energy	Very short rides, hardly surfable except by bodyboarding, bodysurfing and kamikaze surfers on bigger days	Taquaras, Brazil, The Wedge, CA

Table 1. Relationships between beach type and surfing conditions.

On sandy beaches, the profile shape influences the wave breaking characteristics and is highly related to the sediment grain size. While the inherent wave conditions of a particular site exist in a state of dynamic equilibrium with the beach profile, the geotechnical properties of the beach sand is a major factor in defining profile shape. On natural beaches, these processes work in concert to create a long-term stability of the beach profile shape, although erosion of the dry beach is often apparent. Beach nourishment is the process by which sediment is directly imported to the system to offset erosion losses and the resulting engineered beach can create a temporary change in the profile shape. Over time, the natural processes rework the sediments to distribute them across the beach profile based on their geotechnical properties. Finer grained sands generally result in flatter submerged profiles, while coarser sands tend to a steeper profile shape (Figure 4). Bi-modal sources (mix of coarse and fine sediments) can influence the profile shape due to the natural sorting that mobilizes the finer grained component of the sand to the deeper part of active profile, while the coarser grains settle in the high energy swash zone closer to the shoreline.

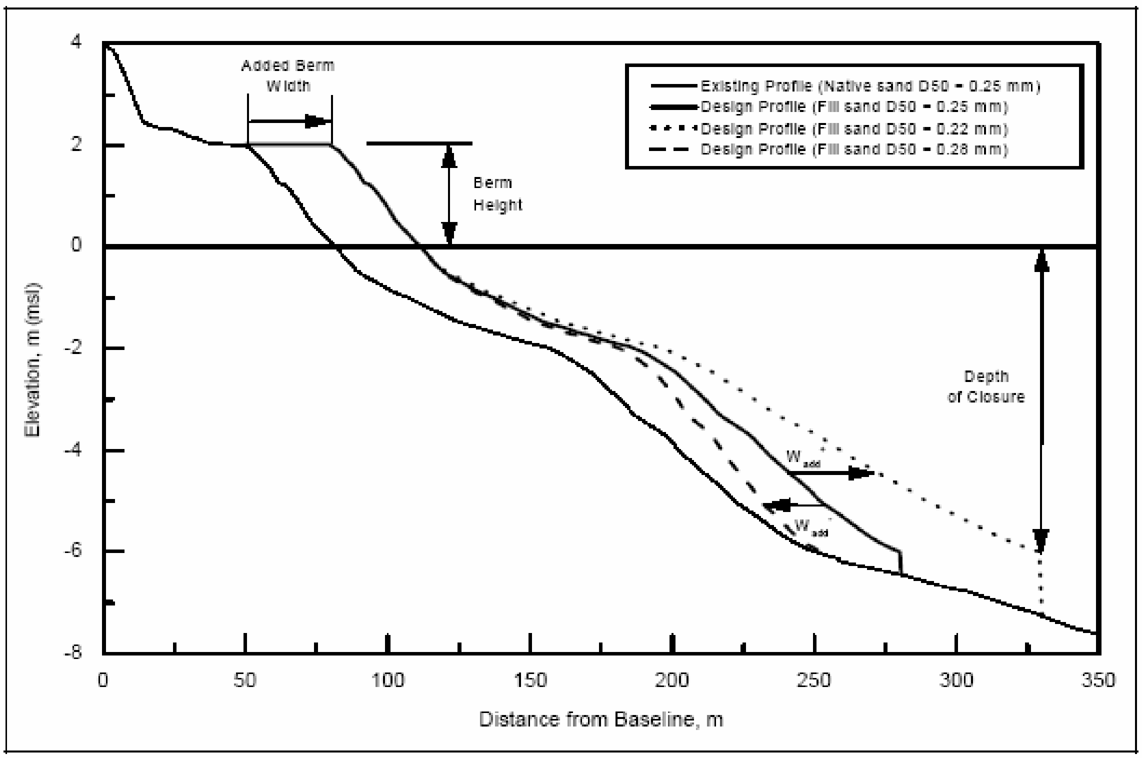

Figure 4. Beach profile shapes for differing grain sizes (Gravens et al. 2001)

Types of surfing breaks on sandy beaches are classified within four broad categories for discussion purposes (Benedet, Pierro and Henriquez 2007):

1. Open beach surfing breaks,
2. Headland bay beach surfing breaks,
3. Surfing breaks adjacent to coastal structures, and
4. Surfing breaks on sandy beaches with nearshore reefs.

Surfing breaks on open sandy beaches generally depend on beach-bar morphology as described in the section above. Intermediate beaches with single or double bar systems often exhibit curved-crenulated bar morphologies (sinusoidal bars and beach cusps) that generally produce plunging waves with tubes and are the characteristic beach type of the most famous beach breaks in the world.

The description of the types of surfing breaks commonly occurring on sandy beaches presented above is helpful in setting the framework for the identification of possible impacts from human interventions (coastal engineering projects) on surfability of these beaches. Each surf break type is subjected to different impacts and has different levels of vulnerability to human interventions on the coast. The discussion presented herein focuses primarily on beach nourishment, although different coastal engineering projects (inlet maintenance, coastal structures, dredging, etc.) may also affect the quality of surfing at these four types of surfing breaks.

ENGINEERED BEACHES

The broad class of coastal engineering projects represents a number of human interventions in the coastal system including beach nourishment and coastal structures such as groins, breakwaters and submerged reefs. The term “engineered beach” may be used to describe these various coastal engineering methods that have been employed at project sites around the world to restore, stabilize and maintain healthy beaches. Beach nourishments may cause negative impacts on surfing if they significantly modify the beach morphology to beach types less favorable to surfing, or if they cover features that cause the surf break (groins, submerged breakwaters, nearshore reefs). Beach nourishment may, on the other hand, enhance surfing by changing the beach type-morphology to beach types more favorable to surfing, or producing temporary peeling breaks at the curved shoreline that occurs in the transition between a nourished and a non-nourished beach.

Beach nourishment is the process of adding sediments to an eroding beach to balance sediment losses that may occur due to numerous causes (Figure 5). Sandy sediments used in beach nourishment projects either come from upland deposits trucked to the beach, or from submarine deposits where the sand is dredged from offshore and pumped hydraulically to the beach. The upland deposits are generally from abandoned beach/dune environments which are remnants from former higher sea level stands. Submarine deposits on the other hand are commonly remnants of beach/surf zone deposits associated with lower sea levels (relict deposits), recent storm deposits, or active depositional environments (i.e. settlement of suspended load in deeper waters). The quality of sediments used in the nourishment of open beaches is one of the most critical parameters in determining whether a specific project will have an impact on beach surfability.

Figure 5. Construction of a beach nourishment project in southeast Florida during a swell event from the northeast (the oblique aerial view is from south to north).

Examples of negative impacts due to beach nourishment include Copacana Beach Brazil, where coarser sediments caused severe beach steepening and the beach turned into a reflective beach type with disappearance of bars, collapsing type breakers and consequently, disappearance of quality surfing waves, or Mammoth County, New Jersey (Walther 2006), where coastal structures responsible for creation of surf breaks were buried by fill sands. Another interesting example of an impact to a surf break related to sand nourishment (or actually lack thereof) is St. Francis Bay Beach in South Africa. In this case, sand dunes adjacent to a famous headland bay point break had been nourishing the beach naturally through wind transport, until they were "stabilized" with vegetation to prevent shifting sands from blowing into nearby housing developments (Mead et al. 2007). The loss of sediment supply resulted in beach erosion and a deepening of the nearshore profile, which in turn prevented the waves from breaking in their former "perfect" peeling fashion.

Examples of surfing improvement due to nourishment include Delray Beach on the east coast of Florida, where the beach nourishment introduced a sandy beach and improved sand bar system where previously the waves were reflecting against a rock revetment that was being used to protect the beachfront highway. The slightly finer material used in the project filled a deeper trough and promoted offshore bar formation. In addition, dredged borrow areas just offshore of the project cause nearshore gradients in wave height that favor breaking in some sections of the beach (wave energy concentration), and ease the paddle out in adjacent sections (wave shadows). The combination of these factors resulted in much longer rides during long-period swells.

It is well known in the local surfing community that Delray Beach is one of the best breaks in southeast Florida today. This point is evidenced by the droves of surfers who show up at the first signs of a new swell as shown in Figure 6 during the Hurricane Isabel swell in September 2003. Upon each nourishment event, local surfers also enjoy surfing a longer peeling wave at the end of the beach fill. After completion of the project construction, the beach and bars are temporarily curved into a taper section at transition between the nourished and non-nourished beach.

Figure 6. Delray Beach, Florida during Hurricane Isabel in 2003 (Photo: John Downing).

Since the first Delray Beach nourishment project in 1973, renourishment with similar sand sources has continued the trend of sand bar reinforcement and promoted Delray Beach's status as a premier surfing spot during large swell events in southeast Florida. Figure 7 shows Delray Beach demonstrating the benefit of an engineered surfing beach during a swell event generated by Hurricane Floyd in 1999. The offshore sand bar that has been maintained as a result of the nourishment events not only created conditions for a world-class wave break, but also shifted the focus of the wave energy from impacting the upland infrastructure to a more natural form of shore protection by breaking the large hurricane swells further offshore.

Figure 7. Delray Beach, Florida during Hurricane Floyd in 1999 (Photo: Byran Boruff).

CONCLUSIONS

This paper discusses various aspects associated with surfing at engineered beaches. It has been shown that the surfability of sandy beaches may be affected by coastal engineering projects including nourishment and coastal structures in both positive and negative ways. In addition to the suggestions presented below, the authors offer specific guidance in a more comprehensive paper recently published in the Journal the American Shore & Beach Preservation (Benedet, Pierro and Henriquez 2007).

With the growing importance of surfing as a recreational activity, it is suggested that surfing considerations be a component in coastal engineering project design, especially in beach areas where surfing is commonly practiced. In that respect, we suggest that coastal engineers continue to evolve their evaluation of surfing as a valuable resource in the coastal community.

To promote the implementation of surfing considerations into the design of coastal engineering projects, the local organized surfing groups should be proactive in their involvement of project developments. Surfing groups should reach out to their local governments and offer assistance in understanding the importance of surfing resources in their area.

With increased awareness, education and interaction between user-groups, project designers and environmental agencies, potential conflicts between coastal engineering practices and the growing surfing community may be avoided through pro-active coordination.

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