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Combining Surfing and Coastal Protection What Is The Perfect Surf?

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Abstract

Works [both hard and soft structures] for coastal protection are being required to include surfing amenity and safety as a design criteria but designing coastal protection works to include surf quality as a design criteria introduces a range of variables and expectations.

As the sport of surfing encompasses a wide range of activities in the surf zone, the type of wave that is suitable need to be determined and the relevant wave parameters evaluated. Integration of coastal protection and surf improvement is practical but a design brief simply to improve "surfing" needs to be better defined or the result can be seen as a failure. The expectations of existing and potential users needs to be well understood

1. Introduction

As coastal managers increasingly recognise surfers as a key stakeholder in coastal protection projects and the social and economic benefits of surfing to the community, as well as safety issues, works [both hard and soft structures] for coastal protection are being required to include surfing amenity and safety as a design criteria. However, designing coastal protection works to include surf quality as a design criteria introduces a range of variables and expectations.

Surf is defined in the concise Oxford dictionary as "waves breaking on the shore or on a reef." The sport of surfing encompasses a wide range of activities in the surf zone and many Australians consider themselves surfers. The quantification of surfing amenity appears simple in theory as considerable research has been done by researchers such as Walker, Daley and Black to determine key parameters to define surf quality. A review of the extensive literature on surfing and artificial surfing reefs was undertaken by Couriel and Cox (1996) for Gold Coast City Council prior to the design of the artificial reef at Narrowneck as part of the Northern Gold Coast Beach Protection strategy. This reef is an erosion protection structure with a secondary objective to improve surfing. Unfortunately some stakeholders believed it was constructed to create the perfect surf.

The integration of surfing into the design of the Narrowneck reef and the proposed reef to protect Noosa Main Beach showed that surfing is a complex and highly variable activity and the "perfect" surf for one group of surfers may not be "perfect" or even suitable for another group of surfers. In trying to include surfing in the design process, it became apparent to the authors that much of the work on surfing related to short to medium length surf boards ridden by expert surfers and the "perfect" surf was considered to be a challenging hollow [plunging] wave. Unfortunately for coastal managers, surfers use a multitude of surf craft with different performance that require different skills and types of waves. Thus, surfers are not a single stakeholder. Surfing in Australia includes a wide and diverse range of equipment, such as:-

- Body surfing
- Body boards (and mattresses)
- Short boards
- Mini Malibu
- Long boards (Malibu)
- Surf skis and paddle boards
- Surf kayaks and canoes
- Surfboats
- Sailboards
- Jetskis

The skill level of the surfers targeted and the need for safety for all surf users also has a large impact on what is the "perfect" surf for any particular location. Also, the wave climate will restrict what is practical - an area with a short period low wave height will never be able to produce a large plunging "pipeline" type wave.

2 SURF CHARATERISTICS

In evaluating surf quality, surf characteristics can be defined by parameters such as:-

- Breaker type
- Breaking wave height
- Breaking wave celerity
- Peel angle (α)

Other factors such as wind strength/ direction, tidal range, accessibility, crowding and water temperature also affect the surf quality and surfability.

To date, surf characteristics have been defined primarily by the breaker type and the Irribarren Number (ξ) commonly represents the type of breaking:

$$\xi = \frac{S}{\sqrt{H_b / L_0}}$$

where (S) is the bed slope, (H_b) the breaker height and (L_0) the deepwater wavelength. Chue (1983) studied the breaker type related to ξ as given in table 1. While the Irribarren number is a good guide, it does not fully describe the surf type.

The type of breaking wave is very important as waves at the spilling end of the range are safer for beginners and slower surf craft but may not be suitable for all craft. For example, a body surfer will have difficulty catching a spilling wave but a surf ski will not. Also, the breaking type relates to the difficulty of the take off and thus the ability and experience. This means a steep take-off on a plunging breaker is more suitable for expert surfers whereas a flatter slope will provide a spilling breaker that means an easy take-off for less experienced surfers and a safer ride.

The breaker type must be considered with the other parameters. As the breaking wave height increases, the preferred type of wave for most, if not all, types of surfing shifts towards the spilling end of the range. The wave velocity at breaking determines the speed of the surf craft necessary to catch the wave and a fast wave may require techniques such as tow on surfing to provide sufficient speed. The peel angle needs to be considered as it determines the speed of the surfer (Vs) to keep ahead of the break. However, to add complexity, some types of surfing, such as surfboats and canoes may not attempt to keep ahead of the break and this is clearly evident at the world famous Waikiki where outrigger canoes surf straight into the beach generally on safe spilling waves. In a tourist area such as Waikiki where many inexperienced tourists want to surf, this is probably the "perfect" surf for that location.

Table 1 – Breaking wave type compared to Irribarren number [ref Chue (1983)]

Mode of Breaking	Irribarren Number ξ	Description
SPILLING	$\xi<0.4$	"Full" or "Fat" wave
PLUNGING	$0.4<\xi<2.0$	"Tubing" or "Hollow" wave
COLLAPSING/ SURGING	$\xi>2.0$	"Unsurfable" wave

The different requirements of various craft is emphasised if the expertise levels for a surf boards are considered as per Table 2 while an expert on a surf board may attempt an 8m plunging wave with a peel angle of as low as 30 degrees, very few bodysurfers, canoes or surfboats would survive let alone successfully such a wave.

Table 2 – Surfing level and wave parameters

	H_b (m)	α (deg)	Vs (m/s)
Beginner	<1.2	$60<\alpha<90$	< 3.0
Intermediate	<2.5	60	< 7.5
Expert	<8.0	>30	<12.0

Different surf craft can safely utilise different types of waves as generalized in figure 3.

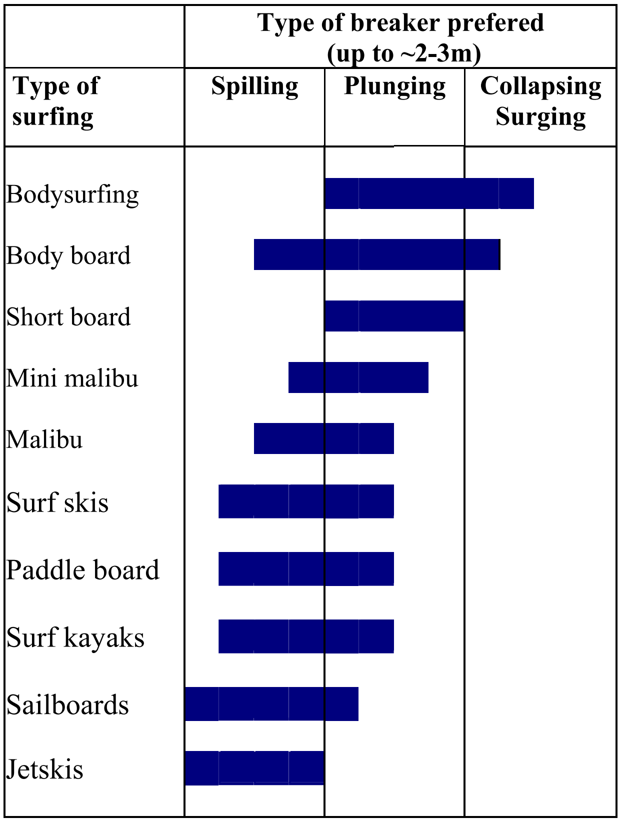

Figure 3 – Type of surfing vs. type of breaker

3. Coastal Protection and Surfing

As wave breaking results in wave energy dissipation, combining surfing which requires breaking waves with coastal protection is not incompatible. However, as breaking wave height can be maximized by energy conservation and coastal protection by energy dissipation, there is some conflict and challenge in balancing the needs of the client in the design process.

Coastal protection works incorporating nourishment, groynes and breakwaters usually significantly alter the local bathymetry and thus wave type and breaking characteristics such as the breaker type, breaker height and peel angle. For large structures the shape of the structure and the seaward underwater slope are important in their affect on wave breaking and many of the popular surfing locations in Australia and elsewhere are man made or influenced. A few notable artificial surfing spots on the Gold Coast include the Narrowneck reef, groynes at Kirra and the sand bank formations off Duranbah beach [downdrift of the Tweed training walls]. There are also some notable locations worldwide where dangerous conditions have been created. The wedge in California is very popular but surfers need to prohibited in dangerous conditions. The nearshore and onshore nourishment placement locations for the Tweed River entrance sand bypass scheme have been heavily influenced by the need to minimise adverse impacts on surfing.

As waves approach the shore they are transformed by shoaling processes that slow, refract and steepen the waves until they break. The seabed bathymetry and friction influence the way waves shoal and refract. In coastal engineered structures, as steep a slope as is stable is usually specified to minimise volume and cost. However, the slope of a structure affects the wave breaking characteristics. Using the Irribarren Number for a given wave height and period, as the slope is varied from near vertical to near flat the type of breaker changes from potentially collapsing to spilling. However, the Irribarren Number does not address the depth of the slope, change in slope or friction on the slope. Sensitivity analysis on the Narrowneck reef design confirmed that only the upper part of the slope significantly affects the final wave breaking. Cost constraints need also be considered as a mild slope may increase the volume and cost of the structure. Thus, for economy structures can be designed to have a steeper slope as water depth increases.

The depth of breaking depends primarily on the deep water wave height, the wave period and the seabed slope near to the breakpoint. The shallowest section of submerged structures (reefs, nourishment etc) determines the smallest wave that can cross the structure. Thus, the crest height is important to both coastal protection and surfing. Therefore, a deep structure will be less efficient for coastal protection and surfing than a shallow or emerged structure. However, as coastal protection may only rely on breaking the larger storm waves, it is most critical for surfing if it is necessary to ensure that small waves can be ridden at high tide. The crest height introduces stability and safety issues. For example, a shallow crest may be exposed between waves and "suck dry" in larger waves and / or lower tides making surfing dangerous in these conditions.

The breaking wave height is related to the offshore wave height but is strongly affected by the shoaling slope and energy dissipation before breaking. With a steep smooth slope, significant wave height increase can be achieved at the breakpoint. The increase in breaking wave height increases the surfability in small waves and/ or higher tide levels.

While advantageous for surfing this wave height increase at breaking may increase setup inshore promoting rip currents and thus reducing safety.

A friction coefficient is included in some shoaling formulae and roughness of the seaward slope influences both surfing and coastal protection in opposite ways. For example, high friction from seagrasses or other bed roughness will significantly increase energy dissipation and reduce wave height. Moreover, roughness can promote the wave to break sooner as the wave trough celerity is reduced.

For surfing, the shoaling zone just before the breakpoint is also important as this is where a surfer needs to get enough speed to match the wave speed and take-off. The slower the wave in this zone or the faster the surfcraft, the better will the surfer be able to acquire the sufficient speed to catch the wave. However, if the wave shoals too quickly, the wave will break into a fast plunging breaker and the surfer will need to accelerate quickly onto the wave face, which requires a reasonable level of skill as the wave height increases.

Orientation of structures is usually designed to provide the most beneficial wave transformations and sediment transport for coastal protection. However, the orientation of a structure also affects the wave breaking peel rate defined by Walker (1974) as a function of the peel angle α and the wave celerity C_b at the break point.

$$V_p = \frac{C_b}{\sin\alpha}$$

On a larger or complex structure, there is opportunity to provide various peel angles. The rideable wave is defined as the speed of incipient breaking slower than the speed that a surfer can maintain on his board [or other surfcraft]. The ideal peel angle is determined by the potential surfcraft speed and the experience of the surfer.

4. Safety

Safety is an increasingly important aspect in the design of coastal works. In general, spilling breakers are safer than plunging to collapsing breaker but this does not preclude use by a wide range of surfcraft. The type of materials used for construction and the location of the structure(s) will also influence the risk - an offshore structure will reduce accessibility. Also, secondary effects such as rip currents and exposure of submerged sections of the structure between waves needs to be considered in the design of coastal protection and / or surfing structures. Management practices can reduce accessibility and areas can be designated for as not suitable for swimmers as is done when natural rip currents form along a patrolled beach.

5. Narrowneck Artificial Reef

The Narrowneck reef is intended to provide a control point to reduce ongoing nourishment for the northern Gold Coast beaches (McGrath et al 1999) The area has good accessibility and is used by a wide range of surfers and a secondary objective of the structure was to improve surfing. To minimise risk of injury rock was not considered suitable and the structure is constructed of large sand filled geotextile containers. Suitable geotextile fabrication and installation methods were needed to be developed for the project but the final cost of the structure was considerably less than if constructed of rock.

The crest was designed to be at RL –1.5m AHD (Black 1999). After initial expected seabed changes, the crest height now varies from about -2m to –3m. At the present crest level, wave breaking is not initiated at high tide below a wave height of about 1.5-2m. Even with this crest height “sucking dry” does occur as the wave height and period increases. After initial monitoring and sensitivity analysis by Griffith University the reef is to be topped up but for safety the crest level height is being lowered to –2m while further monitoring is carried out.

Numerical modelling of the reef shows that the platform can be lower than design for the degree of erosion protection required as waves still break on the reef if you cut off 0.5-1 m from the crest platform. However, modelling indicates that the actual slope of the reef dissipates less energy at wave impact than a steeper reef but more around the crest. The wave energy reaching the beach is essentially the same for the different slopes with the difference being in the modes of energy dissipation.

The present surf can be defined as mixed plunging-spilling breaker that offers a fast take-off and a slower section afterward. The shape of the wave is more related to the wave height than the wave direction. For small swell, the A-frame shaped wave provides short-ride with fast section and can be defined as a spilling breaker. For bigger swell (1.5-2m), the plunging wave provides a long ride with alternative fast and slow sections. Amazingly the take-off is easier than for smaller waves, because the shoaling zone is longer and there is time to get some speed in paddling.

Narrowneck can not be described as a world class reef, but more as a classic reef for intermediate to expert surfers using a wide range of surfcraft. This reef presently is an unusual wave that provides the best waves at low tide with over 1m of swell. As the swell height increases, it becomes surfable for a wider range of the tide.

While the perfect design shape has not been constructed due to practical and budget constrains, the reef demonstrates that this has not been necessary. The reef is a very popular surfing area and has attracted new users including fishermen and divers. It is also increasingly popular for wave jumping by sail and kite boards in the afternoon when the wind is generally onshore and not suitable for surfboards. Observation indicates that the reef does improve the surfability of the waves even in onshore wind conditions and has a higher user capacity as more waves are catchable and the length of the ride removes surfers from the takeoff zone for a longer time. The reef also has improved the shorebreak for surfing due to the salient shape formed.

A number of storms have occurred since construction of the reef. Little erosion occurred shoreward of the reef and further coastal protection reefs are planned along the Gold Coast. Future reefs will need to address surf quality and safety.

6. Noosa

The proposed submerged berm or reef at Noosa Main Beach is intended to reduce ongoing nourishment requirements to sustainable levels (Jackson 2000). As the area is generally very calm, Noosa is a popular area for families and swimmers. The brief required for amenity and safety to be preserved. The adjacent First Point area provides good longboard waves in larger swells and non interference with this famous surf was specified in the brief.

During the design process, the crest was lowered to RL-2m AHD for safety. Even so, the coastal protection is still adequate and the final shape is predicted to provide a high class surf for experienced surfers in larger wave conditions.

Construction of this reef is to be of large sand filled geotextile containers and work is expected to start in early November 2001.

7. CONCLUSION

Integration of coastal protection and surf improvement is practical but a design brief simply to improve "surfing" needs to be better defined or the result can be seen as a failure.

Much of the research on surfing to date has been based on surfboards but surfing is broader than surfboards and further research on a wider range of surfcraft is needed. The expectations of existing and potential users needs to be well understood as to an inexperienced surfer or the parent of small children, the perception of the "perfect" wave differs greatly from the pro surfer or surf competition organizer. Thus, the wide range of performances makes designing the "perfect" surfing wave more complex but maybe more forgiving as a certain type of wave will tend to attract the most suitable surfcraft for that wave type. Data collected in the monitoring of the Narrowneck reef indicate that it is practical to construct a coastal protection structure that also is a safe multi-functional surfing structure.

8. REFERENCES

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