Proceedings of Littoral 2002
22-26th September 2002 Porto, Portugal

The Challenge of Combining Coastal Protection and Improved Surfing Amenity

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Abstract

Coastal protection and/or improvement projects have rarely addressed the issue of surf amenity and safety. Good surfing conditions, facilities and activities are important to the image and economy of many coastal resorts. Safety is also increasingly important to avoid injury and litigation from the increasing number of surfers. The inclusion of amenity for surfers in beach protection works is feasible but not simple. 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.. A number of prototype structures designed to improve surfing amenity and safety have been constructed in Australia and monitoring of these existing structures has lead to a greater understanding of the critical design parameters. Reef structures are providing both coastal protection and surfing amenity.

1. INTRODUCTION

Effective Integrated Coastal Management should consider environmental, social and economic issues to ensure that any works are sustainable and provide suitable amenity for users of the area that is to be protected. Each area has unique features and particular users or stakeholders that need to be considered in the design of any coastal protection works.

In the past, few coastal protection and/or improvement projects have addressed the issue of surf amenity and safety. In some cases the surf conditions created by the protection works have reduced or even destroyed the surf amenity for some surfers and / or created dangerous conditions. In other cases, inadvertently, coastal protection works have improved the surf conditions for some surfers but with a high safety risk factor.

As more and more people use the water as well as the beach, "surfers" are increasingly a major and influential stakeholder. In most coastal areas, surfing activities are gaining popularity and the young surfers of the past are becoming today's influential businessmen and leaders. The inclusion of the consideration of surfing amenity in the design of coastal structures has lead to a better understanding of the economic benefits and safety aspects that can be achieved.

In Australia, there has been increasing use of sand filled geotextile containers to construct groynes and submerged [reef] breakwaters to provide coastal protection while meeting the requirement for reducing the risk to surfers and providing improved surfing conditions for a wide range of surf users.

Three recent examples of beach protection strategies in the State of Queensland in Australia which consider surfing amenity and safety in the design parameters are:

- Northern Gold Coast Beach Protection Strategy
- Noosa Main Beach Protection Strategy
- Palm Beach Beach Protection Strategy
- Maroochydore groyne

Research for these projects and monitoring has shown that combining surfing amenity with coastal protection is important but is not a straightforward matter as there are a number of conflicting requirements.

2. ECONOMIC BENEFITS

Good surfing conditions, facilities and activities are important to the image and economy of many coastal resorts. The economic value of beaches such as the Gold Coast (Jackson & Smith 1997) has been well researched but little has been done to quantify the benefits of surfing. It has been estimated that a major international surfing competition can provide at least A$1.2M (0.7M Euro) into the Gold Coast economy (Raybould & Mules 1998). Benefits of a surfing competition or festival accrue through:-

- Spending on infrastructure and services by organisers and competitors
  - accommodation
  - catering
  - transport
  - specialist support services

  - hire of function rooms
- Increased tourism by spectators attracted to the event.
- Publicity from media coverage of the event generating increased awareness of the area and subsequent tourism.

3. SAFETY

The recognition of the need to incorporate surfing in the design should improve the safety of the structure. In the past designers of coastal structures have taken a view that people will stay away from the structure. This is not a realistic attitude and many injuries and deaths have occurred due to surfers impacting on hard structures. There is also the very serious consideration of litigation if dangerous conditions are created.

Many manmade waves have proven to be very dangerous. For example, there have been a number of serious injuries, leading to paraplegia and litigation, at the Wedge in Newport Beach (California). The curved shape of the groyne combined with the high slope gradient creates a high focusing of energy and a dangerous wave that can only be ridden by experienced or talented surfers. The wave can increase in height from 1 to 3m in just a few seconds. The unexpected wave height increase can catch an inexperienced surfer unawares. This kind of wave can provide a thrill for the few surfers with the ability to safely ride it without the risk of death or serious injury.

Litigation is becoming increasingly common and a recent court judgement in Australia found in favour of a surfer injured at the famous Bondi Beach. He was injured on a natural shallow sand bar. Similarly, a court case is underway where a local authority at Maroochydore in Queensland is being sued for the death of a surfer caught in a strong rip current on an unpatrolled beach.

4. DESIGN CRITERIA

4.1 General

The design criteria will influence the type of structure and determine the extent to which surfing aspects are considered important. In some areas, there will be little or no surfing activities and in other areas, it will be sacred. The works implemented should satisfy the largest range of beach and surf users (Jackson, Tomlinson and D'agata (2001)). Even tourists who only look at the beach and surf may be a significant stakeholder and it may be important to ensure that any structures do no adversely affect the vista. The integration of the surfing amenity and safety into the design may lead to some reduction in the coastal protection efficiency of the structure and a compromise will usually need to be found.

4.1.1 Public Consultation

In the setting of design criteria, public consultation is important to provide input to the designers on community expectations and requirements. Public consultation will provide answers to the following questions.

- What types of surfing activities are presently occurring?
- What surfing activities would be beneficial to the area?
- What happens if you change the type of breaking wave of a local surf break?
- Types of structure that are acceptable.
- What extent of storm erosion is acceptable?

4.2 Type of Surf

Key environmental parameters that define the type and characteristics of surf include:-

- Breaking wave height
- Breaker type
  - Spilling
  - Plunging
  - Collapsing/surging
- Wave period
- Breaking wave celerity
- Peel angle (α)
- Water depth at break point
- Velocity of undertow at break point

As the sport of surfing encompasses a wide range of activities in the surf zone, the type of wave that is suitable needs 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.

Unfortunately for coastal designers and 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. This is evident on the southern Gold Coast beaches where large scale (over)nourishment has changed surfing conditions. With the filling of the previous shallow lagoon, surfboard riders have a better quality wave but bodysurfers are pushed into the more dangerous wave breaking zone. It is obvious that "surfing" includes a wide and diverse range of equipment and it is difficult to satisfy all surfers as different types of breaking wave are preferred by different surfers (See Figure 1).

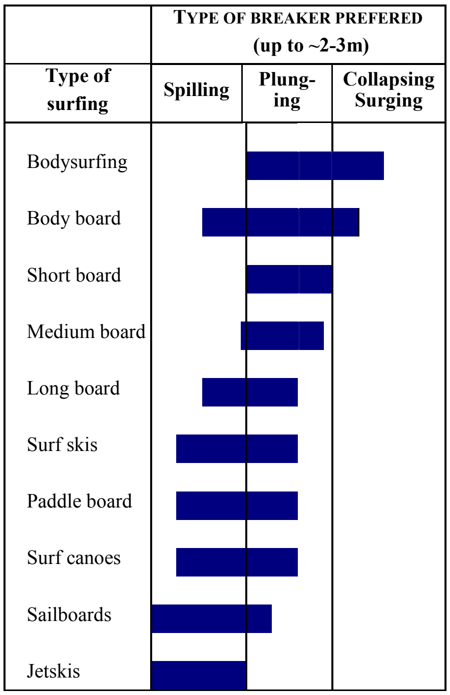

Figure 1 – Type of Breaker preferred

The integration of "improved" surfing into the design of the Narrowneck reef and the protection of existing surfing amenity for 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. For example, the perfect wave for a tourist in a outrigger canoe at Waikiki is very different to the perfect wave at Pipeline for the professional short board surfer.

In trying to include surfing amenity in the design process, it became apparent to the authors that much of the work on surfing related only to short to medium length surf boards ridden by expert surfers and the "perfect" surf was considered to be a large and fast challenging hollow [plunging] wave.

4.3 Type of Coastal Structure

Coastal protection works can include a wide range of works either in isolation or a combination. Generally, coastal protection works include:

- Sand nourishment
- Groynes
- Breakwaters
    - Emerged
    - Submerged (reefs)
- Sand bypassing

With increasing restrictions on dredging and limited supplies of sand for beach nourishment, a combination of a structure with beach nourishment to stabilise the nourished beach is a common solution. The type and design of structure will determine the impact on the extent of protection, surfing amenity and safety. In the past, the complexity in the design of reef structures has encouraged the use of more simple structures such as groynes. However, with better computer modelling and the need to construct safer structures, recent investigations in Australia have concentrated on submerged reefs as these provide a benign structure in calm weather hidden from view below water level.

Before implementing the design or construction of any structure, there is a need to undertake feasibility studies of environmental conditions such as the wave climate, the type of sediment and littoral transport involved in the equilibrium of the beach. The surfing aspect must take into consideration the number of days that provide reasonable surfing conditions and the quality of the surf that will be provided. The beach protection must deal with morphological changes in the area of influence of the structure. Natural and unnatural factors can affect the local conditions and prevent any further continuation in the implementation process.

Three different design options are possible:

1. protection
2. surfing
3. protection and surfing combined

The most difficult design option for a Coastal Engineer is option 3, which combines the requirement for beach protection and the improvement of surfing quality without compromising the protection requirement. This can be compared to the creation of a sculpture that will be both artistic and practical or useful. Design tools such as numerical models will not give you any sense of aesthetic qualities. Though a lot of progresses has been made in the understanding of surfing features, surfing design requires observation and practical sense. The "perfect" wave depends on many interdependent key parameters that numerical models to date cannot integrate.

5. DESIGN OF REEFS FOR PROTECTION AND SURFING

5.1 Overview

To be effective, the beach protection option only requires the adaptation of parameters such as the length of the structure, the distance offshore, the crest height and the general orientation of the structure according to the wave climate. The surfing option must integrate more parameters such as slope to make a wave breaking suitable to the practice of surfing.

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 non-breaking wave that can cross the structure. As wave breaking dissipates energy, the water depth over a submerged structure is important to both coastal protection and surfing. A shallow artificial reef structure will cause smaller waves to break providing coastal protection as well as surfing in mild wave conditions. However, a shallow submerged structure will be more dangerous with the tendency to suck dry in larger waves. Also, a shallow crest may result in strong rip currents and even increased erosion due to water level set up shoreward of the reef.

In the design of the surfing component of the structure care needs to be taken so not to diminish beach protection below an acceptable efficient level.

The safety issue becomes a major concern in popular coastal regions like the Gold Coast. Dangerous conditions must be avoided and certainly not created by the reef itself. It is important to prevent unnatural rip current formations where swimmers are carried offshore. Locally, a fast shoaling wave can lead to steep and dangerous plunging breakers where people can injure themselves with classic spinal injuries. This kind of injury is common on all beaches around the world, but is preventable where man-made structures are concerned..

The complexity of the design can lead to construction difficulties and the need to avoid dangerous conditions such as voids where limbs can be trapped. (even the entire body in case of a bad wipe-out).

The crest height introduces stability and safety issues. For example, a shallow crest may be exposed between waves and "suck dry" in larger, longer period waves (+ 2m) and / or lower tides making surfing dangerous in these conditions (Narrowneck monitoring). These dangerous conditions are infrequent, but the work of the Coastal Engineer is to prevent these issues from occurring.

The freedom of access to the ocean is a consideration of importance in the design of the artificial structure. In contrast to developed snow skiing areas, beaches can be easily accessed anytime by anybody. Thus, any artificial structures need to be weel signed and needs to be safe for all kinds of environmental conditions and for the various users who will access it. This can however, diminish surfing quality.

5.2 Sensitivity Analysis

Characteristic dimensions of a submerged or emerged breakwater determine the creation of salient or tombolos at the lee of the reef. However, the influence of bathymetry has not yet been fully evaluated and future studies should demonstrate the fact that emerged structures do not affect the local wave field as do submerged structures. Dimensions play a role in the width or length of the salient or tombolo created as well as the depth at the apex of the structure. Numerical models that do not take into account diffraction will have difficulty in predicting any variation of this nature. Empirical formulas must be used to evaluate the morphological changes.

There is a need to conduct sensitivity testing on different key parameters influencing improvement in surfing conditions, as indicated by improving the number of days that are surfable, the cleanness of the wave face as well as the wave breaking celerity. The key parameters that affect the level of protection as well as the type of wave breaking are:-

- Crest height
- Shape, Orientation to beach
- Reef Slope Porosity and Roughness

5.2.1 Crest height

Models can be used to assess the impact of crest height on wave propagation and energy dissipation. Monitoring of different tide levels helped to understand the relationship between the crest height and the type of breaking.

5.2.2 Shape of the structure

Narrowneck and Noosa reefs have been designed to focus wave energy. Designs vary and provide different wave focusing and wave breaking. As wave propagation is influenced by changes in water depth, it becomes obvious that the surfing features will be dependant on the design depth contour. The shape of the structure (straight parallel, concave, convex) effects the wave propagation, wave focusing, wave refraction and diffraction. The first requirement of beach protection cannot be enforced. Thus, a detailed assessment of the energy dissipating on the structure and the energy propagating in the lee of the structure must be made, to avoid individual peaks of high energy on some locations of the shoreline.

5.2.3 Reef Slope Porosity and Roughness

The slope on which the wave shoals primarily determines the breaking type and the take-off difficulty. For expert board riders, ideal slopes are smooth and with a steep gradient to maximise the wave height and energy at the break point. For coastal protection and safer surfing conditions, a flat and hydraulically rougher slope to dissipate wave energy is desirable.

The progresses made in the geotextile industry has lead to new construction materials that are resistant to the marine environment and safer for surfers. The use of geotextiles containers instead of conventional rocks in coastal structures, however, opens up a new field of unknown parameters. The influence of porosity on the way waves are breaking and dissipating energy on the structure is still to be fully determined. Geotextiles sandbags attract marine growth. After less than 2 weeks marine life develops on the bags and changes the local roughness. Artificial seaweed is used in some parts of the world to dissipate wave energy. Thus, we must also assess the influence of marine growth on the dissipation of wave energy, although this is not considered a key parameter.

6. MONITORING RESULTS

Numerical models are unable to solve wave propagation equations on sharp discontinuities in depth contours with random waves. Moreover, all friction effects on new materials like geotextiles and flow distributions in random waves are sometimes unpredictable. The combining effects of wave breaking, wave shoaling and undertow current induce local disturbances that cannot be resolved with sufficient accuracy by the model to be visualized. The monitoring of real projects helps to understand the influence of critical factors, which numerical models cannot accurately predict, for example:

- The influence of local winds
- The influence of bathymetry irregularities
- The influence of the shape of bags
- The level of difficulty of the wave
- The influence of wave period
- The influence of roughness

A number of projects in Australia have been designed and constructed with safe surfing conditions as an important design parameter. These include:-

- North Kirra Groyne
- Narrowneck Reef
- Maroochy Groyne

These projects have provided data for the design of reef structures proposed for Noosa and Palm Beach in Australia.

6.1 North Kirra Groyne

The 100m long North Kirra groyne was the constructed in 1985 as a temporary structure to help restore the beach in front of the Surf Club until the large scale regional erosion problems were investigated and rectified (Jackson 1985). As the groyne was to be constructed in popular body surfing area and after regional beach restoration works it was expected that the groyne head would intermittently be exposed in the surf zone, safety was a prime consideration. To provide a "soft" surface, the groyne was constructed of sand filled geotextile tubes which allowed the crest to be lowered to reduce the visual impacts and barrier to beach walkers. The groyne had a rounded head and proved to be hydraulically smooth and this provided an unexpected recreational structure for surfers to safely jump off and slide along with the waves. The lack of turbulence at the head and along the sides resulted in very little scour or turbulence normally associated with rock groyne structures. The adjacent rock groynes have scour up to 3m at the head and have caused a number of injuries. This structure lead to a greater appreciation of sand filled geotextile structures in popular surfing areas although vandalism was an ongoing problem until it was covered by large scale beach nourishment.

6.2 Narrowneck reef

The Narrowneck reef is part of the Northern Gold Coast Beach Protection Strategy that includes reef construction to stabilise initial beach nourishment from navigation channel improvements and ongoing maintenance nourishment from sand excavated from building sites and navigation dredging (McGrath *et al* 2000). The reef is in an area popular with beach walkers and a wide range of surfers. Safety and surfing amenity were important design criteria and of 13 options, a reef constructed of large (150 – 300t) sand filled geotextile containers was considered the most appropriate structure to avoid adverse impacts and to best achieve all of the design criteria. Construction commenced in August 1999 and the first sate comprising the bulk of the structure was completed in December 2000. Conventional hydrographic surveys and video imagery have been used to assess changes in the beach. The hydrographic survey is being undertaken by GCCC surveyors and the surveys also provide data on the reef and seabed levels out to beyond RL –30m. The video monitoring is being carried out by the Water Research Laboratory [WRL] at the University of NSW using an ARGUS coastal imaging system. This automated video monitoring system is used to obtain hourly images of the beach and wave breaking from four cameras which when combined, provide continuous coverage of 4.5 km of the coast. This gives information on the shoreline and wave breaking changes due to all events including storms when hydrographic survey is not practical. Digital image processing techniques are then applied on a routine (daily to weekly) basis to extract a range of quantitative information from the growing image database. The video system has also been used to assess wave breaking frequency and potential surfability.

The reef was originally designed with a crest height of only 0.5m below low water to optimise surfing for a small number of very experienced surfers. The safety risk was considered too great and the crest level has been lowered to 1.5m below low tide. This still results in the crest "sucking dry" in larger wave conditions. Despite the lowered crest and acceptance of more practical tolerances from the original design, the reef still provides improved surfing conditions and is still effective as a coastal protection structure. The video monitoring (WRL 2002) shows an additional ~20m increase in beach width to the immediate down drift northern side of Narrowneck reef , and of the order of 40-50m accretion on the updrift southern side.

The location of the reef nearshore in the wave breaking zone and construction using flexible sand filled geotextile containers was expected to restrict the attachment of marine growth. However, this has not been the case and the large amount of kelp and seagrasses that has attached to the reef hasattracted fish, fishermen and divers.

The Narrowneck reef has provided considerable data on the design and behaviour of large sand filled geotextile containers. The reef has now been tested by 9 wave events with Hm > 5m as well as impacts by surf boards, boat anchors, knives and spears. The container design has evolved during the project and the present container design and composite geotextile has overcome problems that reduced the durability of initial containers. Monitoring of this reef is continuing (Jackson *et al* 2002) providing data for the design of the 3 reefs at Palm Beach on the Gold Coast.

6.3 Maroochy Groyne

The 100m long Maroochy Groyne was constructed at Maroochydore (approximately 100 km north of Brisbane) in 2001 to stabilise a nourished beach. The groyne is in a popular swimming area and was designed and constructed with a low crest height using 5t sand filled geotextile containers for safety and to allow future removal if required. This groyne has provided good beach protection combined with safe surfing conditions for inexperienced surfers.

7. PROPOSED STRUCTURES

7.1 Noosa Reef

A long shore parallel reef was proposed to reduce erosion such that the nourishment requirements were sustainable. The area in which the reef is to be constructed is sheltered and is used mainly by swimmers and inexperienced bodysurfers. The computer modelling process resulted in a complex shaped shallow crested reef that would increase the wave height at breaking to provide the best possible surfing conditions. As there were concerns that this would create very unsafe conditions, flume testing was used to evaluate the wave breaking characteristics. The results (Tomlinson & Corbett 2001) resulted in lowering of the crest and redesign of the reef is being considered.

7.2 Palm Beach

Three reefs have been included in the Palm Beach Beach Protection Strategy (Griffith Centre for Coastal Management 2001). Surfing is not a key design parameter but safety to surfers is important. Using the data from the Narrowneck reef and flume modelling of the Noosa reef, the reefs have been designed with a low crest height along the body of the reefs but shallower end sections where wave breaking will provide a safe surfing wave.

9. CONCLUSIONS

The inclusion of amenity for surfers in beach protection works is feasible but not simple. It is easier to construct a coastal protection structure or a surfing structure as some requirements are contradictory. However, investigations and monitoring have lead to designs that provide both.

ACKNOWLEDGEMENTS

Gold Coast City Council and Noosa Council have provided data to assist these studies.

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