**Recommendation for Reef Ball Technologies;**
**Snorkeling Trail, Guest Adapt A Coral /Transplant Program,**
**Propagation of Rare Locally found Clubtip Finger Blue Coral,**
**Submerged Breakwater(s), Surfing Enhancement, and**
**Beach Enhancment.**

***For***

Bahia Principe Tulum and Akumal Hotels,
**Quintana Roo**
**Mexico**

***Submitted to***

**MARENTER, S.A. DE C.V.**

**By The**

REEF BALL
Development Group, Ltd.

**With Partners Including:**

***LEE E. HARRIS, Ph.D., P.E.***
**Consulting Coastal/Ocean/Civil/Engineer**

**&**

REEF BALL FOUNDATION

# Executive Summary

## Introduction

The Bahia Principe Tulum and Akumal Hotels can be classified as world class resorts. Both properties are successfully operating, catering mainly to Spanish clients. Spanish clients tend to be more active than many Europeans and tend to look for more active holidays. We observed guests snorkeling, diving, sailing, wave boarding, swimming, boating, diving and other sports on the properties Even the gymnasium was frequently used, which is rare in many resorts. After our short stay, we believe that the oceanic assets of the property were under utilized and under promoted.

The major oceanic assets of the property include a beautiful, sand lined, lagoon protected by a natural fringing reef, excellent snorkeling reefs within this protected area, copious beach areas (due to submerged breakwaters and sand renourishment in addition to some natural beach created by the fringing reef and bay structure), higher wave energy in two locations outside the fringing reef (one of which could be used for a surfing/water sports area, the other creates a soothing sound which is excellent to create a holiday like atmosphere), a Spanish Galleon wreck (which was suggested to be a snorkeling destination), high water quality (in terms of coral growth), seagrass beds (which support the abundant life on the reef), nearby scuba diving opportunities, steady sailing winds and abundant tropical fish life.

Such oceanic assets are the envy of most Caribbean resorts. It is the opinion of the Reef Ball Development Group, Ltd. that much of these special assets are under-utilized by the hotels and the basis of this report is to suggest enhancements to these water assets to take full advantage of their contribution to the properties value (and its ability to attract and retain more guests).

## Purpose of this Report

MARENTER, S.A. DE C.V. contacted the Reef Ball Development Group, Ltd. to provide an assessment of possible ways to enhance the water based assets of the The Bahia Principe Tulum and Akumal Hotels using techniques that are environmentally sensitive or positive and which require little or no maintenance. Due to the uniqueness of the site, Reef Ball Development Group, Ltd. recommended that MARENTER, S.A. DE C.V. contact a renown world expert on submerged breakwaters, Dr. Lee Harris of the Florida Institute of Technology, to get an objective 2nd opinion of options available to address these issues. Dr. Harris and the CEO of the Reef Ball Development Group, Ltd., Todd Barber, visited the site (staying on property as guests) and performed an initial assessment on September 1st- 3rd, 2001. This report is our recommendations as a result of the visit and subsequent analysis of site data.

## Recommended Solution

Having carefully analyzed the usage patterns, as well as the physical structures of the property and adjacent ocean, we have many suggestions of how Reef Ball technologies can help The Bahia Principe Tulum and Akumal Hotels to gain a competitive advantage for maintaining higher occupancy rates in the face of increase competition in the Mayan Riviera. Because each suggestion is, in and of itself, a complete project we have broken them down into components.

· Creation of a Snorkeling Trail.

Reef Ball Development Group has many experiences in creating snorkeling trails.


The proposed trail would be made entirely of Bay Ball sized Reef Balls that would be constructed on site by guests (aided by staff) and deployed by guests (aided by staff). Additionally, a coral transplant and propagation station would be constructed at the end of the existing dock (to the left of the above picture) where guests could snorkel out on the reef ball trail and plant corals. This could be a profit center where the guests would pay a small price to purchase a coral and be trained how to plant it. (Often, they are given one coupon per room for a free coral to be transplanted). The trial would escort the guests safely to the natural reef in the area and may contain signs to protect the natural reef and also to point out interesting things on the reef. A special feature, unique to the resost, could be a transplant and prorogation program highlighting a rare Blue Clubtip Finger Coral (Porites) that we can likely coax into the forma proites, divaricata, and furcata. Finding unique biological assets like the Blue Clubtip will help to provide guests

with a truly unique experience. Guests building or planting their own reef are highly motivated to return to the resort year after year.

Careful observation of the natural fringing reef also reveals a reduction in protection near the exposed rocks at the left of the above picture. From the first picture, you can see the area where waves are not breaking because of this reduced protection. This is one reason the beach needed to be renourished. By building a mini-breakwater using Bay Balls, this area can be p rotected. It will take about 5-8 rows of Bay Balls to create protection, but these can be added over time if desired. In all of this bay area, it is too shallow to rely on stability of the weight of the Bay Balls alone. Sand anchors or fiberglass rebar anchoring systems will need to be used. This is a simple matter that can be done during installation by staff or even with guest assistance. The cost of such a program is relatively inexpensive requiring a small investment in molds, coral handling facilities, signage and materials plus staff training. However, staff resources would need to be dedicated to the program long term. (Usually one or two staff members will be required at least part time).

· Extension of Current Sand Filled Container Breakwater


In the Cancun area, most breakwater solutions have used sand filled containers and sand pumping just like you have effectively used in the lagoon area. Although these solutions can be temporarily effective, they neither are long-term solutions nor considered to be positive from an environmental perspective. Maintenance costs can be high and the look of the property can be ruined in some people's opinion. Although used by guests as a place to rest, many resort operators are concerned with the potential liability of guests being hurt when on top of geo-textile breakwaters since they can become slippery over time and can harbor sharp -shelled animals too.

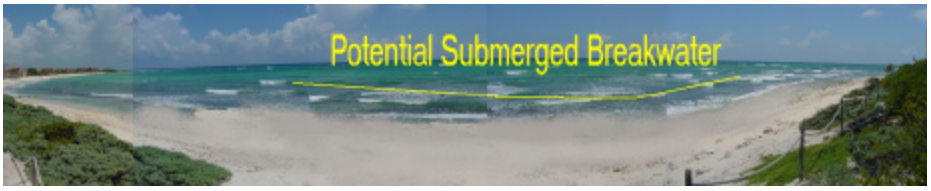
Because the current geo-textile breakwaters are functioning so well to create the beach, it can be deduced that they were properly placed in terms of distance from shore, depth and width. There is no need to replace this breakwater unless maintenance or storm failures require it. However, since management is considering extending the breakwater, it makes sense to consider a longer-term investment into a permanent solution involving submerged, maintenance free structures. Using Reef Balls, the resort will also be increasing the snorkeling assets in the property's waters. Reef Balls are particularly

effective at building sand without requiring sand renourishment so this will help reduce on-going beach maintenance costs too

· Creation of Surfing Reef


Just north of the proposed breakwater extension, we observed several guests riding wave boards. This area gets a focused wave climate due to the shape of the fringing reef. Protect Tubes ™ can be used to enhance the surf in this area making it idea for watersports such as surfing, wind surfing, kite boarding, body surfing and wave board riding.

· North Point Breakwater




The north end of the property has an underdeveloped waterfront area which could be developed as a beach. Site engineering would determine which approach to use.

· South Point Breakwater

The South Point area is a rocky shore with a very small "beach entry" (pictured on the right) located in about the center of the left picture. This area is not protected by a fringing reef at all. We were told there was an old Spanish shipwreck offshore here.

We completed a biological survey of the area and quickly realized that this area would not be suitable for water sports. The open reef has a large number of fire corals and sea urchins. The totally unprotected waters here would require a larger and more expensive breakwater system, likely with multiple staggered rows, to be effective. Before we completed the biological survey, we believed that two submerged groins connecting a parallel breakwater might create an enclosed safe swimming area. However, this area would still likely contain sea urchins due to the shallow and rocky bottom and would not be suitable for most activities in the water.

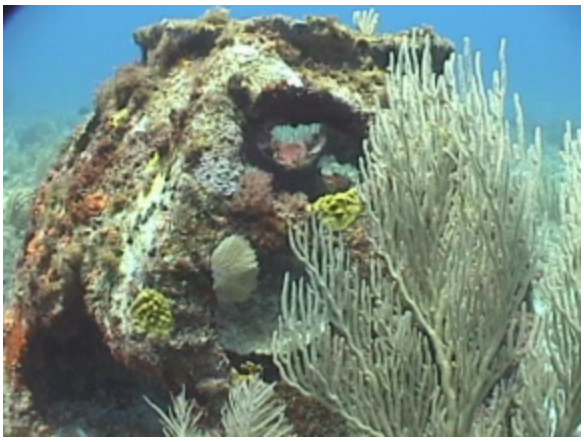
What we did notice is that many guests gathered in this area just to listen to the sounds of the crashing waves. Our suggestion would be to use decking to create a walkway across the rocks and to create specialize concrete artificial reef units that would concentrate the wave forces and cause them to create "blowholes" shooting water up into the air and over the decks creating an exciting walkway where guests could listen to loud waves and get wet if they choose from the decks. This would require custom engineering, but it would create a spectacular attraction on the properties.

**Background Information on Reef Balls**

**Why Reef Balls?**

Since snorkeling, diving and other water activities are nearly as important as a beach to many potential guests of the property, it only made sense to consider solutions that create the conditions which would build a natural coral reef in addition to protecting the beach.

In our recommendations, we balanced the required emphasis on guest uses; enhancement of the property value; long term stability; safety for water entry/use; reduction in wave run up, physical protection of the beach storm events ; and functionality, (i.e. the creation and retention of desired beach width and slope).



**3 Years Natural Growth in Cancun**

As an added bonus, our approach creates a richly diverse biological reef system that will contribute an estimated hundreds of thousands of kilos of biomass to the Mayan Riviera each year of which approximately 30% will be fish life.

(About 180 Kilos per Reef Ball Per Year for hundreds of years to come)


**Ultra Reef Balls being deployed at Gran Dominicas Hotel in the Dominican Republic, note the appearance of the Reef Ball submerged breakwater as only a dark line in the water. This would be the same look generated at the Bahia Principe Tulum and Akumal Hotels.**

## Stability

Physically, the site experiences a significant wave climate and the Mayan Riviera faces threats from hurricanes such as Gilbert. Reef Balls can be engineered heavier, with anchoring systems, and with modular bases for extra weight. Reef Balls can be combined with Protect Tubes ™ to create deeper water structures. The actual design chosen for your property will depend on the recommendations of Dr. Lee Harris in his engineering studies of your property.

## Longevity

Reef Ball has a long history of using high tech concrete to engineer structures designed to last centuries rather than decades. Our work has required it because longevity is an important design criterion when building coral reefs that potentially last for thousands of years. By using specially designed, high strength concrete and using proprietary admixtures, we will create a high strength, abrasion resistant concrete, (without iron rebar in the modules), that will have an engineering life of hundreds of years. Therefore, the client can consider this solution a final one. Appendix A contains the typical concrete mix design used to build our modules. We will use a similar custom mix for you.

## Beach Creation

There are three options to obtaining the beach sand; sand nourishment, natural accumulation of sand, or a hybrid approach of seeding some while accumulating the rest.

Environmentally, a natural accumulation of sand is desired and Reef Ball submerged breakwaters are normally set up with this system.

**Right: Natural accumulation of sand in the Reef Ball Dominican Republic Beach Creation Project after 4 months.**[5]

However, there are not always optimal sand reserves in the nearby sand sources. Even if possible, sometimes the client desires a more immediate beach solution.

Therefore, sometimes we recommendation a hybrid sand renourishment and natural replenishment project rather than relying solely on the natural build up of sand over time.

**1 month after a category III direct hit from Hurricane Georges showing natural replenishment by Reef Balls.**

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## Environmental Responsibility

Many projects has activities that will impact the surrounding reef.. If pumping is used, the beach renourishment process can create some siltation and therefore silt guards should be used. (Placement of sand by land-based trucks is therefore preferred but possibly cost prohibitive).

Your previous projects and guests have had some impact on the coral reefs in the lagoon. We observed several corals damaged by guest contact, sedimentation, entanglement with trash, etc.

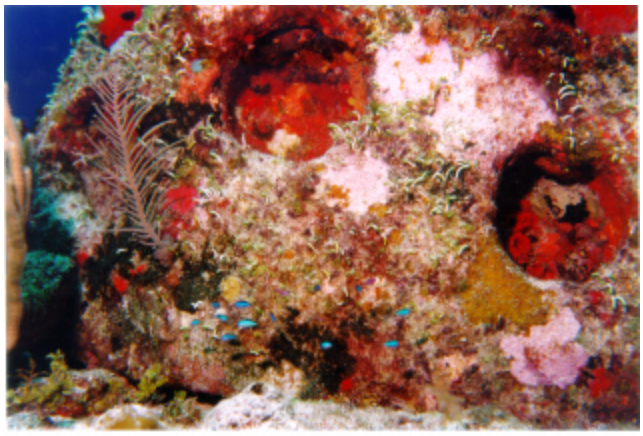
Fortunately, placement of the Reef Balls will create an artificial fringing reef, which over 5-25 years will turn into a natural coral fringing reef. However, the use of coral transplant technologies can turn the Reef Balls into a natural coral fringing reef in just a fraction of that time. It can also be a fun activity for guests.

**The next photos is a Reef Ball in Mustique in 30 feet of water and transplanted with corals.**

**The Mustique pictures were taken during the installation of corals in November 2000 by Mustique Water Sports. Over a 3-year period, these Reef Balls will turn into a natural coral reef.**
**Photos Courtesy of Mustique Water Sports**

**Right: A small sized Reef Ball (3 feet x 2 feet). This Bay Ball sized Reef Ball was deployed in Cancun, Mexico. This picture was taken 3 years later and shows only natural growth (no coral transplants were added to this Reef Ball).**

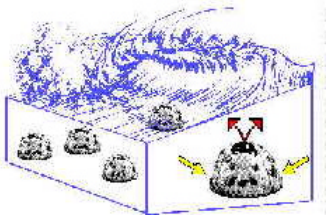
**The Reef Balls in Mustique will look similar to this photograph with much larger corals in 3 years. The smaller size Reef Balls could be added to the lagoon to make a snorkeling trail.**



[Note: It would also be a relatively small add on project if the client desires that the Reef Balls used to create the submerged breakwater have built in coral transplant receptors so that corals could be transplanted now, or in the future on the submerged breakwater.]

Given the importance of the water assets of the property, we believe the hotel should seriously consider coral transplants on all the reef balls used on the property.

## Why Reef Balls Work Better than Solid or Rock Submerged Breakwaters

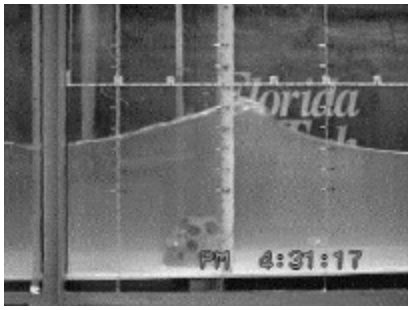


Reef Balls were initially designed to be biologically active (to create natural reefs) and to be stable in hurricanes. Essentially Reef Balls needed to be the base of a natural reef. To do this, we had to design our holes to create whirlpools so that corals could be fed better by passing currents. Additionally, we created a large hole in the top of the Reef Ball so that waves and currents would be jetted from the top, adding to the stability of Reef Balls. Our goal was to use the least amount of concrete to make a unit that was stable in hurricanes.

Traditional and barrier submerged breakwaters work by making waves break. As a wave breaks, it loses much of its energy. The problem with these systems is that if the wave does not break, very little energy is lost. And as the wave is lifted over the submerged breakwater, if it does not break, then the acceleration, as it goes down on the other side of the breakwater, can create washout.


**Wind tunnel demonstrating whirlpool effect of Reef Balls**

Reef Balls work on an additional principle. Being full of holes that create whirlpools, and offering a variety of angles of reflection from the round shape, any wave that traverses a field of Reef Balls has to "fight itself" and therefore looses energy in relation to the number of rows of Reef Balls that are traversed. The original wave keeps its shape; it just gets smaller and continues to the beach without washout. Therefore, it does its normal job of carrying sand, at the lower energy level, to the beach.




**Reef Ball Stability Tests at FIT Wave Tanks**

Non-submerged structures that stick out of the water rely on reflection to stop waves. Reflection puts a huge stress on walls and that is why most reflective structures must be massively engineered and even then failure is possible. Non-submerged structures are also unappealing to the eye in most installations. This reflection effect can also push sand away from the property. This is why seawalls often accelerated the rate of sand loss. Reflection of waves has been blamed on a variety of problems (both physical and environmental) with traditional engineering techniques and therefore Reef Ball Development Group, Ltd. does not recommend reflective technologies.

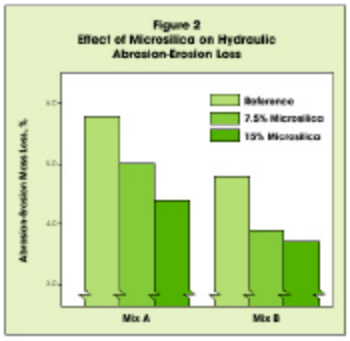
## Participating Sub-Contractors & Partners

There will be a variety of companies participating in this project working through the Reef Ball Development Group, Ltd. and contracted through MARENTER, S.A. DE C.V.. MARENTER, S.A. DE C.V. may at its discretion either contract individually with these companies or work through Reef Ball Development Group, Ltd. to manage the construction as a single or multiple projects.

Todd Barber, CEO of the Reef Ball Development Group, will be the point contact for MARENTER, S.A. DE C.V. to oversee these projects due to their unique and complex nature. Mr. Barber is the founder of Reef Ball Development Group, Ltd. and has been working restoring reef systems worldwide since 1992. His work in the management-consulting field with the Alexander Group and TPF&C before starting Reef Ball makes him well qualified to assist in the management of complex projects. Reef Ball has conducted over 3000 projects in over 40 countries worldwide deploying over ½ a million Reef Balls. Information on the companies Mr. Barber manages can be found at www.artificialreefs.org.

**Dr. Lee Harris**, Ph.D., P.E., Consulting Coastal, Ocean and Civil Engineer of the Florida Institute of Technology will be doing the engineering, physical modeling, survey work and scientific monitoring of the project. He has worked with submerged breakwaters since the 1980s and has been involved with hundreds of projects worldwide.

W.R. Grace will supply critical admixtures including Force 10,000 Microsilica, Adva Flow, Grace Microfibers, Darex II and other proprietary admixtures used to insure that your Reef Balls and breakwater will last for hundreds of years and will be strong enough and abrasion resistant to handle the constant sandblasting effect subjected to a submerged breakwater. We have elected to engineer your breakwater with the some of the best concrete technology available today that is also designed to enhance the biological performance of your breakwater as a living reef. Rick Conlin is in upper management at W.R. Grace and will be our liaison with W.R. Grace. He has worked designing special mixes for the Reef Ball Group since 1993.




The Reef Ball Foundation is a 501(c) non-profit charitable organization. Its mission is to help restore our world's ocean ecosystems and to emphasize and protect our natural reef systems through preservation, technology, and innovative public education opportunities, and community involvement. The Foundation works with governments , businesses, schools, research institutes, and community organizations. Kathy Kirbo is the Executive Director of the Foundation and she will assist with the coral transplant guest experience program, if you elect this option. If you wish to qualify as a Reefs Around the World project, then your expenditures could be a tax write off as a donation to a US based charitable organization.

If a US based tax write off is important to the client, further discussions with the Reef Ball Foundation are warranted. The project could easily be certified to be part of our Charity's Reefs Around the World Project.

Appendix A:

## Reef Ball Sizes, Weights, Volume & # of Holes

| Style | Width | Height | Weight | Concrete Volume | Surface Area | # Holes |
|---|---|---|---|---|---|---|
| Ultra Ball | 6 feet (1.83m) | 4.5 feet (1.37m) | 4 )00-6000 lbs (: 814-2722 kg) | 1 yard 0.76m$^3$ | 150 ft$^2$ 13.9 m2 | 29-34 |
| Reef Ball | 6 feet (1.83m) | 4 feet (1.22m) | 3 )00-6000 lbs (: 360-2722 kg) | 0.75 yard 0.57m$^3$ | 130 ft$^2$ 12.1 m2 | 29-34 |
| Pallet Ball | 4 feet (1.22m) | 3 feet (0.9m) | 1 500-2200 lbs (( 80-998 kg) | 0.33 yard 0.25m$^3$ | 75 ft$^2$ 7.0 m2 | 17-24 |
| Bay Ball | 3 feet (0.9m) | 2 feet (0.61m) | 3 '5-750 lbs (: 70-340 kg) | 0.10 yard 0.08m$^3$ | 30 ft$^2$ 2.8 m2 | 10-16 |
| Mini-Bay Ball in development | 2.5 feet (0.76m) | 1.75 feet (0.53m) | 1 50-200 lbs ( <g) | less than 4 50 lb bags | | 8-12 |
| Lo-Pro | 2 feet (0.61m) | 1.5 feet (0.46m) | 7 )-100 lbs ( <g) | less than 2 50 lb bags | | 6-10 |
| Oyster | 1.5 feet (0.46m) | 1 foot (0.30m) | 3 )-45 lbs ( <g) | less than 1 50 lb bag | | 6-8 |

## APPENDIX B: REEF BALL TYPICAL CONCRETE SPECIFICATIONS

### PART I - GENERAL

**1.01 Section Includes**

A. Concrete proportioning and products to be used to secure concrete, which when hardened will produce a required strength, permeability, and resistance to weathering in a reef environment.

**1.04 References**

A. ACI-211.191-Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.

B. ASTM C 260- Standard Specifications for Air-Entraining Admixtures for Concrete.

C. ASTM-C 1116 Type III- Standard Specifications for Fiber Reinforced Concrete or Shotcrete.

D. ACI - 305R -91- Hot Weather Concreting.

E. ACI - 306R -88- Cold Weather Concreting.

F. ACI - 308- Standard Practice for Curing Concrete.

G. ASTM C 618-Fly Ash For Use As A Mineral Admixture in Portland Cement Concrete.

H. ASTM C 494-92- Standard Specifications for Chemical Admixtures for Concrete.

I. ASTM C 1202-91- Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

J. ASTM C 33- Concrete Aggregates.

K. ASTM C 94- Ready Mix Concrete.

L. ASTM C 150-Portland Cement.

M. ACI 304- Recommended Practice For Measuring, Mixing, Transporting and Placing concrete.

N. ASTM C 39 (Standard Specifications For Compressive Testing)

O. ASTM C-1240-93 (Standard Specifications for Silica Fume Concrete)

**PART II PRODUCTS**

2.01 Portland Cement: Shall be Type II and conform to ASTM C-150

2.02 Fly Ash: Shall meet requirements of ASTM C-618, Type F. And must be proven to be non-toxic as defined by the Army Corps of Engineers General Artificial Reef Permits. Fly Ash is not permitted in the State of Georgia and in most Atlantic States. (In October, 1991, The Atlantic States Marine Fisheries Commission adopted a resolution that opposes the use of fly ash in artificial reefs other than for experimental applications until the Army Corps of Engineers develop and adopt guidelines and standards for use.)

2.03 Water: Shall be potable and free from deleterious substances and shall not contain more that 1000 parts per million of chlorides or sulfates and shall not contain more than 5 parts per million of lead, copper or zinc salts and shall not contain more than 10 parts per million of phosphates.

2.04 Fine Aggregate: Shall be in compliance with ASTM C-33.

2.05 Coarse Aggregate: Shall be in compliance with ASTM C-33 #8 (pea gravel). (Up to 1 inch aggregate can be substituted with permission from the mold user.) Limestone aggregate is preferred if the finished modules are to be used in tropical waters.

2.06 Concrete Admixtures: Shall be in compliance with ASTM C-494.

2.07 Required Additives: The following additives shall be used in all concrete mix designs when producing the Reef Ball Development Group's product line:

A. High Range Water Reducer: Shall be Adva Flow as manf. by W.R. Grace.(ASTM C-494 Type F)

B. Silica Fume: Shall be Force 10,000 Densified in Concrete Ready Bags as manf. by W.R. Grace. (ASTM C-1240-93)

C. Air-Entrainer: Shall be Darex II as manf. by W.R. Grace (ASTM C-260)

2.08 Optional Additives: The following additives may be used in concrete mix designs when producing Reef Ball Development's product line.

A. Fibers. Shall be either Microfibers as manf. by W.R. Grace, or Fibermesh Fibers (1 1/2 inches or longer) as manf. by Fibermesh. Either product can be in ready bags.
B. Accelerators: Either a non-Chloride or Daracell as manf. by W.R. Grace may be used but only when needed due to temperatures less than 40 degrees F. (ASTM C-494 Type C or E)
C. Retarders: Shall be in compliance with ASTM-C-494-Type D as in Daratard 17 manf. by W.R. Grace
2.09 Prohibited Admixtures: All other admixtures are prohibited. Other admixtures can be submitted for approval by the Reef Ball Development Group, Ltd. by sending enough sample to produce five yards of concrete, the current MSDS, and chemical composition (which will be kept confidential by RBDG Ltd.) A testing fee of $2,500 must accompany the sample. Temporary approval will be granted or denied within 10 days based on chemical composition, but final approval may take up to 3 months since samples must be introduced in a controlled aquarium environment to assess impacts on marine and freshwater species.

**PART III Concrete Proportioning:**

**A. General:** The intent of the following proportions is to secure concrete of homogeneous structure that will have required strength and resistance to weathering.

**B. Proportions:**

| | One Cubic Yard | One Cubic Meter |
|---|---|---|
| Cement: | 600 lbs. (Min.) | 356 kg |
| Aggregate: | 1800 lbs. | 1068 kg |
| Sand: | 1160 lbs | 688 kg |
| Water: | 240 1bs. (Max.) | 142 kg |
| Force 10K: | 50 lbs | 30 kg |
| Darex AEA: | 3 oz. | .1 1iters |
| *Adva Flow (Superplastisizer): | 25- 45 oz. | 1-1.75 liters |

*NOTE: Adjust Adva dosage as needed to obtain workable, placeable mix (170-250mm / 7-10 inch slump), and to achieve .40 w/c ratio.

Fibers: 0-3# (Max.) as needed to reduce micro cracking 1# (Min.) required if Silica Fume exceeds 50#

Accelerator: As needed to achieve de-molding no sooner than: 3-4 hours for heavy duty molds (All Polyform side balls) 6-7 hours for standard molds (Molds with any tether balls)

NOTE: Silica Fume or Force 10K shall be dosed at a 10# minimum in Bay Balls and Pallet Balls while Ultra & Reef Balls shall require a minimum of 25#. All molds must use at least 50# for floating deployments. All mold sizes must use at least 50# for use in tropical waters unless special curing procedures are followed.

* This product is being specified not only for strength, but also to reduce pH to spur coral growth, to reduce calcium hydroxide, and to increase sulfate resistance. It is a non-toxic pozzalan.