

High-relief Artificial Reefs for Biodiversity Enhancement and Coastal Defence

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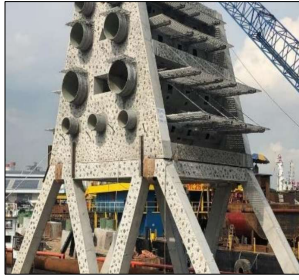
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Introduction



- ❖ More than half of Singapore's natural reefs have been lost to coastal development
- ❖ Purpose-built structures mimicking natural reef systems can transform an open water environment above a barren seafloor into a rich, reef-associated biodiversity zone
- ❖ The "Reef Garden Project", providing 1000 m² of new space for the development of reef-associated biota, was developed by Jurong Town Corporation in collaboration with National Parks Board and deployed in Sisters' Islands Marine Park, Singapore

Figure 1: High-relief Artificial Reef

- ❖ High-relief reefs – artificial structures that extend entire or almost entire water column can:
 - enhance marine biodiversity and ecosystem development in Singapore
 - attract epibenthos/ coral species/ fishes within a short time frame
 - offer opportunities in marine biodiversity research
 - increase marine leisure activities

Design Considerations



- ❖ Design based on favorable conditions for
 - corals and epibenthos
 - fish species
- ❖ Environment Impact Study (EIS) to determine the impact of Artificial Coral reef structures on various aspects of seabed, ecology, navigation safety etc.
- ❖ Frame's sloping surfaces and pipes' curved surfaces to minimize sediment accumulation
- ❖ Openings for current flow and light penetration

Figure 2: Artificial Reef – Recycled Materials

- ❖ Alkaline materials & others like PVC/ Fiberglass used to reduce overall weight and enhance biofilm formation to encourage coral attachment
- ❖ Surface area of upper section increased by incorporating rectilinear, fiberglass mesh panels at different levels to
 - reduce shading and allow sediment fall through
 - maximize space for coral growth

Results & Discussion

Construction Methodology

- ❖ Total 8 numbers of Pre-fabricated High-relief Reef structures deployed:
 - 4 no.s. of 12m (L) X 6m (W) X 7m (H) @ 85 ton each
 - 4 no.s. of 12m (L) X 6m (W) X 11m (H) @ 145 ton each
- ❖ Multi-level configuration takes advantage of varying amount of sunlight penetration through top 6m of water column
- ❖ The main frame was cast in concrete with rough surfaces to favour coral growth
- ❖ Used PVC/fiberglass pipes to enhance biofilm formation
- ❖ Used rocks from Jurong rock cavern to increase substrate textural complexity, necessary for encouraging natural settlement
- ❖ No piling works carried out, hence, minimum seabed disturbance
- ❖ Stability attained using the structure's weight and wide base coupled with steel anchors and counterweights below the structure

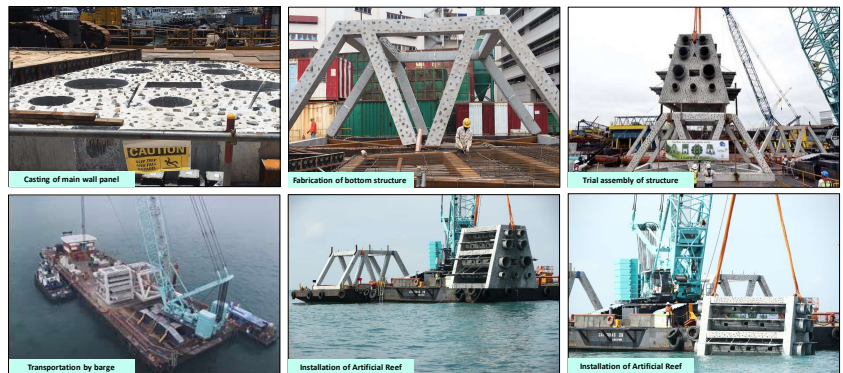


Figure 3: High-relief Artificial Reef – Construction, Fabrication & Launching

Coastal defence and shoreline protection

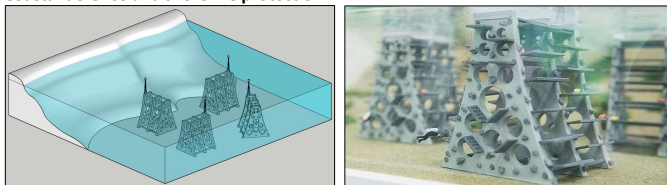


Figure 4: Artificial Reef – Coastal defence & seabed protection

- ❖ Possible reduction of wave energy, wave height and sea-bed erosion.
 - 97% of average wave energy reduction¹
 - 84% of average total wave height reduction¹
 - 50% reduction in the sea-bed erosion²

¹The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. Ferrario, F.; Beck, M.W.; Storlazzi, C.D.; Micheli, F.; Shepard, C.C.; & Airoidi, L.; Nature Communications, 2014. DOI: 10.1038/ncomms4794

²Coral reefs for coastal protection: A new methodological approach and engineering case study in Grenada. Borja G. Reguero; Michael W. Beck; Vera N. Agostini; Philip Kramer; Boze Hancock. Journal of Environmental Management, 2018, pp. 146-161.

Relocation & Transplantation of Corals onto High-relief reefs



Figure 5: Artificial Reef – Progressive Growth of Corals

- ❖ Close to 2000 coral colonies from various locations have since been transplanted to the structures
- ❖ Different coral genera were translocated after detailed identification by NParks and coral reef researchers
- ❖ The transplanted coral colonies and naturally recruited biodiversity are enhancing overall marine species richness of the Marine Park

Conclusions

- ❖ High-relief artificial reefs:
 - provide ecosystem services by mimicking natural reef slopes and help enhancing marine biodiversity, especially of the open sea
 - provide structural support that could stimulate reef development and recovery
 - provide shelter and food for marine organisms

- ❖ High-relief artificial reefs:
 - increase coral larvae density, which can influence settlement, post-settlement colony abundance and coral cover
 - absorb wave energy and provide a coastal defence service