BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, December 2013. Vol. **10**(2), 621-628

Study of Macro Algae for Marine Biotechnology Material from Large scale Offshore Cultivation from Multiple Mooring System of Large Aquaculture Ocean Floating Structure

O. Sulaiman Olanrerwaju, A.S.A.Kader and WN. Wan Shamsuri

[1,2]Marine Technology Center, University Technology Malaysia, Skudai, UTM Skudai, 81310 Johor, Malaysia.
[3]Faculty of Science, Department of Physics, University Technology Malaysia, Skudai, UTM Skudai, 81310 Johor, Malaysia.

DOI: http://dx.doi.org/10.13005/bbra/1173

(Received: 15 August 2013; accepted: 10 October 2013)

Macro-algae farming have become one of the natural resources which are economically important. Macro alage are used as food in many Asian countries, and extracts for use as food additives (gelling agent, preservative etc.) and in other industries (textiles, pharmaceuticals, biomass energy etc.). The existing cultivation systems for macro-algae are not environmentally, socially and economically sustainable. Lack of suitable platform for large scale cultivation and potential coastline disturbance necessitates the need to develop novel deployment technology for deep and opens water cultivation. Macro-algae are useful biomaterial for food, food supplement, gels, solar cell, clean animal feeds, biomass energy, pharmaceutical, fracking product. To avoid mooring system failure, selecting an appropriate breaking strength and limit state for mooring lines is necessary, this paper describe multiple interacting mooring system design that account for forces and environmental loadings on the system. The paper describe evaluation of optimum mooring performance in wave, wind induced current loadings on mooring components, analysis of anchor, buoy, riser elements and compensator sinker that are involved in the multiple mooring system dynamics are presented. The paper also discuss establishment of appropriate safety factors and coefficient for the design of very large offshore aquaculture floating structure.

Key words: Macro algae, Material, Mooring, Offshore.

Introduction of development of large scale production of seaweed that meets the increasing market demand and provides alternative livelihood schemes for local populations using ocean farming technology is envisaging coming with consequential impact and risk of environment. Sheltered sites being used for marine farming culture locations is becoming limited, due to pressures from tourist development, urbanization, marine trade and the consequences of environmental lobbies. Also, unfavorable environmental factors such as nearshore pollution from sewage is leading to requirement for use of marine farming sites further offshore to water depths of 50 m or greater in order to mitigate the problem associated with current seaweed farming. Developing Open water structure that will cater for problem of inshore sites limitation will be useful for future large scale aquaculture farming. Also, with such technology, inshore areas would be protected from industrial activities. Such structure will also mitigate impact of cage fish farming on the local environment and natural resources conflicts between coastline inhabitants e.g. fishermen and the farming industry. Offshore aquaculture is expected to expose the system and the farm to wave, current and wind forces or range of maximum wave heights of 5-10 m, current speed of 2-3 knots and wind speed of 35 m s-1.

* To whom all correspondence should be addressed.
Tel: +60177244339, Fax : +607 557 4710

The seaweed extract, Carrageenan is an important hydrocolloids product for food addictive ingredient and is highly demanded in the world market. The demandfor seaweed has also created a huge market for its raw material from the Cottonii seaweed also known as Kappaphycus (Eucheuma spp). However, due to many negative factors confronting the culture operation of the Cottonii seaweed such as, weather, escalating operational costs, environmental issues and the unreliable supply of good quality of seaweed seedling, has been suppressing the production of the Cottonii seaweed. It is generally agreed by the seaweed industry expert that the current Cottonii seaweed culture operation system worldwide is unsustainable and unable to meet the increasing demand for Carrageenan. The seaweed culture industry in Malaysia is also not immune to these adverse factors. Ever since the start of the culture of Cottonii seaweed in Malaysia, primarily in the East Coast of Sabah; the crop has been growing basically in the same culture configuration system, which is a family run cottage industry format and labour intensive operation and grown exclusively in the shallow lagoon in Semporna. Due to the difficulty of work for this kind of conventional seaweed culture method, the seaweed culture operation is not attractive to the local people and thus recorded a decline in local participation in the industry. This is one of the main factors impacting on the development of the seaweed culture industry and affecting the production of seaweed in the country despite the attractive incentives provided by the Government and the pristine culture environment that the Country possesses[1].

This study involve industrial design and review of model conceptual design of the offshore floating structures scientifically by improving the existing capability of traditional system for commercialized scale seaweed farming in Malaysia. Static and dynamic response study, transient response, maximum loading, floating structure interaction force and spectral analysis of the species will be performed for the novel offshore aquaculture floating system for open water plantation.

The new system will provide an effective solution for seaweed cultivation on a commercial scale in the coastal waters off Peninsular Malaysia. In line with the current drive by the Government for Economic Transformation, this project success will spur the development of the seaweed industry in the country and uplift the economic livelihood of the coastal fisherman, the rural poor and marine biotech industry. The current system is a physical system that is based on traditional knowledge and experience. A scientific based system, with proven structural integrity, well mitigated risk of system failure and environmental loading, for reliable very large floating aquaculture offshore structure with Intellectual Property (IP) filed is required. The design of the features inherent in the Project is meticulously crafted for deployment specifically in the East Coast of Peninsular Malaysia, where seaweed farming has not been done in the past, species studies is simultaneously required to be carried out to identify species that can grow in Peninsular Malaysia. The system design geared to accommodate the strong sea currents and periodic monsoon season that is prevalent off the South China Sea, in Terengganu is key to delopmnet of the reliable technology.

The novel concept design from this research will lay down the foundation for operational models and culture methods to attain to the problems and bottlenecks facing the seaweed culture industry in the Country. The offshore technology conceptual design work being proposed in this research involve transforming the conventional culture method to a modern farming approach to drastically increase production output and create value for the seaweed industry chain. The new system is designed for operation in the deeper water and large culture areas. The novel design will streamline the seaweed culture operation to achieve efficiency, cost effectiveness and sustainability. The new design can initiate social economic project by improving production and generating higher income for farmer thereby helping the marginalized rural coastal communities to raise their living standards.

Types of Macroalgae

In Malaysia, commercial seaweed farming started in Sabah waters in the 1970s. Sabah, mainly Semporna,Lahad Datu, Kudat, and Kunak. Is the major producer of seaweed in the country. Although the sector has developed enormously over the past few years (111,298 tonnes wet weight in 2008), seaweed production and national target by 2010 of 250,000 tonnes (wet weight) is however yet to be achieved.

1. Phaeophyta(brown algae)
2. Rhodophyta(red algae)
3. Chlorophyta(green algae)

The feature of macro algae are:

They form different group e.g eukaryotic and marine photosynthetic organisms

They are plant like organism

They comprise of a blade or lamina, the stipe and holdfast for guiding the entire structure to hard subsrates in marine environments

They are in different forms e.g long blades, branched, leavy and form mats. Moreover, theyposses air bladders that behave as floating devices for stand upright free floating on ocean surfaces.

They possess high level of structural polysachirides that are potential biochemical feedstock for production of liquid biofuels.

The alga are widely used as food products to health food for supplement vitamin, a few tens of grams of alga every day are sufficient to cover the vitamin and mineral salt intakes of a human.It is however possible to improve the nutritional value of these foods by means of glucanase or cellulase-based enzymatic pretreatment. Conversely, certain species –such as the *Porphyra tenera* (Laver) **-** have a very high nutritional value, with a digestibility in excess of 70 % with more than 30 % of proteins. In South East Asia where alga are widely consumed, Countries like Ireland use use alage “dulse” (*Palmaria palmata*), together with more conventional salads. In Norway, “black butter” is prepared using boiled algae, In France, eleven species were approved for human consumption.

List of algae approved by the ’’Conseil Supérieur d’Hygiène Publique’’ (High Board of Public Health) in December 1988 (Ifremer)

Species	Common or commercial name
Porphyra sp.	Nori - laver
Undaria pinnatifida	Wakame
Himanthalia elongata	Sea bean
Ulva sp.	Sea salad
Palmaria palmata	Dulse
Chondrus crispus	Irish moos or Pioca or lichen carragheen
Gracilaria verrucosa	Ogonori
Enteromorpha sp.	Aonori
Ascophylum nodosum	Black Goemon
Fucus vesiculosus et spiralis	Black Goemon
Spirulina sp.	Spirulin

Mooring system

Local in Sabah used rope, tie them to rope and suspend them with bottle of water. Local in any part of the world have deploy various system near shore, because of harsh environmental condition.

The mooring system is unique in the following sense:

It will provide opportunity to farm in offshore and deep water environment by providing reliable station keeping that would not lead to loss of seaweed in the presence of adverse environmental force.

The methodology develop for the modest test to get required hydrodynamic coefficient is different

In addition to this the reliable station keeping would provide food security, Eliminate shallow water environmental risk. It also enables opportunity to cover uncertainty gap in the design of offshore aquaculture system,

The holistic approach that incorporate model test, simulation mathematical model system integration compensation system and the methodology are unique elements that make the mooring design unique.

Potential for integrated use with offshore platform: Offshore and Deepwater aquaculture system development

The system has potential for integrated use with offshore platform: Offshore and Deepwater aquaculture system development

Risk of Multiple Mooring System

Quantitative risk analysis generally provides a more uniform understanding among different individuals, but requires quality data for accurate results. Quantitative analysis involve introduction of science, holistic and sustainability approach to analyses and quantify risk. It leads necessary weightage to assist decision required for the system in question. A mooring device is failed when the mooring reaction force W, due to oscillation of the floating structure, exceeds the yield strength R. The floating structure drifts when all its mooring devices are failed. Failure of a mooring device indicates presence of an event satisfying the following condition [5]:

Zk (t) = Wk (t; X) > 0 0 ≤ t ≤ T

where *X* is natural condition parameters, *T* duration of the natural condition parameters, and Rk the random variable for the final yield strength of mooring device *k*, *X* and Rk are independent of each other. The total reliability for years of service life is approximated by the following equation:

$$RN(T) = (1 - P_f(T))^N$$

Failure probability for oscillation of the floating structure is

$$[M_{ij} + m_{ij}(\infty)]X(t)'' + F_v(X)' + \sum_{j=1}^{n}\int_{-\infty}^{t} x_j(\tau)L_{ij}(t-\tau)d\tau + F_M(X,X) = F_{current}(t) + F_1(t) + F_2(t)$$

where X: displacement vector of horizontal plane response of the floating structure; Mij :inertia matrix of the floating structure; mij (“): added mass matrix at the infinite frequency; Fv: viscous damping coefficient vector; Lij : Memory influence function; FM: Mooring reaction force vector; Fcurrent : current load vector, F1 and F2: first and second current force vectors respectively. Estimation of wave force vector is generally expressed as the sum of linear wave force proportional to wave height and the slowly varying drift force proportional to the square of the wave height. See the equation below:

$$F(t) = F1(t) + F2(t)$$

$$- \int h_1(\tau)\,\zeta(t-\tau)\,d\tau + \iint h_2(\tau_1,\tau_2)\,\zeta(t-\tau_1)\,\zeta(t-\tau_2)\,d\tau_1\,d\tau_2$$

Where h1 ( ) h2 (1, 2) are the vectors of impulse response function of wave force. (t) is the time series of surface elevation of incident waves. Current are considered the dominant impact factor to algae cultivation offshore, Static loads due current are separated into longitudinal load, lateral load. Flow mechanisms which influence these loads include main rope drag, main buoy drag, seaweed drag, and planting lines drag. The general equation used to determine lateral and longitudinal current load are:

$$F = \frac{1}{2}\rho V^2 A\, C_d$$

Figure 3b and 3c shows 2 and many system arrangement and Figure 4 shows spread mooring analysis

Environmental uncertainty analysis

The model test is required to determine

Fig. 1(a). Saccharinallatissima

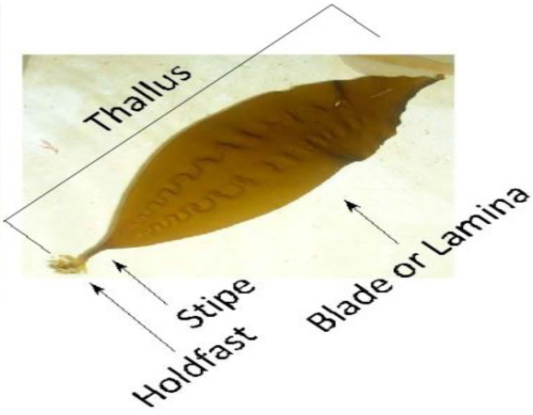

Fig. 1(b). Ascophllumnodosum

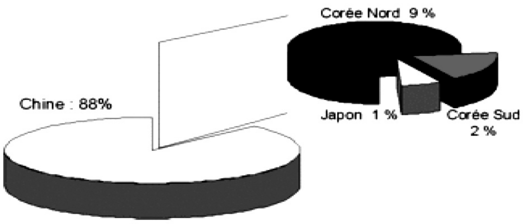

Fig. 2(a). Brown alage

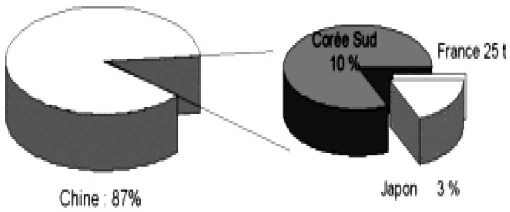

Fig. 2(b). Red alage

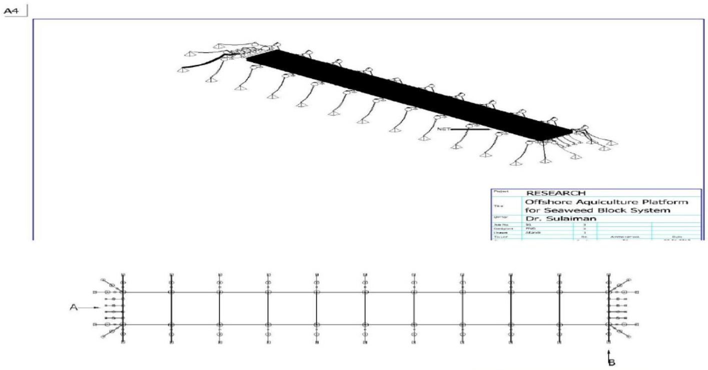

Fig. 3(a). The system

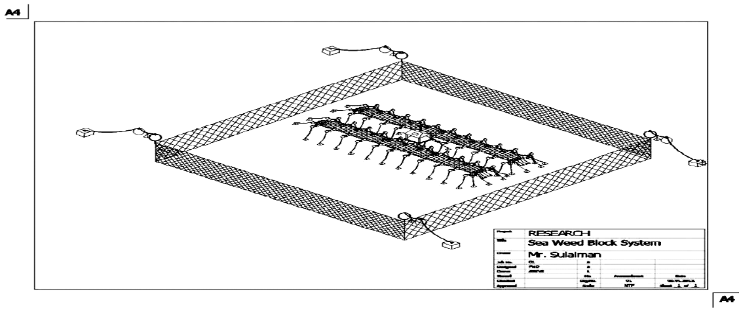

Fig. 3(b). Two systems

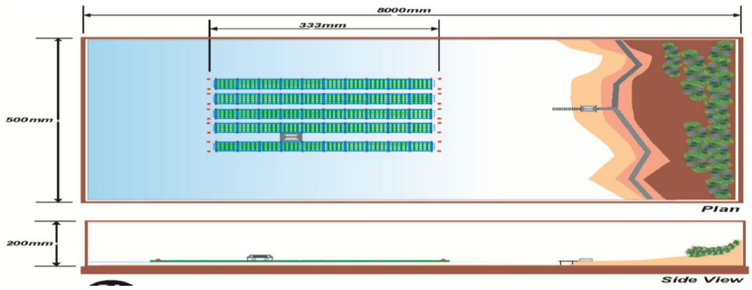

Fig. 3(c). Many system arrangements

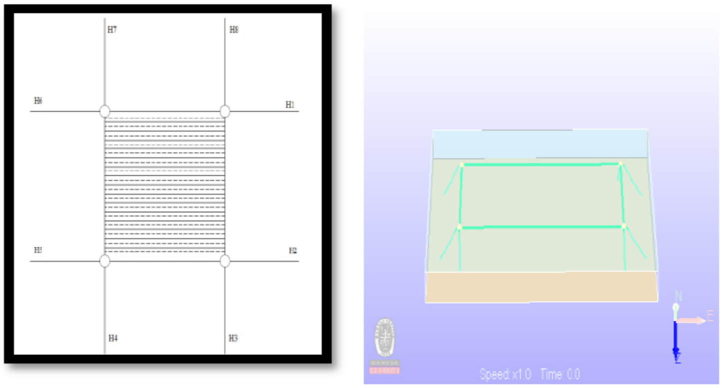

Fig. 4. Spread mooring system

Fig. 5. Model test

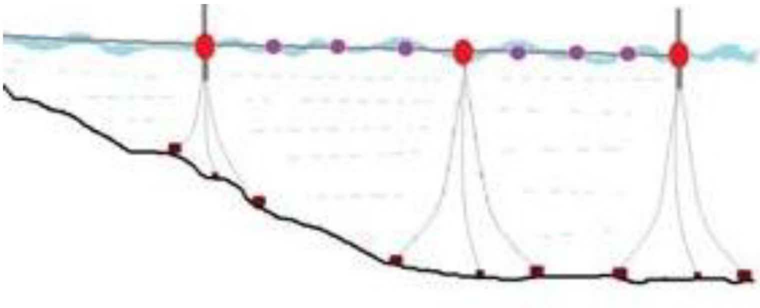

Fig. 6.

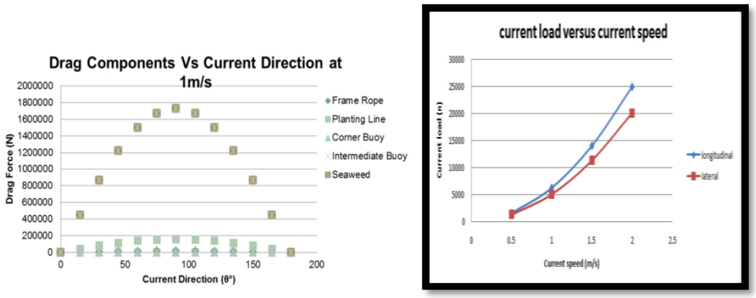

Fig. 7. Drag load on the system

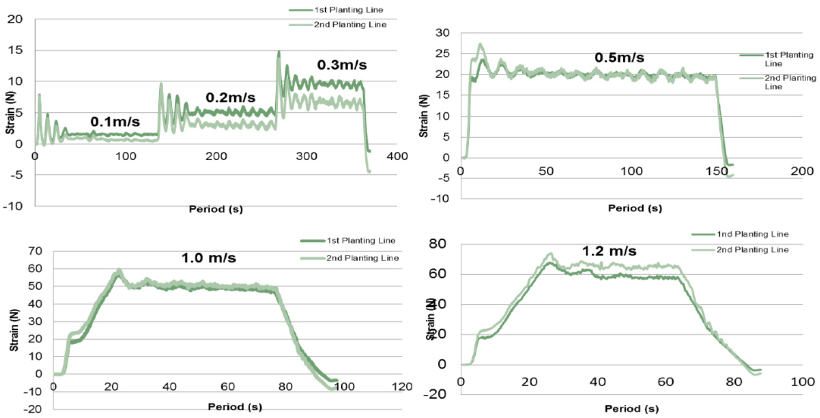

Fig. 8. Determination of hydrodynamic coefficient

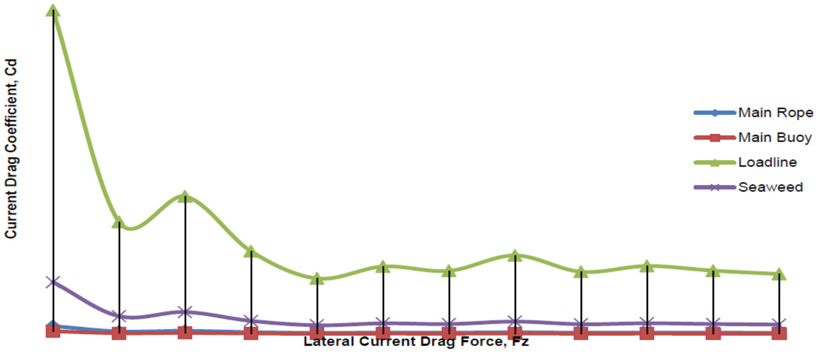

Fig. 9. Lateral current drag coefficient

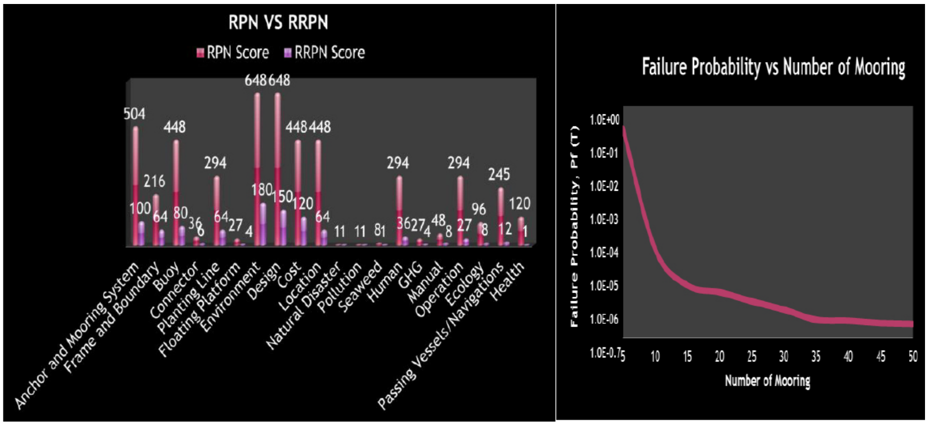

Fig. 10(a-b). Risk of multiple mooring systems

the hydrodynamic loads due to waves and currents acting on seaweed and its mooring system components. The total system loads must be suitable for use in designing a seaweed culture mooring system to avoid failure with potential loss of the valuable crop and possibly requiring costly repairs or replacement of the mooring system components. The model tests involved [6]:

- Measure drag loads of actual seaweed by towing
- Dynamic tests to measure added mass and damping using PMM. Originally, it was planned to use the planar motion mechanism (PMM).

A towing test conducted at UTM marine Lab involved (Figure 5) one method of research to determine the hydrodynamic loading coefficients (added mass and damping) in a few different configurations[6]. The samples which are seaweed are dried, but will restore to nearly nominal properties when soaked in water for a period of time. In typical practice, the rows of seaweed are held using ropes separated by about 2.6 m between rows. Static loads due to current are separated into longitudinal load, lateral load[7]. Flow mechanisms which influence these loads include main rope drag, main buoy drag, seaweed drag, and planting lines drag. The general equation used to determine lateral and longitudinal current load are

$$F = \frac{1}{2}\rho V^2 A C_d$$

Anchor System

The anchor system sizing and establishment of risk based design is required to determine the number of anchor to deploy (Figure 6).

Provide high level of reliability for the system to survive serious environmental loading.

Provide risk free and reliability method of deployment of aquaculture system offshore.

Figure 7 shows that strain increases with the increasing of current speed. The graph indicates that the second planting lines have a lower value compares to the first lines. This is due to the shielding affecting which the turbulent current acting on second line resulting the lower drag. Towing in the longitudinal direction revealed much less drag of about 0.3 at speed of 1m/s. Almost steady drag is observed between 05-0.8 (Figure 8).

Figure 8 shows result of hydrodynamic drag load buy subjecting the seaweed to different current load.

Figure 9 shows the graph of four different samples, main rope, main buoy, loadline and seaweed current drag coefficient with twelve different lateral current drag forces. From the figure of loadline result is to observed that more lateral current drag coefficient at every force compared to main rope, main buoy and seaweed. This is because the loadline has less weight compared with another and more force is needed. Hence, lateral current drag coefficient is higher. When the lateral current force is higher, the drag coefficient is higher.

Figure 10a shows result of qualitative analysis of the system, risk area required to be focus on is deduce from this. Especially quantitative risk is deduced to be investigated for the environmental loading and the design. From the mooring risk analysis the optimum required mooring line can be selected. Figure 9b shows that probability of failure against the consequence of the number of mooring and the current velocity. As conclude that, at per year 10-4 the best required mooring is about 10 until 15 number of mooring to avoid the probability of the system failure. It is observed taht the the probability of failure against the consequence of the number of mooring and the current velocity. As conclude that, at per year 10-4 the best required mooring is about 10 until 15 number of mooring to avoid the probability of the system failure

CONCLUSION

Developing a system that would be able to stay at sea and allow cultivation algae in the best environment and at large scale represent carbon capture system that improves GHG environmental impact. Cultivation in open sea, will help to eliminate human interference, Serve as water pollution biodegradation agent. Producing seaweed offshore would reduce salinity shock impact to ocean and coastal inhabitant

REFERENCES

1. Suzuki, H. *et al*., " ISSC committee VI.2 : Very Large Floating Structures," 16th International Ship and Offshore Structures Congress, Southampton, UK, 2006; 391–442.
2. Watanabe, E., Utsunomiya, T., and Wang, C.M., "Hydroelastic analys of pontoon-type VLFS: A literature survey," *Engineering Structures,* 2004a; **26:** pp. 245–256.
3. Fujikubo, M. and Yao, T., "Structural modeling for global response analysis of VLFS," *Marine Structures*, 2001; **14**: 295–310.
4. Alexey Andrianov, Hydro elastic Analysis of Very Large Floating Structures (M Eng thesis), TU Delft,2005 Page 11 of 11 Copyright@2010 by the author, copying of any portion of this proposal without the written permission of the writer is illegitimate and subjected to legal actions.
5. Salama MM, Storhaug T, Spencer B. Recent developments of composites in the oil/gas industry. SAMPE J Design of Offshore Aquaculture Structure For Seaweed Oceanic Plantation (04-01-12-SF0146) Design of Offshore Aquaculture Structure For Seaweed Oceanic Plantation (04-01-12-SF0146) Page 5 of 22 2002; 38:30–8.
6. Shaw J, Walsh T, Lundberg C, Reynolds H. Field experience in the application of spoolable carbon fiber pipe. In: Proceedings of3rd international conference on composite materials for offshore operations; 2000.
7. Kaur, C. R., Developing Malaysia's Seaweed Aquaculture Sector. Retrieved November 1, 2011, from BairdMaritime: http://www.bairdmaritime.com, 2009
8. J. P. Jones., Fleet Moorings. Design of fleet mooring 110-135. Naval facilities Engineering Command, 2006.