SELECTING A DESIGN OF SUSTAINABLE INLAND CONTAINER SHIP FOR BANGLADESH BASED ON ECONOMICAL AND ENVIRONMENTAL PERFORMANCES

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ABSTRACT

A sustainable design of a container ship from alternative options has been selected for inland shipping in Bangladesh. In this selection process commercial attractiveness of these vessels were compared at first by using net present values (NPV) of the investment as well as assessing the required freight rate (RFR) for carrying unit container. Environmental impact assessment (EIA), another important parameter nowadays, has also been assessed to analyse the consequences imposed by all the models on environment throughout the lifetime. Before making the final selection, their service qualities were also discussed. Considering all parameters, the ship with hatch cover has been found to be the best option for inland waterways in Bangladesh.

Keywords: *Economic performance, environmental impact assessment, ship design, global warming*

1.0 INTRODUCTION

Bangladesh is going to add a new fleet of container ships in her inland waterways in order to enhance the mobility of containers from and to the country's sea ports. It will definitely ease pressure on road and train transportation for delivering container. To do so inland container ports and the container handling facilities are being developed. New container ships are being owned by some public and private entrepreneurs.

In most of the cases commercial attractiveness of ships are considered for choosing the project. A design selected on the basis of only economic performance may not sustain for long. People all over the world have become more aware of their consumption of goods and services and their impact on the natural resources and quality of environment. As a result, new stricter regulation is coming day by day to tackle global and local issues like climate change, ozone layer depletion etc. Such regulations often increase the cost of operation. So it is always wise to take these possibilities into account while planning to launch a new project.

The main objective of this paper is to focus on selecting a design considering not only the commercial attractiveness but also the environmental burden imposed by the ships. The quality of service is also considered in this selection process.

Hasegawa and Iqbal [1], Iqbal and Hasegawa [2] and Iqbal and Shill [3] adopted methodology to compare inland water and road transportation systems to find the best option for carrying cargo and passenger. This method included comparison of economical benefit, environmental burden imposed and service quality rendered by the transportation systems. In this paper similar methodology was used to compare alternative design of container ships. Here the environmental impact assessment was carried more in depth using the software SimaPro [4].

2.0 METHODOLOGY

For economic analysis net present values (NPV) of the investment after considering the total price of the ships and operating costs throughout its entire life span has been estimated for a number of alternative designs of container ships suitable for inland waterways of Bangladesh for the proposed Dhaka-Chittagong route. The minimum freight charges required to carry a container (TEU) between the same route, that is, required freight rate (RFR) [5], are also estimated and compared to find the commercial attractiveness. In all the cases 12% rate of return (RR) on the investment was taken into account.

Environmental impact assessment (EIA) is the technical qualitative and quantitative characterization and assessment of the consequences of absorption and emission of various materials and substances from and to the environment. The impact analysis addresses ecological and human health consequences and resource depletion and could be divided into three sub-phases:

- Classification: sorting of parameters into environmental effect categories.
- Characterisation: calculation of the potential contribution of the environmental loading to each effect category.
- Valuation: assessment of the total environmental impact of the product life cycle.

In this study SimaPro, an EIA database software, was used to assess the consequences on the environment carried by the alternative container ships in their whole life cycle. The effect categories considered here included carcinogens, respiratory organics/inorganics, climate change, radiation, ozone layer depletion, aquatic acidification/eutrophication, land use, mineral extraction, fossil fuel extraction, etc. These effect categories have impacts on resources, human health, global warming, habitat alteration, biological diversity and other hazards. Assessing the potential contribution of the ships to all these impact types, total damages were assessed and compared to find which one will impose minimum burden to our environment.

Finally discussing the service quality available from the alternative ships, the best alternative was proposed for the inland shipping in Bangladesh.

3.0 MODEL CONSIDERED

Four model designs of container ships were considered in this analysis. Although, the choice of primary parameters/hull form coefficients is a matter of design style and tradition, but due consideration must be given if there is any constraints in that route. In this study, a dimensional constraint on the limit of length, breadth, draught and air draught has been imposed compatible with the proposed route. For example, a constraint on length is set by the dimensions of regulatory body's restriction considering river width, maneuverability of ship to turn in this narrow waterway etc. A limit on draft for the vessels is set by the existing availability of the depth of water in the ports as well as navigability of approaches throughout the season to which the ship is intended to trade.

The particulars of the models shown in Table 1 have been selected after considering all the constraints. A typical General Arrangement of container ship has been shown in Figure1. Figure 2 shows the different components of life cycle assessment of ships and Table 2 contains the amount of some of the materials and energy used in various phases of the ships' life cycle. The figures shown in the tables were the major input data in this analysis.

Table 1: Particulars of Selected Container Ships Considered

Ship Type	Length (M)	Breadth (M)	Depth (M)	Speed (KN)	Engine Power (KW)	Capacity (TEUs)
Closed Top Container Ship (With hatch cover)	75.5	13.15	6.2	10	1130	108
Open Top Container Ship (without hatch cover)	75.4	13.15	8.0	10	1130	108
Deckloading Container Ship	75.4	15.66	4.2	10	1140	100
Deckloading Container Ship	75.1	13.15	4.2	10	910	80

Table 2: Materials and Energy Consumption during Construction, Maintenance and Operation of four selected container ships

Ship Type	Construction and Maintenance Phase				Operation Phase	
	Material			Energy	Diesel (kg)	Lub Oil (kg)
	Hull	Machinery	Outfitting			
	Low alloy Steel (kg)	Ferrochromium High Carbon Steel (kg)	Brass (kg)	Electricity (MJ)		
With hatchcover	8.33E5	6.95E4	7.5E3	1.53E6	1.47E7	2.92E5
Without hatchcover	8.94E5	6.95E4	7.5E3	1.63E6	1.47E7	2.92E5
Deckloading (B = 15.66m)	8.74E5	6.95E4	7.5E3	1.6E6	1.48E7	2.95E5
Deckloading (B = 13.15m)	8.25E5	6.95E4	7.5E3	1.52E6	1.26E7	2.49E5

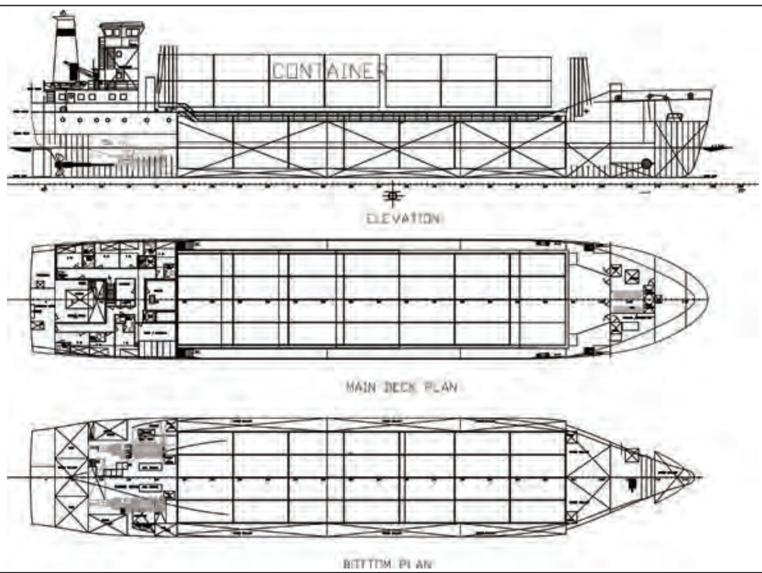

Figure 1: Typical General Arrangement of closed top container ship for inland shipping in Bangladesh

4.0 ECONOMIC PERFORMANCE OF THE MODEL SHIPS

Considering 30 years life time, required freight rate (RFR), that is, minimum freight charge required to attain 12% rate of return on investment as first cost of ship and operating cost, was estimated for carrying 1 TEU container through a distance of 307 km between Dhaka and Chittagong. Fifteen off-hire days per annum for maintenance was taken into account in this estimation. Net present value (NPV), another parameter for comparison of economic performance, was also estimated here to find economically the most attractive ship model. For this estimation 8000 Tk./TEU, which is the current rate charged by railway, was considered.

Both the parameters were calculated according to I.L. Buxton [5]. The Results are shown in Figure 3 and Figure 4.

The ship with hatch-cover showed the best performance, that is, the minimum required freight rate of Tk. 6035/TEU and the highest net present value of Tk. 365,149,000. All with 12% rate of return on investment. The ship without hatch-cover was the next. The worst among the four was the ship with deck loading and 13.15m breadth. This is because the ship with hatch-cover had the capacity of 108 TEUs and comparatively low construction cost. The construction costs of the deck-loading type ships were comparatively higher due to its heavy deck construction to withstand the containers' weight.

5.0 ENVIRONMENTAL IMPACT ASSESSMENT

Environmental impact assessment of the models were carried out using the software SimaPro. Amount of some major materials and energy required to construct and operate the model ships were used as input to the system. The percentage of the materials which were considered to be recycled was also used as input. SimaPro developed life cycle model of the ship with the inputs and outputs from and to the environment. The life cycle model of the container ship with deck-loading and 15.66m breadth is shown in Figure 2. Similar models were generated for other three ship models. Then, using SimaPro, the environmental burden imposed by the ships were assessed. The results were shown in Figure 5 as the comparison of environmental impacts for four different models, Figure 6 as the damage assessment and Figure 7 as the single score of the consequences of environmental burden. In these results the impacts on human health, ecosystem quality, climate change and the use of resources are shown. The best option from the environmental point of view was the ship with deck-loading and 13.15m breadth and the worst was the ship with deck-loading and 15.66m breadth. The impacts imposed by two other ships are very close in magnitude, with only a very little better result for ship with hatch-cover [6].

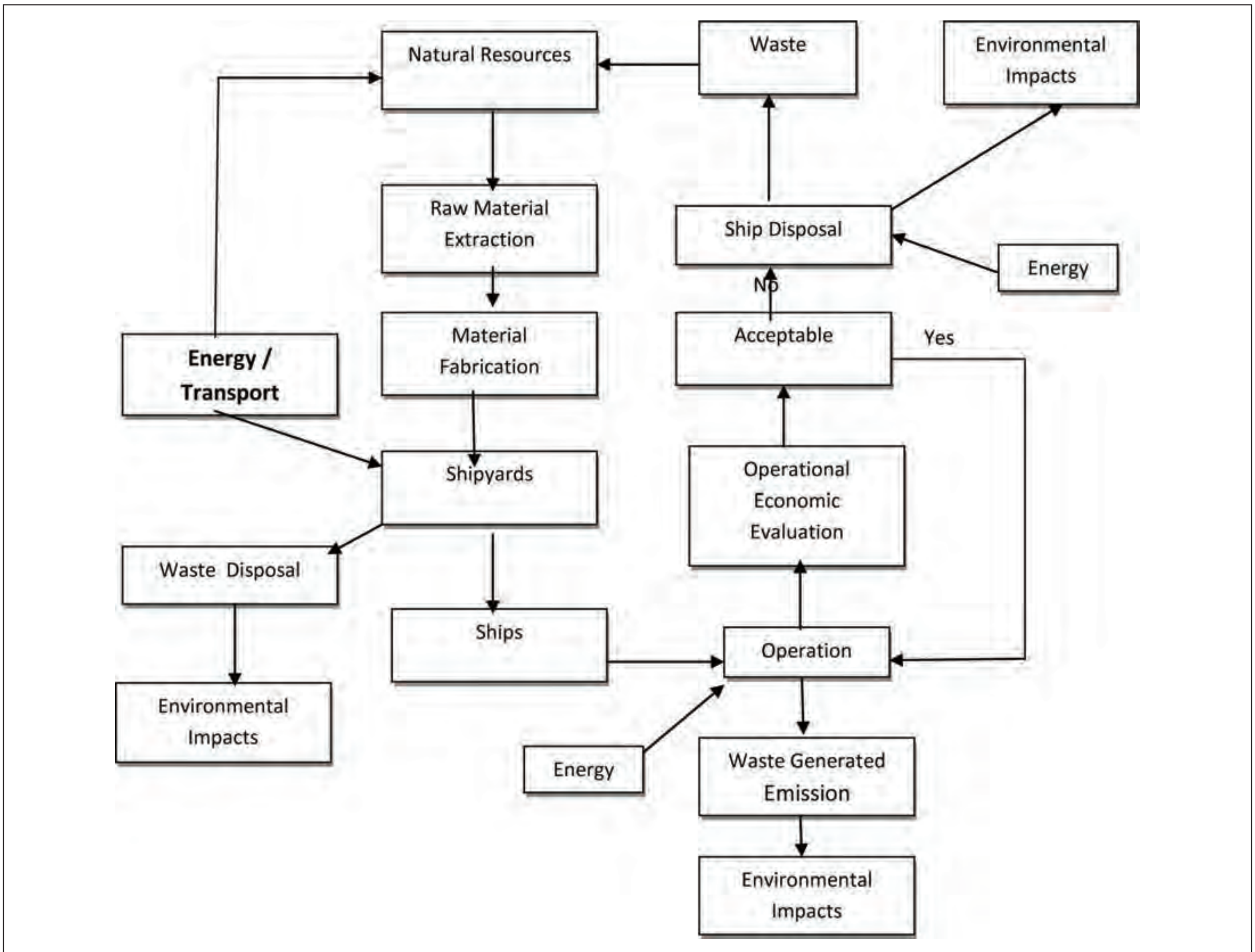

Figure 2: Life cycle assessment of container ships

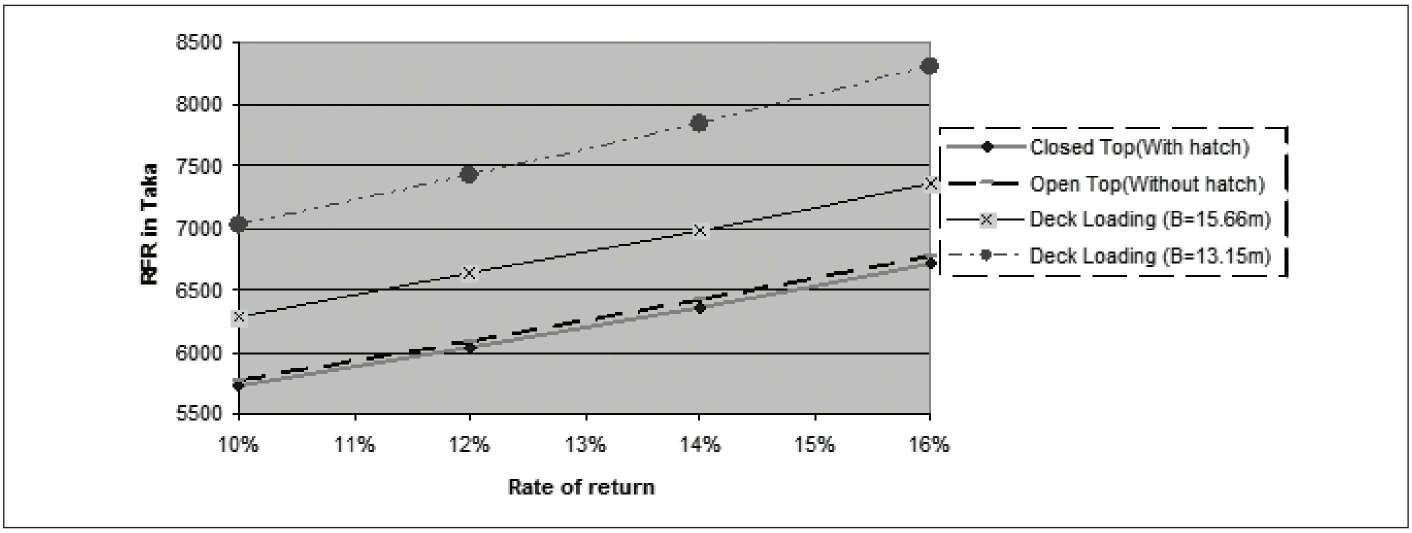

Figure 3: Required freight rate for carrying 1 TEU between Dhaka and Chittagong by alternative container ships

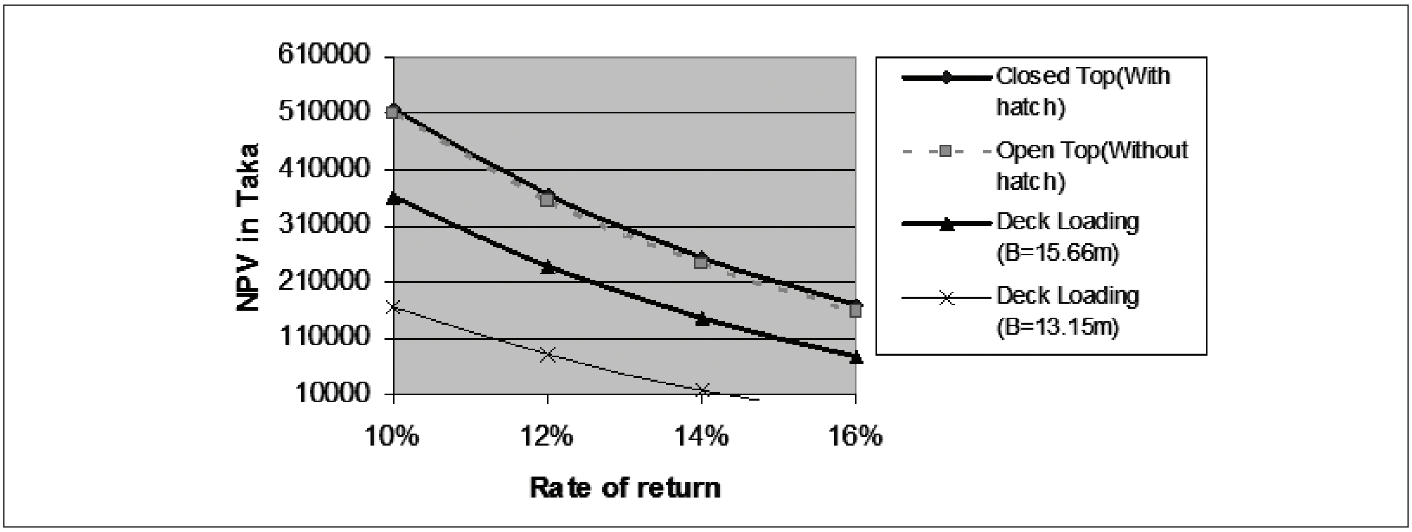

Figure 4: Net present value of the cash flow for carrying containers between Dhaka and Chittagong by alternative container ships

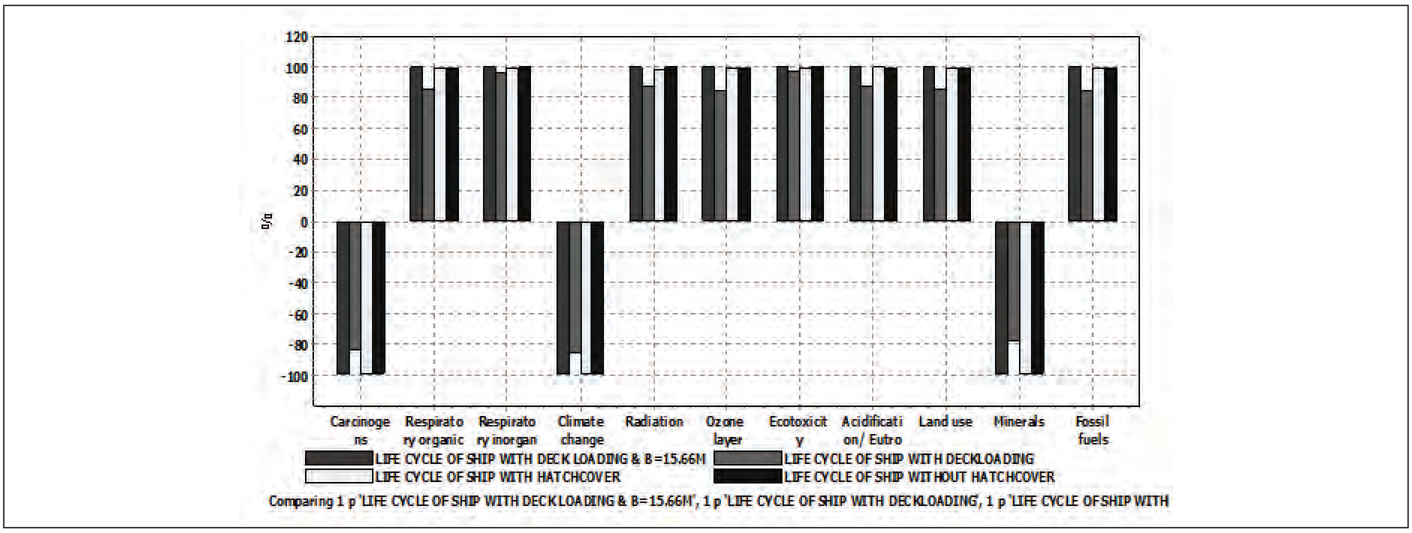

Figure 5: Comparison of environmental impacts for four model ships

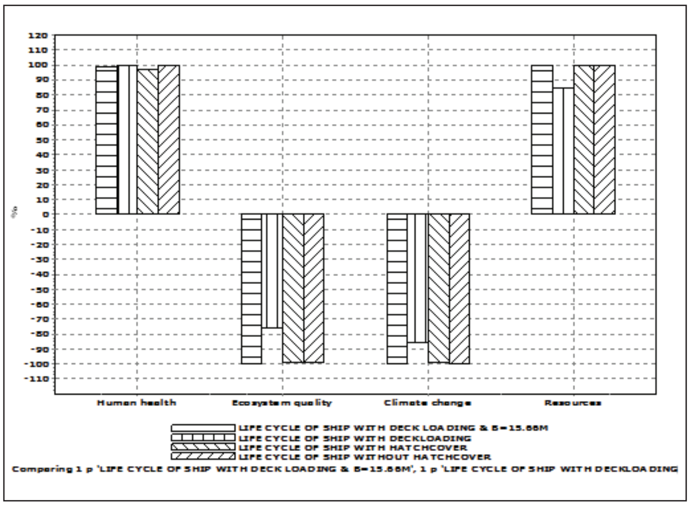

Figure 6: Damage assessment of four model ships' life cycle

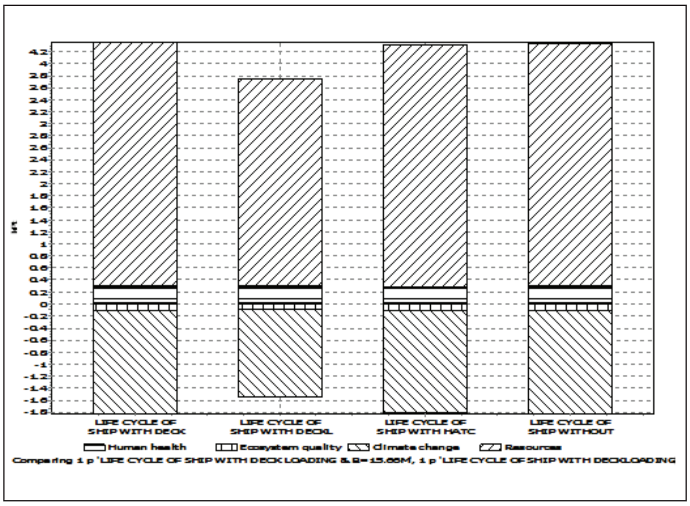

Figure 7: Single score of the consequences of environmental burden of four model ships

6.0 SERVICE QUALITY

For loading and unloading of the containers, deck-loading type ships will be favourable. But it deserves special cares against the flooding of sea water in the hold during a coastal navigation in rough sea condition and hence the vessel shall need an extra ship's depth to keep the freeboard. On the other hand ship with hatch-cover will protect the containers from adverse weather condition and from the hull strength point of view, it will enhance the longitudinal and tensional strength of ship. Among the models considered here the ship with and without hatch-cover have more capacity of carrying containers, which is 108 TEUs.

7.0 CONCLUSION

Analysing three different criterion like economic benefit, environmental burden imposed and service quality, the ship with hatch-cover would be the best option among the models of the container ships considered. The following reasons were in support of this option:

- it would require minimum freight rate to attain specific rate of return on investment,
- it would ensure maximum net present value of the total cash flow in its life time,
- though the ship with deck-loading and 13.15m breadth showed minimum damage to the environment, the ship with hatch-cover got more capacity of carrying 108 TEUs containers.
- the loading – unloading facility is in favour of deck-loading type container ship, but the ship with hatch-cover would protect the containers from damage occurred by bad weather.

There are uncertainties in such analysis. One should be aware of these uncertainties while using such model for comparison of different projects. The reasons behind these uncertainties are usually due to:

- uncertain data,
- uncertainties on the correctness of the model,
- uncertainties caused by incompleteness of the model,
- different opinion on weights of various impact categories, etc. ■

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