Sustainable Solutions in Structural Engineering and Construction
Edited by Chantawarangul, K., Suanpaga, W., Yazdani, S., Vimonsatit, V., and Singh, A.

ISBN: 978-0-9960437-0-0

FINANCIAL FEASIBILITY OF THE SUNDA STRAIT BRIDGE CONCEPTUAL DESIGN USING THE VALUE ENGINEERING METHOD

MOHAMMED ALI BERAWI, BAMBANG SUSANTONO, PERDANA MIRAJ, GUNAWAN, ABDUR ROHIM BOY BERAWI, and ALBERT HUSIN

Civil Engineering, University of Indonesia, Depok, Indonesia

Sunda Strait Bridge (SSB) is a mega-infrastructure project offered by the Indonesian government, expected to contribute to national economic growth by bridging economic connectivity between two major islands in Indonesia. At first, SSB construction was offered as a US$10 billion project in 2010. Then in 2011 it was revised into a US$25 billion project with additional scope of work, i.e., industrial area development along the site. Yet it was still unattractive to private investors due to a lack of technical and financial feasibility. Thus, the Value Engineering (VE) approach was used to increase and improve the project's feasibility by generating innovative ideas. Innovation through additional functions for SSB development is comprised of: 1) development of renewable energy-based power plant by using tidal and wind power; 2) integration of oil and gas pipelines; (3) fiber-optic pipelines; 4) tourism development in Sangiang Island accessed by either road bridge or hanging train; and 5) development of industrial area. The life-cycle cost analysis by IRR and NPV approaches confirmed that SSB development with additional functions increased the internal rate of return of the overall project up to 7.26% and had a positive NPV.

Keywords: Innovation, Life cycle cost, Life-Cycle analysis, Transportation, Value for money, Fiber-optics, Tourism development.

1 INTRODUCTION

Infrastructure development plays an important role in stimulating a nation's economic growth. In 2011, the infrastructure industry contributed 5.5% to Indonesia's GDP with real growth of 9.3% (BMI 2012). Sunda Strait Bridge (SSB) is a mega project offered by the Indonesian government as an initiative to connect Java and Sumatra Islands. Initially, it was offered as a US$10-billion project in 2008. However, due to a lack of feasibility, in 2011 it was revised to a US$25-billion project with an additional scope of work, i.e., industrial area development along the site. SSB is planned to be one of the longest bridges in the world at 30 kilometers, and is expected to be an efficient means for transporting people and goods between the two islands. According to Berawi (2010) and the Coordinating Ministry for Economic Affairs (2011), other potential areas that are parallel with SSB's development have been explored in the past three years, including the possibility to install liquid and gas pipes, fiber optics, industrial area development, and energy utilization.

SSB's development requires comprehensive study in planning, funding and construction techniques. This research proposes to produce a conceptual design of SSB in order to improve project feasibility and to provide added value to the project by using the Value Engineering (VE) approach. VE has been systematically applied to analyze the function of a system expected to produce optimum outcomes concerning project quality (Sik-wah Fong and Shen 2000), by combining various knowledge among stakeholders (Zack *et al.* 2009), producing technology breakthrough (Yang *et al.* 2012), and stimulating efficiency as well as innovation in order to obtain maximum value for the project (Berawi and Woodhead 2008, Chen *et al.* 2010). Implementation of VE in this study follows the stages that exist on the VE job plan, which is then finalized with an evaluation phase to calculate the feasibility of the project using LCC method. The This research analyzes the financial feasibility of SSB's conceptual design with four additional functions: energy, tourism, telecommunications, and industrial area, in addition to transportation as its main function (Berawi 2013), by considering the life-cycle cost.

2 METHODOLOGY

This research was conducted by using qualitative and quantitative approaches, with structured questionnaire and focus-group discussion as the research instruments. The questionnaires were distributed both online (softcopy) and offline (mail/hardcopy), and were used to identify the stakeholders' perception on the ideas generated by the VE process. Online distribution was conducted via e-mail to seven (7) mailing lists related to the SSB project, while offline distribution was conducted by sending questionnaires to 90 respondents. Respondents were selected because they represent SSB key stakeholders, most holding key positions in various government and private institutions.

The data collected from the questionnaire survey was then analyzed by using descriptive analysis to find the mean value, frequency distribution, and inferential statistics through Cronbach's Alpha and one-sample T-test. Meanwhile, life-cycle cost (LCC) analysis was used according to the five identified functions (transportation, energy, telecommunication, tourism and industrial development) by calculating the initial costs, operational and maintenance costs, and revenues. In term of SSB financial feasibility calculation, Net Present Value (NPV) and Internal Rate of Return (IRR) were used to consider the discounted rate and inflation in each sector.

3 RESULT AND DISCUSSION

Innovation in SSB is driven by seeking potential resources around the Sunda Strait. There are natural resources such as strong winds, ocean waves caused by tidal current, potential tourism in the local Sangiang and Prajurit Islands, efficient distribution of oil and gas, and the development of an internet network between Java and Sumatra, which became the launching pad for incorporating additional functions into the SSB project.

A FAST diagram was produced during function analysis and creativity stage by utilizing VE in the process. Besides transportation, the main function of the SSB, the FAST diagram also produced four major additional functions: energy function, comprised of tidal-power plants, wind-power plants, and oil and gas pipelines; telecommunication function; tourism function; and industrial-area development.

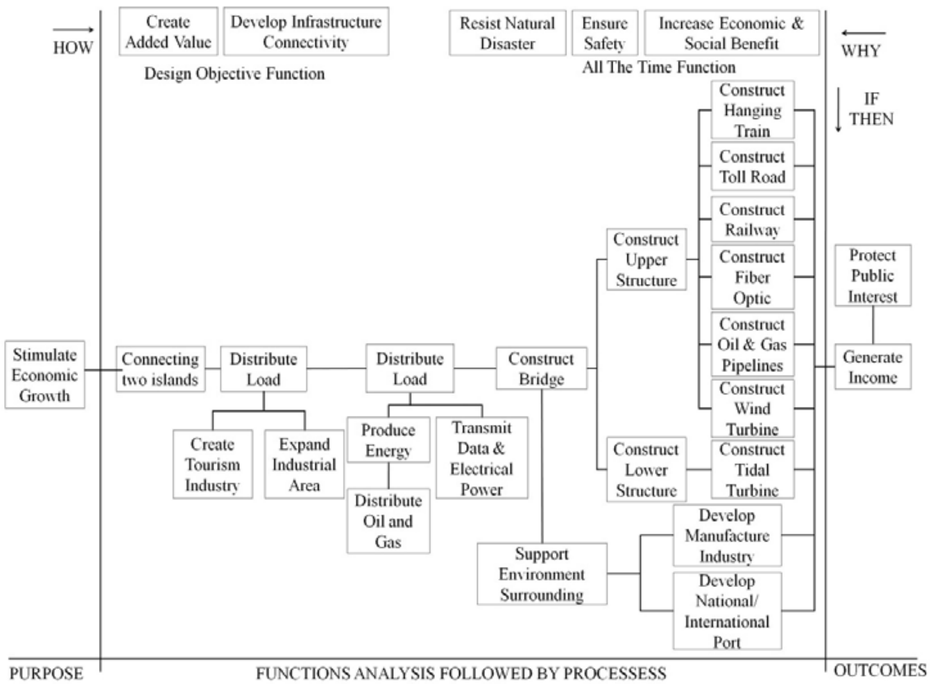

Figure 1. SSB FAST diagram.

3.1 Questionnaire Survey

Questionnaires were created in a structured manner to be easily filled out by the respondents. The survey obtained 35 returned questionnaires. Most of the respondents worked at private companies (43%), and the second-largest group (26%) worked at government agencies. Meanwhile, more than 40% of the respondents were post-graduate degree holders. Over 40% of the respondents had architect/engineer backgrounds, and 20% of them were in managerial and general director positions.

Most of the respondents prioritized fiber-optic lines, followed by tourism development and oil and gas distribution pipelines, as potential functions to be integrated into the SSB design. Regardless of the respondents' feedback, tidal power is argued to have more value by generating electricity, and offering a new step in renewable energy implementation. Cronbach's Alpha showed that the questionnaire survey had very consistent variables, ranging from 0.5 to 0.8, and indicated good reliability. Furthermore, focus-group discussion acknowledged those identified functions that were generated through value engineering process, which were then developed into a visualization concept of SSB as shown in Figure 2.

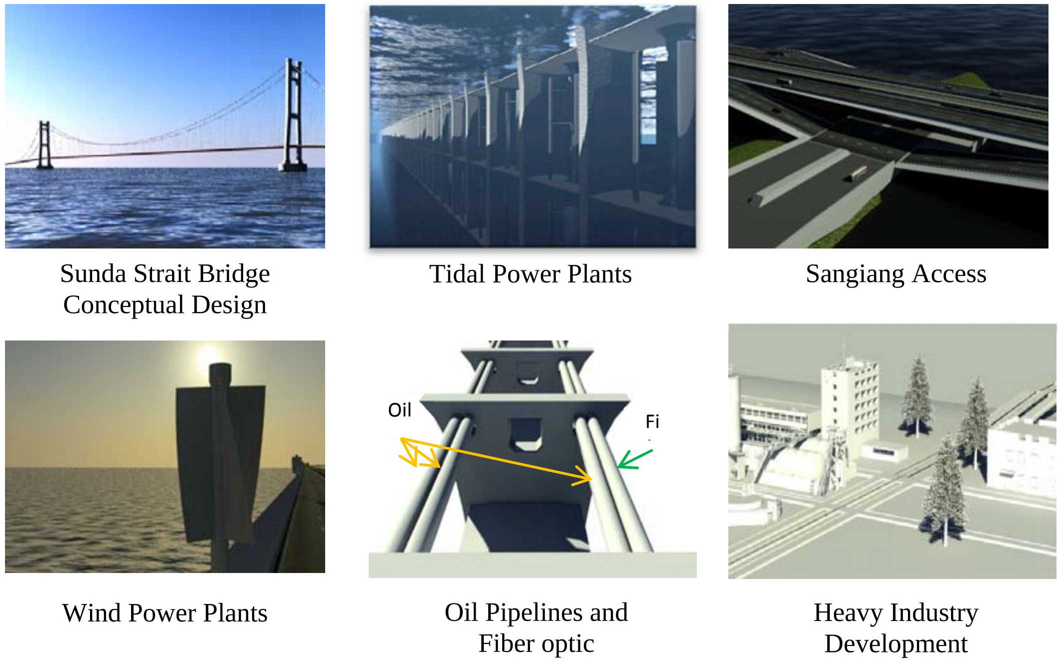

Figure 2. Visualization of SSB conceptual design.

3.2 Life-Cycle Cost Analysis

Life-cycle cost serves as the evaluation stage in exercising VE, and is intended to get the decision based on benchmarking. First, the transportation function in the SSB conceptual design consists of a bridge structure that is divided into two types: 7.4 km of suspension bridge and 21.4 km of concrete-viaduct bridge. Messina Bridge in Italy was used as a benchmark to calculate the initial costs due to similar transportation facility and technology. The estimated construction cost for the transportation function is US$10,626.45 million, with operational and maintenance around US$2,201.98 million for 27 years. The estimated revenue for the transportation function was obtained from toll-road tariffs and railway tariffs. Toll-road tariffs was classified into first class for US$48, second class (trailer and buses) for US$107, and sixth class (motorcycle) for US$7; meanwhile, passenger trains were charged around US$4 per person and freight trains US$1.5/ton. As the result, the revenue gained for this function would be US$15,541.96 million for the 2024-2050 period.

Second, the energy function, i.e., tidal power, wind power, and oil and gas distribution: According to benchmarks, Davis turbine technology would used as the tidal power turbine in the SSB conceptual design. Assuming that the Sunda Strait current is around 2 m/s and the turbine efficiency in generating electricity is 35%, the potential output of the turbine is expected to reach 500 mW. Meanwhile, a 42-inch oil and gas pipeline will be built stretching 90 km between Banten and Lampung to connect two oil depots with 3,000 BOE capacities. Thus, the initial cost required for the energy function is US$1,143.78 million, with operational and maintenance costs around US$562.13 million for 27 years. Considering that the electricity charge is set to

US$0.08/kWh, oil distribution toll fee at US$0.18/barrel, and gas distribution toll fee at US$0.06/mmbtu, the revenue of the energy function will be around US$7,132.38 million for the 2024-2050 period.

Third, the tourism function, i.e., the hanging train located on the bridge, and cable car and theme park located in Sangiang Island. These concepts were selected based on similar systems in Germany, Malaysia, and Hong Kong. Therefore, the initial cost required for the tourism function is US$4,163.31 million, with US$108.74 million for operational and maintenance costs. The projection for tourists using the hanging train and cable car facilities from Sangiang Resort is 60%. Hanging train and cable car tariff is set to US$3.13/person, Sangiang Resort entrance fee US$36.50, and hotel pricing US$104.20 per night. Therefore, the revenue obtained will be around US$27,036.75 million for the 2024-2050 period.

On the other hand, the initial cost for the telecommunication function is estimated based on fiber-optic construction by PT Telkom valued at US$15,937.50/km, and by assuming that the public works would be covered by the SSB span. Operational and maintenance costs for the fiber optic is estimated from USDOTRITA at US$1,187.5/km/cable/year. Subsequently, construction costs are estimated at US$0.46 million, with US$0.93 million for operation and maintenance costs. By assuming a fiber optic charge of around US$8,500 per year, the revenue generated for the telecommunication function would be US$10.73 million in 27 years.

Finally, industrial areas will be located in Banten Province on Java and Lampung Province on Sumatra, in areas of 3,000 Ha. Several considerations have been made: the land acquisition cost would be US$52/m^2, and infrastructure development for industrial areas US$21/m^2. Therefore, the construction cost for the industrial area function would be around US$3,645.83 million. Since the area is to be sold off gradually, operational and maintenance costs are not taken into account. Thus, the revenue gained from this function will be around US$9,664.95 million. The summary of the analysis can be seen in Table 1.

Table 1. Life-cycle cost analysis summary.

Function Components	Construction cost	O&M cost (2024-2050)	Revenue (2024-2050)
Transportation	$ 10,626.45 million	$ 2,201.98 million	$ 15,541.96 million
Energy	$ 1,143.78 million	$ 562.13 million	$ 7,132.38 million
Telecommunication	$ 0.46 million	$ 0.93 million	$ 10.73 million
Tourism	$ 4,163.31 million	$ 108.74 million	$ 27,036.75 million
Industrial Area	$ 3,645.83 million	-	$ 9,664.95 million
Total	$ 19,579.83 million	$ 2,873.78 million	$ 59,386.77 million

3.3 Analysis of Financial Feasibility

The overall result showed that SSB investment indicated a prospective financial feasibility, with an IRR of 7.26% and a positive NPV. Yet, the IRR value obtained ranged from 1.14% to 29.13% among the identified functions. Therefore, an incremental ROR analysis was conducted as capital share (initial cost sharing) calculation, which was expected to give a balanced IRR above the discounted rate (6.81%) among the identified functions. A summary is shown in Table 2.

4 CONCLUSION

Innovation through additional functions for SSB's development includes: 1) power plant development based on renewable energy using tidal and wind power, 2) integration of oil and gas, (3) fiber-optic pipelines to the bridge, 4) tourism development in Sangiang Island accessed by either road bridge or hanging train, and 5) development of industrial areas. Life-cycle cost analysis using IRR and NPV approaches confirmed that SSB development with additional functions increased the IRR of the overall project up to 7.26%, and gave a positive NPV.

Table 2. Incremental ROR analysis and capital share.

Function	Capital Share	IC Before (US$Million)	IC After (US$Million)	IRR Before	IRR After
Tourism	40.00%	4,163.31	8,413.89	13.01%	7.23%
Energy	11.30%	1,143.78	2,344.57	14.72%	7.27%
Industrial dev.	4.00%	3,645.83	4,070.89	8.30%	7.28%
Telecommunication	0.03%	0.46	3.12	29.13%	7.24%
Transportation	-	10,626.45	4,747.36	1.41%	7.29%

Acknowledgments

This research is fully supported by grants from National Priority Research Grant-Master plan for Acceleration and Expansion of Indonesia Economic Development (MP3EI) and International Collaboration Research Grant, University of Indonesia.

References

Berawi, M. A., *Peran, Tantangan dan Prospek Pertumbuhan Jasa Konstruksi* Indonesia. Keynote Speaker, GAPEKSINDO National Seminar, Jakarta, 12 October 2010.

Berawi, M. A., and Susantono, B., Developing conceptual design of mega infrastructure project: creating innovation and added value, *Value World*, 36, 12(20), 2013.

Berawi, M. A., and Woodhead, R. M., Stimulating innovation using function models: Adding product value. *Value World,* 31(2), 4-7, 2008.

Business Monitor International (BMI), *Indonesia Economic Growth*, 2012.

Chen, W. T., Chang, P. Y., and Huang, Y. H., Assessing the overall performance of value engineering workshops for construction projects. *International Journal of Project Management*, 28(5), 514-527, 2010.

Coordinating Ministry for Economic Affairs, *Master Plan for Acceleration and Expansion of Indonesia Economic Development*, 2011.

Sik-wah Fong, P., and Shen, Q., Is the Hong Kong construction industry ready for value management? *International Journal of Project Management*, 18(5), 317-326, 2000.

Yang, L. R., Chen, J. H., and Wang, H. W., Assessing impacts of information technology on project success through knowledge management practice, *Automation in Construction*, 22, 182-191, 2012.

Zack, M., McKeen, J., and Singh, S., Knowledge management and organizational performance: an exploratory analysis, *Journal of Knowledge Management*, 13(6), 392-409, 2009.