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Mobility Design Concept for Port Cities

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Abstract: This paper discusses the concept of Mobility Design referring to the good practices on urban transportation all over the world as well as to some experiences by the author and his team. Firstly, six important principles (walkable town, safe and secured bicycles, transit first, parking management, modal shift, and leading demonstration) are introduced with some references to confirm the importance of Mobility Design to realize the vision of the cities as well as to solve the problems of the cities related to urban transportation. The author also mentions the experiences in Yokohama city as an example of big port cities to apply the concept of Mobility Design into the city. Several features of port cities are discussed such as importance of freight transport management on road traffic network, multi-modal and inter-modal concepts taking water transport into consideration. The paper concludes with the importance of vision making with mobility designing for better quality of lives in port cities.
Keywords: Port-City, Transportation, Mobility Design

Introduction

This paper discusses the concept of Mobility Design referring to the good practices on urban transportation all over the world as well as to some experiences by the author and his team. Firstly, six important principles (walkable town, safe and secured bicycles, transit first, parking management, modal shift, and leading demonstration) are introduced with some references to confirm the importance of Mobility Design to realize the vision of the cities as well as to solve the problems of the cities related to urban transportation. The author also mentions the experiences in Yokohama city as an example of big port cities to apply the concept of Mobility Design into the city. Several features of port cities are discussed such as importance of freight transport management on road traffic network, multi-modal and inter-modal concepts taking water transport into consideration. The paper concludes with the importance of vision making with mobility designing for better quality of lives in port cities.

Concept of Mobility Design

The academic discipline of transportation planning used to revolve around demand forecasting, which represented an important process in obtaining quantitative findings that could corroborate the need for road infrastructure, railroad facilities, and other elements of the social transportation infrastructure. Meanwhile, the study of traffic engineering has adopted a more practical perspective that sought to solve traffic flow and

safety issues through the application of engineering concepts; it has taken an extremely dedicated approach to "motorization" and the problems of traffic accidents that come along with it.

Looking at cities themselves, one can also see how actual conditions and frameworks have continued to transform and evolve. The examples are many: years ago, the prominent thrust was the idea of vigorously pushing forward from industrial development to economic growth. That gradually gave way to, for instance, the idea of respecting cities as collections of valuable historical stock, the idea of focusing on urban poverty issues to promote social participation of the lower classes, the idea of encouraging the social inclusion of elderly people unable to drive their family cars, the idea of conserving supplies of limited resources, the idea of building "creative cities" that uncover new value through enhanced personal interaction and activity, and the idea of fostering sustainable cities that aim to cut down on carbon dioxide emissions in hopes of combating global warming and strive to balance economic efficiency. These are just several transitions that illustrate this evolutionary process.

From the perspectives of the environment, welfare, and urban economics, car traffic has become an increasingly important issue to confront. Many cities have changed their constructs and environments on the assumption that people would be using cars−and these cities are now experiencing the difficulties of the problems outlined above. Given these realities, it would be fair to say that any effort to establish the ideal form, circumstances, and orientation of a city has to take transportation into consideration. Buchanan underscored this idea in his discussion of central London with the concept of "traffic architecture."

Incorporating the transportation function into the city-formation process is an element of urban design. One could also very well say that transportation figures prominently into the process of weaving the complex web of interactions among residential housing, green spaces, and the resulting scenery into the larger fabric of the city landscape. Framing transportation too firmly as a purely engineering-oriented endeavor confuses the issue; although transportation has facets that belong squarely in the engineering category, researchers have to approach transportation from a more interdisciplinary vantage point. In this paper, "transportation" is thus best understood as "mobility." If urban design serves to shape people's lives and lifestyles by tweaking the positioning and configuration of buildings, roads, and parks, "mobility" design would be a better fit than "transportation" design to describe the process of constructing environments and possibilities for movement. Mobility design, like virtually all other components of urban design, has to come to terms with an array of different conditions. The concept that fits these ideas most neatly is the UK's method of Comprehensive Traffic Management (CTM), which uses maps to manage the capacity, demand, and priority levels of existing, historic central city areas in the larger the consensus-forming process. For the city to control the cars—and not the other way around—on limited road space in a limited urban area, there is an

obvious need for meticulously defined priorities governing road space capacity, the corresponding demand levels, and the corresponding zones and time periods. The resulting arrangement of these priorities is the design of mobility. Situated on the conceptual framework between demand forecasting and road safety, mobility design plays an integral role in keeping the two connected. In this regard, innovation of mobility is required

Figure 1 describes the concept of Mobility Design from management points of views. Transport space is a part of city space, both of which are interrelated. Several different modes of transport share the space. As the space is limited, management policies should be incorporated into designing. Circulation, Space utilization and demand would be managed taking priority into consideration. Walking is the primitive mode of transport, which should have the first priority when demand management is discussed.

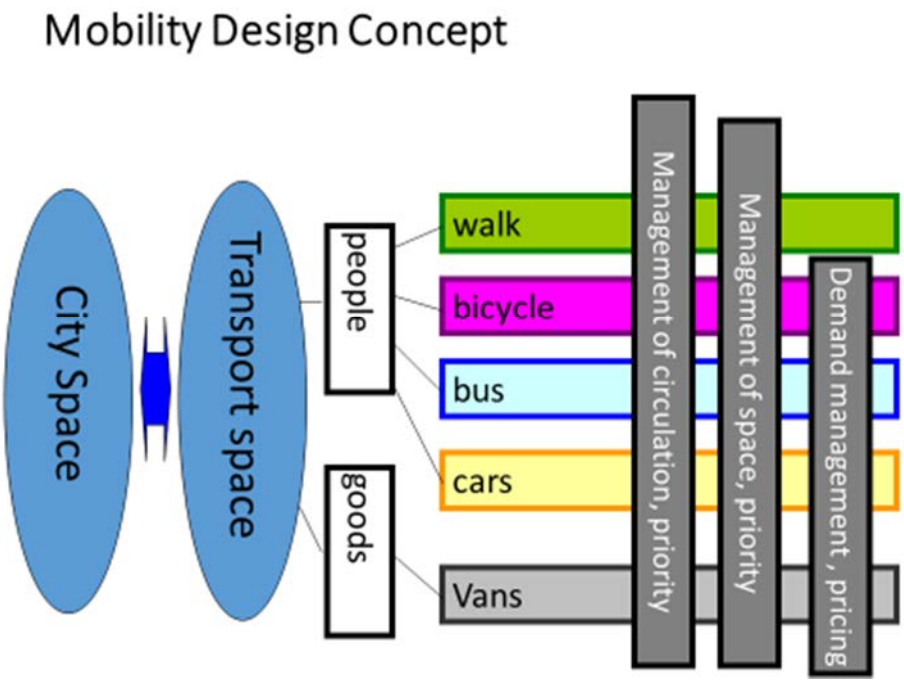

Figure 1. The concept of Mobility Design.

In this paper, the author sets the four strategies such as, walkable town, secured bicycle, transit first and parking management. Those strategies are deeply related to the goal of the city policy, which should be “sustainable city”. Sustainable city should provide less environmental impact, more efficient financial system and more economic activities, and social equity. People could use environmentally friendly modes and anyone could be accessible to town centers frequently, which stimulates economic activities of the city. In this context, needless to say, walking, bicycle and public transport should be considered comprehensively as well as parking should be managed in an appropriate way.

Walkable Town

City center should be walkable and enjoyable as well as Nodes such as stations and stops. Curitiba, Brazil is referred as one of the earliest cases of pedestrianized projects, which was done in 1972. Copenhagen still continues to expand the pedestrian precinct since 1970's. Streets in city centers would be shared with vehicles in time and is space. Shared space concept could be one of the options. Asahikawa-city, Japan also succeeded in a pedestrianized project in 1972, which still works well.

As public transport modes have an important role for mobility, areas around stations and stops becomes very important. More walkable space could be provided. One of the oldest cases for suburban railway station plaza design would be observed in Welwyn in London, UK, which is well known as "the second case of Garden Cities". As shown in Figure 2, the sufficient green space in front of the station building surrounded by shop streets provide better environment to citizens especially railway passengers.

Figure 2. Welwyn, London

Comprehensive approach is expected such as done in Seoul, Korea. In Seoul, removal of expressway to regenerate the ancient canal in the city center was done in conjunction with traffic flow improvement and public transport improvement. Parking management was well done to reduce on-street parking, which could provide more capacity on arterial streets. Curitiba-like urban bus reforming was done with pedestrian space expansion, both of which have enabled modal shift from cars to public transport modes. Therefore, removal of 12 lanes in total in downtown was realized.

Secured and Safe Bicycles

Bicycles are very popular recently all over the world. They are environmentally friendly and very healthful. A lot of European cities and Chinese cities provided enough space for bicycle so far. Some countries including Japan did not follow this trend. Instead, in order to reduce traffic accidents between bicycles and vehicles, bicycles are forced to share the space with pedestrian, which has made people think bicycle could have a freedom as pedestrian has. As a result, some cyclists never follow traffic regulation which makes a lot of troubles.

Bicycles should be secured and safe. Infrastructure design and operation should be taken care of this aspect as well as cyclist should understand and follow traffic regulation and recognize the responsibility.

As the space is limited, conflict management between pedestrian and bicycles both at intersections and bus stops could be designed carefully. One excellent example is observed in Mitaka, Japan, where the space is redistributed without road widening as shown in Figure 3.

Figure 3. Bicycle lane layout near a bus stop, Mitaka.

Transit First

There are many cases of LRT and BRT in the world. In case of well-known successful cities, LRT and BRT are well coordinated to fit with city strategies, which has enabled modal shift from cars to public transport. In those cities, public transport use is much faster, safer, cheaper, smarter and more enjoyable. Strasbourg, France has connected LRT with pedestrianized project and parking management. Curitiba has connected bus system (later named as BRT) with urban space management. Bogota, Colombia has strengthen BRT in conjunction with gas tax increase, license plate control, ICT-aided security management. Clear priority on public transport with pedestrianizing projects is critical in order to achieve modal shift. Any public transport project without car usage control would

never work well. In case of Bogota, as the region has been growing, traffic congestion is not well improved. Even though, BRT is worth well as citizen has a punctual and reliable option for their mobility as shown in Figure 4.

LRT is much better under the conditions that transit mall option is required and expected, budget is available and independent line is accepted (i.e. no need to care feeder services in the area). Medellin, Colombia, has recently introduced LRT (shown in Figure 5), which needed four years for consensus building.

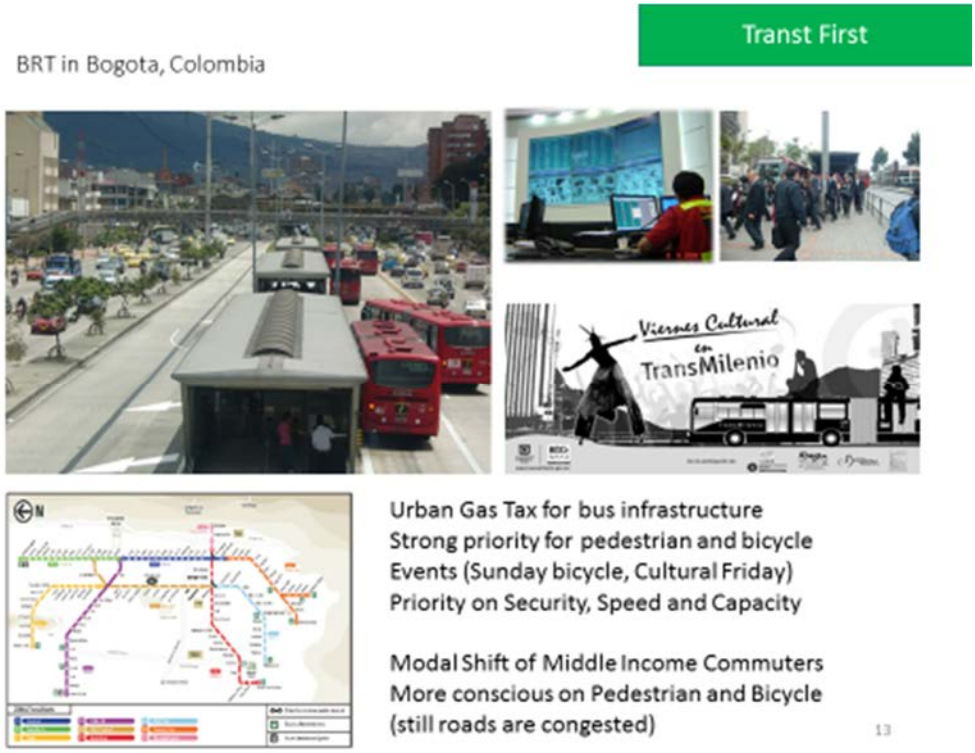

Figure 4. Transmilenio in Bogota (most successful BRT)

Figure 5 LRT in Medellin

Parking Management

Parking management should contain off-street parking facilities and on-street parking regulation. Parking fee should be regarded as one of the tools for pricing mechanism. The management scheme should not be independent from walkable town management and transit first policies. Freiburg, Germany is one of the excellent examples where on-street parking regulation, parking facility relocation, parking fee control, public transport operation and management and pedestrian precinct designing are integrated appropriately.

As sharing system has become very popular such as car-share, ride-share and bike-share, parking management needs some sort of improvement on how to collaborate with those sharing cases. In Paris, electric vehicle sharing system named as “Auto lib” (Figure 6) is well connected with on-street parking regulation.

Figure 6 Electric vehicle sharing system in Paris (“Auto Lib”)

Port city aspect

When mobility design approaches are applied into port cities such as in Yokohama, two additional points could be mentioned. One is port-related freight transport management and the other is waterfront land scape.

In case of Yokohama, in former days, huge amounts of heavy vehicles occupied the streets in downtown areas as there were no other routes for them. Heavy traffic flow provided risks of accidents and disturbed street landscape. In 2006, according to the opening of lower-deck of Yokohama Bay Bridge (Figure 7), traffic management was successfully rearranged, which has lead dramatic reduction of heavy vehicles on the streets in downtown Yokohama (Figure 8). Port should be economically active, which generate a lot of freight transport demand on the streets to be managed somehow. One of the advantage of bay-crossing bridge is to mitigate traffic problem as well as to give symbolic image of the bay to the citizens and tourists.

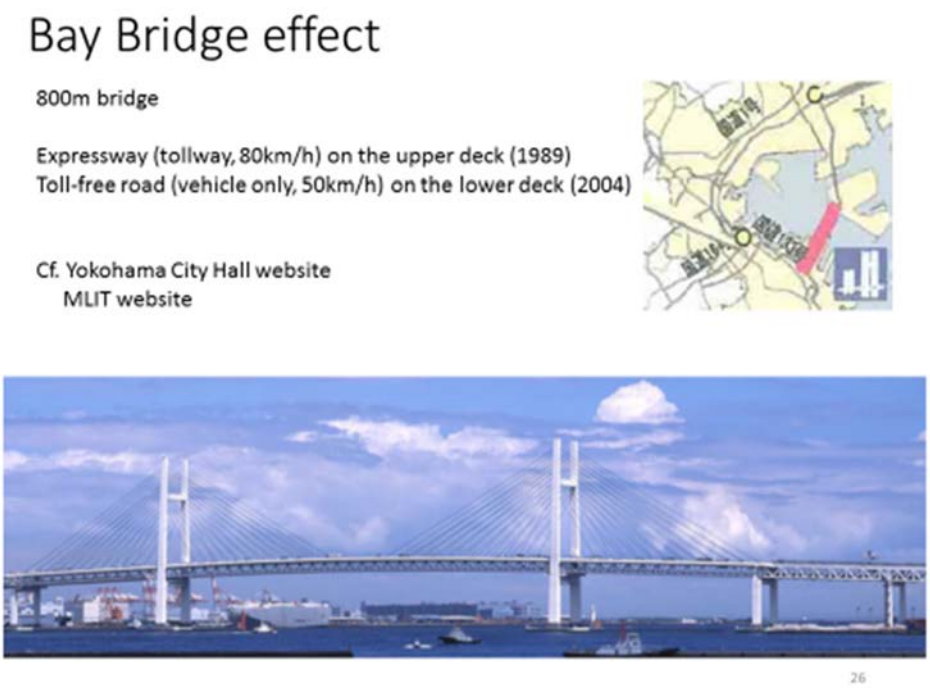

Figure 7 Yokohama Bay Bridge

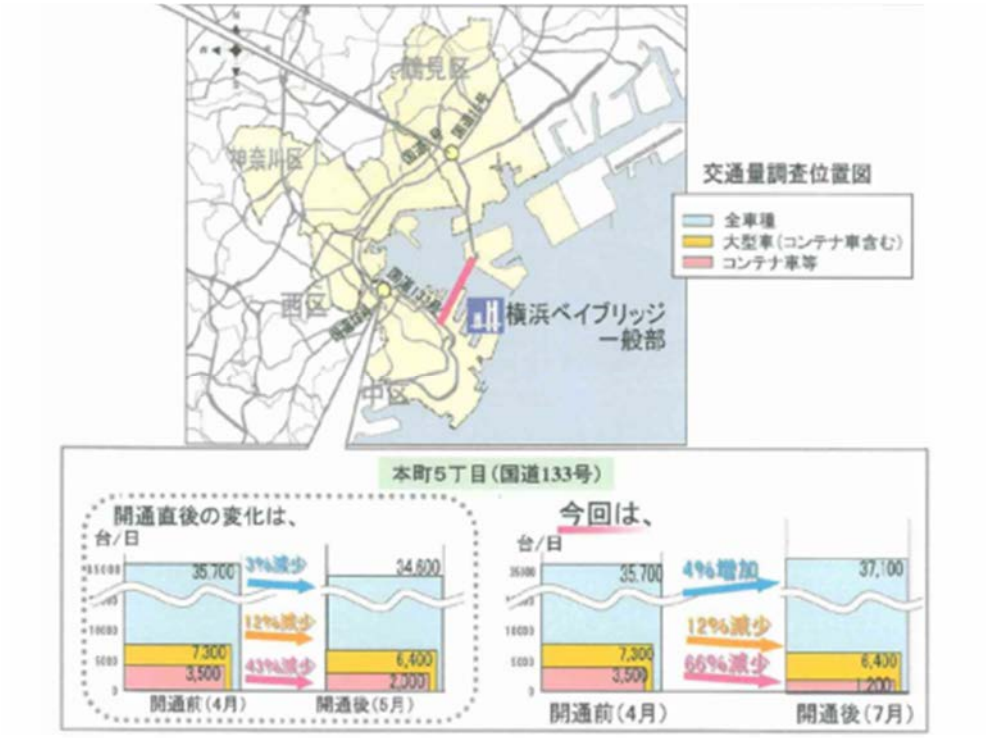

Figure 8 Effect of Yokohama Bay Bridge (from the website of MLIT, Japan)

Waterfront regeneration has been done in many places all over the world. The area should be walkable and accessible by public transport in the context of mobility design.

Conclusions

The paper discussed the concept of Mobility Design, followed by the important four strategies with several advanced cases quoted from all over the world. In the context of Port cities, tourism function, City Center function, waterfront geography and port freight transport function should be considered comprehensively. Yokohama's experience shows the effect of route reassignment of heavy freight transport vehicles, which could contribute to enabled re-distribution of urban streets, where mobility design strategies are well applied.

References

1) Nakamura, Fumihiko. 2014, Role of connected mobility concept for twenty-first-century cities Trial approach for conceptualization of connected mobility through case studies, IATSS RESEARCH Vol.38 No.1 pp.52-27
2) Toyama, Yurie. Okamura, Toshiyuki. Nakamura, Fumihiko. Tanaka, Shinji. Wang, Rui. 2013, A study on BRT applicability on large cities in developing countries, Proceeding of 13th WCTR, Rio de Janeiro, Brazil.
3) Sanit, Peamsook. Nakamura, Fumihiko. Okamura, Toshiyuki. Wang, Rui. 2012, Evaluating Transit-Oriented Development along Urban Railway in Bangkok, Thailand, Journal of International City Planning, the City Planning Institute of Japan in 2012 pp.111-123
4) Yokohama City website
5) Ministry of land, Infrastructure, Transport and Tourism, Japan, website

Pros and Cons of Recent Ocean Engineering Activities in South Korea – from Foundation to Ocean Tree

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Abstract: Although "every institution, every society has its rationalizers to defend it and its code to justify it," as mentioned by Waller (1970), the current stagnation of ocean industries in South Korea is likely sustain for a while. Consequently, a shift should be made to overcome the current stagnation in Korean waters. This study presents the pros and cons of the recent ocean engineering activities in Korea and its deep standstill. To support this presentation, the following works are implemented. First, we introduce the general roles and activities of the academics, societies, government, research institutes, and industries, all related ocean engineering. Second, memorable specific projects, whether these are pros and cons, are addressed such as Busan North Port Project. Finally, the concept proposed, "ocean tree" is re-introduced to summarize several aspects such as social and natural phenomena controlling the global size of the ocean tree, each industry adjusting its own space, research capability supporting the tree trunk, and the foundation providing fertile soil. Balancing those aspects is so significant. In other words, re-sizing, re-locating, and re-distributing of the aspects are quite necessary. Otherwise, a certain moment at which we cannot control a series of unpredicted disasters and economy recession would come.

Keywords: Ocean engineering; foundation; ocean tree

Introduction

The Great Recession started in December 2007 affected the entire world economy, the worst global recession since World War II (Davis, 2009). It was a major global recession characterized by various systemic imbalances, and was sparked by the outbreak of the U.S. subprime mortgage crisis and the financial crisis of 2007–2008. Considering the European sovereign debt crisis, austerity, high levels of household debt, trade imbalance, high unemployment, and limited prospects for global growth in 2013 and 2014, the economic side effects continue to provide obstacles for many countries to achieve a full recovery from the recession (Bown and Crowley, 2013; Cuestas *et al*., 2011; Vos, 2012).

The former president of the USA, Bill Clinton (2011) emphasized that "No one can take the future away from us. But we can take it away from ourselves." His message is targeting the millions of good people who are looking for the chance to be part of America's recovery, and their own. The president of South Korea, Park Geun Hye (Yonhapnews, 2013) also mentioned at the US Congress: "It will be written with a revived economy, with a people that are happy, with a flourishing culture, and on a pathway to a reunified Peninsula. These are the four tenets that guide my government." Considering the commitments, it seems that "recovery" and "revived economy" are the

major concern of all of the countries and individuals in the world.

In order to transform itself into one of the world's leading economies Korea needs to manage macro economy in a sound manner, stabilize the livelihood of citizens, and prepare for future risks. For the purposes, this paper focuses on the roles and activities of academics, societies, government, research institutes, and industries. And then, memorable specific activities are introduced to pinpoint how Korean coastal and ocean engineers have worked on these matters such as optimal design of rubble mount structures, oil spill monitoring, system design on ecosystem control structures, Busan New Port, Busan North Port Redevelopment Project, Saemangeum Seawall Project, coastal erosion control technique project, red tide information system, offshore wind farm, and offshore structures. Finally, the "ocean tree," is introduced to summarize, conceptualize the contents in the paper and the future of coastal and ocean engineering activities in Korea.

Academics

The first "Ocean Engineering" program started in 1979 at Pukyong National University. Since then, several universities have launched ocean engineering programs. However, considering correlation, conflict, or overlap with civil engineering or naval architecture, some programs have changed their names, merged into other departments, or remained in the ocean engineering program. For example, at the first stage, the three universities – Pukyong National University (PKNU), Korea Maritime University (KMU), and Donga University (DU), all located in Busan, the 2nd largest city in South Korea – only operated ocean engineering programs but DU withdrew the program because of the overlap with civil engineering (and resources engineering) subjects. KMU also had changed the department name to "Ocean Development" but recently regained the name "Ocean Engineering". Gyeongsang National University (GNU) and Chonnam National University (CNU) launched "Ocean Civil Engineering" program in 1982, 1987, respectively, and still use the name. Kunsan National University (KNU) started a new department called "Ocean Science and Engineering" in 2013 by combining Oceanography and Ocean System programs, which were established in 1988 and 1996, respectively. In 2008, KAIST (Korea Advanced Institute of Science and Technology) started a graduate program called "Ocean System Engineering". This new program focuses on education for graduate students and research such as offshore plant engineering, ocean environment and renewable energy, underwater technology, ocean systems modeling and simulation, ocean systems management, and port and coastal engineering, which show current research trends.

Summarize the programs, Table 1 shows the list. It should be noted that programs oriented naval architecture and shipbuilding are not included in the table although those program names also include ocean engineering in part such as "Naval Architecture and Ocean Engineering." Now there are 20 universities operating naval architecture and

shipbuilding oriented programs in South Korea. Including 18 programs in 2-year colleges, the number becomes 36, which is larger than 14 in 2006, 16 in 2007, 26 in 2008, 29 in 2009, and 36 in 2010. This indicates how the number of programs increases in recent years mainly because of a new era of shipbuilding and offshore industries.

Table 1. Ocean engineering programs in Korea

University Name	Department Name (current)	Established Year
Pukyong National University	Ocean Engineering	1979
Gyeongsang National University	Ocean Civil Engineering	1982
Korea Maritime University	Ocean Engineering	1985
Chonnam National University	Ocean Civil Engineering	1987
Kunsan National University	Ocean Science and Engineering	1988, 1996, 2013
KAIST	Ocean System Engineering	2008

Because of the broad areas in ocean engineering, the ocean engineering–oriented programs can be classified into their specialties as shown in Fig. 1. For the reference, some programs in the USA are shown in the figure (MIT: ocean engineering; TAMU: coastal and ocean engineering program; FAU: ocean engineering; and FIT: ocean engineering). The field has four-quadrature, which is divided as C (costal-oriented), O (offshore-oriented), U (underwater-oriented), and N (naval architecture-oriented) quadrature. Most naval architecture programs in South Korea locate in between O and N-quadrature.

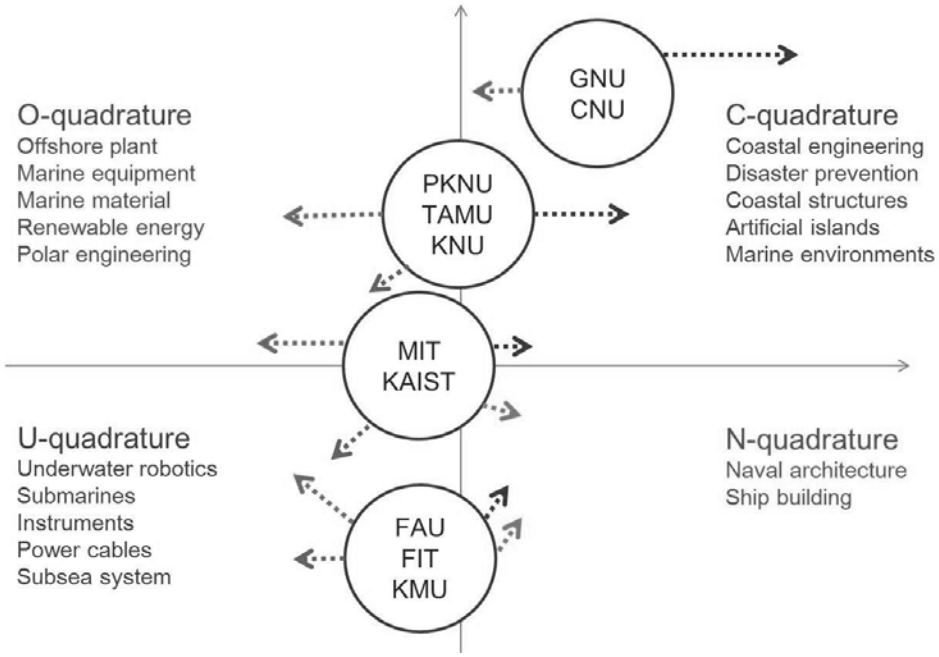

Figure 1. Classification of ocean-oriented engineering programs.

Recently, the Ministry of Education launched a new project called BK21 Plus. This

project is one of the largest government-supporting human resource development funds in the history. The ocean engineering program at PKNU received a BK21 Plus Fund from the Ministry of Education for 7 years, titled “Creative Human Resource Team for Eco-friendly, Multi-functional Coastal-harbor Structural System.” This project focuses on the graduate student development by emphasizing “Eco-friendly,” “Multi-functional”, and “Coastal-harbor Structural System” with a vision called “SMART,” which indicates S: share, M: multi-player, A: action, R: relationship, and T: tomorrow. In terms of the quality of research papers, employment quality of graduates, and education system level, the project will be evaluated biyearly. The ocean civil engineering program at CNU also received a BK21 Plus Fund for human resources development in offshore wind farm supporting structures, but terminated upon evaluation in 2015.

Societies

The first society related to Ocean Engineering is the Korean Society of Ocean Engineers (KSOE), founded in 1986. Initiated by the foundation, other societies were also established such as the Korean Society of Coastal and Ocean Engineers (KSCOE) in 1989 and the Korean Society for Marine Environment and Energy (KSMEE) in 1997, as shown in Table 2. These societies are members of Korean Association of Ocean Science and Technology Societies (KAOSTS) along with the Society of Naval Architecture of Korea (SNAK) and Korean Society of Oceanography (KSO), and accordingly a joint conference have been operated every spring in addition to each own annual fall conference. The three societies publish journals: Journal of Ocean Engineering and Technology (bimonthly) by KSOE, Journal of Korean Society of Coastal and Ocean Engineers (bimonthly) by KSCOE, and Journal of the Korean Society for Marine Environment and Energy (bimonthly) by KSMEE. Moreover, KSOE publish an international journal – Journal of Advanced Research in Ocean Engineering providing a medium for the publication of original research and development technology in marine/material science and engineering.

Table 2. Ocean engineering-oriented societies in Korea

Society Name	Major Fields	Established Year
KSOE	Ocean Eng. (structures, materials, fluids, & robots)	1986
KSCOE	Coastal and Ocean Eng. (fluids & structures)	1989
KSMEE	Marine Environments and Energy	1997

The Korean societies have had strong connections with international societies. KSOE hosted the ISOPE-2014 Busan Conference, which is the 24th International Ocean Polar Engineering Conference in Busan in 2014 with the cooperation with ISOPE (International Society of Offshore and Polar Engineers). KSCOE hosted the 34th International Conference on Coastal Engineering (ISCE) in Seoul in 2014 under the auspices of the Coastal Engineering Research Council (CERC) of the Coasts, Oceans,

Ports and River Institute (COPRI) of the American Society of Civil Engineers (ASCE).

Each society also operates special research groups to exchange research ideas and provide joint research opportunities. The KSOE is operating research groups: (1) Underwater Robotics, (2) Offshore Structures and Applied Materials, (3) Design of Offshore Structures, (4) Deep Ocean Waters, and (5) Coastal Disaster Prevention. By the KSCOE, the following subdivisions are working: (1) Design Education, (2) Coastal Disaster Prevention, (3) Use of Coasts, and (4) Coastal Environments. The KSMEE is providing research groups: (1) Sustainability Ocean Energy, (2) Ocean Climate Change, and (3) Hebei Spirit Accident (oil spill).

Government

As Korean ocean management functions had been scattered (or sectorial management) as in other countries until the middle of 1990s, the ocean policy was fragmented; hence, various conflicts and negative effects occurred such as the Sea-Hae ferry accident killing 221 on the west coast and the Sea Prince oil spill accident in 1990s (Cho, 2006; Kim, 2012). Accordingly, the Kim Young Sam Administration planned to establish a consolidated new ocean-related organization in 1996, and finally the Korean government established the Ministry of Maritime Affairs and Fishery (MOMAF) to make and implement integrated ocean policy and to confront to the urgent needs for the red tides, oil spills and ferry accident, EEZ (Exclusive Economic Zone) delimitation issues and islands conflict with China and Japan, etc.

In the process, several government agencies were merged into MOMAF such as Maritime and Port Administration Office, Fishery Administration, Coast Guards, Marine Environment Office, Maritime Safety Tribunal, Hydrographic Office, and more. The government Act for MOMAF can be summarized: (1) development and integration of marine policy, (2) development of shipping industries and safety of ships, (3) port development and operations, (4) promotion and development of fisheries, (5) marine science and technology research, and (6) conservation of marine environment.

However, the Lee Myung Bak Administration divided the functions of MOMAF into Ministry of Land, Transportation, and Maritime Affairs (MLTM) and Ministry of Food, Agriculture, Forestry, and Fisheries (MFAFF) so that MOMAF was not included in his cabinet in 2008. In 2013, the Park Geun Hye Administration regained the functions of the previous MOMAF by launching Ministry of Oceans and Fisheries (MOF) to implement integrated ocean policy. The revived MOF is pondering what new growth engines it should pursue consistent with the national policy goal of building the creative economy. The ministry plans to create new marine industries based on marine technologies, a combination of the conventional marine industries, biotechnology, ICT (Information and Communication Technology), and environmental technology, under the goal of realizing the creative economy. The Ministry is also responsible for work related to the domestic fishery industry and is delegated by MFDS (Ministry of Food

and Drug Safety) the responsibility for inspection of fishery products marketed domestically as well as those for export.

Initially, the MOF is aiming to expand inroads into the marine bio market through development and commercialization of new medicines and materials using marine organisms and it will upgrade the Korean fish breeding and seed industry to the levels of advanced countries by focusing on genetic analysis of marine resources and crossbreeding. The ministry plans to nurture the state-of-the-art marine development industry through the development of underwater robots, deep-sea submersible vehicles with a maximum depth capacity of 6,000 meters, and the convergence of ICT with new technologies. It is also seeking to commercialize eco-friendly energy technologies such as hydroelectric wave energy farms and cooling/ heating systems using ocean thermal energy, in response to climate change. It is also planning to add value to the shipbuilding and marine plant industry. The MOF's tasks for developing new marine industries are designed to create decent jobs and new growth engines with the mission of realizing the creative economy in the oceans and fisheries fields.

Without R&D, the mission cannot be completed. Thus, the MOF plans to establish mid- and long-term oceans and fisheries R&D plans by consolidating the oceans and fisheries fields, which have been bifurcated so far, in order to lay an R&D foundation and improve investment efficiency. In this regard, the MOF plans to raise its budgetary outlay to KRW1 trillion (US$940 million) by 2017 as part of efforts to ramp up its capacity in R&D activities. It devotes to maximizing R&D outcomes by shifting the R&D paradigm from a focus on basic research to R&D activities related to commercialization and industrialization. The move will strengthen the groundwork for exploring new growth engines and creating jobs with the goal of raising the percentage of the oceans and fisheries sectors out of the gross domestic product (GDP) to 7 percent. A deep-sea mineral resources mining robot dubbed "Minero" was test-operated by the Ministry of Oceans and Fisheries and the Korea Institute of Ocean Science & Technology (KIOST).

The MOF endeavors to provide support to step up the nation's competitive edge in ballast water treatment technology to keep in line with environmental and safety standards set by the International Maritime Organization (IMO) while striving to expand R&D investments in marine disaster preparedness. It will do its utmost to ensure that a combination of the conventional fisheries industry, biotechnology, and ICT will have synergetic effects on the fisheries and marine biotechnology sectors. The ministry also strives to expand R&D investments in the marine tourism and leisure sectors to give a shot in the arm to both fields. Research topics in coastal engineering fields include global climate change related problems, integrated coastal zone management, coastal disaster prevention and environmental systems, ecosystem rehabilitation considering fisheries functions, and design and monitoring of port and coastal structures.

Research Institutes

There are ocean engineering-oriented research institutes such as the Korea Institute of Marine Science and Technology Promotion (KIMST), Korea Maritime Institute (KMI), and Korea Institute of Ocean Science and Technology (KIOST). KIMST is a public organization established under the Ministry of Oceans and Fisheries (MOF) for planning and evaluating national R&D projects for ocean science and technology and the promoting their commercialization. KMI is also a public organization established under MOF for maritime and fisheries policy development and its competitiveness improvement by focusing on maritime and coastal policy, logistics and port, fisheries policy, and future strategy. KIOST is the new name of KORDI (Korea Ocean Research and Development Institute) and the largest research institute in the ocean engineering field in South Korea, focusing on ocean science, applied ocean technology, operational ocean science and technology, ocean observation, South Sea, East Sea, and maritime and ocean Engineering. KIOST also operates a graduate school (Ocean Science & Technology School) by concentrating on Fusion Study in the Ocean Science and Technology. Table 3 shows the list and major roles of the three institutes.

Table 3. Ocean engineering-oriented research institutes in Korea

Institute Name	Major Roles	Established Year
KIMST	Policy development, R&D management	2005
KMI	Policy development, R&D management	1984
KIOST	R&D	1973

In addition, there are some research-oriented agencies such as Korea Fisheries Resources Agency (FIRA). The agency was organized in 2010 to fertile fishery resources and well-being of human life with the following major research fields: (1) pilot marine ranch project, (2) coastal marine ranch project, (3) marine forest enhancement project, and (4) releasing hatchery-produced seeds. Among them, development and post-management of artificial reefs (ARs) has been carried out by the ocean engineering program of Pukyong National University. The project is aiming at developing eco-friendly ARs and analyzing fisheries enhancement effects by pilot ARs, standardization of materials and manufacturing procedure of ARs, and developing and operating integral management system of coastal marine ranch. Another agency is Korea Marine Environment Management Corporation (KOEM) focusing on marine cleanup and conservation, oil spill response program, tugboat, floating crane fleet, etc. For marine cleanup and conservation, various works have been done: cleanup project for sunken wastes, dredging project in polluted sea areas, marine environmental measurement network, marine environmental information system, etc. It should be noted that among the ocean engineering programs mentioned earlier, ocean engineering programs of PKNU and KAIST are the major ones carrying out researches in the fields

of marine environment.

Industries

Korea's major industry consists of semiconductors, shipbuilding, automobiles, and displays. In semiconductors, Korea shares 11.3% of the global market, exports more than US$39 billion, and ranks number 1 in DRAM (Dynamic Random Access Memory), SRAM (Static Random Access Memory), and NAND flash memory. Korea's shipbuilding occupies 40% of all orders worldwide, exports about US$30 billion in 2008, and ranked 1st globally in terms of orders, ship's completion, and order book. However, owing to the current offshore industry declination, it is hard to predict the future of Korea's heavy industry. In automobiles, Korea is the 5th biggest producer for 3 consecutive years with 5.6% share and exports US$33 billion. Major players are Hyundai Motor, KIA, GM-Daewoo, Samsung-Renault, and Ssangyong Motor. In displays, Korea is the number 1 market share in LCD, PDP, and OLED, which produced by LG Display, Samsung Electronics, LG Electronics, and Samsung SDI.

Currently, the words "offshore plant" seems tragedy in heavy industry in South Korea. In other words, "offshore structures" are not connecting dots between the previous shipbuilding-oriented economics and modern demand of energy resources whether they are fossil fuels or renewable energy resources. China already exceeds Korea in the shipbuilding capacity as the history of shipbuilding tells so. Naturally, high tech accumulated fields should be a target for Korea mostly like UK, USA, and Japan have done. However, thanks to low oil price, the offshore plant industry is unlikely to recover its power in the near future.

Offshore plants mean all kinds of offshore structures and facilities including offshore wind farm, deep sea mining, wave energy plant, deep ocean water upwelling structure, URF (umbilicals, risers, and flowlines), topside plants, offshore platforms, and more. Most of these figures, shapes, and functions were not familiar to Koreans. Especially, Korea has weak points in basic and detailed engineering (design) of offshore plants.

Constructions in coastal areas have been active in Korea's industry as well. However, domestic construction industry has been heavily dependent on government-subsidized projects. From the early of 1960 to the mid of 2000, ports, land reclamations, bridges, and oil and gas storages were major sources in coastal development. However, economic depression started from 1997 has given effect on the domestic construction and the recent Korean governmental policy seems not targeting for a new coastal development. Besides, as shown in Table 4, the quality of overall infrastructure of South Korea was ranked no. 18 in the world, which means massive new constructions are not quite attractive; instead, remodeling and renewal projects become issues.

Table 4. Quality of overall infrastructure (World Economic Forum, 2011). Here, IQS indicates quality score (out of 7)

Rank	Country	IQS	Rank	Country	IQS
1	Switzerland	6.7	21	Barbados	5.8
2	Singapore	6.6	22	Spain	5.8
3	France	6.5	23	Malaysia	5.7
4	Hong Kong SAR	6.5	24	United States	5.7
5	Denmark	6.4	25	Taiwan, China	5.6
6	Finland	6.4	26	Qatar	5.6
7	Iceland	6.4	27	Saudi Arabia	5.6
8	Austria	6.3	28	United Kingdom	5.6
9	United Arab Emirates	6.3	29	Czech Republic	5.6
10	Germany	6.2	30	Cyprus	5.5
11	Sweden	6.1	31	Estonia	5.5
12	Portugal	6.1	32	Chile	5.5
13	Japan	6.0	33	Slovenia	5.3
14	Netherlands	6.0	34	Turkey	5.3
15	Canada	6.0	35	Namibia	5.3
16	Luxembourg	5.9	36	Croatia	5.2
17	Belgium	5.9	37	Australia	5.2
18	South Korea	5.9	38	Israel	5.1
19	Bahrain	5.9	39	Puerto Rico	5.1
20	Oman	5.9	40	Lithuania	5.1

Table 5. History of Korea's overseas construction (International Contractors Association of Korea: 2013)

Period	Major Achievements
Real Growth (2005 – Present)	Annual contract amount exceeds US$ 50 billion for 3 consecutive years: US$ 71.66 billion (2010), % 59.13 billion (2011), US$ 64.88 billion (2013) Reached US$ 500 billion cumulative of contracts in Jun. 2013
Adjustment (1998 – mid of 2000s)	Intensive restructuring of construction industry due to financial crisis in Asia in 1998 Transition to higher value-added type of works from civil and architecture to plant
Acceleration (mid 1990s – pre financial crisis in 1997)	Asian markets at the forefront of expansion US$ 14 billion in contracts, a record high, in 1997 just before financial crisis
Depression (mid of 1980s – early of 1990s)	Sharp drop in contracts due to the recession in the Middle East economics Awarded the 2nd phase of Great Man-Made River Project in Libya 1990 (US$ 4.6 billion)
Expansion and Maturity (late of 1970s – early of 1980s)	The first advance into Middle East market by winning Saudi Arabia road construction contract in Oct 1973 Achieved the amount of US$ 10 billion in contracts won for three consecutive years and enter the top 2 in overseas construction
Pioneering Days (1965s – mid of 1970s)	The first advance into overseas construction market by winning Thailand express way construction contract in Nov 1965 Southeast Asia construction based mostly on development loads and U.S. military projects

Accordingly, most Korean construction companies seek for overseas construction projects with the accumulated the 50-year knowledge and experience of design, construction, and maintenance as shown in Table 5. It seems that the old good era comes again but this reality have effect on the job openings – few jobs for newly college graduate students mainly because most construction companies have recruited experienced engineers who have worked for at least 5-year and the overseas project are

highly dependent on constructing plants. Consequently, construction-oriented ocean engineering programs (e.g., ocean civil engineering) have faced difficulty to recruit excellent high school students and dispatched the graduates to better job markets so that they changed their curriculum and/or the department names for targeting offshore structures, ocean renewable energies, and new blue-chip areas. However, this shift seems not a proper movement at this stage.

Memorable Activities

Optimal Design of Rubble Mound Structures

Rubble mount breakwaters have been constructed to protect harbors and beaches from strong waves. Considering the previous older types only consisting of sloped layers of stone and the recent ones facilitating concrete blocks, the breakwaters have the advantage of being economical and easy to construct severe wave conditions. Also, rubble mount breakwaters get smaller wave reflection than the vertical type breakwaters and require less maintenance (Sawaragi, 1995).

Various works have been done to establish the stability of rubber mount breakwaters (Ryu *et al*., 1992; Ryu and Kim, 1994) such as (1) wave controlling function of rubble mound breakwaters, (2) destruction mechanism of rubble mount breakwaters, and (3) new design formula for rubble mound breakwaters.

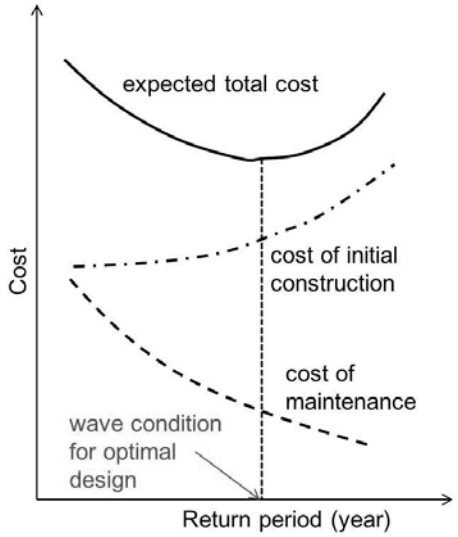

Figure 2. Construction, maintenance, and total costs as functions of wave conditions (Ryu *et al*., 1992).

Cost effectiveness is an important factor in the optimal design concept of rubber mound structures. Ryu *et al*. (1992) reported optimal design of rubble mound structures under irregular waves. In the report, an optimal design algorithm and optimization of the cross-section of rubble mound structures were introduced. Moreover, initial

construction cost (ICC), maintenance cost (MC), and total cost (TC) were considered as shown in Fig. 2. In order to examine the applicability of the algorithm, the design sensitivity for the structural dimensions and total costs are analyzed and compared with those of conventional methods using design examples. From the results of comparative studies, the algorithm is found to be applicable, and it will be more useful and powerful algorithm for the design of rubble mound structures under the complex design conditions, design constraints, and cost functions.

Oil Spill Modeling

Oil spills have been occurred in Korean waters and other countries. The most recent accident in Korea was the Hebei Spirit oil spill that began on the morning of 7 December 2007 local time. It is Korea's worst oil spill ever, surpassing a spill that took place in 1995. The oil spill is about one-third of the size of the Exxon Valdez oil spill. Fig. 3 shows the residents cleaning up a beach slick with oil after the Hebei Spirit oil spill (Time, 2007).

Figure 3. Residents clean up a beach slick with oil on Sunday, Dec. 9 2007, following South Korea's worst-ever oil spill (Time, 2007).

A great amount of effort has been spent by Korean and other government agencies, oil industries, and researchers over the past decades to develop more realistic models for oil spills. Lee *et al*. (1990) reviewed the structure of oil spill models in terms of oil spill incidents, oil fate and behavior, environmental sensitivity and impact, and contingency planning. In the review, the following matters were discussed: (1) The quality of data input to the models plays an extremely important role in the success of the model prediction; (2) Most of the existing models use only temporally variable wind, current, and wave data with the assumption of spatial uniformity over the study area; and (3) Even though some sophisticated models have been uses previously, these models have not addressed uncertainties of model prediction.

Currently, oil spill models have been improved. For example, a multi-scale prediction

system for the Yellow Sea was successfully developed and used to predict oil spill movement after the Hebei Spirit accident. Kim *et al*. (2013a) found that compared to observations, their simulation without tides predicted faster oil spill movements, whereas the simulation with tides predicted comparable oil spill movement. It is shown that the simulation without tides produced a stronger subtidal current than the simulation with tides because of reduced frictional effects.

Figure 4. Preparedness and distribution of the recovery equipment of Korea as of 2006 (Lee and Jung, 2013).

Moreover, to cope with oil and hazardous and noxious substance (HNS) spill accidents, risk assessment and national measure plan were established in Korea. Lee and Jung (2013) created risk matrices to assess the accidents occurred between 1994 and 2005. The study reported that (1) the worst scenarios of future oil and HNS spill accidents were established, and the maximum spill amounts were estimated using previous accidental data and a correlation from IPIECA (International Petroleum Industry Environmental Conservation Association) and (2) the maximum spill amounts were estimated at 77,000 and 10,000 tons of oil and HNS, respectively. Lee and Jung (2013) emphasized that it is important to establish preparedness and effectiveness of recovery equipment (see Fig. 4) and to train Korea coastal guard and response practice.

System Design on Ecosystem Control Structures

The enhancement of coastal fishing grounds in South Korea has been desperately demanded not only because of shrinkage of fishing grounds along its coasts due to international regulations and domestic modern industrial development but also because of international competition due to the open economy under the World Trade Organization (Kim *et al*., 2008). In order to enhance the fishing grounds, the Koran

government has operated a marine biological habitat-enhancement project since 1971.

As a part of the project, artificial concrete reefs, selected because of their ease of construction and stability, occupied a total of 1570 km^2 of South Korea waters, at a cost of US$ 515 million, by 2001. These artificial reefs (ARs) provide a place to live, breed, feed, and shelter to marine organisms from predators as well as creating an environmentally friendly solution to coastal protection. Currently the enhancement project continues as follows: (1) new installation of concrete reefs; (2) management of aged concrete reefs; and (3) new project associated with new types of reefs and fish farming projects.

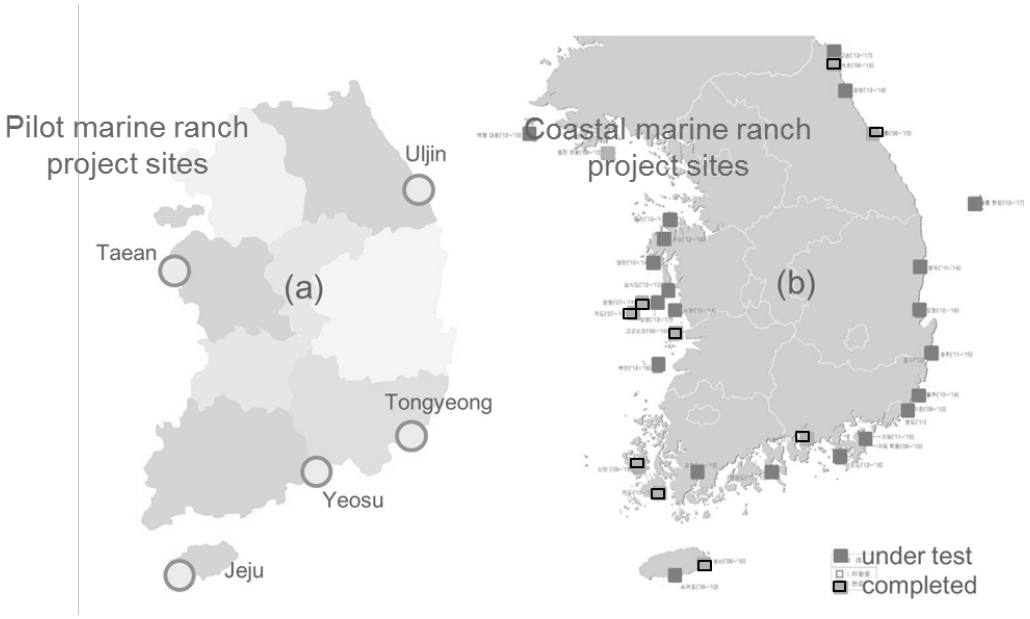

Figure 5. Location of (a) pilot marine ranch project and (b) coastal marine ranch project.

FIRA (Korea Fisheries Resources Agency) have focused on pilot marine ranch project and coastal marine ranch project as shown in Fig. 5. The pilot marine ranch project aims at technology development for systematic and effective construction of marine ranch and raising public awareness of the project. The associated research projects have been investigated for (1) marine tourism and leisure marine ranch, (2) in-depth analysis on effects of marine ranch before expanding project volume, and (3) developing marine tourism and leisure programs to nurture a public marine part. The coastal marine ranch project aims at practical application of marine ranch technology, improving fishery production and income of fishing communities, and promotion of business sized marine ranch to foster a plausible business model. The project have been directed into competing construction of 50 marine ranch sites with high success potential by 2020 and scaling up the marine ranch to mega size starting 2012 when the Pilot project is completed.

Busan New Port

In 1996 the construction of Busan New Port was determined as a private investment project by Ministry of Monetary and Economy. As a result, Pusan New Port Corporation (PNC) was established in 1997, and the Port achieved accumulated 10 million TEU in 2011. PNC is a global container terminal, managed and operated by the global terminal operator DP World. Its shareholders include Samsung Group, DP World, Hanjin Group, and Hyundai Construction, *et al*. PNC, as the largest container terminal in Korea with 2 km of quay, provides customers with the most efficient and reliable service. PNC has 16-17 m depth alongside to accommodate greater than 10,000 TEU class.

A project for constructing 1.49 km of breakwater and 600 m of berth was started in October 1997 and was completed in December 2002 at an investment of KRW123.3 billion (US$116 million). Dredging soil ground revetment construction, divided into two construction areas i.e. construction area one and two, were started in September 1999 and May 2000, respectively. Construction area one, involving 8916 m of revetment, 23 m of breakwater and 930 m of bridge, was completed in 2004, and construction area two, involving 7401 m of revetment was also completed in 2004. Construction of the connecting pier, multi-purpose wharf, and entrance passage was finished in 2006. Phase 2-3 of the Busan New Port (BNP2-3) officially commenced in January 2012.

It is one of the best container terminals in the world in terms of efficiency and productivity with state-of-the art facilities and systems. Its wide container yard makes it possible to provide speedy on-dock service, reducing customer's cost as well as providing efficient cargo handling. In addition, through the rod railroad networks, cargoes can be delivered swiftly to their destination in the country.

Busan North Port Redevelopment Project

Busan North Port Redevelopment Project is underway in the location of Busan North Port piers. The Phase 1 covers coastal ferry pier to pier 4 about 1,527,247 m^2, and the Phase 2 covers piers 5 and 6. Project expenses are 8,519 trillion won (2.39 trillion won for infrastructure, 6.48 trillion won for facilities construction such as commerce, business, and prismatic composition).

This project was initiated because: (1) changes in Busan's port, such as construction of the Busan New Port, have created the need to re-organize Busan's port functions; (2) changes in the social environment have increased the need for waterfront development; (3) there is now the need for an integrated passenger terminal; and (4) simultaneous development of the port and the surrounding areas is needed, especially the former downtown area which used to be the dynamic and vibrant in order to revitalize heart of the city. Accordingly, the purpose is: (1) making the port the international marine tourism hub of the Southeast Coast tourism belt; (2) developing the port to serve as a

gateway to the Eurasian continent and remain a focal point for global shipping; (3) creating opportunities for residents to enjoy their leisure time at newly developed waterfront areas; (4) stimulating stagnant local economy and revitalizing Busan through integrated development of the port and former downtown areas. This project is now under construction and the conceptual layout is as shown in Fig.6.

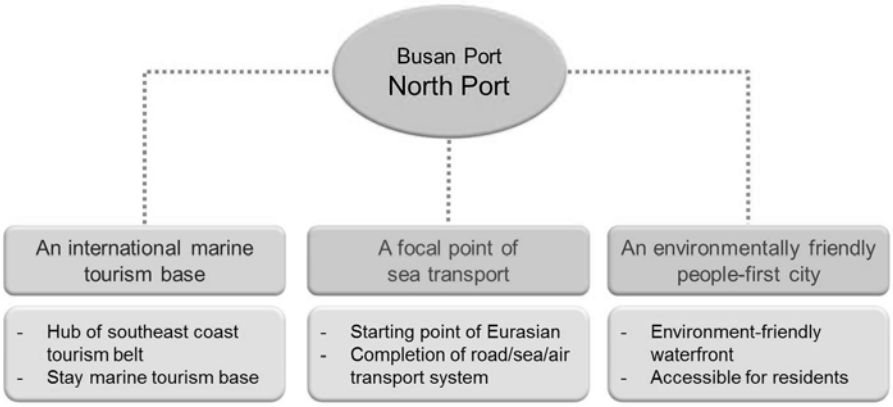

Figure 6. Conceptual layout of Busan North Port Redevelopment Project.

Saemangeum Seawall Project

Saemangeum is an estuarine tidal flat on the coast of the Yellow Sea in South Korea. It was dammed by the Korean government to convert the area into either agricultural or industrial land. The project of filling in the estuary began in 1991, but was slowed by a series of court actions by environmentalists (Kim, 2010). Saemangeum was completed on April 27, 2010 by spending KRW41794 billion (US$39.3 billion), officially becoming the longest seawall ever built with the length of 33.9 km, breaking the record of Zuiderzee Works from 1932.

On August 2, 2010, Saemangeum was certified by Guinness World Records as the longest man-made sea barrier in the world. The completed seawall is some 33.9 km long, and replaces a coastline that was once more than 100 km long; and the reclamation provides 283 km^2 of a land and 118 km^2 of a lake. Prior to the completion, it had played an important role as a habitat for migratory birds. The completion of this seawall is likely to be a major contribution of the decline of many species.

Coastal Erosion – Coastal Erosion Control Technique Project

Beach erosion problem has begun to arise since 1990s in Busan, Korea. Major causes of the beach erosion are construction of harbor facilities or fishing ports, revetment, coastal roads, aggregating gathering nearby an estuary and hinterland development (Kim *et al*., 2013b). Haeundae Beach, one of the most famous beaches in South Korea, also experiences beach erosion, which is not desirable because of its highly value for relaxation, water sports, and leisure. Accordingly, the Korean government and engineers have tried to solve the problem. Coastal structures have been

considered as the most-widely used method for the erosion control in the ways of hard structures, soft-structures, and their combinations. However, a specific method or technique has not been selected because there is conflict between environmentalists and engineers and the local residents and businessmen are afraid of the side effects upon the completion of a beach control structure whether it is soft or hard.

In contrast, Songdo beach (also locates in Busan, Korea) is a representative case study using soft engineering erosion control, combining artificial structures such as submerged breakwaters and jetties, and eco-friendly, littoral nourishment (Lee *et al*., 2013b). Historically, the coastline of Songdo beach had declined a great amount and the beach erosion was serious. Thus, Busan Metropolitan City implemented the Songdo Coastal Refurbishment/Rehabilitation Project (2003 – 2006). To systematically cope with beach erosion, the Ministry of Oceans and Fisheries (MOF) launched "Coastal Erosion Control Technique Development" project over five years until 2017. For the project 17, research bodies (including engineering companies, universities, and research institutes) have been grouped together to construct or analyze (1) management system development, (2) sediment behavior, (3) prediction model development, (4) erosion mitigation technique, and (5) risk evaluation technique.

Red Tide Monitoring – Red Tide Information System

Over the past three decades, a total of US$121 million in economic losses (fish/shellfish kills) has occurred in the Korean aquaculture industry due to harmful algal blooms (HABs) (Park *et al.*, 2013), as shown in Fig 7. Prior to the early 1980s, HABs occurred during the summer in Korea (June–August), but since then have frequently occurred in spring and autumn. Bloom durations were mostly less than 1 week in the 1980s, but the duration of HABs has often lasted more than 1 month since 1995 (Park *et al*., 2013). Since official paralytic shellfish toxin (PST) monitoring has begun, PST exceeding the permitted PST standard was first detected in shellfish in 1982 (NFRDI, 2006) and human positioning first occurred in 1984. Paralytic shellfish poisoning (PSP) has occurred almost every year in Korean waters since 1982. Accordingly, effective management and control of HAB outbreaks are a primary concern of the aquaculture industry.

Potential control methods have been used for migration and control of HAB outbreaks. Chemical control methods have been evaluated, including the use of surfactants, aerial dusting with copper sulfate, and the use of chemical flocculants. Biological control methods also have been suggested such as competition for nutrients by bacteria etc. (Park *et al.*, 2013). Precautionary management acts by monitoring network and emergency management and have been done by physicochemical control (clay dispersal) and biological control (algicidal bacteria and protistan grazers). Clay dispersal is used as the prime mitigation technique for HABs in Korea. It is recognized that the dispersing yellow clay is recognized as the best practical method, as clay is

relatively inexpensive and easy to apply in the field without notable effects on aquatic organisms and water quality (Yu *et al*., 2004).

South Korea initiated the red monitoring in the coastal waters biweekly or monthly from May to August since 1972. NFRDI (National Fisheries Research and Development Institute) has implemented this monitoring as an element of environmental monitoring program by establishing RTIS (Red Tide Information System). In recent, the regular HABs monitoring has been carried out from March to November to assess the water quality status of water and outbreaks of HABs since 1996. For coastal patrolling, 24 watch teams, organized in the local maritime and fisheries administration, patrol 92 posts established along the coast every day to observe the ocean color and collect phytoplankton samples from May to October since 1996. Based on the frequency of red tide breaks in the last 5 years, the patrolling time scale was divided into 3 grades, i.e., daily, weekly, and biweekly patrolling.

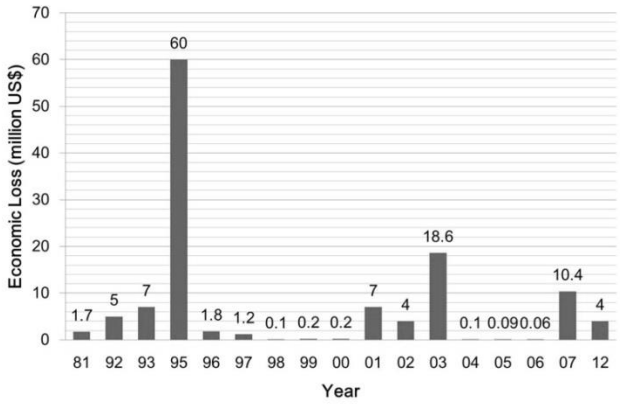

Figure 7. Economic losses (fish/shellfish kills) in the aquaculture industry by HABs in Korea over three decades (Park *et al*., 2013).

Offshore Wind Farm – BuAn YoungGwang Project

Despite relying on imported sources for 97% of its energy needs, South Korea had been slow to tap into and develop its wind power resources. A systematic plan for developing national renewable energy began in 1980s, accumulated by a social recognition for a stable energy supply (Lee *et al*., 2013a). At the first stage, hydropower obtained from dams was the primary resource for renewable energy production. However, the suitable places were limited and dam construction gave side effects; hence, the construction has not progressed. To respond the need, the South Korean government established a National Energy Master Plan (Lee et al., 2009), in which the proportion of new and renewable energy is planned to be increased more than 11% by 2030 from 1% of 2009 (Kim *et al*., 2012; US Energy Information Administration, 2011; see Fig. 8). Recently, in South Korea, R&D have focused on developing or utilizing the energy resources such as wave energy, tidal energy, tidal current energy, ocean thermal energy,

wind energy, etc.

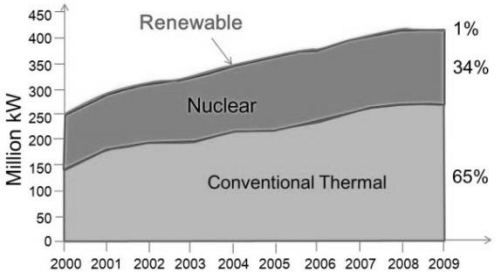

Figure 8. Korea's net electricity generation by type (2000-2009).

The Korea government announced that it will invest KRW2 trillion (US$9 billion) in building a 2.5 gigawatt (GW) offshore wind farm, one of the largest farms in the world. Located offshore of South Korea's southwestern coast, the offshore wind farm will be built in three phases by South Korean companies led by Korea Electric Power Corporation (KEPCO), the country's largest electric utility, as shown in Fig. 9. The first is a 100 MW demonstration phase to be completed by 2014. Wind turbines with capacities ranges from 3 MW to 7 MW will be erected mainly off the coast of Jeollabukdo and Jeollanamdo provinces in three stages at a projected cost of US$353 million. A second 400 MW phase is scheduled for completion in 2016 at a cost of US$1.4 billion.

In offshore wind power industry when the submarine (or subsea) cables take the power to an offshore transformer and the offshore transformer converts the electricity to a high voltage (about 33kV) and send it 8 to 16 km to a national or international grid at a substation on land, safety assessment of submarine power cable is an issue. Accordingly, as the use of submarine power cables increases, their protection should be more significantly managed. The possible causes – anchor colliding and dragging – have been considered, and some protectors were tested (Yoon and Na, 2013). KR (Korea Register) is conducting a guideline for power cable protection for the offshore wind power farm project.

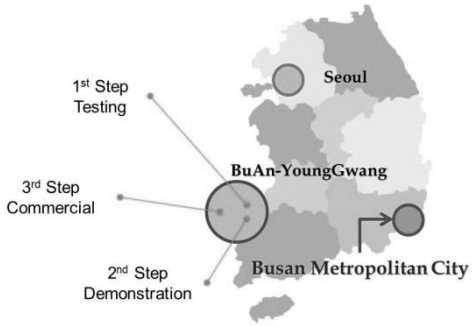

Figure 9. Korea's offshore wind farm project.

Offshore Structures – MODU

Fixed and floating offshore structures, whether associated with the production of oil and gas, or with marine renewable energy, present complex technical challenges to the maritime industry, particularly as such structures are increasingly employed in deeper waters and extreme climatic conditions. The Korea' big three have successfully manufactured offshore structures although there have been issues on design capability and low oil price.

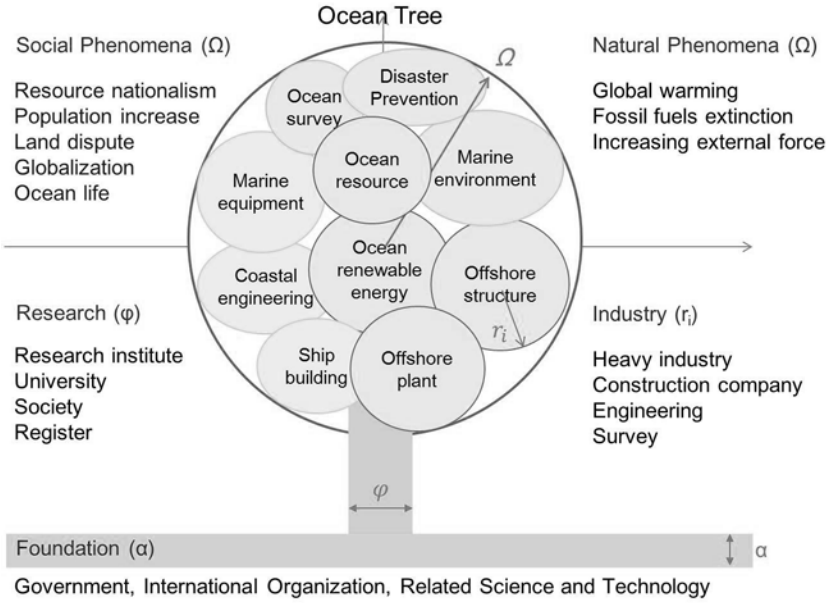

Figure 10. Ocean Tree.

Discussion

This study presents coastal and ocean engineering activities in South Korea, by introducing the general roles and activities of academics, societies, government, research institutes, and industries and specifying major projects such as optimal design of rubble mount structures, oil spill monitoring, system design on ecosystem control structures, Busan New Port, Busan North Port Redevelopment Project, Saemangeum Seawall Project, coastal erosion control technique project, red tide information system, offshore wind farm, and offshore structures. It is shown from the activities and projects that Korean coastal and ocean engineers have worked on solving problems and constructing sound industries. Without their scarifying, the achievements would not have been possible. However, from the previous hard works, there have been many things to be solved. Especially, the coastal environmental issues caused by the rapid development should be clear for future generations. In addition, ocean renewable

energies have to be stabilized to establish stable and clean energy generation. Ocean plant industry should be revived through capturing high engineering (design) capability.

Fig. 10 shows the "ocean tree" summarizing this paper. The ocean tress explains that social and natural phenomena Ω control the global size of ocean tree, each industry r_i adjusts its own space, research capability φ supports the tree trunk, and the foundation α provides fertile soil. In other words, as human needs for utilizing oceans increase, the ocean tree will grow with its own components. Accordingly, balancing supports by research and foundation are significant and so do the roles of research institutes, universities, societies, and registers. Otherwise, a certain moment at which we cannot control a series of unpredicted disasters and economy recession would come.

References

Bown, C.P. and Crowley, M.A. 2013. Import protection, business cycles, and exchange rates: Evidence from the Great Recession. *Journal of International Economics* 90, 50-64.

Cho, D.O. 2006. Evaluation of the ocean governance system in Korea. *Marine Policy* 30, 570-579, 570-579.

Clinton, B. 2011. Back to work: Why we need smart government for a strong economy. Alfred A. Knopf, New York.

Cuestas, J.C., Gil-Alana, L.A., Staehr, K. 2011. A further investigation of unemployment persistence in European transition economies. *Journal of Comparative Economics* 39, 514-532.

Davis, B. 2009. What's a global recession? The Wall Street Journal. Internet website: http://blogs.wsj.com/economics/2009/04/22/whats-a-global-recession/tab/print/

International Contractors Association of Korea (ICAK) 2013. History of Korea's overseas construction. Internet website: [http://eng.icak.or.kr/intro/intro_01.php].

Kim, C.S., Cho, Y.K., Choi, B.J., Jung, K.T., You, S.H. 2013a. Improving a prediction system for oil spills in the Yellow Sea: effect of tides on subtidal flow. *Marine Pollution Bulletin* 68, 85-92.

Kim, G., Lee. M.E., Lee, K.S., Park, J.S., Jeong, W.M., Kang, S.K., Soh, J.G., Kim, H. 2012. An overview of ocean renewable energy resources in Korea. *Renewable and Sustainable Energy Reviews* 16, 2278-2288.

Kim, H.S., Kim, C.G., Na, W.B., Kim, J.K. 2008. Chemical degradation characteristics of reinforced concrete reefs in South Korea. *Ocean Engineering* 35, 738-748.

Kim, K.H., Shin, S., Widayati, A.Y.W. 2013b. Mitigation measures for beach erosion and rip current. *Journal of Coastal Research*, Special Issue No 65, 290-295.

Kim, S.G. 2010. The evolution of coastal wetland policy in developed countries and Korea. *Ocean & Coastal Management* 53, 562-569.

Lee, H.W., Kobayashi, N., Ryu, C.R. 1990. Review on oil spills and their effects. Research Report No. CACR-90-03, Center for Applied Coastal Research, University of Delaware.

Lee, M.E., Kim, G., Jeong, S.T., Ko, D.H., Kang, K.S. 2013a. Assessment of offshore wind energy at

Younggwang in Korea. *Renewable and Sustainable Energy Reviews* 21, 131-141.

Lee, M., Jung, J.Y. 2013. Risk assessment and national measure plan for oil and HNS spill accidents near Korea. *Marine Pollution Bulletin* 73, 339-344.

Lee, S.K., Migi, G., Kim, J.W. 2009. Energy technology roadmap for the next 10 years: The case of Korea. *Energy policy* 37, 588-96.

Lee, W.D., Kim, M.K., Hur, D.S., Cho, W.C., Yoon, J.S. 2013b. Characteristics of sand transport around the submerged breakwaters installed in Songdo Beach, Busan, South Korea. *Journal of Coastal Research*, Special Issue No 65, 2143-2148.

National Fisheries Research & Development Institute (NFRDI) 2006. Monitoring of paralytic shellfish toxins in shellfish in Korean waters. Annual Report of NFRDI on PSP of Korea, Busan, Korea (written in Korean).

Park, T.G., Lim, W.A., Park, Y.T., Lee, C.K., Jeong, H.J. 2013. Economic impact, management and mitigation of red tides in Korea. *Harmful Algae* 30S, S131-S143.

Ryu, C.R., Kang, Y.K., Kim, J.W. 1992. Optimal design of rubble mound structures under irregular waves. *Proc. 23rd International Conference on Coastal Engineering*, *ASCE*, 1503-1516.

Ryu, C.R., Kim, H.J. 1994. Failure rubble mound structures due to the storm duration and the irregularity of ocean waves. *Proc. 24th International Conference on Coastal Engineering*, *ASCE*, 1526-1540.

Sawaragi, T. 1995. Coastal engineering – waves, beaches, wave-structure interaction. Elsevier.

Time 2007. Korea's oil spill still spreading. Internet website: http://content.time.com/time/world/article/0,8599,1693383,00.html

US Energy Information Administration (EIA) 2011. Korea South. Internet website: [http://www.eia.gov/countries/country-data.cfm?fips=KS].

Vos, R. 2012. European debt, unemployment threaten to slow down global economy – UN. UN News Centre. Internet website: http://www.un.org/apps/news/story.asp?NewsID=40962&Cr=global+economy&Cr1.

World Economic Forum 2011. Executive Opinion Survey, World Economic Forum.

World Yards 2011. Worldyards statistics: Overall ranking including offshore. Internet website: [http://www.worldyardsstatistics.com/ss_allranking.php].

Yoon, H., Na, W.B. 2013. Safety assessment of submarine power cable protection by anchor dragging field tests. *Ocean Engineering* 65, 1-9.

Yonhapnews 2013. Park proposes Northeast Asia peace initiative in congressional speech. Internet website: [http://www.yonhapnews.co.kr/medialabs/president/speech_en.html].

Yu, Z., Sengco, M.R., Anderson, D.M. 2004. Flocculation and removal of the brown tide organism Aureococcus anophagefferens (Chrysophyceae), using clays. *Journal of Applied Phycology* 16, 101-110.

Logistics Decision Support Model for Ports Emergency Management

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Abstract: Disaster preparedness and Emergency Logistics center efficiency is a key success factor for any effective disaster management practices. This paper present new tool for the Logistics mangers and decisions makers to improve the Emergency logistics center capability, the disaster preparedness and emergency logistics management efficiency are the main factors in sea ports efficiency. Using an empirical Systems Dynamics model as "Vensim" software to simulate the current performance and show the strong and the weakness points of the system performance. It presents the results of the decision-makers and administrators responsible for disaster control in Jeddah Islamic port before, during and after the disaster. First, a systems dynamics framework is constructed from causal loop diagrams (Simonović, 2011), stock and flow diagram (Sterman, 2001) and these are adapted to produce a national policy model planning for disaster relief. Moreover, its show a series of dependent and independent variables in the emergency logistics centre. Following by simulate these data in scenarios to reach the optimum performance and quality of the emergency logistics centre.

Keywords: Disaster response policy, Crisis management, Effective service delivery, Logistics and quality management, Port Management, Systems Dynamics.

Introduction

As computer capacity grew, system dynamics methodology was applied to subsystems of a dynamic system model envisaged in this research for a national disaster response coordinator. In resourcing national and international sites that could be expected to be at risk, Rawls and Turnquist (2010) developed a resources and transport network model that considers uncertainty in demand; Zhang and Xu (2010) established an adaptable forecast demand model, and Li, Ru, and Xu (2010) modelled reorder points for consumables. Franke, Charoy, and Ulmer (2010) and Besiou, Stapleton, and Van Wassenhove (2011) used dynamic systems models to analyse field vehicle fleet variables in humanitarian operations. Recently, Nourjou, Hatayama, Smith, Sadeghi, and Szekely (2013) designed a Geographic (local) Incident Coordinator that integrated site information with artificial intelligence capability for a spatial intelligent coordinator system for emergency relief coordinators to improve decision making capacity and efficiency. Similarly, Magariño and Gutiérrez (2013) analysed case studies of coordination of messages during disaster responses, building a multi-agent-based approach to message networking. Realising the risk for inaccurate or biased entries into such data banks, Smari, Clemente, and Lalande (2014) incorporated a guarantee for privacy of attributes into a collaborative graphic tool that assists decision making in emergency response management. As computer capacity increases, the models researchers are building appear to become more comprehensive and interactive.

Dynamic network models prove effective for evacuation planning. Saadatseresht, Mansourian, and Taleai (2009) used models to plot evacuation routes in Iran, and Kongsomsaksakul, Yang, and Chen (2005) produced a model to determine the location of shelters along evacuation routes. Zhang, Liu, Zhang, and Wang (2010) posited that people could evacuate by foot or car to intermediate assembly points, a system widely in use in Australia for bushfire risk. In all, many researchers of diverse nationalities adopted systems modeling to analyze many aspects of emergency relief operations; however, as noted there is little investigation of the coordinating national organisations, or the use of modelling to develop their ongoing capacity and knowledge built up from experience of such events. It is the objective of this paper to gather sufficient data from the literature, the government, the media and primary investigation to develop such a model.

Methodology

This paper follows Jahre, Jensen, and Listou's (2009) call for theory development in emergency relief to understand logistics needs in different stages of a crisis through a mixed method approach. It comprises a literature review and primary and secondary data collection to develop a system dynamics model for emergency response (Badiee, Wang, & Creswell 2012). Systems planning included models to isolate elements of the disaster response (Özdamar & Demir, 2012; Sheu, 2009; Yi & Kumar, 200; Yuan & Wang, 2009). Gonçalves (2008), who suggested a multi-level systems dynamics model for national disaster relief, was of interest in the research design, in collecting qualitative data from the decision makers to understand the processes involved in the emergency response. In effect, Gonçalves' suggested model incorporated first the emergency response: the number of people requiring relief, the number receiving relief, and the shortfall in real time (as a process). As part of the model, the second system described the effectiveness of the coordinating agency in its capacity to provide relief (organizational capability), to replenish resources for operators to continue providing relief, or to regroup quickly after the disaster in preparation for future calls. This model was therefore selected as it tracks the relief effort across staff and volunteers, resource logistics, and rescues, showing locations, supplies and the need for replenishment.

The sample comprised the population: that is, those involved in disaster relief operations in the country. A decision was made to collect data by survey, individual public servants were not identifiable; those in Red Crescent and similar organizations were similarly difficult to identify. Yet there was a description for each responsible position in a given organization, and the individuals occupying those positions were selected for their competence and knowledge. The questions on the survey were guided by Bharosa, Lee, and Janssen (2010); Aitken, Leggat, Harley, Speare, and Leclercq (2012); and Hammad, Arbon, and Gebbie (2011).

Descriptive analysis was used for demographics to categorise the functions of the decision makers and the operators. A systems dynamics framework is constructed from causal loop diagrams (Simonović, 2011), stock and flow diagram (Sterman, 2001) and these are adapted to produce a national policy model planning for disaster relief (Deegan, 2005). Flow equations were informed by Georgiadis and Vlachos (2003) and Sterman (2001). In the quantitative

analysis phase, control theory techniques (Jagacinski & Flach, 2011) were employed together with the statistical analysis, as noted (Altay & Green, 2006). Validation followed Bagheri, Darijani, Asgary and Morid (2010) and Bossel (2001). The systems model is developed through this methodology.

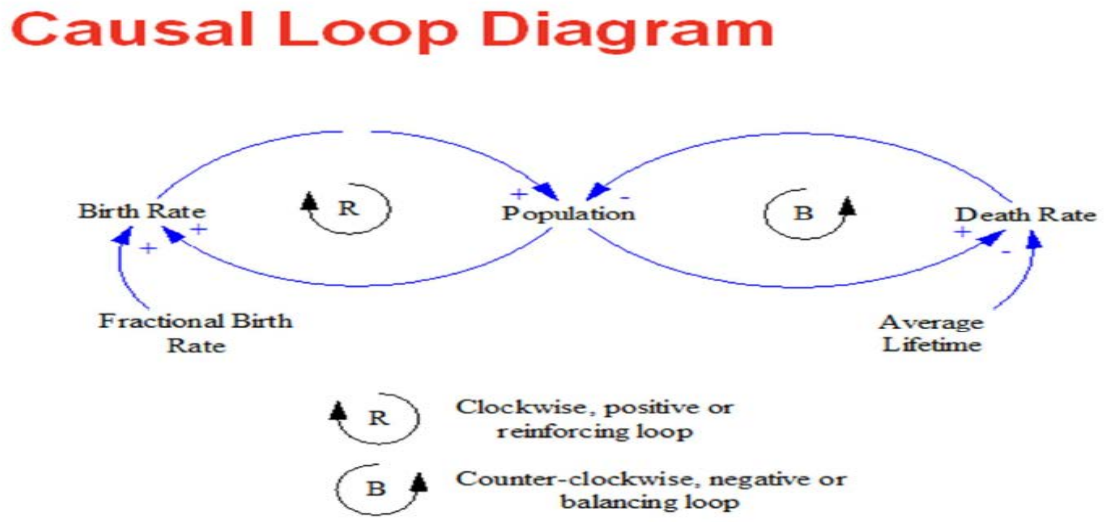


Figure 1.A System Dynamics & Emergency Logistics Model for Post-disaster Relief Operations Source: Abosuliman, S.S.

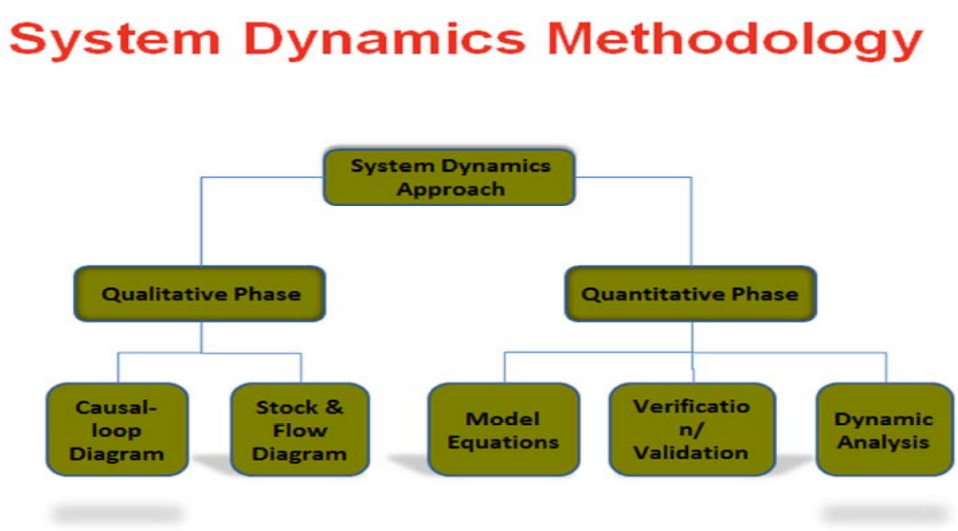


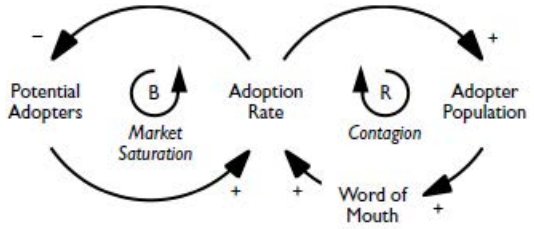
Figure 2.A System Dynamics & Emergency Logistics Model for Post-disaster Relief Operations. Source: Abosuliman, S.S.

Dynamic systems modelling

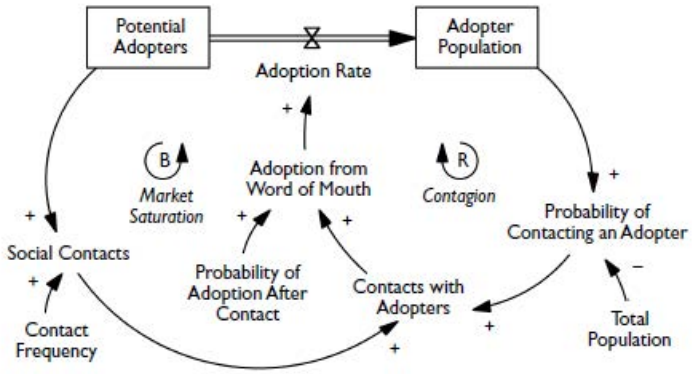
Systems planning for emergency response incorporates many fields: logistics, communications and administration (Smith, 2013). Smith acknowledges the technological advances made in emergency response policies and practices over the years, but supports Altay and Green's (2006) observation regarding the human element and the eroding of commitment until the next event occurs. Gonçalves (2008) also advocated using dynamic systems modelling to include analysis of the emergency crews' response and later operations which could be used to enhance the capability of the coordinator. It was also a permanent program that could counter the effects of personnel changes and changes to organizational responsibilities.

According to the commentators, systems dynamics can accurately represent the dynamic complexity of these operations. Sterman (2001) described the process of systems modelling, using adoption rates below.

1. Causal loop diagram



2. Causal diagram showing stock and flow structure



3. Model equations

Adoption Rate = Adoption from Word of Mouth [+ Adoption from Other Sources]

Adoption from Word of Mouth = Contacts with Adopters × Probability of Adoption After Contact

Contacts with Adopters = Social Contacts × Probability of Contacting an Adopter

Probability of Contacting an Adopter = Adopters ÷ Total Population

Social Contacts = Potential Adopters × Contact Frequency

4. Simulation

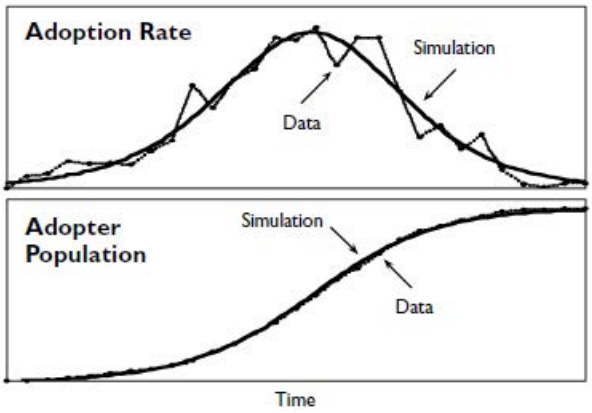


Figure 3.A System Dynamics & Emergency Logistics Model for Post-disaster Relief Operations. Source: Abosuliman, S.S.

Systems planning

Systems planning precedes a response to a humanitarian crisis, and several researchers have offered logistics, management, communications and complex modelling systems to overcome the issues of resources, chaos, and aid (Beamon & Balcik, 2008; Aslanzadeh, Rostami, & Kardar, 2009). However, Beresford and Pettit (2009) use the Thai tsunami response to question the traditional approach of preparedness, response and recovery, noting that the Thai government was under-prepared and the scale of the disaster quickly overwhelmed supply routes and communications. The Thai government now uses a less rigorous model, based on local communication networks, early warning systems, and danger mitigation rather than placement of large scale emergency resource stocks.

Disaster management systems

Manufacturing processes in the form of workflow management systems are an emerging interest for disaster workforce planners. Hofmann, Sackmann and Betke (2013) advocate the use of elements of workflow management systems in the dynamic environment of disaster response management to address challenges of rapidly changing resources and actions, and their condition, location and time. Hofmann et al. refer to adaptive workflow management systems, which they propose provide flexibility and improved management, for example, designing the system to incorporate geographic imaging systems and real time analysis of situational resource flows.

Real time information is the subject of many other models. For example, Preece, Shaw, and Hayashi, (2013) developed a viable system response model to order information processing to improve the quality of the information which is affected by merging data flows from systems into the primary disaster model. Crooks and Wise (2013) used crowdsourced data from social media to identify those most in need of assistance and to understand the nature and extent of the devastation to assist the disaster response managers. Similarly, Peters- Guarin, McCall, and van

Westen (2012) used local knowledge of flood hazards, forecasting models and risk scenarios embedded into geographic information systems.

In India, Phalkey et al. (2012) studied the early detection of flooding and the capacity of the rural healthcare system to cope with casualties. A flood in 2008 overwhelmed the primary healthcare services in Jagatsinghpur, Orissa state and this was used for the study. The researchers found that despite the regularity of flooding, there was no preparation of disaster planning at the 29 healthcare centers, no clear lines of command, and no access to contingency funds for use in local emergency response. Phalkey et al. also advocated for contractual arrangements to be put in place to aid emergency supplies of living needs such as feed and supplies for domestic animals. Strong primary healthcare systems, as the author's state, provide an important center for services and distribution to the affected population.

Hazard Assessment Systems

Commenting for the United Kingdom's Royal Society, Vörösmarty et al. (2013) stated that although rural populations in flood-prone areas confront a greater risk than urban populations, there is increasing risk to urban areas through rapid urbanization. The notion of climate change or global warming concerned many researchers, such as Scheid et al. (2013) mapping risk areas in Hamburg, Germany. In Nanjing, China, Wu et al. (2013) developed a sediment analysis system for a flood hazard assessment model based on a variable fuzzy recognition model for the lower Yangtze River. The result was that flood hazard assessment based on the variable fuzzy recognition model although consistent with the results calculated by the projection pursuit model, was simpler and visual. Thus the Wu model should be capable of greater analytical use of flood sediment, thereby improving the scope and results for determining current, old and ancient flood risk areas.

The effects of rapid urbanization across flood plains concerned Wright (2014). Wright explained that flood risk is derived from complex conditions concerning rain events, topography, and drainage networks. The intensity of floods is compounded in urban locations as compared with

that occurring in less populated areas. However, as Fatti and Patel (2013) state, this may be affected by the country's level of disaster planning. Wright studied decades of weather events at Charlotte, North Carolina and Atlanta, Georgia using high-resolution rainfall data and analysis to identify flood risk validated through rain gauges and cross-referencing this with stream flows and topology. Wright found that the effects of rainfall events changed at both sites and were affected more by water channeling 'rather than changes in the properties of extreme rainfall' (Wright, 2014, Abstract). However, the timeframes and the nature of the urbanization (houses with gardens, higher density flats, paved roads and gutters) remained a challenge. Extreme rainfall events over Charlotte were used to construct 'storm catalogues' used to estimate local storm area reduction factors from the conventional area reduction factors. It was found that conventional reduction factors cannot identify the properties of extreme rainfall and this finding has implications for assessing flood risk. Applications of a stochastic storm transposition and the gridded surface subsurface hydrologic analysis models found issues with existing analyses of several predictive models, including expected rainfall duration and intensity. Wright developed a simple storm classification system to describe the rainfall events at Charlotte. When extrapolating the data into these models, the researcher concluded that model uncertainty, climate trends using relatively short simulation periods and natural climate variability remain issues in predicting catastrophic storm events.

In Egypt, with relatively similar desert conditions to the Arabian Peninsula, Ghoneim, and Foody (2013) noted that flash floods occurred with relative frequency in the wadi El-Alam basin in the Eastern Desert. Ghoneim and Foody (2013) also used hydrological modelling to predict the occurrence of flash flooding. They found that a flood peak at the primary outlet required at least 40 mm rainfall. Other factors concerned the location of rainstorm, as the nature of the topography created more dangerous flows in the higher reaches of the basin than the same effect of rain in the less elevated terrain. The permeability of the surface, rock, vegetation or urban development also affected the nature of the flooding. The model developed by Ghoneim and Foody (2013) is applicable to similar rapid assessment of such hazards in mountainous desert such as the Hijaz Mountains.

Conclusion

Crises do not fit into a pattern, and disaster relief is no exception. There are several approaches to humanitarian logistics and these can be characterized as type and size of the disaster, its location, and preparedness and response of the accountable entities. These points are widely recognised in the broad literature on systems planning. This study is concerned with a specific type of organisational response to floods, so that problem has alignment within the broad field of humanitarian logistics. For example, location and size of the disaster can be estimated for flood relief, as the flood inevitably follows a severe rain event in a catchment. Further, whilst breakdowns in communications occur due to the disaster. Yet these matters are post-disaster; people die or are hurt in a few seconds, whereas the work of placing resources effectively to secure the area and manage the catastrophe takes considerable time.

Systems planning are theoretical responses of researchers to isolate elements of the disaster, resources and routes into the area, and the removal of people through evacuation. The East Asian researchers in their largely no-warning zones of disaster (earthquakes, tsunamis) advocate that victims can leave. This is problematic; one would expect that able-bodied survivors would attempt to rescue those less fortunate and those hurt would be unable to flee. However, there are elements of path selection relevant to this research, as the catchment areas above the counter or along the coast can be ascertained and various extreme events modelled from these. It is then a matter of selecting the best fit of the many models that researcher's trialed for emergency response organizations.

Recommendations

• System dynamics model for emergency center capability in sea ports should be developed and validated.

• Modelling the organizational dynamics in specific situations allows better understanding of

a) The behaviors' that develop and

b) The potential policies that might be used to improve performance.

• From the modelling process, managers could develop their systems thinking skills allowing them to better grasp the dynamic complexity in humanitarian relief systems

• Better coordination in information sharing and faster processing of the information are needed

• Avoid the lack of resources such as latest information processing equipment available to relief workers

• Coordination among clusters are recommended for an efficient logistics relief operation

• Optimal decisions can be made based on the developed model

• Furthermore, having the models at hand, managers gain an appreciation for the consequences of

• Interactions among variables, experience first-hand

• Eliminate the long-term side effects of current decisions

References

Abosuliman, S.S., A. Kumar, and F. Alam. Flood Disaster Planning and Management in Jeddah, Saudi Arabia - A Survey. In International Conference on Industrial Engineering and Operations Management. 2014. Bali, Indonesia.

Abosuliman, S.S. A System Dynamics & Emergency Logistics Model for Post-disaster Relief Operations. PhD Thesis. RMIT University Melbourne, Victoria September 2014.

Abosuliman, S.S., A. Kumar, and F. Alam. (2013). Saudi Arabia New Development in Disaster Management control, A Case Study of Jeddah City. Australian and New Zealand Disaster & Emergency Management Conference - EARTH: FIRE AND RAIN - Brisbane, 28 - 30 May 2013.
Abosuliman, S.S., A. Kumar, F. Alam and R. Rasjidin. (2013). Disaster Planning and Management in Jeddah, Saudi Arabia. International Conference on Economics and Statistical Sciences– ICESS, 20 January 2013, Melbourne, Australia. (Paper has been accepted).

Abosuliman, S.S., A. Kumar, F. Alam and R. Rasjidin. (2013). Disaster Response in Jeddah, Saudi Arabia: Systems Analysis - The First Saudi International Conference on Crises and Disaster Management-FISCCDM,12 February 2013, Riyadh, Saudi Arabia.(Paper has been accepted)

Adivar, B., Atan, T., Oflaç, B., & Örten, T. (2010). Improving social welfare chain using optimal planning model, Supply Chain Management, 15(4), 290–305.

Aljohani, N., Alahmari, S., & Aseere, A. (2011, 14 June). An organized collaborative work using Twitter in flood disaster. In Proceedings of the ACM WebSci'11, Koblenz, Germany.

Almazroui, M. (2011). Sensitivity of a regional climate model on the simulation of high intensity rainfall events over the Arabian Peninsula and around Jeddah (Saudi Arabia). Theoretical and Applied Climatology, 104(1-2), 261-276,

Al Saud, M. (2010). Assessment of Flood Hazard of Jeddah Area 2009, Saudi Arabia. Journal of Water Resource and Protection, 2, 839-847.

Al Saud, M. (2011), Uncertainty of mitigation measures to floods in Jeddah, Saudi Arabia. Paper presented at the Fall meeting of the American Geophysical Union, San Francisco, CA.

Alshehri, S., Rezgui, Y., & Li, H. (2013). Public perception of the risk of disasters in a developing economy: the case of Saudi Arabia. Natural Hazards, 65(3), 1813-1830.

Aslanzadeh, M., Rostami, E., & Kardar L. (2009). Logistics management and SCM in disasters. In R. Farahan, N. Asgari, & H. Davarzani (Eds.) Supply chain and logistics in national, international and governmental environment: contributions to management science, Heidelberg, Germany: Physica-Verlag HD

Ban, J., Zhang, X., & Huang. X.Y. (2010). Diagnostic analysis and numerical simulation of Jeddah rain storm on November 25, 2009, Paper presented at Workshop for National Center for Atmospheric Research, Boulder, CO.

Beamon, B. & Balcik, B. (2008). Performance measurement in humanitarian relief chains, International Journal of Public Sector Management, 21(1), 4-25.

Bell, J. & McMullen, P. (2004). Ant colony optimization techniques for the vehicle routing problem. *Advanced Engineering Informatics, 18*(1), 41-48. 153

Bello, O. & Aina, Y. (2014). Satellite remote sensing as a tool in disaster management and sustainable development: Towards a synergistic approach. *Procedia-Social and Behavioral Sciences, 120*, 365-373.

Bent, R. & Van Hentenryck, P. (2006). A two-stage hybrid algorithm for pickup and delivery vehicle routing problems with time windows. *Computers & Operations Research*, *33*(4), 875–893.

Beresford, A. & Pettit, S. (2009). Emergency logistics and risk mitigation in Thailand following the Asian tsunami. *Journal International Journal of Risk Assessment and Management 13*(1),21.

Berkoune, D., Renaud, J., Rekik, M., & Ruiz, A. (2012) Transportation in disaster response operations, *Socio-Economic Planning Sciences, 46*(1), 23-32.

Besiou, M. Stapleton, O., & Van Wassenhove, L. (2011). System dynamics for humanitarian operations. *Journal of Humanitarian Logistics and Supply Chain Management*, 1(1), 78- 103.

Bharosa, N., Lee, J.K., & Janssen, M. (2010). Challenges and obstacles in sharing and coordinating information during multi-agency disaster response: propositions from field exercises. *Information Systems Frontiers, 12*(1), 49-65.

River School boat for Transportation of Students Safely

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Abstract

The paper presents a School Boat to ensure efficient management of the "Road to School Program"(*Programa Caminho da Escola)* ensuring children's access to education establishments. In the design of the watercraft, they considered the paths from the community where the student resides, to the school facilities, at the Amazon river Zone.

There are presented the main characteristics of the watercraft that answered the claims of main users, students, ship-owners and pilots of rural municipalities, and by order the Ministries of Education, through the National Fund for Education Development (*Fundo Nacional de Desenvolvimento da Educação*, or *FNDE*), for this researcher‘time take severals interviews to consider all opinions.

There are discussed the main motivations that guided its development. The adjustments they still needed for better behavior in the waterways, especially Amazonian regions and other riverside regions.

Keywords: Port-City, Transportation, Shipbuilding Technology, Safety Transportation, Students.

1. Motivation

Statistical data from the Brazilian Ministry of Education (MEC) report that the lack of school transport has contributed greatly to school dropout. Adding to this is the insufficient transport to such demand; the difficulties by acquiring the municipalities of the poorest municipalities, for not only matters relating to bidding, but also by the limited resources available; the known bad condition of the few existing vehicles; the use of unsuitable vehicles to transport students.

In Brazil, 4.8 million students of basic education, living in rural areas and study in public schools depend on the daily school transport, free offered by the government to have access to education. In the northern region of Brazil (Amazonia), where is one of the largest river basin in the world, 650 thousand students depend on rural areas of school transportation public, and it is estimated that more than 300 thousand use watercraft to reach the schools.

Due to this fact, the Federal Government created the” Road to School Program”, with the objective of renewing and standardize the fleet of vehicles used for school transport through the granting of financing to municipalities for acquisition, through the Brazilian

Social and Development Bank/BNDES (*Banco Nacional de Desenvolvimento Social*), bus and new watercraft/boat. In addition to renew and standardize the existing fleet, the program aims to reduce costs for the acquisition and maintenance.

In a survey conducted by the FNDE have identified, until now, **210** municipalities, with **142** in the northern region, using watercraft in school transport students of basic education. Considering the capacity of the boats used in each school route, 7,696 routes have been identified as shown below, and 7,270 (95.5%) are the municipalities of the northern region (Amazon Area) (Table 1).

Table 1: Routes Number Distribution depending on the passenger capacity of school boats.

Capacity	No.of Routes
Up to 5 students (with / without motor)	1,085
From 5 to 15 students	1,943
From 15 to 25 students	1,887
From 25 to 35 students	1,658
Above 35 students	1,123
TOTAL	**7,696**

In cooperation with the Brazilian Navy, the FNDE / MEC is producing 674 (six hundred and seventy four) School Boat moved with gasoline, and capacity to carry twenty (20) students. In this first batch of waterway vehicles with unique specifications for transporting students, 551 units have been produced and donated to municipalities and states, especially the northern region of Brazil, of which 123 are in production and they be distributed until March 2012.

In a study conducted by FNDE in partnership with the Tocantins Federal University to characterize riverside waterway population school user of transport and test the first model of School Boat produced in Brazil, were covered over 6000 kilometers in the rivers of the northern region. The result of this study indicated that, besides the lack of continued supplies stations, the high price charged for a liter of gasoline substantially burdens the cost of maintaining the watercraft. In addition, the watercraft used by local communities fueled by diesel, despite the precarious security conditions and the lack of comfort, have a low cost and easy maintenance compared watercraft moved to gasoline.

So considering all these aspects, and the need to maintain the effort of the Federal Government, in cooperation with States, Federal District and municipalities, to improve the quality of Brazilian public education. They justified the continuation of actions aimed at the renewal of the fleet of school vehicles under the “Road to School Program”. And at this stage, make available through price record other models of watercraft, with more appropriate specifications to reality and that, in addition to transport a larger number of students, provides an alternative with lower maintenance costs and falls within the legal requirements of the *Road to School Program* to plead financing from BNDES. Thus, in

another step of this Program, two models of watercraft were built, the School Boat Medium and School Boat Big (LE-M and LE-G respectively), shown in Figure1.

Figure 1: School boats for passengers transport in the Amazon region.

2. Dimension

The total length and other dimensions of school boat they built with the values set out in Table 2:

Table 2: Dimensions and main characteristics of school boat.

Classification	LE-M	LE-G	Tolerance
Total Length	7,800 meters	11,000 meters	±2%
External Width	2,530 meters	2,530 meters	±2%
Height External	2,665 meters	2,665 meters	±2%
Capacity of adult passengers	20 seated	29 seated	-
Capacity of students-children	33 seated	49 seated	
No. ofcrewmembers	01	01	-
Capacity of Diesel Oil	Minimum of 300 litres	Minimum of 300 litres	±5%
Range at maximum speed	Minimum of 200 km	Minimum of 200 km	-
Autonomy in Maximum power	Minimum of 10 hours	Minimum of 10 hours	-
Maximum power for continuous operation	Greater than 60 HP	Greater than 100 HP	-
ship cruise Speed	20 km/h	20 km/h	±5%
Maximum Speed	Up to 25 km/h	Up to 25 km/h	±5%

3. Vessel Characteristics

3.1 Propeller and Rudder

At stern of the watercraft contains a propeller (figure 2), a rudder and a skeg (partial protection of the propeller),

For rudder fixing used 4 special screw bolt and propeller contain 2 nuts for fixing and more confidence of manoeuvering and propulsion systems.

Figure 2: (1) Propeller, (2) rudder, (3) skeg and (4) propeller shaft bracket

3.2 Bridge-house

The bridge-house of LE-M consists of four (4) windows on the right side of the vessel (starboard) and four (4) on the left side (portside). This vessel has two equal sides.

The bridge-house of LE-G consists of six (6) windows on the right side and five (5) on the left side of the watercraft and an opening (with cover) on the roof of the vessel (Tijupá) for ventilation and emergency exit.

There are still two doors fore (front) and a door on each side, closing all the doors and the bridge-house material, especially its attachment to the hull are firm to ensure the safety of students. Both vessels are illustrated in figures 3 and 4.

Figure 3: View profile of the Medium school boat LE-M

Figure 4: View profile of the big school boat LE-G

3.3 Gangway

On both boats, the gangway has the following equipment installed: two signal lights, one green starboard and a red to port, a mast with a white light, a searchlight (lighthouse), a horn and a radio antenna (figures 5 and 6).

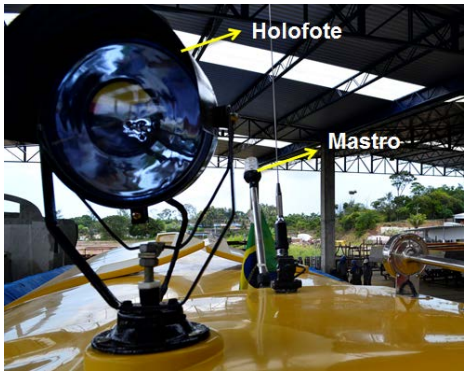

Figure 5: Installation of searchlight and mast with navigation light.

Figure 6: Port navigation light

3.4 Anchor

The boats have an iron ten (10) kilograms (kg) in Medium School boat LE-M and fifteen (15) kg on the Big school boat LE-G. Its location and the material for the positioning thereof are along with the bonds in the fore part of boat for easy handling by the pilot.

3.5 Furniture and Sanitary

The Medium School boat LE-M has ten (10) double seats and a simple bench, arranged as follows: 6 (six) double behind the engine, two (2) double the engine side, and a preferred two (2) double in front of the engine, and a single for the command.

The Big School boat LE-G has sixteen (16) double seats and two (2) single benches arranged as follows: seven (7) double behind the engine, two (2) double the engine side, seven (7) double being preferential in front of the engine, a single vessel at the right and one on command. The vessel LE-G has a sanitary consisting of a sink and a toilet because the journey is longer.

All furniture fixed perfectly, before they discussed with users so that all trips are more comfortable and safe. Figures 7 and 8 show the general arrangement of school boats and Figure 9 shows the sanitary equipment of big school boat LE-G, while Table 3 summarizes the number of benches of the boats.

Table3 : Number of benches available in school boats.

Benche	LE-M	LE-G
Bench of 1,00m	09	16
Bench of 0,50m	02	01
Driver Bench	01	01

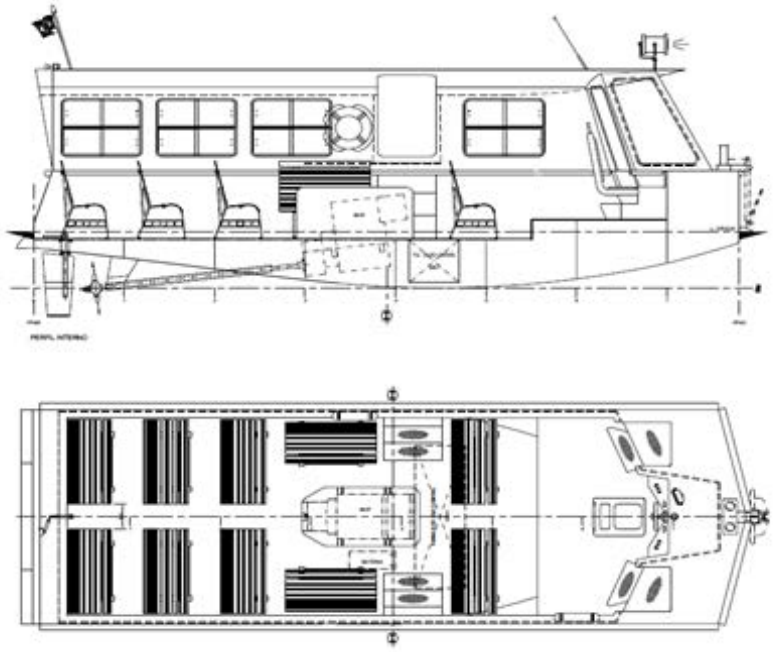

Figure 7: Medium school boat LE-M

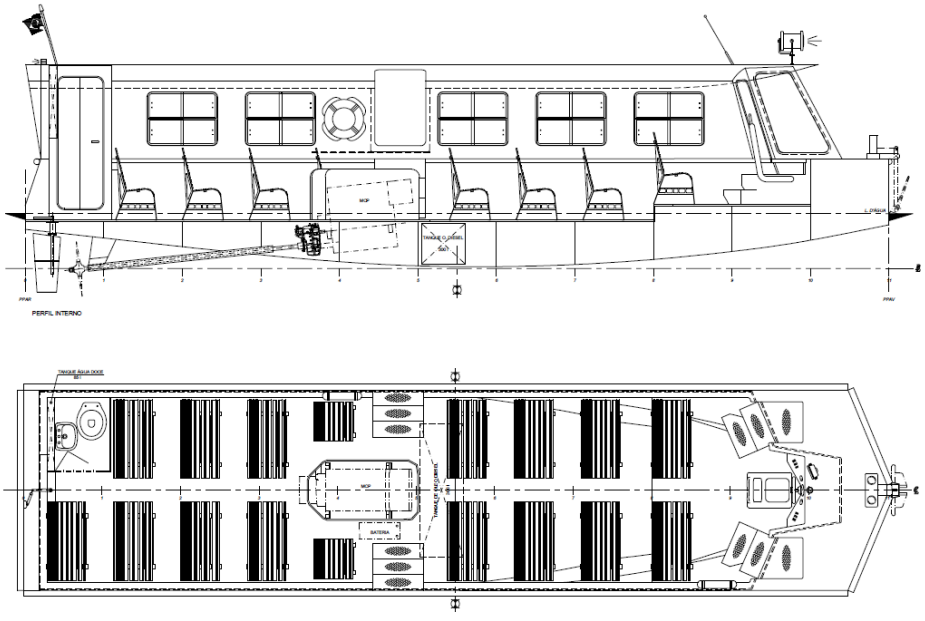

Figure 8: Big school boat LE-G

Figure 9: Lavatory and toilet available only in Big school boat.LE-G

Figures 10 to 13 show the inside of both watercraft.

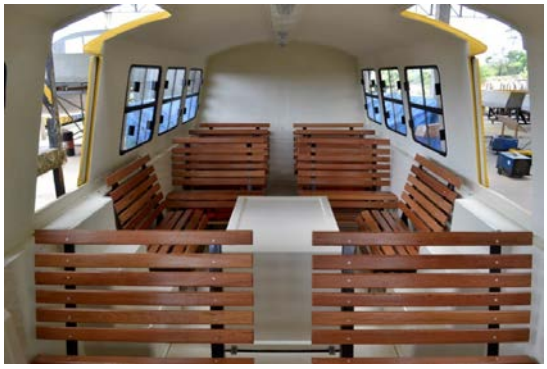

Figure 10: Internal aspect of bridge-house and boards attached to the roof and benches already assembled in the big school boat LE-G(view from back).

Figure 11: Internal aspect of bridge-house and boards attached to the roof and benches already assembled in the boat school big (view from fore).

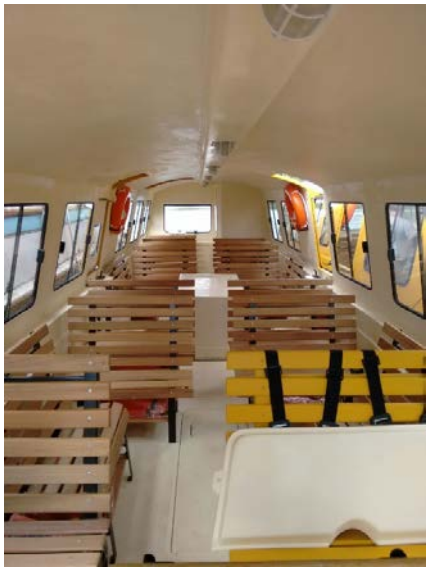

Figure 12: Internal aspect of bridge-house and boards attached to the roof and benches already assembled in the big school boat LE-G (view from back).

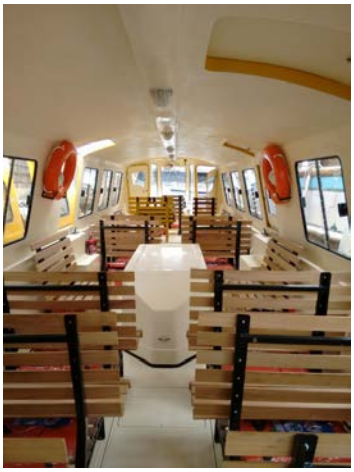

Figure 13: Internal aspect of bridge-house and boards attached to the roof and benches already assembled in the big school boat LE-G (view from back).

3.6 Panel and Navigation Equipment

Both vessel have the following navigation equipment and installed in the panel:

- -one crono tachograph with GPS,
- a manometer engine oil pressure,
- a manometer reverser oil pressure,
- a hobbs meter, a starter key, panel with light switch,

- a battery charge indicator,
- a marine VHF radio, a key of the windshield wiper,
- a switch for horn, a drive switch searchlight, an engine control lever.
- All equipment identified in the pane, as seen in Figure 14.

Figure 14: School Boats Panel equipment

3.7 Electric Power Supplier

The vessel have an alternator and at least one lead-acid battery type. The boats feature a main switch of power distribution, positioned next to the engine giving greater security to the system. Table 4 shows the minimum capacity in ampere-hours available in school boats.

Table 4: Minimum capacity of batteries of boats.

Classification	Minimum capacity (A/H)
LE-M	95
LE-G	110

Figure 15: The main switch power distribution

3.8 Engine and Reverser

The vessel have the engine protection with thermo-acoustic enclosure, as shown in figure 16.

Figure 16: thermo-acoustic enclosure of the MCP.

The Medium School boat has an engine 4 (four) cylinders MWM mark D229-6 74 hp, while the boat has a large 6-cylinder engine MWM mark D229-6 110 hp. The engines of both boats identified by mark, model and power on the nameplate located on the right side of the engine (Figure 17).

Figure 17: Main engine of Medium School boat LE-M (left) and main engine of Big School boat LE-G (right).

Thevessel are are also equipped with a gearbox (ZF-41 model or equivalent) coupled to the motor.

Figure 18: Reverser.

3.9 Safety of passengers

The LE-M has 29 (twenty nine) lifejackets Class III children and three (3) lifejackets class III adult under the seats, two (2) buoys lifeguard with heaving line (nylon rope to recoil the float), a chemical powder fire extinguisher 4 (four) kg.

The LE-G will present 49 (forty nine) lifejackets Class III children and five (5) life jackets class III adult beneath the seats, two (2) buoys lifeguard with heaving line (nylon rope for collecting the buoy), two (2) fire extinguishers (a 6 CO2 (six) kg and a powder of four (4) kg).

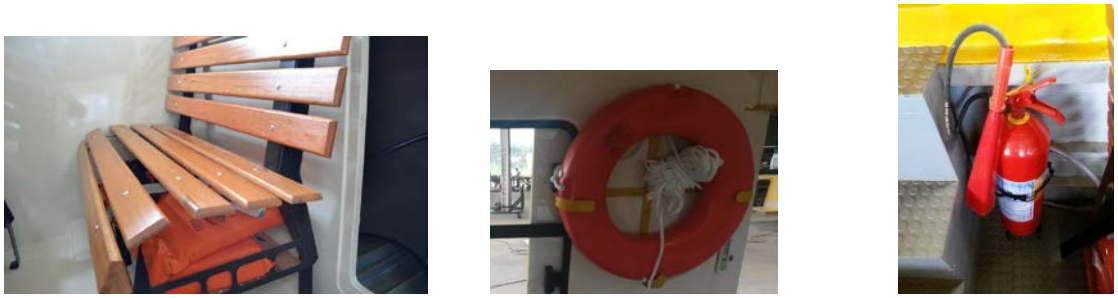

Figure 19: Bench, lifebuoy and fire extinguisher present in school boats.

4. Systems and components - Construction

4.1 Hull

4.1.1. Hull Structure

The boats built with sheet metal and structural steel profiles, the structural quality weldable, in the following specifications ABNT NBR 6648, NBR 6649, NBR 6650, according to the application.

The structure of the hull is of the longitudinal type, electrically welded by MIG process, in accordance with the shipbuilding standards and adequate to the quality of steel used.

4.1.2. Hull Lines

The shape of the lines of the hull of the watercraft will be type “V” deep fore tending to U reverse open, with side bowlines on both sides, in the region of amidships to fore, to minimize formation of interfering waves on the shore or in boats in the vicinity.

4.1.3. Thickness of sheet metal and profiled steel

The sheet metals and profiled steel to be used in the construction of the hull of the vessel must be in structural steel and have respectively the minimum thickness of 3.18 mm for the hull plating, floors, mirrors and side decks, and 4.76 mm for the parts of longitudinal and transverse structural reinforcements.

4.1.4. Treatment and Painting

All sheet metals and profiled have clean surfaces and blasted with abrasive blasting in Metal-Quasi-White standard, immediately after receiving a background coat of paint type "primer" base epoxy bi-component.

The hull of the finish paint scheme consists of number of required ink in type epoxy bi-component color coats "Yellow School" required number of coats of paint bi-component non-slip epoxy base on the main deck floor fore, except inside the fuel oil tank which must remain unpainted.

The back and on the sides, are painted in its entire length, a horizontal band with the following specifications:

- black with 400 mm with a maximum tolerance of ± 10 mm. Width, half height, which should be entered in capital letters, the couplet “ESCOLAR" (SCHOOL) in Arial type, with height of the letter of 280mm, with a maximum tolerance of ± 10 mm, color "Yellow School", painted polyurethane system bi- component, and

thickness of the dry layer between 50 and 60 µm, as is the default in the Road to School's FNDE.

- At the top front of the bridge-house, it is painted the couplet "SCHOOL" in Arial type, with a height of 280 mm ± 10 mm letter, in black, painted in bi polyurethane component system, and thickness of the dry layer between 50 and 60µm .

4.2 Accessories

The vessel are equipped with at least the following equipment and systems:

Table 5: accessories available in boats.

Acessory	LE-M	LE-G
Double rotary head dock fore	01	01
System dock reverse	01	01
Rubrails rubber hose 3 inches in diameter, in a continuous line on the sides and forward mirror	01	01
15kg Anchor - (± 5% tolerance)	-	01
10kg Anchor (± 5% tolerance)	01	-

4.3 Circulation corridors

The central circulation corridor should be free of obstacles that affect the security and integrity of students and their width should be 300 mm to ensure mobility within the watercraft.

5. Fuel consumption

It realized an experimental verification of the fuel consumption of school boats held, moved to gasoline and diesel provided by the Road to School Program (FNDE), under typical conditions of use. The methodology followed the described conditions

5.1 Methodological procedure for measurement

5.1.2 Transported load

In order to have the maximum loading conditions, were placed twenty (20) gravel bags of about 40 kg each (see Figure 2 and 3) as passengers were four adult persons in each boat, including pilot, totaling 1,100 kg load in each vessel.

Figure 20: View loading the gasoline boat (BG)

4.2. Path and Boat Operating Data in Test

Figure 21 shows the path traveled during the test, and Table 1 shows the geographical coordinates of the points of the path, obtained by GPS. Table 2 shows, for each boat (BG, Motor gasoline, BD, boat diesel), the distance between sections, average and maximum speed, information obtained by GPS, and the journey time measured via timer

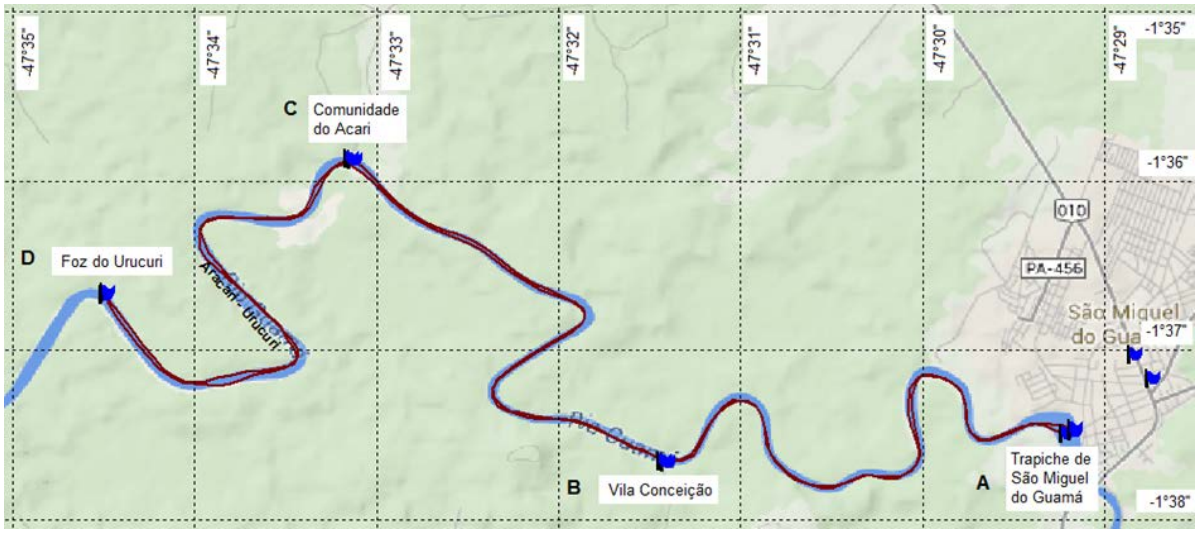

Figure 21: Path traversed in test

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Table 6: Location of reference points of the paths,

Localities	Location		
	Point	Latitude	Longitude
Trapiche de São Miguel	A	01° 37' 28" S	47° 29' 09" W
Vila Conceição	B	01° 37' 39" S	47° 31' 25" W
Comunidade do Acari	C	01° 35' 53" S	47° 33' 07" W
Foz do Urucuri	D	01° 36' 40" S	47° 34' 28" W

Table 7: Operating data of the boats in the test.

Stretch	Distance Traveled [km]		Average Speed [km/h]		Maximum Speed [km/h]		Path Time [hh:mm:ss]	
	BG	BD	BG	BD	BG	BD	BG	BD
A to B	6,61	6,63	23,0	16,5	25,1	17,7	00:17:15	00:23:53
B to C	6,27	6,24	23,4	13,4	26,9	16,7	00:16:05	00:27:51
C to D	6,15	6,23	22,2	12,9	24,9	13,9	00:16:37	00:28:56
D to A	19,10	18,99	24,3	14,8	26,2	17,6	00:46:49	01:16:59

5.3. Measurement of Fuel Consumption

The fuel consumption of the boats measured by use of external tanks where the fuel level noted in each reference point on the path. The figures 22 and 23 show the installation of these tanks in boats gasoline and diesel, respectively. The fuel levels in the tanks were properly measured through a beaker calibrated to an accuracy of +/-5 ml (see Figure 7).Table 3 shows the volume of fuel consumed in the sections for the two boats.

Figure 22: External fuel tank in the gasoline boat.

Figure 23: External fuel tank at diesel boat

Figure 24: Calibrated Beaker for measurement fuel volume.

Table 8: Fuel consumption of motor boats in the test.

Strech	Volume (liters)		Consumption (liters)	
	BG	BD	BG	BD
Inicial	50,50	40,50		
A to B	43,75	35,00	6,75	5,50
B to C	36,00	29,30	7,75	5,70
C to D	28,25	25,00	7,75	4,30
D to A	6,00	12,60	22,25	12,40

5.4. Fuel Cost

The fuel purchased at a gas station in the city of São Miguel de Guamá. Figure 8 shows a view of the displays of the fuel pumps at the station at the time of purchase, being the value of a liter of gasoline and diesel, from R $ 3.249 and R $ 2.609, respectively.

R$ -real Brazilian money

Figure 25: Fuel Price in São Miguel do Guamá

6. Results and discussion

From the information presented in the previous section, Table 9 shows the result of consumption and fuel cost for the two tested boats. It observed that consumption per kilometer of BG gasoline fuel boat is about 50% higher than the BD diesel fuel oat, but the cost per kilometer is around 100%, in the same ratio. The consumption per hour of two boats, within its particularities, is within the expected range.

In order to evaluate the cost per portion, Table 10 shows the unit cost, daily, monthly and yearly, for a short stretch (6.6 km, 25 min diesel boat) and one long (19.1 km, 1:15 min diesel boat). There is an annual savings of about R $ 650.00 for a short stretch and R $ 5,000.00 for a long stretch, using a boat diesel instead of gasoline.

Table 9: Consumption and cost for boat fuels on the test.

Stretch	Consumption [l/km]		Consumption [l/h]		Cost [R$/km]		Cost [R$/h]	
	BG	BD	BG	BD	BG	BD	BG	BD
A to B	1,02	0,83	23,48	13,82	3,32	2,16	76,28	36,05
B to C	1,24	0,91	28,91	12,28	4,02	2,38	93,93	32,04
C to D	1,26	0,69	27,98	8,92	4,10	1,80	90,92	23,26
D to A	1,16	0,65	28,52	9,66	3,79	1,70	92,65	25,21
Average	**1,17**	**0,77**	**27,22**	**11,17**	**3,80**	**2,01**	**88,45**	**29,14**

Table 10: Annual fuel cost of boats in the test.

Parameter	Cost [R$]			
	Short Stretch		Long Stretch	
	6,61 km		19,10 km	
	BG	BD	BG	BD
Unitary	1,02	0,83	1,16	0,65
Daily	13,50	10,96	44,50	24,95
Monthly	283,50	230,20	934,50	523,93
Monthly Difference	**53,30**		**410,57**	
Yearly	3.402,00	2.762,39	11.214,00	6.287,13
Annual Difference	**639,61**		**4.926,87**	

5 Conclusion

By the time the development team of the School Boat took the main claim of the users about the fuel and speed, however we must still perform a broader search as for

comfort and the longings of the ship owners. As the next step will be to increase speed, further reduce the travel time, especially for longer.

Concerning fuel consumption tests, it found that the average speed of the boat gasoline was 23.2 km / h and the boat diesel 14.4 km / h, with maximum values of 25.8 km / h 16.5 km / h, respectively.

In tests conducted under conditions of maximum loading, the consumption per kilometer of gasoline boat is about 1.2 l/km and the diesel boat is approximately 0.8 l/km. In relation to the current cost, it has 3.80 R $ / km for the gasoline boat and R $ 2.01 / km for diesel boat.

It verified that the fuel cost of annual boat gasoline in relation to diesel is significant only for long stretches (above 15 km).

7. Acknowledgements

The authors thank the leaders who always encouraged the realization of research and development programs essential to society. In particular the FNDE/MEC (Brazilian Education Ministry), FADESP/UFPa (Pará Federal University) , the IPT and finally the USP for their support in giving our fair share towards a more integrated society to progress.

Planning and Management of Pedestrianized Streets in Mega Cities

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Abstract: Pedestranization of main streets is one of the most practical measures that enables shift the car dependent lifestyle and to walking and transit-oriented lifestyle. The research targets are the weekend vehicle-free main streets in world mega cities. First, the research sorted out the general transition of transportation policies in target cities. Then, it also made case studies on the present management of representative cases. Based on the findings, the research pointed out the key points of planning and management of street and urban open space network. As conclusion, it suggested the process of sustainable management of streets in mega cities in desirable way for local community life and governance.
Keywords: Pedestranization, Traffic regulation, Revitalization of downtown, Activity, Placemaking

Introduction-Walkable/Transit concept for Streets

Recently, more and more streets in the world have been redeveloped under the concepts of walkablity and public transportation transit. They have correlation with citizen life and the value of city itself. For instance, an existing research indicates that the cities with walkability have realized the reduction in body mass index from the viewpoint of public health(Frank, 2006). The other examined that the walkability attracts educated population and induces higher metropolitan GDP(Smart Growth America, 2016).

Japanese cities are also in the paradigm shift of street design, from vehicle-oriented one to people-first one at the moment. The figure1. Represents the typology of the latest

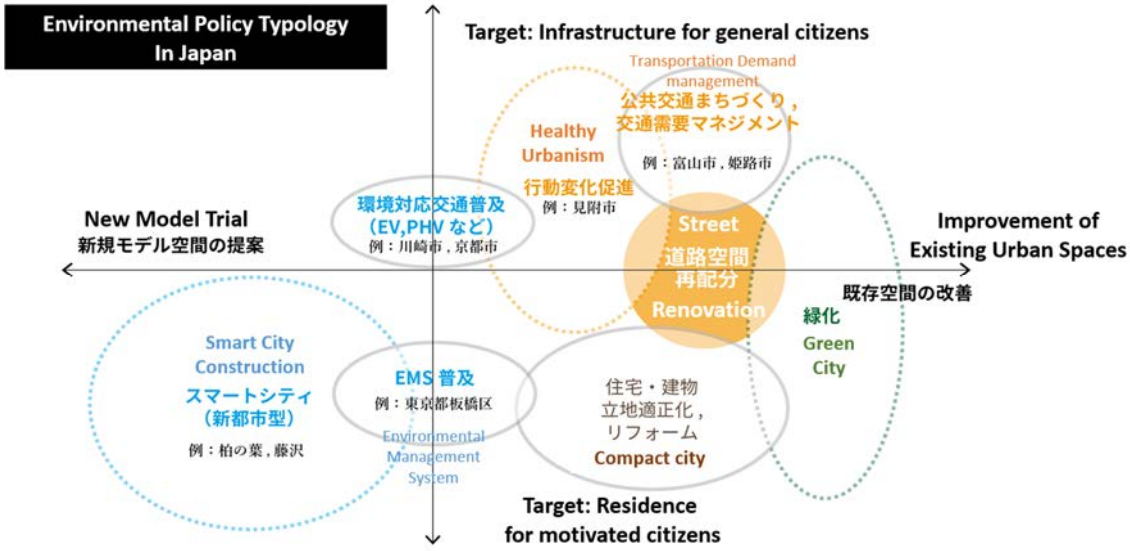

Figure 1. Environmental Policy Typology In Japan

environmental urban policy in Japan. There are several policies such as ‘Compact city’ and ‘Healthy Urbanism’ for the improvement of existing urban spaces. The street renovation is one of the key parts to realize them, for street is one of most fundamental infrastructure forming city structure. Among street network, main streets play a role as incubative space where people can attempt and experience pilot system and hardware due to their characteristics. Namely, a main street is the principal axis of city and the public space for communication and community which represents lifestyle of citizens.

Street Renovation Movement in Japan

The walkable street concept is not the recent implementation. There were another street renovation movement in the past(Figure 2). In Japan, 1970’s, after rapid motorization was the movement phase. Numbers of pede-mall around railway- station area were planned. These were quick prescription against heavy air pollution and accident fatality rising.

It was took the lead mainly by municipal mayors and completed with the collaboration of local communities and in some case, professional traffic planners in police organization.

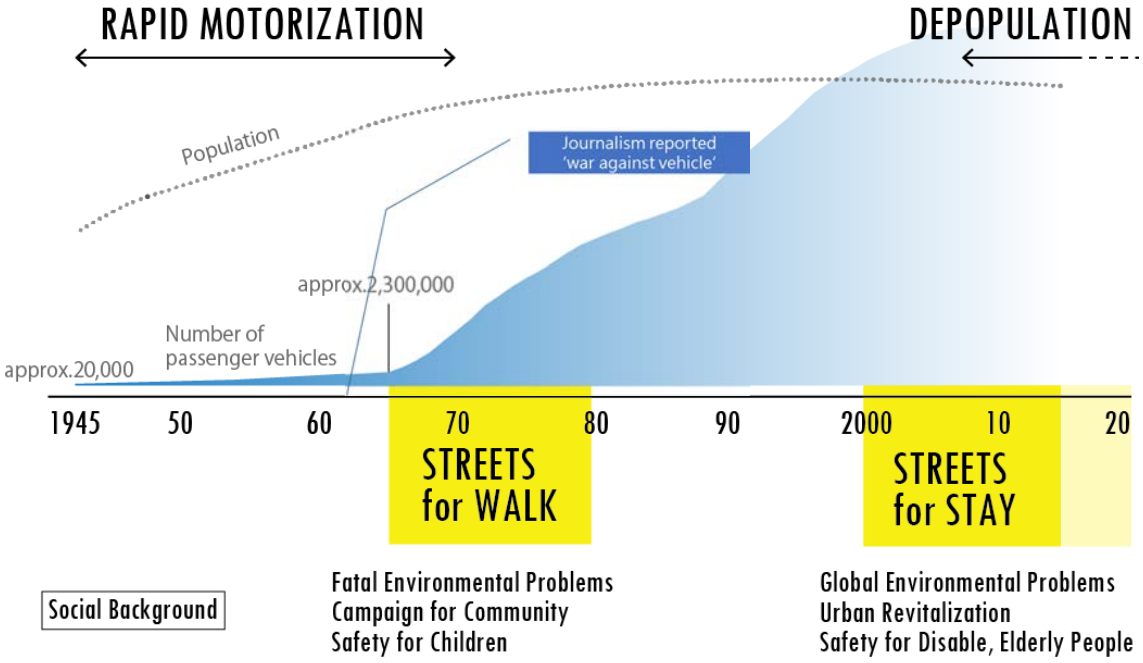

Figure 2. Street Renovation Movement In Japan

1970’s Typical Pedestrian Mall

The typical case at the phase is Asahikawa Heiwa Mall in Hokkaido. Asahikawa is the first city which introduced pedestrian mall in Japan due to mayor leadership. Several similar malls were planned in Asahikawa and all over Japan following Heiwa Mall case.

The redesign was implemented after 30 years of operation and management. As Figure 3 indicates, the plenty of space for safe walk was planned.

The mall was originally planned with 2 core destinations so as to connect existing

Figure 3. Asahikawa Heiwa Mall Before (Left) and After (Right) Redesign

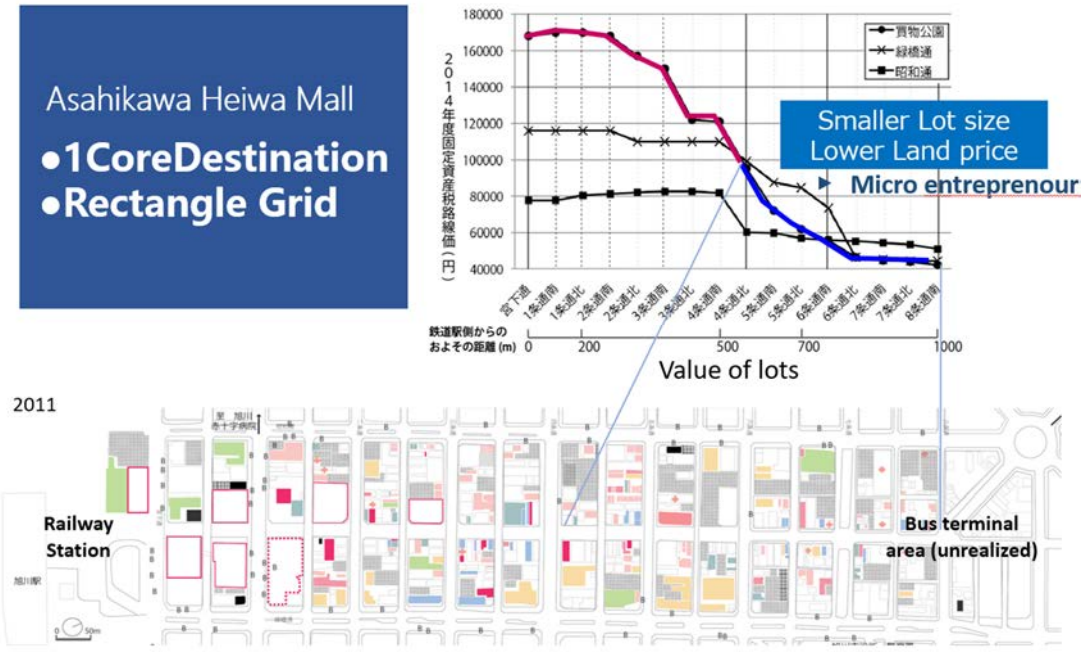

Figure 4. Land Use Condition along Mall and the Value of Lots

railway station and new bus terminal. However, the municipality couldn't acquired the enough land for the terminal. As results, northern small lots have remained undeveloped compared to station-side; nevertheless they have an unexpected good point from the perspective of micro- entrepreneur. The low land price and small size lots are in demand for creative local shops and artists.

The recent issue is the increase of parking lots (Figure 4. Map: Gray color). More parking, less landscape attraction for pedestrian. It is crucial to balance the demand between pedestrians and vehicle users such as visitors from suburb area and tourists by the smart relocation of parking.

These cause the present condition of Heiwa mall. However, the rectangle grid proportion seems to influence these un-integration of land use because a half of stakeholders in 1 grid face to the other avenues. Thus, the decision making in 1 grid becomes divided.

Resent Renovation of Streets

2nd renovation movement has begun in 2000's and it is focused on the diversity of pedestrians and their behavior such as stationary activities and social communication. Due to the efforts of decades, motivated private organizations grew up and they contribute to both of maintenance and programming for various activities on main streets. Such design concept is recognized as 'Placemaking' with flexible operation compared to typical mall.

'Placemaking' is the methodology which has been developed as one of the fields of public life studies. 'Project for Public Spaces', the non-profit advocacy organization in USA has applied it in many of urban open spaces renovation cases. A 'place' is not equal to a vacant 'space'. It is a human-scale realm enhancing community activity of day and night. In this context, a main street should be not only as a linkage of symbolic destinations but also as organic assembly of 'places'. Spatial characters of the successful main streets fulfill it.

(1) Munich Mall: Extension of 1970's Pedestrian Zone

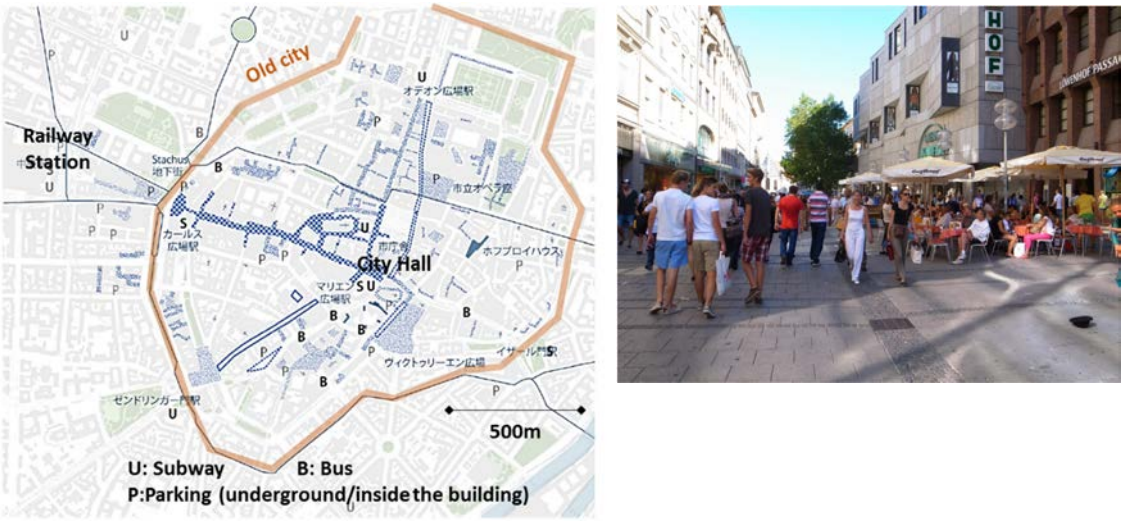

Figure 5. Pedestrian Zone in Munich (Source of Map: Munich City, Referat für Stadtplanung und Bauordnung,2008)

The first example is Munich which have fostered pede-mall, born in the same year as Asahikawa. Inside of the old city, the pedestrian network were introduced (Figure5: blue color).The network consists of both public streets of private open spaces as 'places' where people enjoy drinking beer or art work. Reflecting the city policy pushing the bicycle use, traffic operation became so flexible that the mall is now not limited to pedestrian, open to cyclists for certain time of day.

(2) Tokyo Weekend Pedestrian Zone Regulation (1970-)

The other case is the weekend vehicle regulation in Tokyo. The metropolitan police conducted vehicle regulation in busy streets for safer operation. Figure 6 indicates the

center of Tokyo Metropolitan and the zone. It had extended rapidly in 10 years. The western side developed around railway stations. The eastern side has stretched gradually along Ginza metro line. The air pollution were dramatically improved by this policy.

The zone had been shrunk since 90's and 3 area (Ginza, Akihabara, Shinjuku) remain operated. The most representative area is Ginza. The pedestrianized zone has been recognized as the symbol of the area among private stakeholders and visitors. The spatial governance by local private sector become active after 50 years cooperation with. They've created local rules on landscape and parking location toward 'dairy- walkable district'.

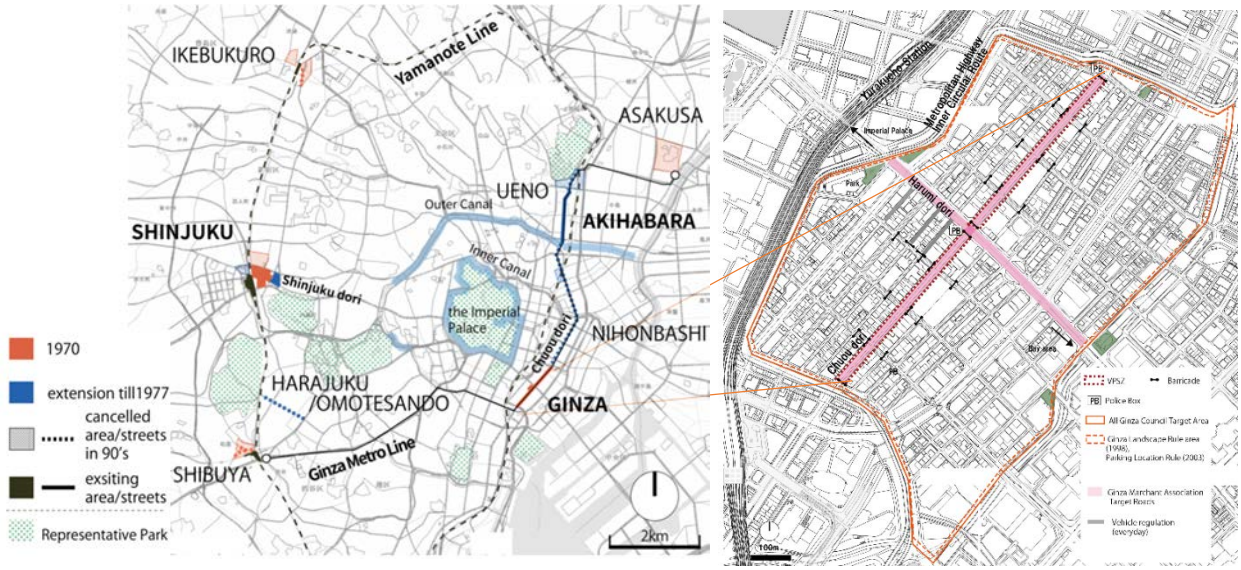

Figure 6. Regulated Zone in Metropolitan(Left) and in Ginza area(Right)

(3) New York 'Plaza Program' (2008-) :From Car lane to People Place

The latest example is street program policy implemented frequently in American cities such as in San Francisco and New York.

The 'Plaza Program' is a case in New York. It achieved success pilot projects such as Times Square on Broadway. They transformed the congested car lanes into squares for people. The traffic safety was also improved because the redesign accomplished the process simplifying intersections.

The pilot projects stimulated the neighborhoods and over 50 local plazas have spread around the city in 2014(Figure7). They've provided New Yorkers the experiences of walkable lifestyle.

The other specific point of this program is that they opened the borders of public realm of streets, waterfront and parks. New York City government broke the wall between administration departments. For instance, some plazas installed the experimental water filtration landscaping or locates waterfront. These are maintained under Cooperation between Transportation and Environment protection departments. The city original street guideline enforce the collaboration considering NY social and spatial features.

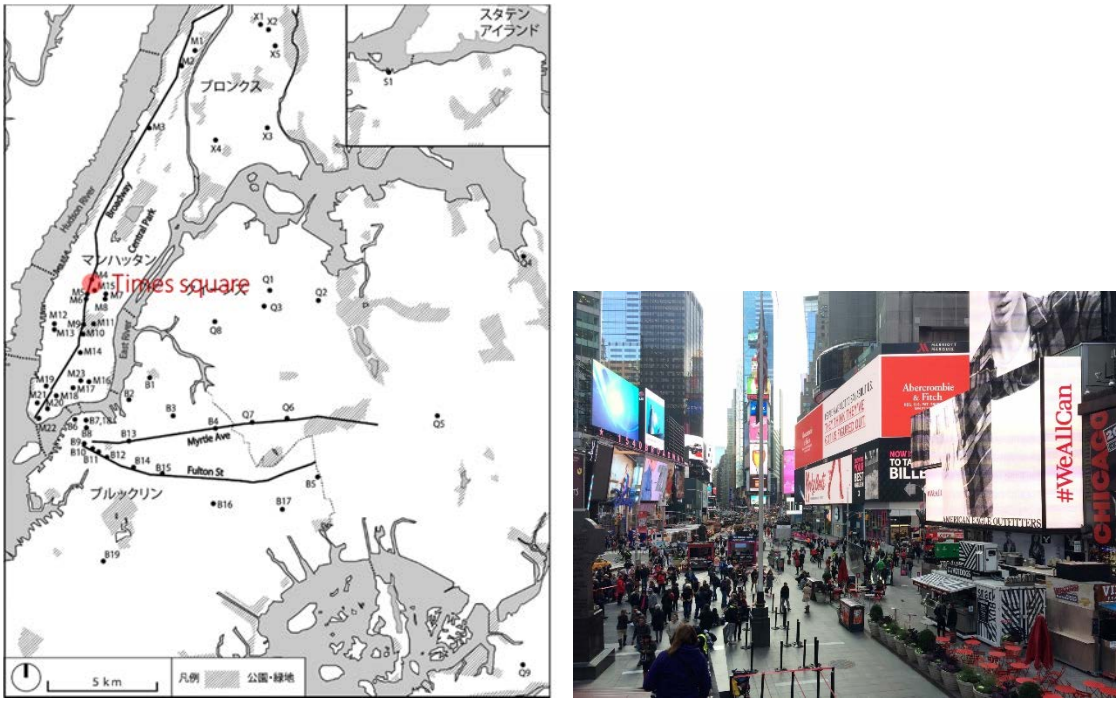

Figure 7. Plaza locations (Left: in 2014) and the Times Square Plazas (Right: in 2016)

Next Walkable Street Design / Trend in 2010’s

Lastly, the paper summarizes the 2 trends in 2010’s.

One is transit mall redesign which are going to be accelerated in future by new technologies on public transportation vehicle and traffic control.

The other is ‘proactive’ planning considering the climate changes. In this context, the street redesign needs to be adopted more not only as traffic network but also Green and Water Network. The ‘Plaza Program’ in New York contains such environmental perspective of planning as I explained above. The city is also developing larger scale ideas as ‘BIG U’ which is a comprehensive strategy to protect coastline, nature resources and the waterfront culture and to create the value of exiting streets as green-web. In a sense, port cities have more potential to make break-thorough than others.

These trends suggests that the next generation of walkable street design requires the co-working process among multi-academic fields.

Conclusions

Based on the results of the case studies, the paper concludes the scheme cycle of planning and management of streets in mega cities (Figure8).

1) The total open space vision should be clarified reflecting the context of city and its spatial structure.

2) The pilot model at the most potential site in the city should be planned as a booster for introducing model in other sites. A guideline is better to be prepared referring the management experiences in pilot case.

3) Under the guideline, decide the optimum location of the project places, regarding them as parts of the environmental circulation in the city. Professions of environmental protection and disaster preventing are required in this phase.
4) Design and Management phase involving much more local communities: By civic participation, the community diversity is reflected to each place. The process is essential for motivating local people for the management by themselves.
These managed places at many sites in the city enhances the whole city image and lifestyle.

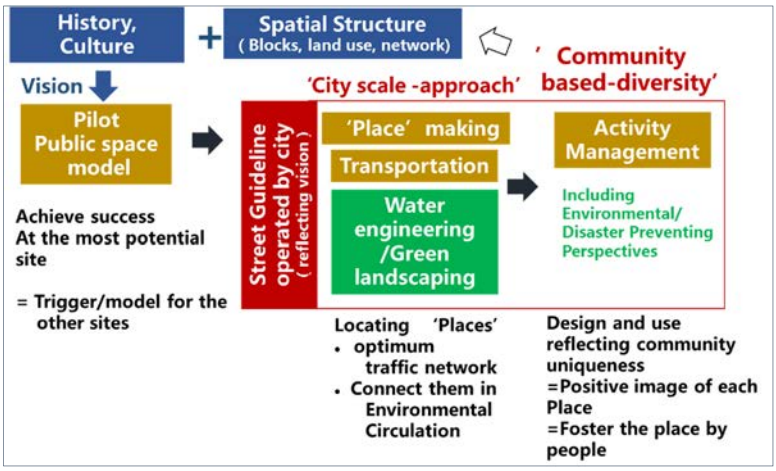

Figure 8. The Scheme Cycle of Planning and Management of Streets in Mega Cities

References

1) Lawrence D. Frank, James F. Sallis , Terry L. Conway , James E. Chapman , Brian E. Saelens and William Bachman:Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality, Journal of the American Planning Association,72, pp.75-87,2006
2) The Smart Growth America:Foot Traffic Ahead, 2016
3) Shino Miura, Atsushi Deguchi : Uses and Management of the Streets Operated By 'Plaza Program' in New York City, Journal of Japan Society of Civil Engineers, Ser. D3 (Infrastructure Planning and Management, 72, 2, pp.138-152, 2016
4) Shino Miura, Atsushi Deguchi : Uses and Management of Heiwa Mall in Asahikawa City, J. Archit. Plan, 80,713, pp.1635-1643, Architectural Institute of Japan, 2015
5) Shino Miura, Atsushi Deguchi : Management System and Transition of Vehicle-Free Main Str eets in Tokyo Downtown,12th International Congress of Asian Planning Schools Association (Proc eedings),2013
6) The City of New York: PlaNYC:East Side Coastal Resiliency Project, 2015
7) Referat für Stadtplanung und Bauordnung :PERSPEKTIVE MÜNCHEN –Innenstadtkonzept,2008

Liquefaction Vulnerability of Urban Port Areas and the Importance of Keeping Accurate Records

A Case History form the 2011 Great East Japan Earthquake

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Abstract: Tokyo Bay area is a home to millions of people as well as the port/factory zone to support urban lives. All the more because the area has been the center of the economics and urban lives, the impact of the sand-liquefaction over a long stretch of landfills along the coast of the Tokyo Bay in the March 11th, 2011 Great East japan Earthquake was serious leaving many houses tilting and lifelines cut off. In recent earthquakes, one of important findings that may have changed people's perception was that sand deposits, which were once liquefied in past earthquakes, can liquefy again in a large earthquake, thus highlighting the re-liquefaction risk, which is considered to be inherent to particular locations. Moreover soils are all hysteresis materials like magnetic tapes that can record past events. Given such a background, the authors have been preparing ground subsidence maps of the liquefied Tokyo Bay shore area. These maps are not exactly hazard maps, but simply a quantitative record of a past event. Therefore it is necessary to elicit important features of soil deposits, which will be reflected upon estimating future hazards.

Keywords: Tokyo Bay shore area; liquefaction potential; the Great East Japan Earthquake

Introduction

Tokyo Bay area has long been a home to millions of people as well as the port/factory zone to support urban lives. On March 11th, 2011, a large earthquake of moment magnitude Mw 9.0 occurred off the Pacific coast of Tohoku, Honsyu Island, Japan. This earthquake is officially named "The 2011 Off the Pacific Coast of Tohoku Earthquake", which is commonly known as the "Great East Japan Earthquake". The Great East Japan Earthquake caused severe soil liquefaction over a long stretch of landfills along the coast of the Tokyo Bay, which area is located about 350 kilometers away from the epicenter. The liquefied swath along the coast of Tokyo Bay reportedly reached 42 km^2 (Yasuda, et al., 2011), and there yet remain serious long-lasting concerns about sewage treatment and possible inundations inside levees.

In recent earthquakes, one of important findings that may have changed people's perception is that liquefaction can recur at the same locations. Wakamatsu (2011) has confirmed that sand deposits, which were once liquefied in past earthquakes, did liquefied again in the Great East Japan earthquake at 145 locations in both Kanto and Tohoku Regions in Japan. Moreover soils are all hysteresis materials like magnetic tapes that can record past events. Actually, after almost all sands were cleared up for rehabilitation, it was observed that subsidence of the liquefied area has remained as clear differences in level between ground floors of pile-supported RC buildings and surrounding sidewalks.

In response to this earthquake, liquefaction-induced ground subsidence map for the eastern part of the Tokyo Bay Shore area was immediately prepared by comparing a set of the Digital Surface Models (DSMs) before and after the earthquake, and subtracting tectonic displacements (Konagai et al., 2015). The soil subsidence map has been further extended to cover the Keihin-Industrialized region that encompasses the metropolis of Tokyo and the eastern part of Kanagawa prefecture (Kajihara et al., 2016). These maps are not exactly hazard maps, but simply a quantitative record of a past event. Therefore it is necessary to elicit important and inherent features of soil deposits, which will be reflected upon estimating future hazards.

Method

A Light Detection and Ranging (LiDAR) system is capable of rapid and accurate collection of topographic and elevation data. The obtained high-resolution digital elevation maps (Digital Surface Models: DSMs hereafter) before the earthquake (in December 2006-January, 2007 for the entire target areas) and after the earthquake (on April 20th 2011 for Urayasu City, September 6th for the area from Ichikawa to Chiba, September 2014 for Ukishima-to-Ougishima area and October 2014 for Shinkiba-to-Toyosu area, **Figure 1**) are raster graphic images of pixels having information of their elevations. Only subtracting a pre-earthquake DSM from the post-earthquake DSM yields the change in elevation, which can include not only the liquefaction-induced ground subsidence but also system-correlated anomalies and the tectonic deformations. Liquefaction-induced shallow ground subsidence is considered to be simply measured with reference to elevations of top ends of pile supported buildings and bridge piers such that any potential horizontal or vertical biases can be cancelled out. Therefore, to find the best matching depth for DSMs to minimize the effect of both system-correlated anomalies and the tectonic deformations, template matching technique is used for end-bearing pile-supported buildings chosen as the template in the source image of target areas.

For cancelling lateral biases, we need to extract Lagrangian components of displacements. However, Comparing DSMs at different times only allows to detect Eulerian ground displacement, in which the description of motion is made in terms of the spatial coordinates which does not follow the motion of a particular target. One method to extract Lagrangian components of displacements is to detect edges of buildings where

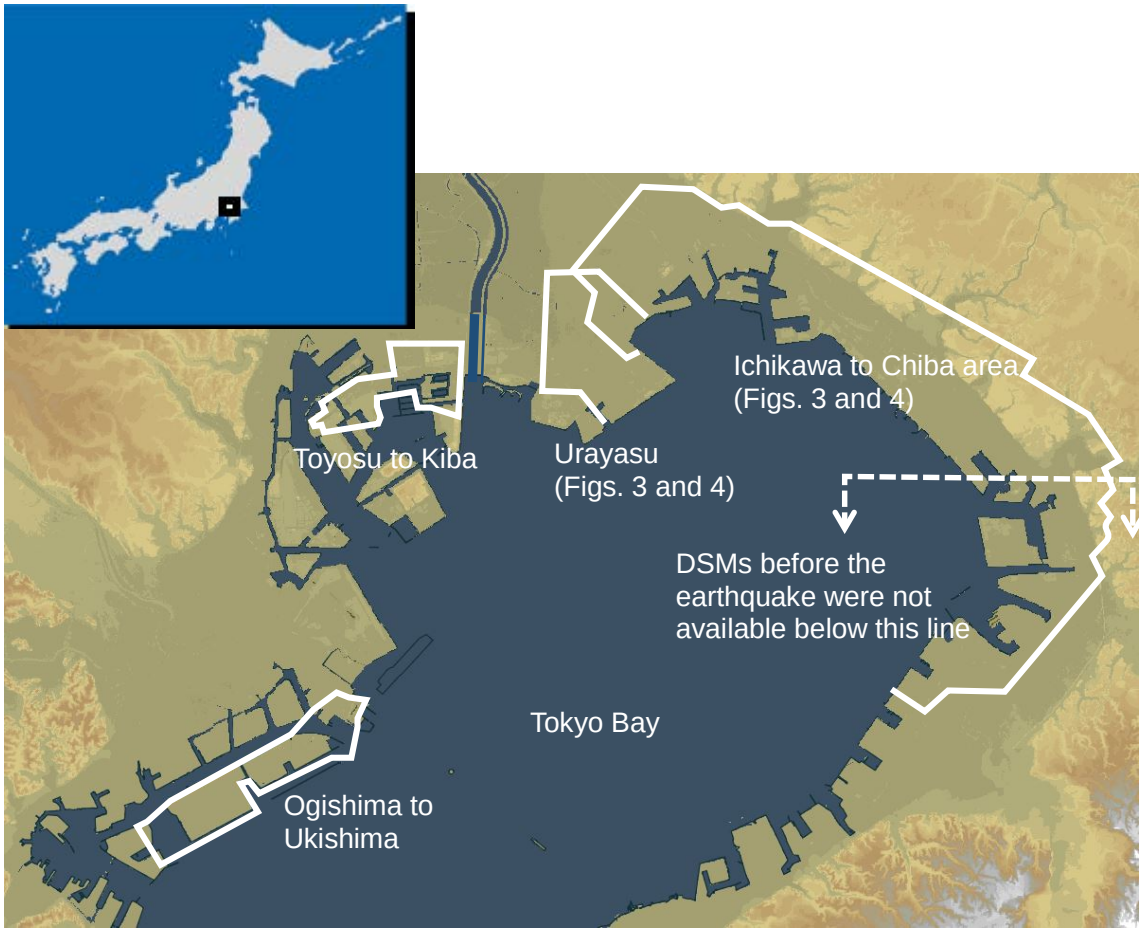

Figure 1 Air-borne LiDAR surveyed areas

elevation changes sharply and keep tracking the motion of the detected edges. However, the DSMs have a spatial resolution of 5.2 pixels/m^2 at most, which is a little too sparse for sharp edge detection. To deal with this problem, Konagai et al. (2013) proposed one method to detect lateral Lagrangian displacements from Eulerian displacements of roofs with sloping surfaces towards walls. As illustrated in Fig.1, several cross-sections of a roof are drawn first, and after those with outshooting objects are excluded, they are averaged for the representative roof shape with two sloping surfaces towards walls on both sides.

If two points on the two sloping surfaces of the roof undergo a rigid-body-translation movement $\{\Delta y \quad \Delta z\}^T$, their lateral Lagrangian components $\{\Delta y \quad \Delta z\}^T$ can be obtained by solving the following simultaneous equations.

$$\begin{Bmatrix}\delta z_1\\ \delta z_2\end{Bmatrix} = \begin{bmatrix}-a_1 & 1\\ -a_2 & 1\end{bmatrix}\begin{Bmatrix}\Delta y\\ \Delta z\end{Bmatrix} \tag{1}$$

where $\{\delta z_1 \quad \delta z_2\}^T$ are Eulerian displacements of the two sloping roof surfaces. It is noted that even a pile-supported building may not be an appropriate target for lateral template matching, because piles are laterally flexible enough to be easily deformed by

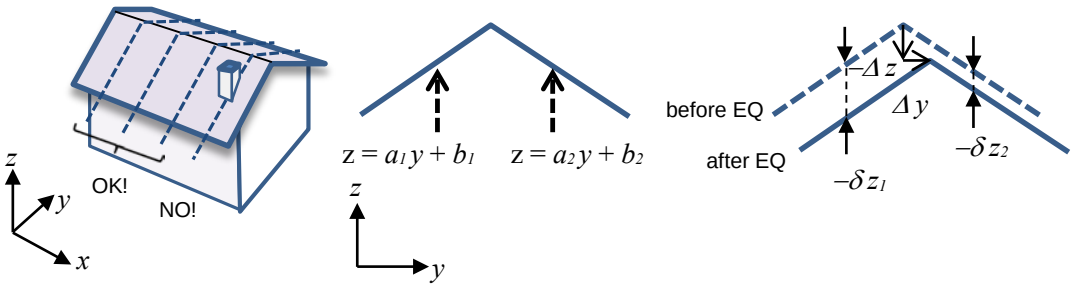

Figure 2 Template building with sloping roofs for adjusting

the movements of their surrounding soils. Therefore buildings in areas with no evidence of liquefaction are taken among the others as templates. More details about the method and its accuracy are available in the authors' previous paper (Konagai etal., 2013).

Maps of Ground Subsidence

Figure 3 shows the obtained soil-subsidence map of the eastern Tokyo Bay shore area, from Urayasu to Mihama, Chiba city (Konagai et al., 2013). An about a 1 km to 2 km wide stripe of soil subsidence extends along the bay. On this stripe, spots of serious subsidence are found clustered in such areas as Urayasu city, Funabashi city, Makuhari area of Chiba City. These spots included Makuhari–Kaihin Park and the areas in front of JR Kaihin–Makuhari Station. It is noticed that these spots are roughly lined up along the foreshore front of an old tidal flat (broken line in **Figure 4(a)**), which was once shown on the map compiled by the Japanese Army in 1877. Sand had been accumulating in this tidal flat since then, and it is seen in the aerial photo of 1972 (**Figure 4(a)**, Geospatial Information Authority, Japan) as a 1km wide light-gray brush; the color is indicating that the brush is a shallow inter tidal zone. The first landfilling project for the eastern area of Makuhari was completed in 1964 as shown in **Figure 4(a)**, and followed by the 2nd three-years landfilling project for the west Makuhari new city complex in 1973. **Figure 4(b)** (Geospatial Information Authority, Japan) shows the aerial photo of the new-city complex in 2006 with the original coastline a few kilometers inland. All these suggest that the newly developed reclaimed land is particularly susceptible to liquefaction.

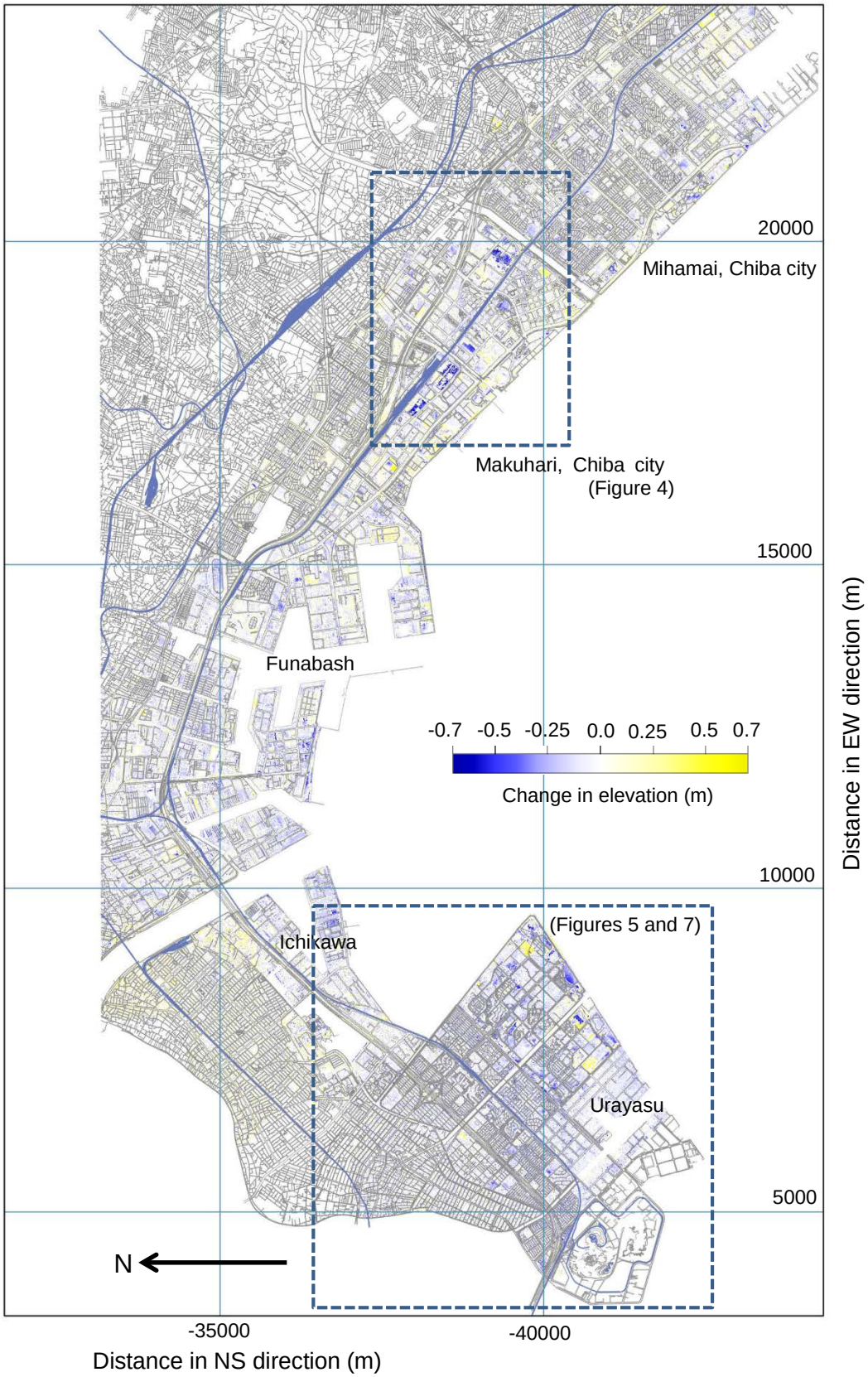

Figure 3 Soil subsidence map for the eastern part of Tokyo Bay shore area (Konagai et al., 2013)

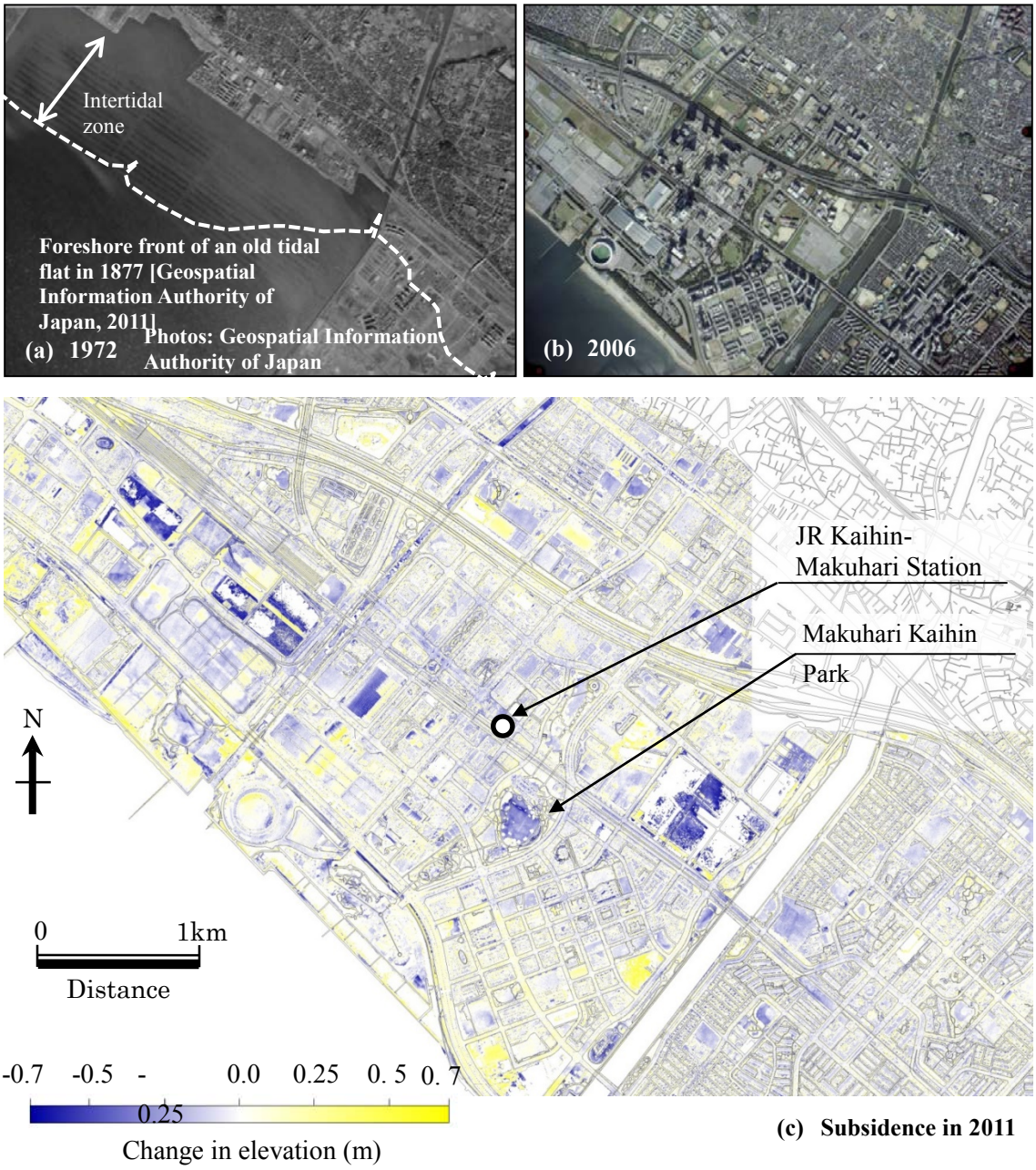

Figure 4 Soil subsidence map of Makuhari. (Konagai et al., 2013)
Aerial photos in (a) 1972, (b) 2006 and (c) soil subsidence in 2011

Elucidating Liquefaction-induced Risks

The maps shown above are not exactly hazard maps, but simply a precise record of liquefaction reality. The next step we should take is to examine the observed soil subsidence in terms of liquefaction potential (PL values hereafter), which potential has long been an empirical and practical index to describe liquefaction susceptibility of soil to a given seismic acceleration amplitude. Road subsidence is discussed herein because

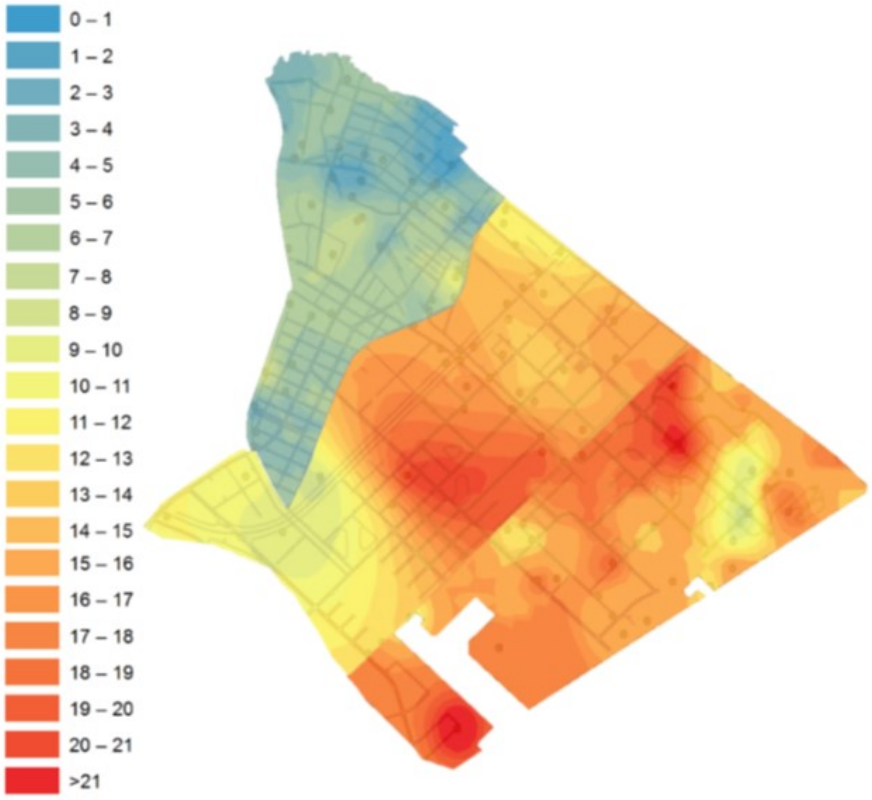

Figure 5 Distribution of PL values over the entire stretch of Urayasu City (Kajihara et al., 2015)

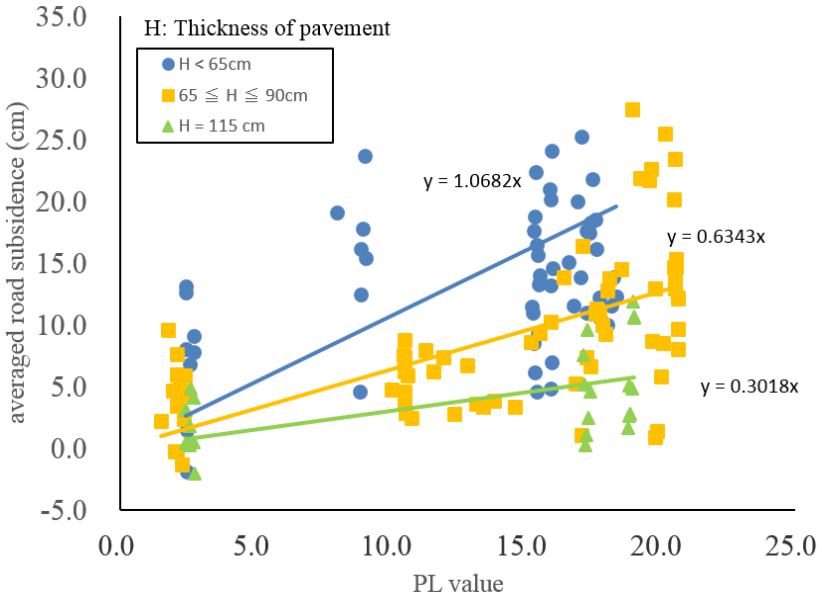

Figure 6 Liquefaction potential and road subsidence for different pavement thicknesses (Kajihara et al., 2015)

roads as well as other lifelines, which are often constructed along/ beneath roads, are particularly susceptible to liquefaction, and can cause serious delay in rehabilitation of

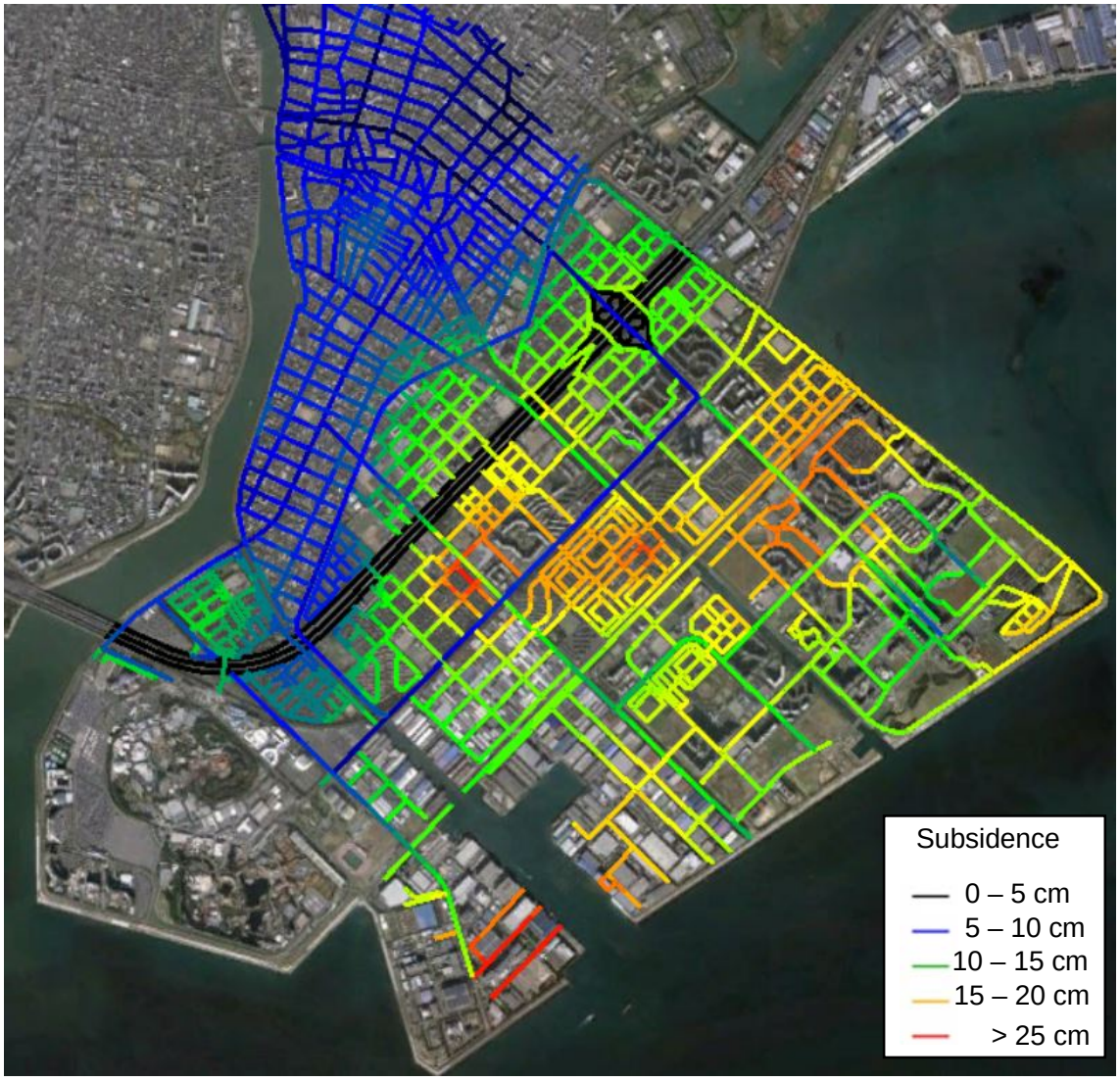

Figure 7 Estimated risk of road subsidence in Urayasu for a scenario earthquake on the scale of the 2011 Great East Japan Earthquake (Kajihara et al., 2015)

earthquake-hit areas. Design specification of highway bridges (2012) requires soil parameters such as plasticity index, mean particle size, fines content, unit weight of soil and ground water level for evaluating values of PL. These parameters were only available at 23 boreholes out of the 109 boreholes in Urayasu though descriptive soil logs were available at all 109 borehole locations. Thus, an attempt was made to infer the above parameters from N-values, namely, blow counts in STP tests (Kajihara et al., 2015), and smooth spatial distribution of PL values was obtained as shown in **Figure 5** with Kriging method that generates an estimated surface of PL at an arbitrary chosen point by computing a weighted average of the known values surrounding it.

When the estimated PL values were compared with the extracted values of road subsidence, it was found that the road subsidence can differ for different pavement

thickness (**Figure 6**). **Figure 6** shows that values of road subsidence increase in general with the increasing P_L values, and this tendency can be more pronounced for thinner pavements than those for thicker pavements.

Though the scatter is large in **Figure 6**, regression lines were obtained for these three clusters of pavement thickness to show the spatial distribution of the road-subsidence risk in Urayasu. However, one thing we should not forget in using these regression lines is that the real ground subsidence in Urayasu (**Figure 3**) was largely affected by the long duration time of the ground motion observed in Urayasu, and PL values themselves were obtained using the sole peak ground acceleration amplitude ignoring the effect of the long duration time. For different scenario earthquakes, all above are to be re-evaluated to be sure, however given the regression lines in **Figure 6** and the PL value distribution over the entire stretch of Urayasu city (**Figure 5**), the subsidence risk was evaluated for the road network in Urayasu for a scenario earthquake on the scale of the 2011 Great East Japan Earthquake (**Figure 7**). The overall trend of the road subsidence shown in **Figure 7** is thus well in accordance with the damage investigation report of the Urayasu city (2012). There is still room for improving the map taking into account the duration time for a different scenario earthquake, but this method surely allows us to prepare a hazard map reflecting a fine texture of subsurface soil conditions, and the map will be used not only for estimating damage extent but also for local government to determine the best routes for emergency vehicles to take.

Summary

Soils are all hysteresis materials like magnetic tapes that can record past events, and recent development of remote sensing technologies such as Laser Imaging Detection and Ranging technology (LIDAR) has enabled the acquisition of images of landforms and the changes in elevation with high precision. Very precise maps of liquefied ground subsidence were obtained for the long stretch of the Tokyo Bay shore area, which has been a world renowned commercial and consumption hub, and hit by the 2011 Great East Japan earthquake. Since the map is a reflection of the fine texture of subsurface ground condition, attempts were made by the authors to elucidate potential risks of damage to road networks in/on liquefied soils. The map of the potential risk will be used not only for estimating damage extent but also for local government to determine the best routes for emergency vehicles to take.

References

Yasuda S, Harada K. 2011 “Liquefaction-induced damage in the reclaimed lands along Tokyo Bay.” Japan Geotechnical Society 2011; 7:38–4 1inJapanese.

Wakamatsu K. 2011 “Geotechnical aspects of the damage caused by the March 11th off the Pacific Coast of Tohoku Earthquake.” 11th Seminar on earthquake disaster management. Japan Society of Civil Engineers;

2011(inJapanese).

Konagai K., Kiyota T., Suyama S., Asakura T., Shibuya K., Eto C., 2013. “Maps of soil subsidence for Tokyo bay shore areas liquefied in the March 11th, 2011 off the Pacific Coast of Tohoku Earthquake.” Soil Dynamics and Earthquake Engineering, Volume 53, October 2013, Pages 240-253.

National Agriculture and Food Research Organization. Rapid Kanto map originally compiled by the Japanese Army in 1877, in: Agricultural Land Use Transition Map; 2012. Available from: ⟨http://habs.dc.affrc.go.jp/index.html⟩. (in Japanese).

Geospatial Information Authority of Japan. Archives of aerial photo graphs for tracing the history of land; 2011. Available from: ⟨http://www.gsi.go.jp/tizu-kutyu.html⟩. (in Japanese).

Japan Road Association, 2012. "Part V Seismic design, Design specifications of highway bridges," Maruzen, Tokyo, Japan.

Kajihara K., Pokhrel R. M., Kiyota T. and Konagai K., 2015. “Liquefaction-induced ground subsidence extracted from digital surface models and its application to hazard map of Urayasu city, Japan,” the 15th Asian Regional Conference of Soil Mechanics and Geotechnical Engineering (ISSMGE-15ARC), Fukuoka.

The Residual Torsion Ultimate Strength of Box Girders with Inclination Cracks

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Abstract: The aim of the present study is to investigate the residual ultimate strength characteristics of box girders with variable inclination cracks under torsional loading. A series of finite element models are established by changing the crack length and crack angle using a commercial FEA program, ABAQUS. The cracks are located at the center and torques are applied on both ends of the box beam. The accuracy of the nonlinear FEA results is verified by a comparison with previous predicted formulas. Based on the FEA results, the relationship between the residual ultimate strength and crack parameters can be indicated in a function with period of π in the form of Fourier series.

Keywords: Residual ultimate strength; Box girders; Torsional loading; Crack parameters;

Introduction

The ultimate strength of an intact ship has providing an important approach to ensure the structure will not collapse under maximum expected bending moment, torsional loading or combined action of loads. For an ageing thin walled structure, it is vulnerable to various types of defects and damages induced by different phenomena such as corrosion and fatigue cracking. In addition to ship's intact strength, it is necessary to have an assessment of the residual ultimate strength of ship structures in damaged conditions. Cracks of any size may be produced at various locations and orientations throughout plates in the process of ship operation due to corrosion and fatigue damage which will lead to the reduction of ultimate load carrying capacity of the hull structure. Giving exact prediction of the residual ultimate strength has great significance to avoid catastrophic failures of damaged structures over the lifetime and to avoid uneconomical over design.

Invaluable data can be obtained from physical experiments for validating theoretical modeling approaches and demonstrating how structures behave under closely damaged loading conditions. However destructive testing of large scale structures, such as ships and bridges, are normally limited by size, complexity of structure and cost constraints. These factors have placed a great emphasis on developing more effective simplified models and robust theoretical techniques to examine structural characteristics. For ships,

box girders are extensively used on hull structure research as the hull is mainly consisted of thin plates, beams and other aggregates. At present, the study of box beam ultimate strength is concentrated in the consideration of the influence of initial imperfection while researches concerning about cracking damage are still less.

Paik(2001) and Sun(2003) investigated the ultimate strength characteristics of ship hulls with large hatch openings under torsion respectively in numerical and experimental ways and the ultimate strength of cracked open box girders subjected to variant loads was researched by Shi(2012) and a simple prediction model of the residual ultimate strength was proposed. The ultimate strength of cracked box girders subjected to pure torque was investigated by Shi(2012) and related simple model for predicting the ultimate strength reduction of the box girders due to cracking damage in various crack sizes and crack locations was proposed.

Considering the arbitrarily shaped path of crack propagation for cracked marine structures(SUMI 1998, Okawa 2006), it necessary to involve the influence of crack inclination on ship structures which has not been investigated before. Groups of box beam models are established through changing crack parameters such as various crack sizes and inclined angles and the strength variation regularity of box beams under different cracking damage forms is investigated. FEA results show that crack length and angle have large effect on the variation of the residual ultimate strength and the relationship between the strength of the box girder and the crack parameters is indicated by simplified prediction formulas based on the finite element numerical results.

Finite element models

The finite element method is widely used in structural analysis due to the development of computers which can fully consider both the material and geometrical nonlinearities when dueling with nonlinear problems through an elasto-plastic material model and large displacements based on the total Lagrangian formulation. The nonlinear shell finite element S4R is used for modeling thin plates when using commercial software ABAQUS. The S4R shell element is a general four nodes shell element, both reduction of integral method and hourglass control mode are employed to improve the overall thin-shell performance which can be used for large deformation analysis of thin plates. The RIKS algorithm is applied as a method of incremental-solution to trace the proper collapse and post-buckling process in structural nonlinear analysis which is a widely used method in structural nonlinear analysis because of advantage of overcoming the difficulties of traditional Newton method across critical points during structural nonlinear buckling equilibrium path and automatically adjusting incremental steps during iterative processes.

To analyze the influence of different forms of cracks on residual ultimate strength of box girders, the simplified box beam geometry model is built as shown in Fig.1 by

changing crack parameters such as the crack length l and angle θ. In this paper, the cracks are considered to be distributed in the center of the plate assuming that they are through thickness and no friction is between the edges and no propagation is allowed. To simplify the analysis, the box length and width were set as $a = b = 1000mm$, the box thickness was fixed at $t = 10mm$. The elastic modulus is $E = 205.8GPa$ and Poisson's ratio $v = 0.3$ .The material was considered to behave in an isotropic elastic-perfectly plastic manner and Mises yield condition is obeyed. The yield stress is $\sigma_Y = 345Mpa$. Gui-jie Shi[15] found the crack width had little influence on the box's ultimate strength by varying the width while the crack width δl was taken as $\delta l = 4mm$ in this paper.

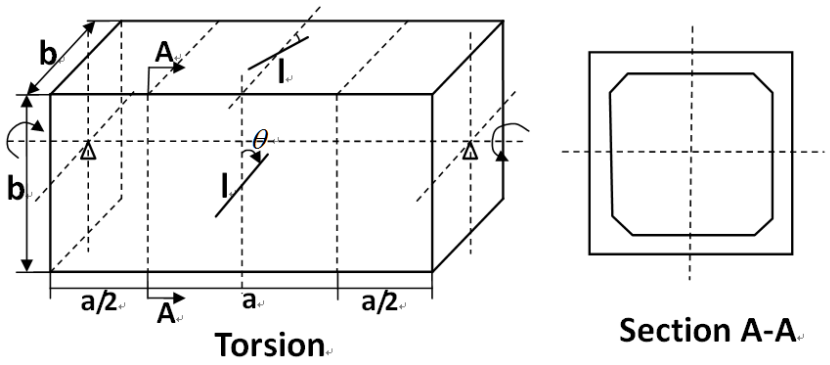


Fig.1. Geometry model of box beams under torque.

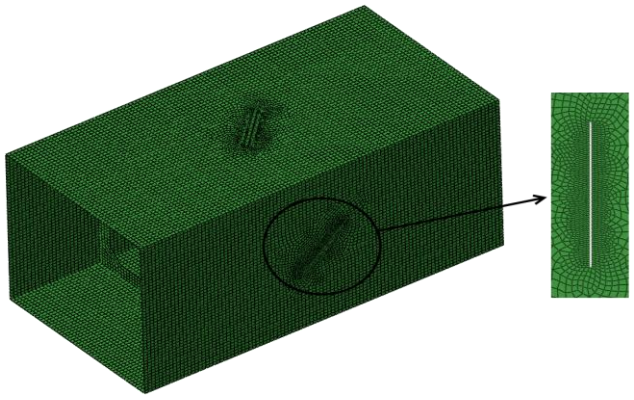


Fig.2. A sample FE meshing method and local mesh refinement of the cracked box.

Fig.2 shows an example of meshing of the cracked box with a refined meshing around the crack and very dense meshing near the crack tips as the total gird size is

taken as $\delta a = 20mm$ and $\delta a / a = 1/50$ which can give satisfied results.

The ultimate strength of box girders under torsion

The residual ultimate strength of a series of cracked box beams in large torsion deflection was investigated by varying the crack length and angle through nonlinear finite element analysis. As to relate the length of cracks to the dimensions of box section width b, the crack length was varied as the ratio of the width b given by ($l =$) $0.2b$, $0.3b$, $0.4b$, $0.5b$ while the crack inclination changed as ($\theta =$) 0° , 15° , 30° , 45° , 60° , 75° and 90° . The crack was considered to be perpendicular to the axis of the box when angle taken as $\theta = 0^\circ$. The boundary condition was assumed as simply supported on both ends of the box girder. In the torsional center of the ends of the box beam, one side was constrained as $ux = uy = uz = 0$, the other was constrained as $ux = uy = 0$, while z direction was along the axis of the box. The torque was imposed by giving a torsional displacement on both ends of the box beam as $\delta\phi_\tau = 0.015rad$, the conversion formula between bending moment and shear stress is as followed,

$$\tau = \frac{T}{2At} \tag{1}$$

where T is the Torque applied at every end of the box girder, A is the enclosed area of the box cross section, t is the box wall thickness.

Fig.3 shows the average torsional shear stress-twisting angle curve when varying the angle of crack in different related crack length l / b. It is observed from Fig.3 the crack inclination has much more impact on the box's strength as the crack length increases. The increasement of angle enhances the box strength within certain limits for a certain length. Changing the angle θ has little influence on the strength of box beams while having the least length as $l / b = 0.2$, where the reduction ratio is only $\Delta\tau / \tau_{\min} = 3.87\%$ between the min angle $\theta = 0^\circ$ and max $\theta = 90^\circ$. On the contrary, the angle has great impact on the box ultimate strength as the min-max changing ratio

reaches to $\Delta\tau/\tau_{\min}=35.5\%$ while large crack size is given at $l/b=0.5$. It is shown from the diagram that the ultimate torsional shear stress has no linear proportional relationship with the inclination at certain crack lengths as the stress changes little along with the angle θ changing around 0° and 90°, however it ranges a lot when θ is around 45°.

Fig.4 gives the average torsional shear stress-twisting angle curve by changing the crack length in various crack inclinations. It is observed from the figure that crack length has large impact on the box ultimate strength when angle θ is small for example as $\theta=0$. However, the length has much less influence on the box torsional strength as the increasement of crack inclination and the influence comes to be least when θ increases to 75°.

Fig.5 shows the distribution of membrane stress when the crack angle varies as the crack length fixed at $l/b=0.3$ (Fig.5(a), (b), (c), (d) are corresponding to $\theta=0^{\circ},30^{\circ},60^{\circ},90^{\circ}$). It is observed that the compressive stress focuses on the crack tips and then develops along the crack while tensile stress mainly distributes around the crack. As the crack angle changes, the stress distribution presents certain angle variation while the compressive stress still focuses on the crack tips.

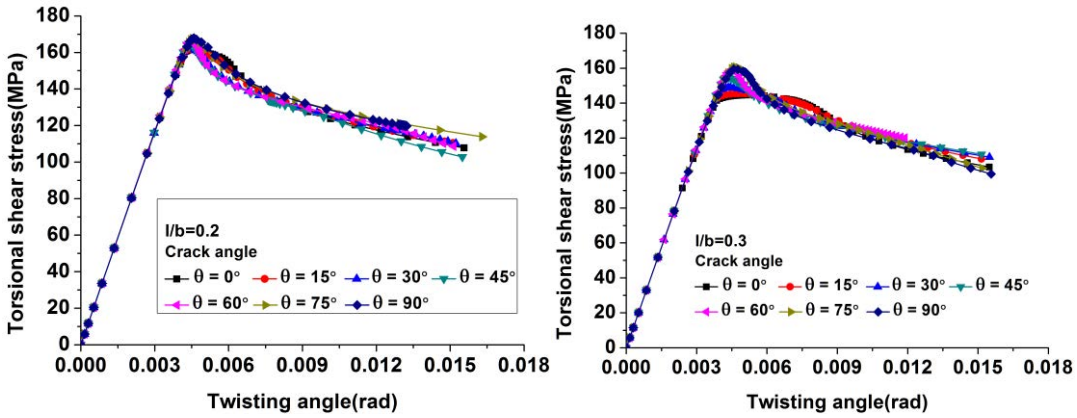


Fig.3. The torsional shear stress-twisting angle curve by changing the crack inclination in varying related crack lengths.

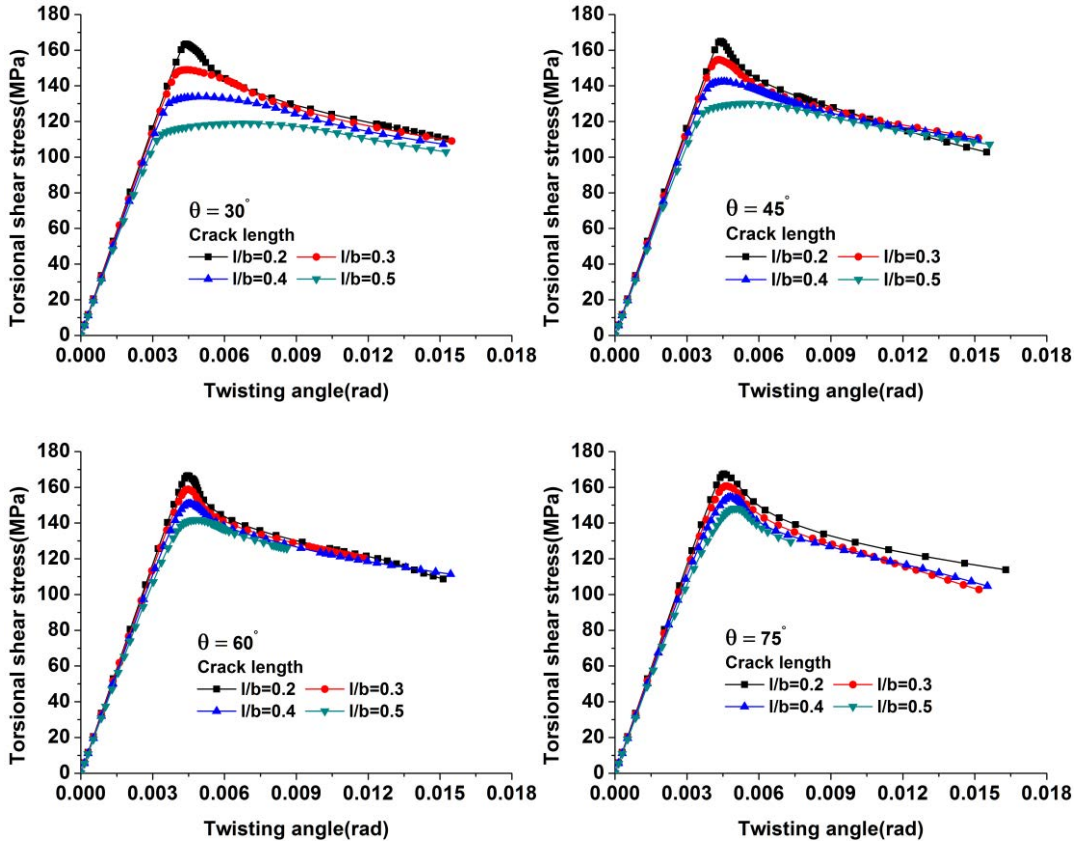
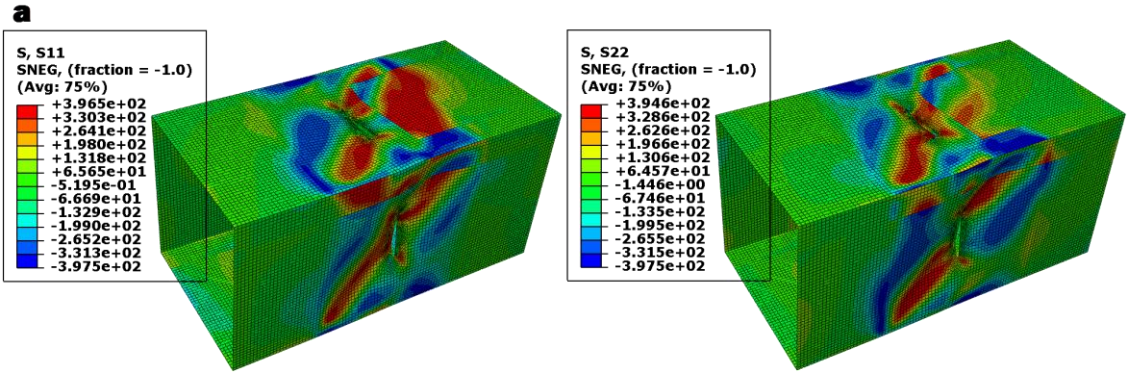


Fig.4. The torsional shear stress-twisting angle curve by changing the crack length in varying crack angles.



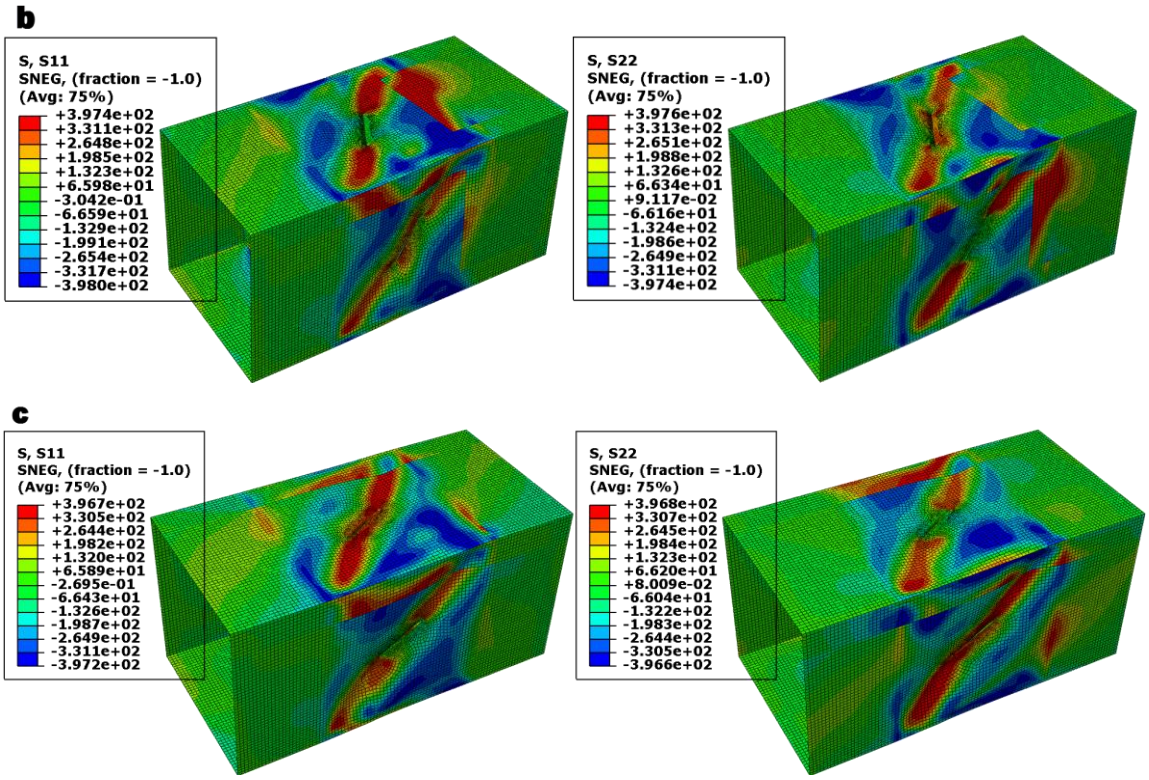


Fig.5. Membrane stress distribution corresponding for different crack angles at crack size of l/b=0.3: (a) $\theta = 0^{\circ}$, (b) $\theta = 30^{\circ}$, (c) $\theta = 60^{\circ}$.

Simplified prediction formulas

The following formula gives the reduction factor of torsional ultimate strength for box girders with transverse cracks:

$$R_f = \frac{\tau_u}{\tau_{u0}} = \frac{A_c}{A_0} = \frac{4(b-2c)t}{4bt} = 1 - \frac{2c}{b} \tag{2}$$

where R_f is the reduction factor of torsional ultimate strength, τ_u is the ultimate torsional shear stress for box beam with cracks, τ_{u0} is the ultimate torsional shear stress for perfect girder, t is the panel thickness, b is the section width of the box girder, $2c$ is the crack length. It has been recognized that the proposed formula in Eq.(2) yields conservative values for the ultimate torsional strength of box girders with transverse cracks($\theta = 0^{\circ}$)[15]. Fig.6 compares the torsional ultimate strength of cracked box girders as obtained from the FEA and from Eq.(2) by varying crack lengths and

angles where the dotted line represents for the predicted results of Eq.(2) and the point distribution for results from the FEM. It shows conservative results still can be obtained by Eq.(2) even though the length and inclination angle of crack happen to change. It can be seen results from formula in Eq.(2) are parallel to that from numerical calculation by ABAQUS in general as $\theta = 0^{\circ}$. However, the predicted results have large difference compared with the FEA results along with the increasement of crack angle which can't be reflected by equation (2). Results from Eq.(2) are smaller than numerical results because the formula is derived based on an isolated thin plate while the four panels are not independent plates but fixed together for box beams.

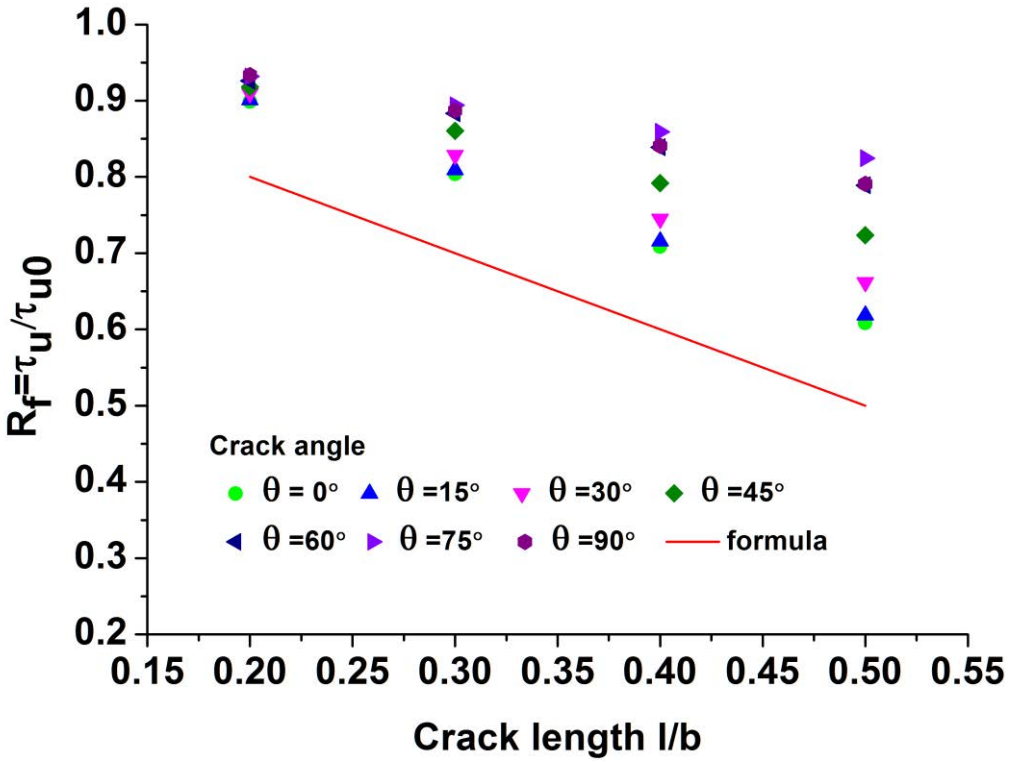


Fig.6. Comparison of ultimate torsional strength reduction between results from Eq.(2) and that from FEA for various crack parameters.

Fig.77 shows the ultimate strength reduction characteristics for different crack angles due to the influence of the reverse of torque orientation. The residual ultimate strength reduces significantly around $\theta = 60^{\circ}$ especially when crack length $l/b > 0.3$. However, on both ends of the curves, the direction reverse has no affect on the ultimate strength and closed curves are developed.

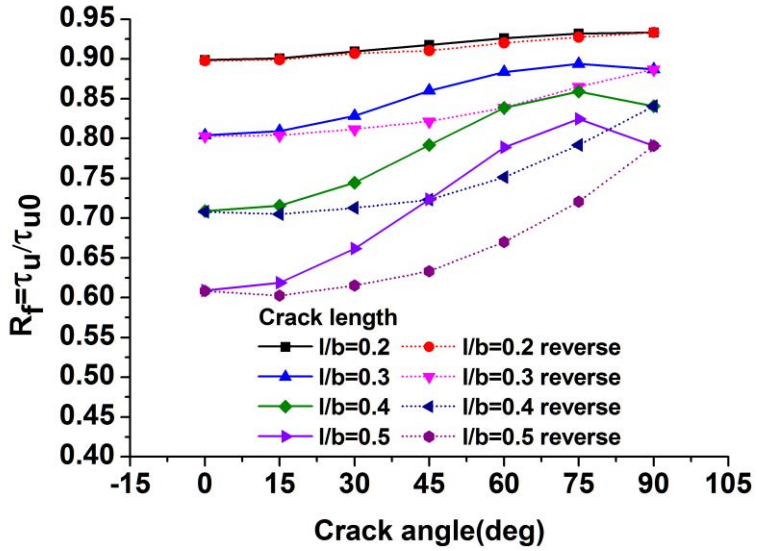


Fig.7. Ultimate torsional strength reduction characteristics considering the influence of the reverse of torque orientation for different crack sizes and angles.

The ultimate strength reduction characteristics of cracked box beam can be indicated as a function with period of π in the form of Fourier series as following:

$$R_f = (1.07 - 0.77\frac{l}{b}) + (0.29\frac{l}{b} - 0.042)\sin(2\theta - \alpha) + (0.08\frac{l}{b} - 0.016)\cos(4\theta + \beta) \tag{3}$$

where $\sin(\alpha) = 0.884$, $\cos(\beta) = 0.386$, l/b is relative crack length, θ is the crack inclination angle.

Fig.8 shows the relationship between the torsional reduction factor and crack parameters in a whole cycle. It is found that the largest ultimate shear stress $\tau_{u(\max)}$ is corresponding to crack angle $\theta = 75^\circ$ while the minimum corresponding to $\theta = 165^\circ$ with the crack size of $l/b \geq 0.3$. The dotted lines in Fig.8 are calculated results obtained from Eq.(3) which agrees well with the numerical results from FEA .

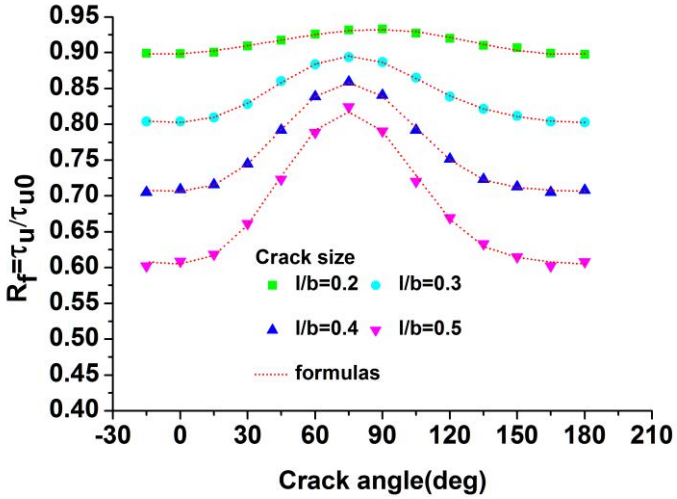


Fig.8. Ultimate torsional strength reduction characteristics in a whole cycle of π for different crack sizes.

conclusions

In the present reseatch, groups of box beam models under torque force were established by changing the crack length l and angle θ. The influence of crack parameters and torsional direction on box ultimate strength was investigated using nonlinear finite element method and following conclusions can be drawn:

(1) It is clear that when the crack size is less than $l/b=0.2$, changing crack angle has little influence on the ultimate strength of a box girder where the reduction ratio is only $\Delta\tau/\tau_{\min}=3.87\%$ between the min angle $\theta=0^{\circ}$ and max $\theta=90^{\circ}$. However, the angle has great impact on the box ultimate strength when crack length increases to $l/b=0.5$ as the min-max changing ratio reaches to $\Delta\tau/\tau_{\min}=35.5\%$.

(2) It is observed that the ultimate strength and crack size have a certain linear proportional relationship in spite of the variation of angle. However, no linear relationship but a trigonometric relationship happens between the ultimate strength and crack angle especially when relative crack length $l/b>0.2$.

(3) Results show that the compressive stress focuses on the crack tips and then develops along the crack while tensile stress mainly distributes around the crack in the initial torsional direction. As the crack angle changes, the stress distribution presents certain angle variation while the compressive stress still focuses on the crack tips. With

the reverse of the orientation of external torsional loading, however, the stress distribution around the crack happens to change as the diagonal areas reverse into tension and crack tips into compression which reduces the ultimate strength of box girders significantly.

(4) It has been proved FEA results are valid compared with results from predicted formula in Eq.(2) which yields conservative values for torsional box girders with transverse cracks($\theta = 0^\circ$). However, the predicted results have large difference compared with the FEA results along with the variation of crack angles which can't be reflected by formula in Eq.(2).

(5) Considering the geometric symmetry of cracks with respect to the box beam and the triangular characteristics with changing of crack angle, the ultimate strength reduction characteristics of box girders due to cracking damage can be indicated in a function with period of π in the form of Fourier series. It is found that the largest ultimate shear stress $\tau_{u(\max)}$ is corresponding to crack angle $\theta = 75^\circ$ while the minimum corresponding to $\theta = 165^\circ$ with crack size of $l / b \geq 0.3$.

References

Yong Hu, Weicheng Cui, Preben Terndrup Pedersen. Maintained ship hull girder ultimate strength reliability considering corrosion and fatigue. Marine Structures. 2004;17:91-123.

Alinia MM, Hosseinzadeh SAA, Habashi HR. Influence of central cracks on buckling and post-buckling behaviour of shear panels. Thin-Walled Structures. 2007; 45:422-431.

Alinia MM, Hosseinzadeh SAA, Habashi HR. Numerical modelling for buckling analysis of cracked shear panels. Thin-Walled Structures. 2007; 45:1058-1067.

Alinia MM, Hosseinzadeh SAA, Habashi HR. Buckling and post-buckling strength of shear panels degraded by near border cracks. Journal of Constructional Steel Research. 2008; 64:1483-1494.

Paik JK. Residual ultimate strength of steel plates with longitudinal cracks under axial compression-experiments. Ocean Engineering. 2008;35:1775-1783.

Paik JK. Residual ultimate strength of steel plates with longitudinal cracks under axial compression-Nonlinear finite element method investigations. Ocean Engineering. 2009; 35:266-276.

Rahman Seifi, Nafiseh Khoda-yari. Experimental and numerical studies on buckling of cracked thin-plates under full and partial compression edge loading. Thin-Walled Structures. 2011; 49: 1504-1516.

Rahman Seifi, Ali Reza Kabiri. Lateral Load effects on buckling of cracked plates under tensile loading. Thin-Walled Structures. 2013; 72: 37-47.

Paik JK. Ultimate strength of perforated steel plates under edge shear loading. Thin-Walled Structures. 2007; 45:301-306.

Paik JK. Ultimate strength of perforated steel plates under combined biaxial compression and edge shear loads. Thin-Walled Structures. 2008; 46: 207-213.

Paik JK, Anil K.T, Pedersen P.T, Park Y. Ultimate strength of ship hulls under torsion. Ocean Engineering. 2001; 28:1097-1133.

Hai-Hong Sun, Soares C.G. An experimental study of ultimate torsional strength of a ship-type hull girder with a large deck opening. Marine Structures. 2003; 16:51-67.

Gui-jie Shi, De-yu Wang. Residual ultimate strength of open box girders with cracked damage. Ocean Engineering . 2012; 43:90-101.

Kyungsik Kim, Chai H. Yoo. Ultimate strengths of steel rectangular box beams subjected to combined action of bending and torsion. Engineering Structures. 2008; 30:1677-1687.

Gui-jie Shi, De-yu Wang. Residual ultimate strength of cracked box girders under torsional loading. Ocean Engineering. 2012;43:102-112.

SUMI Y. Fatigue crack propagation and computational remaining life assessment of ship structures. Journal of Marine Science and Technology. 1998; 3:102-112.

Okawa T, Sumi Y, Mohri M. Simulation-based fatigue crack management of ship structural details applied to longitudinal and transverse connections. Marine Structures. 2006;19:217-240.

Evaluation of Stiffness of Wind Turbine Tower with consideration of Flange-joint Separation

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Abstract: An L-shape flange of a wind-turbine steel tower connection induces flange plate separation by extreme wind loading, which causes the change in the bolt tension force and resultant tower stiffness. In order to evaluate fatigue damage of the connection and deflection of the tower by the extreme wind loading, analytical model of the flange connection considering the separation is necessary. In this study, a wind-turbine tower model with variable stiffness by the flange separation as a function of lateral force at the tower top is proposed and verified by a FEM analysis.

Keywords: Wind turbine, tower flange, joint separation

Introduction

An L-shape flange connection of a wind-turbine tower induces flange plate separation under the extreme wind loading according to the design bolt tension. Then the separation causes the change in bolt tension and resultant stiffness of the tower. In order to accurately evaluate fatigue damage and wind-induced deflection of the tower, an analytical model with considering the flange separation is necessary. In this study, a calculation formula of variable stiffness of a wind-turbine tower due to flange separation under wind loading at the tower top is proposed and verified by FEM analysis.

Bolt Tension Force

Guidelines for Design of Wind Turbine Support Structures and Foundations (2010 Edition)[1] specifies calculation formulae for the bolt tension of a L-shape flange connection based on the Schmid & Neuper's engineering model[2], as shown in Eq.(1). Fig.1 shows this relationship where, as the tower shaft tension increases, the bolt tension T_p increases from the initial tension T_v first and then the flange separation starts at T_{SI}. The bolt tension increases further and the flange separates completely at T_{SII} with yielding of the bolt.

$$T_p = \begin{cases} T_v + pT_S & (T_S \le T_{SI}) \\ T_v + pT_{SI} + \left(\lambda^* T_{SII} - T_v - pT_{SI}\right)\dfrac{T_S - T_{SI}}{T_{SII} - T_{SI}} & (T_{SI} < T_S < T_{SII}) \\ \lambda^* T_S & (T_{SII} < T_S) \end{cases} \quad (1)$$

where

$$T_{SI} = T_v \times \frac{(e-0.5g)}{e+g},\quad T_{SII} = \frac{T_v}{\lambda^* \times q},\quad T_v = N_0 / 1.4,\quad q = 1-p,\quad p = \frac{C_b}{C_b + C_c},\quad \lambda^* = \left(1 + \frac{g}{\lambda^* \times q}\right)$$

and T_s: tower shaft tension per one bolt, N_0: design bolt tension, C_b: spring constant of bolt tension, C_c: spring constant of flange-washer compression, λ*: corrected lever ratio.

Fig.3 shows the relationship between the tower shaft tension and bolt tension for one bolt of a L-shape flange, which was analyzed by a FEM model (Fig.2). Dimensions of the flange and bolt are shown in Table 1.

Fig.4 shows flange deformation and stress at each analysis step. Fig.4(1) shows the flange separation start just after T_{SI}. Fig.4(2) corresponds to the inflection point of the bolt tension before T_{SII} and the complete flange separation. Though this is different from the engineering model (Eq.(1)), it is similar to experimental and analytical results shown in Ref. 2). In addition, Fig.4(3) corresponds to the point after T_{SII} and start of the bolt yielding.

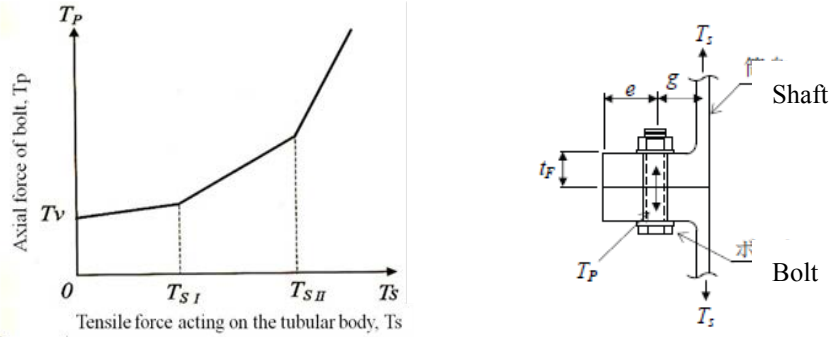


Fig. 1 Relationship between tower shaft tension and bolt tension[1)]

Table 1 Dimensions of flange connection

Bolt	M36 (F10T)
Distance between bolt center and flange edge (e)	65 mm
Distance between bolt center and tower shaft (g)	59 mm
Flange thickness (t_F)	75 mm
Tower shaft thickness	18 mm
Yield stress of tower shaft	255 MPa
Yield stress of bolt	900 MPa

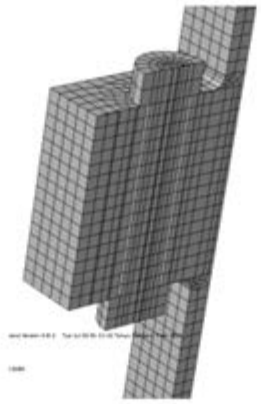


Fig. 2 FE model of L-shape flange (half model)

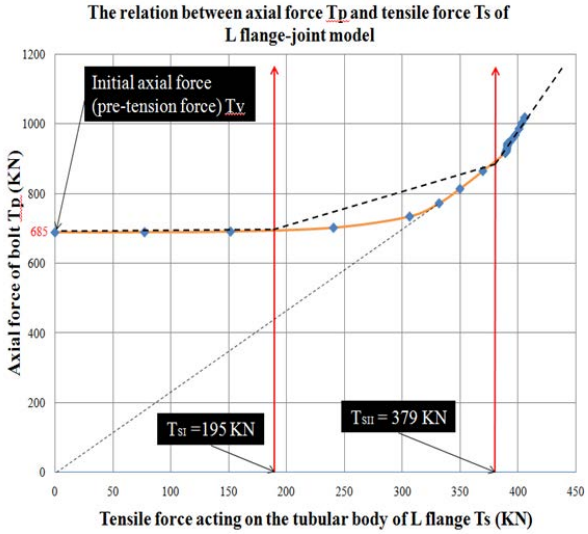
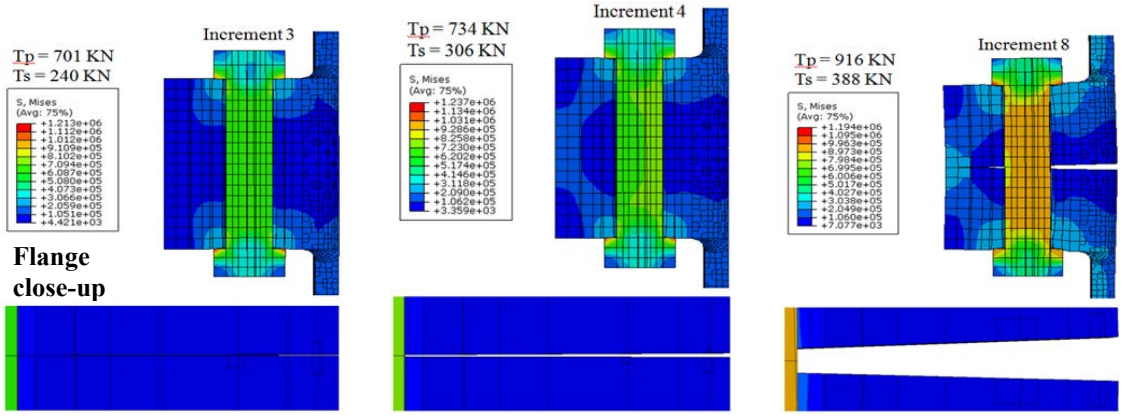


Fig. 3 Analytical result of tower shaft tension and bolt tension



(1) *Ts* = 240 KN (2) *Ts* = 306 KN (3) *Ts* = 388 KN

Fig. 4 Flange deformation and stress by FEM analysis

Analysis of flange connection

A 6.7m part of a tower shaft with a L-shape flange connection, which is subjected to bending moment, was analyzed with using a FE model as shown in Fig.5. The model was referred to an existing 500kW class wind turbine tower with the diameter of 1.675m. Dimensions are same as those in Table 1.

In the analysis, the bending moment is given to the shaft where one end of the shaft is fixed and a horizontal force *P* is given at the other end. Axial force *N* is also considered. Fig.6 shows the relationship between each bolt axial force and the horizontal force *P*. Bolt 1 located at the furthest tension side starts the separation by the lowest *P* and the tension increases. On the other hand, bolts at the compression side (15-) does not change the axial force and decreases the axial force due to compression.

Fig.7 shows the relationship between each bolt axial force and the horizontal force *P*.

The bolt axial force starting the separation T_{SI} was analyzed at 195kN under the analytical conditions. The corresponding horizontal force P is 610kN when the axial force of bolt 2 (same as in the bolt 1) reaches T_{SI}. Then as the horizontal force P increases, the axial force of bolts 3, 4, 5 up to 12 reaches T_{SI} successively and starts the separation at each location. The axial force of bolts 13 and 14 located near the neutral axis does not reach T_{SI}.

Fig. 8 shows the relationship between the horizontal deflection at the loading point and the horizontal force P. The relationship is linear in the beginning and the deflection increases nonlinearly after the horizontal force P exceeds 610kN. As shown in the figure, the flange at the bolt 1location starts the separation at this loading condition. It is understood that the separation causes the decrease in the tower shaft stiffness.

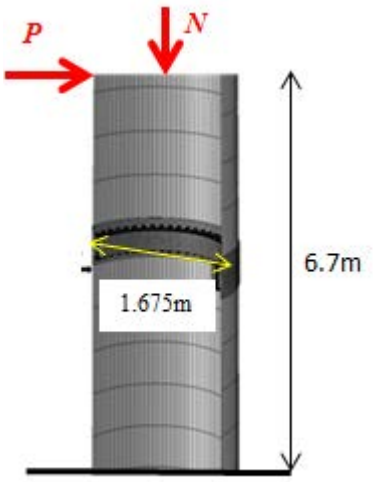


Fig. 5 FE model of tower shaft and flange connection (half model)

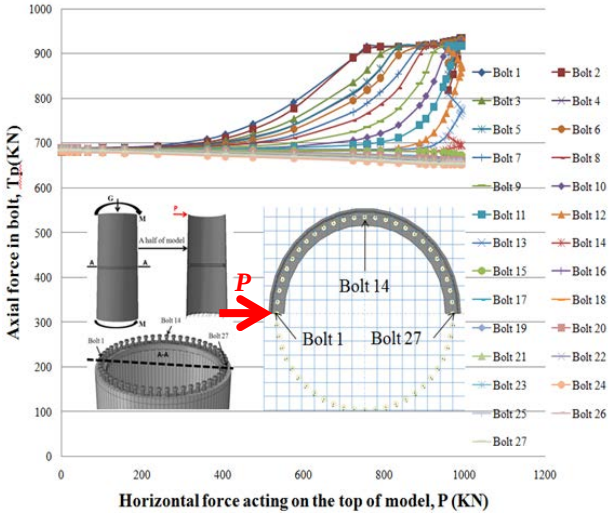


Fig. 6 Relationship between bolt axial force and horizontal force P

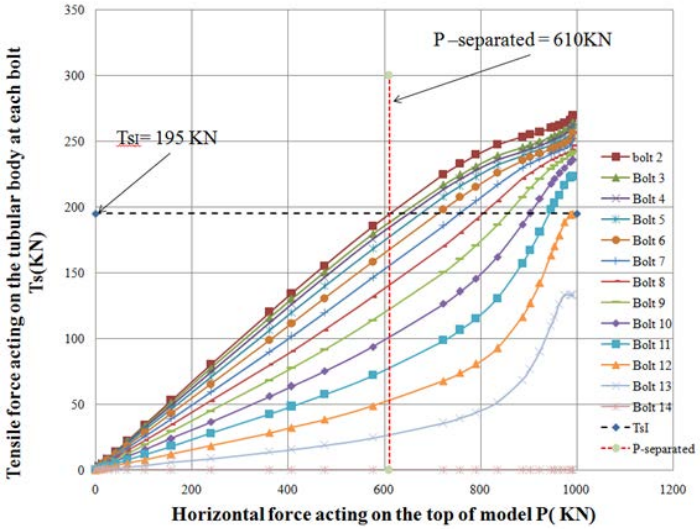


Fig. 7 Relationship between tower shaft tension at each bolt location and horizontal force P

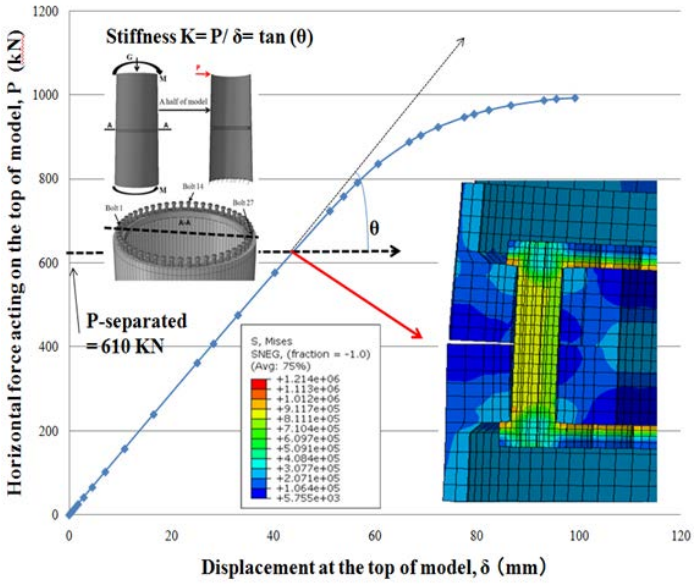


Fig. 8 Relationship between tower shaft deflection and horizontal force *P*

Variable Stiffness Model of Flange Separation

In this section, a calculation formula of variable stiffness of a wind-turbine tower due to flange separation under wind loading at the tower top is developed. As shown in Sec. 3, flange starts the separation locally when the corresponding bolt tension reaches T_{SI} and it completely separates at T_{SII}. This is equivalent to the section loss of tower shaft and it is considered by the reduction of second moment of area of the tower shaft as shown in Eq.(2) where I_0 is the original second moment of area of the tower shaft and $i_0{}^N$ is the second moment of area about the neutral axis of the tower shaft covering by the bolt N. In addition, (1 - K_{Nj}) is the reduction factor of the second moment of area depending on the tension of bolt N where it is 0 at T_{SI} and 1 at T_{SII}.

$$I_j = I_0 - (1-K_{1j})\times i_0^1 - (1-K_{2j})\times i_0^2 - (1-K_{3j})\times i_0^3 - \cdots - (1-K_{(N-1)j})\times i_0^{N-1} \tag{2}$$

where, $K_{Nj} = \dfrac{T_{SII} - T_S^{Nj}}{T_{SII} - T_{SI}}$ $\quad (0 \le K_{Nj} \le 1)$

Using Eq.(2), the tension of the tower shaft at each bolt location due to the horizontal force P with the tower-flange model shown in Fig. 5 is calculated as in Fig. 9. In this calculation, nonlinearity of the bolt near the neutral axis as shown in Fig. 7 is not considered, it agrees fairly with FEM analysis result. In addition, no consideration of the shift of the neutral axis due to the separation might affect the accuracy. Fig. 10 shows the change in the second moment of area obtained by Eq. (2). The second moment of area is constant until the start of the separation at the horizontal force of 610

kN and then gradually decreases according to the expanding of the separation.

Next, using this variable stiffness model, the horizontal deflection of the tower-flange model by the horizontal force *P* at the top is calculated by assuming an equivalent cantilever beam with reducing the second moment of area due to the separation. It is compared with that in Fig. 8 and shown in Fig. 11. It can be seen that the variable stiffness model can simulate the deflection of the tower shaft due to the separation of flange.

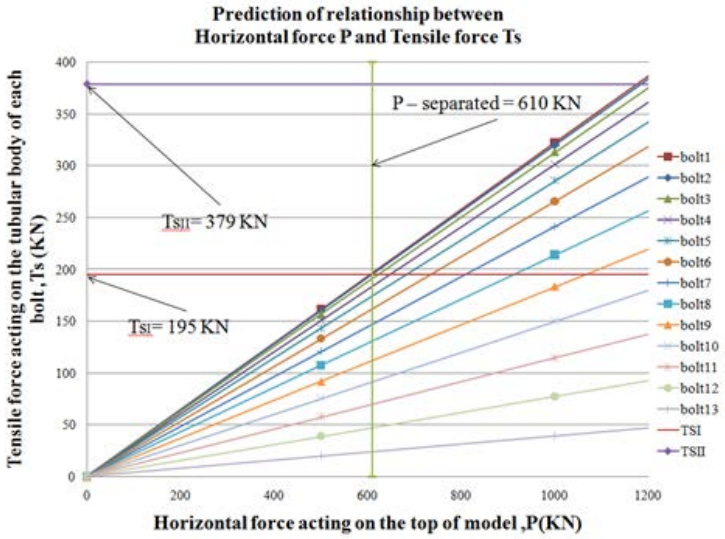


Fig. 9 Relationship between tower shaft tension at each bolt location and horizontal force P by variable stiffness model

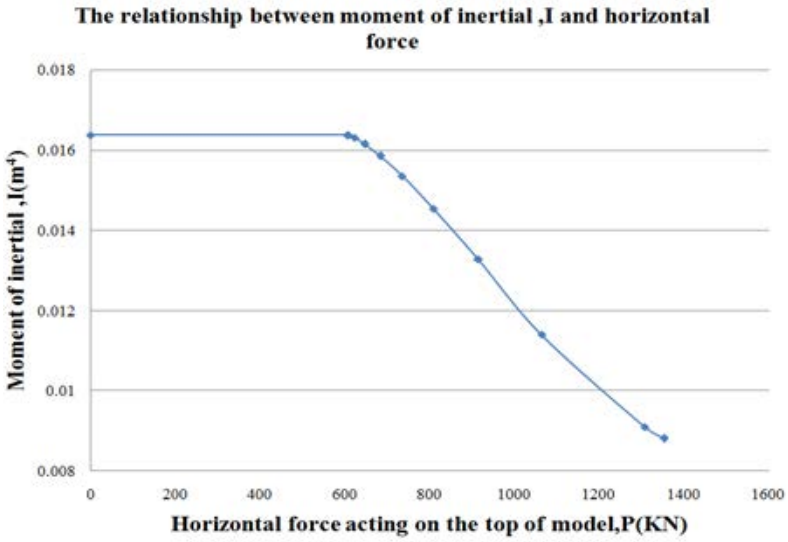


Fig. 10 Relationship between second moment of area of tower shaft and horizontal force *P*

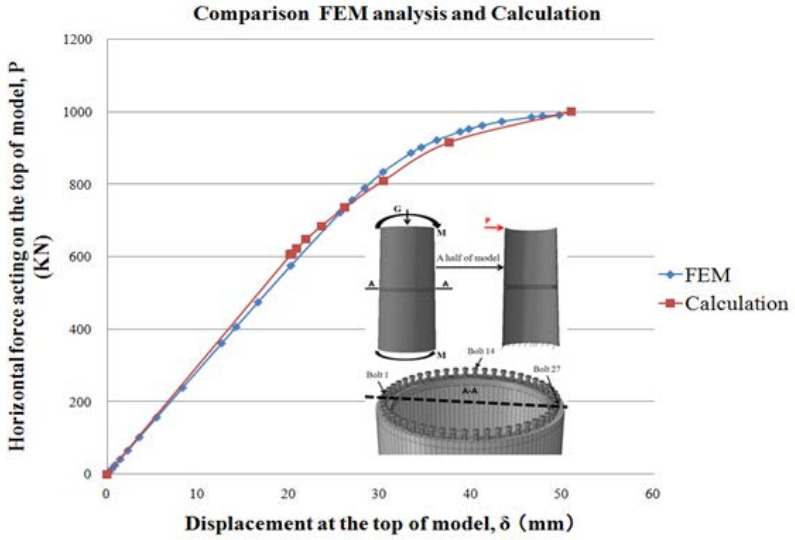


Fig. 11 Relationship between tower top deflection and horizontal force *P* (Comparison of FEM analysis and proposed formula)

Conclusions

In this study, a calculation formula of variable stiffness of a wind-turbine tower due to flange separation under wind loading is proposed and verified by FEM analysis. As a result, introduction of the reduction factor of second moment of area of the tower shaft depending on the bolt tension calculation formula in the Guidelines for Design of Wind Turbine Support Structures and Foundations can well simulate the reduction of tower shaft stiffness.

References

1) Guidelines for Design of Wind Turbine Support Structures and Foundations (2010 ed.), Japan Society of Civil Engineers, 2011.

2) Schmidt, H.,Neuper,M.: On the elastostatic behavior of an eccentrically tensioned L-joint with pre-stressed bolts, Stahlbau, 66, pp.163-168, 1997.

Trajectory Planning for Ship in Close Proximity to a Bank using Model Predictive Control

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Abstract: Safety of ship navigation in ports and other restricted waters is now an important issue with the rapid developing international shipping trade. Trajectory planning is one of the key points about safe navigation in restricted waters. This paper first gives a short review of recent studies on the safe navigation in restricted waters. Then the paper mainly investigates the ship trajectory planning problem considering the hydrodynamic forces from bank effect. The maneuvering hydrodynamic derivatives called asymmetric derivatives which represent the hydrodynamic forces due to ship-bank interaction were obtained using the captive model tests in a circulating water channel (CWC). The state equations where the control input consists of rudder angle and variation of forward speed are given and the model predictive control (MPC) approach is adopted to design the trajectory planning controller. To compensate the disturbance caused by long-existing bank induced forces, a linear quadratic regulator (LQR) is used to first stabilize the system before starting the offset-free MPC scheme. Simulation results under the condition of varying ship-bank distances show the feasibility of this method in ship trajectory planning when proceeding close to a bank.
Keywords: Bank effect; Trajectory planning; Model predictive control; Offset-free.

1. Introduction

Nowadays the world ports witness increasingly larger size and higher speed ships and the safe navigation of ships, especially in narrow shipping waterways, is of the most concern to the maritime authorities (Li et al. 2012). With more density of traffic flow and restricted water areas in the places like ports, straits and channels, the higher risk of accident in restricted waters activates the study related to both transportation safety management and trajectory control of ship proceeding in such environment. Therefore, this section gives a brief review about the recent contributions of researchers in the two areas.

1.1 Safety management in ship navigation

In recent years the methodology of safety analysis and the research of safety assessment, especially the safety assessment gain more and more attention. Some methodologies to study the topic in detail were put forward, such as the fault tree analysis (Fowler and Sørgard, 2000), the Bayesian network (Trucco et al. 2008), the expert judgement elicitation (Merrick and van Dorp, 2006) and the artificial neural networks (Li et al. 2010). In the last decade, the fuzzy theory becomes more and more frequently applied to deal with security status identification and safety assessment in channels (Zhang et al. 2012;

Wu and Hu, 2014). And combined with practical method like probabilistic risk analysis, the fuzzy method is promising in future implementation (Gucma and Pietrzykowski, 2006). At the meantime, the studies on algorithm of collision avoidance to provide guidance for ship navigation in restricted water area are in development, which is dated back to the risk evaluation model proposed by Inoue et al (1993). Miele and Wang (2006) investigated optimal trajectories plan in real time and guidance schemes for emergency collision avoidance in a restricted waterway area. Wang et al. (2011) applied the online self-organizing parsimonious fuzzy neural network (FAOS-PFNN) to identify the surrounding domain of a ship for avoiding collision. Hasegawa and Yamazaki (2013) developed a ship handling simulator for automatic collision avoidance and evaluating difficulty of sailing under various water areas in the world. Moreover, the application of Automatic Identification System (AIS) makes it possible to investigate accurate behavior of collision-involved ships, such research work is carried out by Mou et al. (2010) who focused on the statistical analysis of indicators for collision avoidance, and Miyake et al. (2015) who proposed a series of systematic procedures for the analysis of collision avoidance behaviors using AIS data.

1.2 Trajectory control of ship proceeding in restricted water

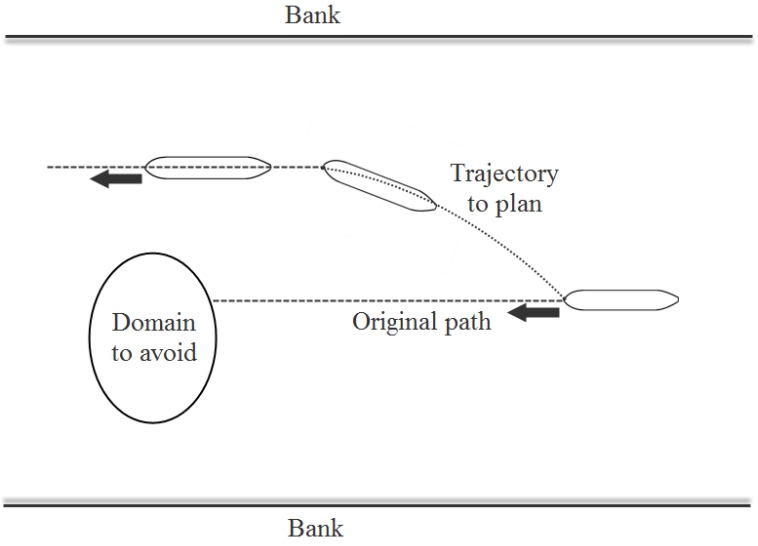

Figure 1. Trajectory control for avoidance in waterway.

Trajectory control in restricted water is usually for ship berthing to dock or avoiding certain domain which is occupied by other ships or constructions (as shown in Figure 1) in the waterway. When a ship moves in proximity to a bank, it will experience a suction force towards the bank and a yawing moment, which is also called bank effect. Many published studies presented the way to estimate the bank induced forces (Norrbin 1974, Ch'ng et al. 1993), and also pointed that the influence of bank effect can be so large to make it difficult to keep the ship's trajectory as desired (Fujino 1968, Sano et al. 2014).

In addition, some traditional control techniques are not suitable to the under-actuated nature of the steering system, i.e., seeking control for sway and yaw with rudder only. Intrigued by the aforementioned problems some researchers have tried more types of control strategies. The earlier applications include adaptive control (Parsons and Cuong, 1980), stochastic control (Rios-Neto and Cruz, 1985) and sliding mode (Papoulias and Healey, 1992; Zhang et al. 2000). As the optimal control theory was put forward to solve the problems of ship path planning (Djouani and Hamam, 1995), it now has proved to be an effective methodology. Many researches based on that to design the ship path controller with various models like linear quadratic regulator (LQR) (Thomas and Sclavounos 2006), evolutionary algorithms (Szłapczyński, 2013) and model predictive control (MPC) approach (Li et al. 2010), where multiple control inputs were all provided to the under-actuated system of horizontal motion. A significant work by Feng et al. (2013) introduced a LQR to the MPC scheme which is vulnerable to external disturbances so that the system can be stabilized to achieve the offset-free path following.

Enlightened by that work, this paper focuses on planning ship trajectory for ship in close proximity to a bank using the offset-free MPC scheme to compensate the hydrodynamic forces due to ship-bank interaction. The rationale of the offset-free MPC scheme aiming at trajectory planning is elaborated in section 2. The illustration of bank induced forces and the corresponding hydrodynamic derivatives is given in section 3. In section 4, the trajectory planning performance of the controller is evaluated on the condition of different ship-bank distances, and the conclusion is drawn in the section 5.

2. Numerical model

2.1 Maneuvering theory

Two coordinate systems are used as shown in Figure 2, where $O_0\xi\eta$ is the space-fixed coordinate system and Oxy is the body-fixed system with its origin O located at the mid-ship. The ship is expected to move in the direction of ξ axis at a speed U. The bank induced forces will change ship motion which generates velocities u, v and turning rate r as well as heading angle ψ. δ denotes the rudder angle and h denotes the separation distance between ship and bank.

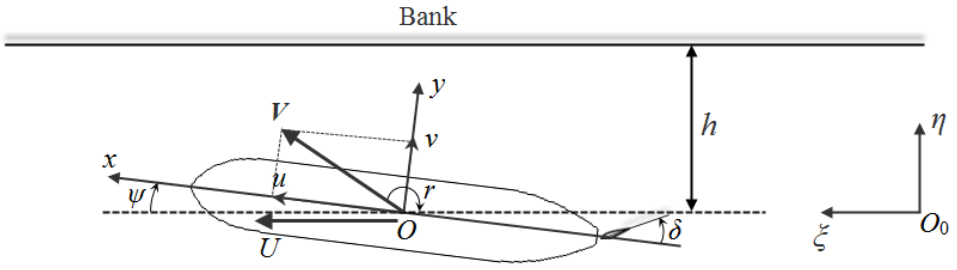

Figure 2. Coordinate systems.

Therefore, the 2-DoF linear maneuvering model of ship horizontal motion has been augmented with the components of hydrodynamic force in terms of ship-bank interaction, which is shown in the following equations.

$$\left(m+m_y\right)\dot{v}+\left(m+m_x\right)ur+mx_G\dot{r}=Y \tag{1}$$

$$\left(I_z+J_z\right)\dot{r}+mx_G\left(\dot{v}+ur\right)=N \tag{2}$$

where m is the ship mass and I_z is the yaw moment of inertia. m_x, m_y and J_z are the added mass and added moment of inertia for the surge, sway and yaw motion. Y and N represent the hydrodynamic sway force and yaw moment acting on the ship, which include hydrodynamic inertia terms and will be expressed by the following polynomial equations.

$$Y=Y_{\dot{r}}\dot{r}+Y_v v+Y_r r+Y_{\eta=0}+Y_\eta\eta+Y_\delta\delta \tag{3}$$

$$N=N_{\dot{v}}\dot{v}+N_v v+N_r r+N_{\eta=0}+N_\eta\eta+N_\delta\delta \tag{4}$$

Herein the force and moment caused by the bank effect are expressed as $Y_{\eta=0}+Y_\eta\eta$ and $N_{\eta=0}+N_\eta\eta$. The subscript "η=0" means the constant bank induced forces on the initial lateral position, and $Y_\eta\eta$ and $N_\eta\eta$ means the force due to the ship's lateral displacement η. The four items are called asymmetric derivatives.

All variables in the Equations 1 and 2 above are nondimensionalized in terms of ship length L, draft d, speed U and water density ρ through the equations as follows.

$$\begin{aligned}
&m'=\frac{m}{0.5\rho L^2 d},\quad I_z'=\frac{I_z}{0.5\rho L^4 d},\quad \dot{v}'=\frac{\dot{v}L}{U^2},\quad \dot{r}'=\frac{\dot{r}L^2}{U^2}\\
&u'=\frac{u}{U},\quad v'=\frac{v}{U},\quad r'=\frac{rL}{U},\quad \eta'=\frac{\eta}{L},\quad x_G'=\frac{x_G}{L}\\
&Y'=\frac{Y}{0.5\rho LdU^2},\quad N'=\frac{N}{0.5\rho L^2 dU^2}
\end{aligned} \tag{5}$$

With substitution of Equations 3, 4 into 1, 2 and nondimensionalization, equations of ship maneuvering is written as

$$\mathbf{M}\begin{bmatrix}\dot{v}'\\ \dot{r}'\end{bmatrix}=\mathbf{N}\begin{bmatrix}v'\\ r'\end{bmatrix}+\mathbf{L}\left[\eta'\right]+\mathbf{F}_R\left[\delta\right]+\mathbf{F}_B \tag{6}$$

where the denotations are as follows.

$$\mathbf{M}=\begin{bmatrix}-Y_{\dot{v}}'+m' & -Y_{\dot{r}}'+m'x_G'\\ -N_{\dot{v}}'+m'x_G' & -N_{\dot{r}}'+I_z'\end{bmatrix} \tag{7}$$

$$\mathbf{N}=\begin{bmatrix}-Y_v' & -Y_r'+m'\\ -N_v' & -N_r+m'x_G'\end{bmatrix} \tag{8}$$

$$\mathbf{L}=\begin{bmatrix}Y_\eta'\\ N_\eta'\end{bmatrix}\quad \mathbf{F}_R=\begin{bmatrix}Y_\delta'\\ N_\delta'\end{bmatrix}\quad \mathbf{F}_B=\begin{bmatrix}Y_{\eta=0}'\\ N_{\eta=0}'\end{bmatrix} \tag{9}$$

With variables v, r and η existing in (6), the heading angle ψ could be added and the

following expressions can be deduced.

$$\begin{bmatrix} \dot{v}' \\ \dot{r}' \\ \dot{\psi}' \\ \dot{\eta}' \end{bmatrix} = \begin{bmatrix} -\mathbf{M}^{-1}\mathbf{N} & \begin{matrix} 0 \\ 0 \end{matrix} & \mathbf{M}^{-1}\mathbf{L} \\ \begin{matrix} 0 & 1 \\ 1 & 0 \end{matrix} & \begin{matrix} 0 & 0 \\ 1 & 0 \end{matrix} \end{bmatrix} \begin{bmatrix} v' \\ r' \\ \psi \\ \eta' \end{bmatrix} + \left[\mathbf{M}^{-1}\mathbf{F}_R\right][\delta] + \left[\mathbf{M}^{-1}\mathbf{F}_B\right] \tag{10}$$

Since this dynamic system accepts a small scale variation of speed that is defined as Δu, the bank induced suction force and yaw moment in relation to forward speed can be expressed in the following form.

$$F_{bank} = 0.5\rho L d Y'_{\eta=0}\left(U+\Delta u\right)^2 = 0.5\rho L d Y'_{\eta=0}\left(U^2+2U\Delta u+\Delta u^2\right) \tag{11}$$

$$M_{bank} = 0.5\rho L^2 d M'_{\eta=0}\left(U+\Delta u\right)^2 = 0.5\rho L^2 d M'_{\eta=0}\left(U^2+2U\Delta u+\Delta u^2\right) \tag{12}$$

The last term in the equations above is of second order and negligible, while the second term directly shows the contribution of the perturbation velocity Δu to the bank induced forces. Keeping only leading order terms in the perturbation, the matrix of ship-bank hydrodynamics is rewritten as

$$\mathbf{F}_B = \begin{bmatrix} \dfrac{F_{bank}}{0.5\rho L d U^2} \\ \dfrac{M_{bank}}{0.5\rho L^2 d U^2} \end{bmatrix} = \begin{bmatrix} Y'_{\eta=0} \\ N'_{\eta=0} \end{bmatrix} \cdot \left(\frac{U^2+2U\Delta u}{U^2}\right) = \begin{bmatrix} Y'_{\eta=0} \\ N'_{\eta=0} \end{bmatrix} (1+2\Delta u') \tag{13}$$

Now the linearized ship maneuvering model can be written into the state equation with matrix form.

$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{B}\mathbf{u} + \mathbf{E} \tag{14}$$

where

$$\mathbf{x} = \begin{bmatrix} v' & r' & \eta' & \psi \end{bmatrix}^T, \quad \mathbf{u} = \begin{bmatrix} \delta & \Delta u \end{bmatrix}^T \tag{15}$$

$$\mathbf{A} = \begin{bmatrix} -\mathbf{M}^{-1}\mathbf{N} & \mathbf{M}^{-1}\mathbf{L} & \begin{matrix} 0 \\ 0 \end{matrix} \\ \begin{matrix} 1 & 0 \\ 0 & 1 \end{matrix} & \begin{matrix} 0 & 1 \\ 0 & 0 \end{matrix} \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} \mathbf{M}^{-1}\begin{bmatrix} \mathbf{F}_R & 2\mathbf{F}_B \end{bmatrix} \\ \begin{matrix} 0 & 0 \\ 0 & 0 \end{matrix} \end{bmatrix}, \quad \mathbf{E} = \begin{bmatrix} \mathbf{M}^{-1}\mathbf{F}_B \\ 0 \\ 0 \end{bmatrix} \tag{16}$$

2.2 Trajectory planning control

The continuous-time model of Equation 14 can be transformed into discrete-time scheme given a specific sampling time, which is

$$\mathbf{x}_{k+1} = \mathbf{A}_d\mathbf{x}_k + \mathbf{B}_d\mathbf{u}_k + \mathbf{E}_d \tag{17}$$

The standard MPC scheme can be formulated based on the discrete model but unable to eliminate the steady cross-track error due to the existing disturbance of bank effect. So the proposed offset-free MPC scheme is derived from the steady state system equations under steady disturbance $\mathbf{E}_d$, namely

$$\begin{cases}\mathbf{x}_\infty = \mathbf{A}_d\mathbf{x}_\infty + \mathbf{B}_d\mathbf{u}_\infty + \mathbf{E}_d \\ \mathbf{y}_\infty = \mathbf{C}_d\mathbf{x}_\infty\end{cases} \tag{18}$$

Where $\mathbf{u}_\infty$ is the steady state control; $\mathbf{y}_\infty$ is the output that is controlled to approach the desired value. Considering the following equation:

$$\mathbf{u}_\infty = -\left[\mathbf{C}_d\left(I-\mathbf{A}_d\right)^{-1}\mathbf{B}_d\right]^{-1}\mathbf{C}_d\left(I-\mathbf{A}_d\right)^{-1}\mathbf{E}_d \tag{19}$$

However, $\mathbf{A}_d$ has two eigenvalues at 1 and it leads to a singular (I- $\mathbf{A}_d$) matrix. To resolve that the original system is first stabilized through feedback while the MPC scheme determines the optimal control input at each time step. In this study, the stabilization is achieved by an LQR controller. The cost function and weighting matrices for the LQR controller are chosen to be the same as for the MPC. More specifically, the control input at each time step is divided into two parts:

$$\mathbf{u}_k = \mathbf{u}_k^{MPC} + \mathbf{u}_k^{LQR} = \mathbf{u}_k^{MPC} - \mathbf{K}_{LQR}\mathbf{x}_k \tag{20}$$

And the modified system dynamics becomes

$$\begin{aligned}\mathbf{x}_{k+1} &= \mathbf{A}_d\mathbf{x}_k + \mathbf{B}_d\left(\mathbf{u}_k^{MPC} - \mathbf{K}_{LQR}\mathbf{x}_k\right) \\ &= \left(\mathbf{A}_d - \mathbf{B}_d\mathbf{K}_{LQR}\right)\mathbf{x}_k + \mathbf{B}_d\mathbf{u}_k^{MPC} = \bar{\mathbf{A}}_d\mathbf{x}_k + \mathbf{B}_d\mathbf{u}_k^{MPC}\end{aligned} \tag{21}$$

Since the system is stable, the corresponding control input to overcome the ship-bank interaction forces can be calculated by:

$$\mathbf{u}_\infty^{MPC} = -\left[\mathbf{C}_d\left(I-\bar{\mathbf{A}}_d\right)^{-1}\mathbf{B}_d\right]^{-1}\mathbf{C}_d\left(I-\bar{\mathbf{A}}_d\right)^{-1}\mathbf{E}_d \tag{22}$$

As to the standard MPC scheme, first we define the cost function to be minimized

$$J\left(\mathbf{U}_k^{MPC};\mathbf{x}_k\right) = \sum_{j=0}^{N_P-1}\left[\mathbf{x}_{k+j}^T\mathbf{Q}\mathbf{x}_{k+j} + \left(\mathbf{u}_{k+j}^{MPC} - \mathbf{u}_\infty^{MPC}\right)^T\mathbf{R}\left(\mathbf{u}_{k+j}^{MPC} - \mathbf{u}_\infty^{MPC}\right)\right] \tag{23}$$

$$\mathbf{U}_k^{MPC} = \left[\mathbf{u}_k^{MPC}, \mathbf{u}_{k+1}^{MPC}, \cdots, \mathbf{u}_{k+N_P-1}^{MPC}\right] \tag{24}$$

N_P is the prediction horizon; $\mathbf{Q}$ and $\mathbf{R}$ are the weighting matrices for the states and control inputs, respectively. $\mathbf{U}_k^{MPC}$ is the optimal control sequence, in which the $\mathbf{u}_k^{MPC}$ only is remained by the MPC scheme as the actual control input to be implemented. Notice that $\mathbf{u}_\infty^{MPC}$ is included in the cost function to achieve offset-free path planning. The optimal control sequence is subject to

$$-\mathbf{u}_{\max} - \mathbf{u}_{k+j}^{LQR} \le \mathbf{u}_{k+j}^{MPC} \le \mathbf{u}_{\max} - \mathbf{u}_{k+j}^{LQR} \tag{25}$$

$$\begin{cases}\mathbf{u}_{k+j-1}^{MPC} - \mathbf{u}_{k+j}^{LQR} \le \Delta\mathbf{u}_{\max}T_s + \left(\mathbf{u}_{k+j}^{LQR} - \mathbf{u}_{k+j-1}^{LQR}\right) \\ \mathbf{u}_{k+j}^{MPC} - \mathbf{u}_{k+j-1}^{LQR} \le \Delta\mathbf{u}_{\max}T_s - \left(\mathbf{u}_{k+j}^{LQR} - \mathbf{u}_{k+j-1}^{LQR}\right)\end{cases} \tag{26}$$

where j=0, 1 ,…,N_P; $\mathbf{u}_{\max}$ is the rudder saturation deflection; $\Delta\mathbf{u}_{\max}$ is the maximum rudder turning rate; T_s is the sampling time.

3. Results of asymmetric hydrodynamic forces

Table 1 lists the principal dimensions of the test model KVLCC2, which is a crude oil tanker as a benchmark for study of ship hydrodynamics. The PMM test was conducted

in the CWC at Shanghai Jiao Tong University. The dimensions of measuring section are 8.0m×3.0m (water width) ×1.6m (water depth). The ship-bank interaction force and moment is measured by off-centerline straight towing test, of which the experimental scene is shown in Figure 3. The velocity of water flow was set at 0.703m/s, which corresponds to the Froude number F_n=0.142. As Figure 4 shows, the straight towing tests for determining the asymmetric hydrodynamic derivatives were conducted by locating the ship off the centerline with the distance b=0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95m.

Table 1. Principle dimensions of the KVLCC2

Parameters		Full scale	Model
Length between perpendiculars	L m	320.00	2.4850
Breadth	B m	58.00	0.4504
Design draft	d m	20.80	0.1615
Displacement	Δ m^3	312540	0.1464
LCB from Mid-ship	x_B m	11.04	0.086
Scale		128.77:1	

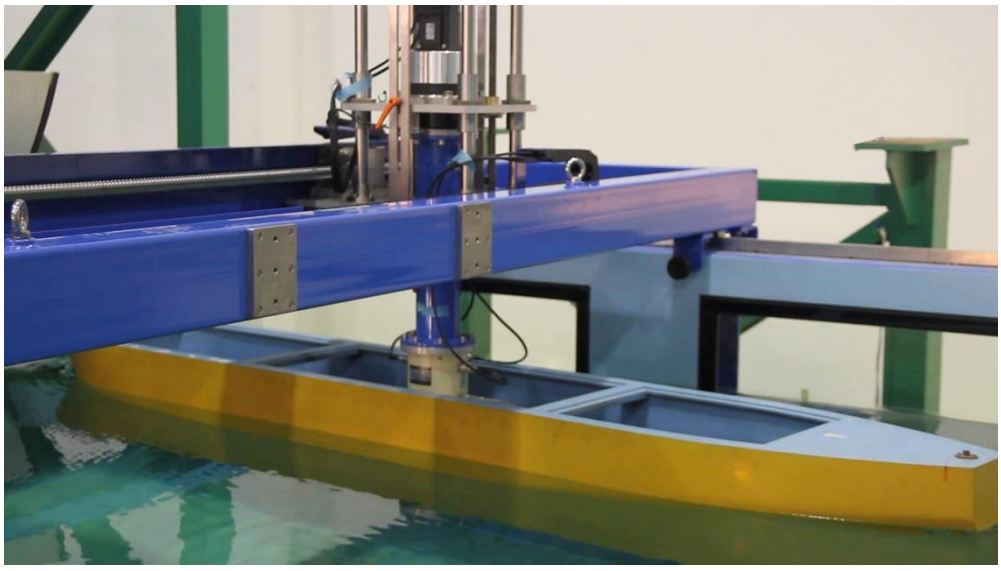

Figure 3. Experimental scene of the PMM test in CWC.

Figure 5 plots the nondimensional hydrodynamic forces of ship-bank interaction. As the sign of the values indicate, the suction force to the bank wall and the bow-out moment were acting on the ship hull and they are increasing as the ship approaches the bankside. The value of Y' and N' also equals $Y'_{\eta=0}$ and $N'_{\eta=0}$ in the current position. In this paper the case of b=0m, 0.5m and 0.65m are selected as η=0 respectively, and the points around each selected case are used to fit a curve by the polynomial regression. Then the first-order coefficient for the polynomial is the asymmetric derivative Y'_η or N'_η. The curves of case b=0m, b=0.5m and b=0.65m are shown in Figure 6. The coefficients Y'_η and N'_η

in the three locations are presented in Table 2.

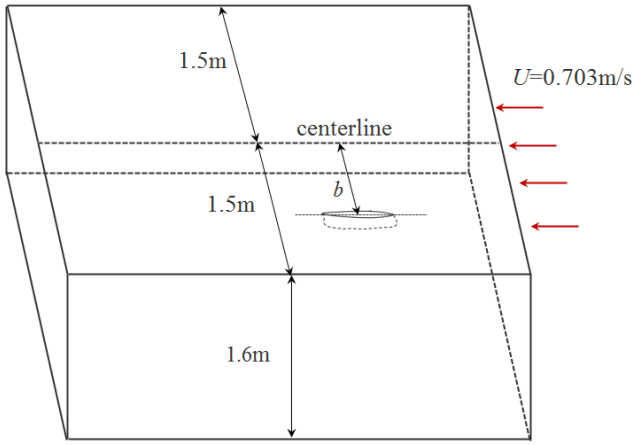

Figure 4. The arrangement of model ship in testing the asymmetric hydrodynamics.

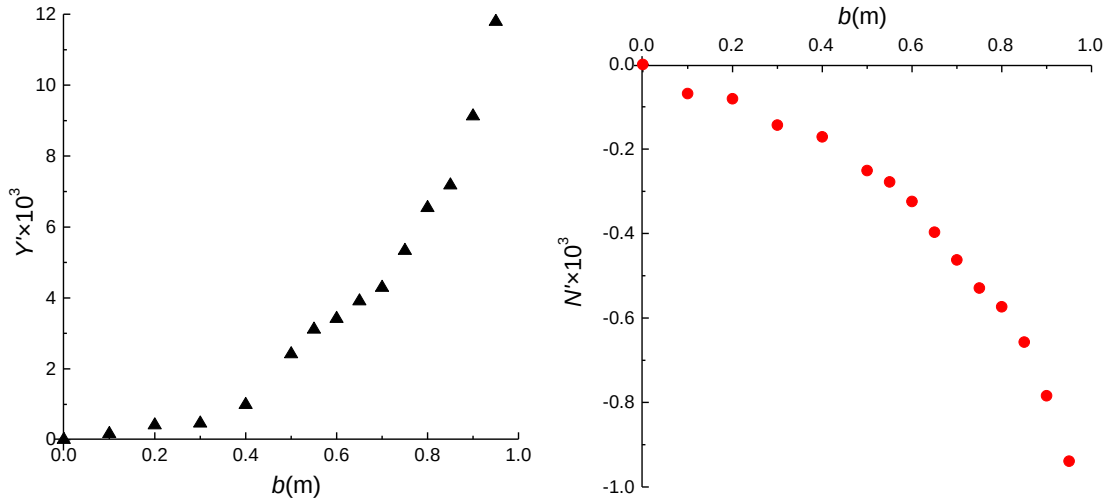

Figure 5. Asymmetric hydrodynamic force and moment.

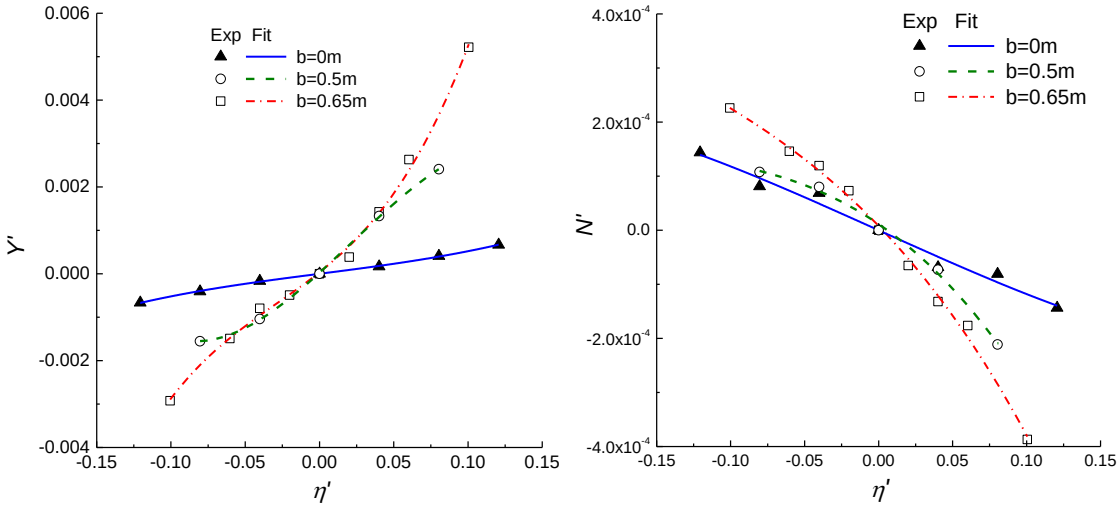

Figure 6. Asymmetric hydrodynamic force and moment versus η'.

Table 2. Asymmetric derivatives

	b=0m	b=0.5m	b=0.65m
Y'_η	0.00105	0.0255	0.0237
N'_η	-0.00112	-0.00174	-0.00309

4. Offsset-free MPC application in trajectory planning

The controller focuses on the trajectory planning problem illustrated in Figure 1. First it is tuned in the condition of h/L=0.5 where the bank effect can be ignored. The actuator constraints are $\mathbf{u}_{max}=[0.524\ 0.07]^T$ and $\Delta\mathbf{u}_{max}=[0.21\ 0.02]^T$; the sampling time Ts=1sec. Next, simlation results in different ship-bank distances are discussed.

4.1 Controller tuning

The first tuned parameter is the length of prediction horizon, of which the simulations are shown in Figure 7. It reveals that the simulation results converge to the disired lateral value when N_P reduces to 20. And this is also good for the viewpoint of time consumption. With no requirement of the optimization in the longitudial displacement for this case, the role of length of prediction procedure is not quite clearly seen, but it should be noted that an adequate length of prediction horizon is necessary to ensure the accuracy of the path following. So the length of prediction horizon is set as N_P =20 for further tuning of the weighting matrices.

The weighting matrices **Q** and **R** shape the closed loop response to achieve the desired trajectory in the form of $\mathbf{Q}=\{q_1,q_2,0,0\}$ and $\mathbf{R}=\{r_1,r_2\}$. The tuning for the matrices is actually the trial-and-error program to find the optimum ratio between q_1 and q_2 as well as the ratio between r_1 and r_2. Before the repeating process of changing ratio and simulating, the initial values of the weighting matrices can be given by referring to the works of previous researchers (Feng et al. 2013; Mucha and el Moctar, 2013). We choose q_1=1000 and r_1=1, r_2=2 while varying the value of q_2 to examine the simulation results. As shown in Figure 8, with the increasing of q_2/q_1, the augment appears in the cross-check error as well as the settling time. When q_2/q_1=1, the system succeeds in outputting a larger rudder deflection at the first stage to force the ship quickly into the expected path and then yielding smaller fluctuation of speed to stabilize the ship course during the rest of the sailing. So $q_1=q_2$=1000 is chosen as the value of matrix **Q**. The tuning of r_2/r_1 is conducted with the value of r_1 kept at 1. In the range from r_2/r_1=0.01 to r_2/r_1=100 the simulation results of ship trajectory and control input are nearly the same as the simulation for r_1=1, r_2=2. This implies that the **R** matrix has very limited influence on the trajectory adjustment performance. And a medium ratio like r_2/r_1=1 or 2 is adopted in all the following simulations.

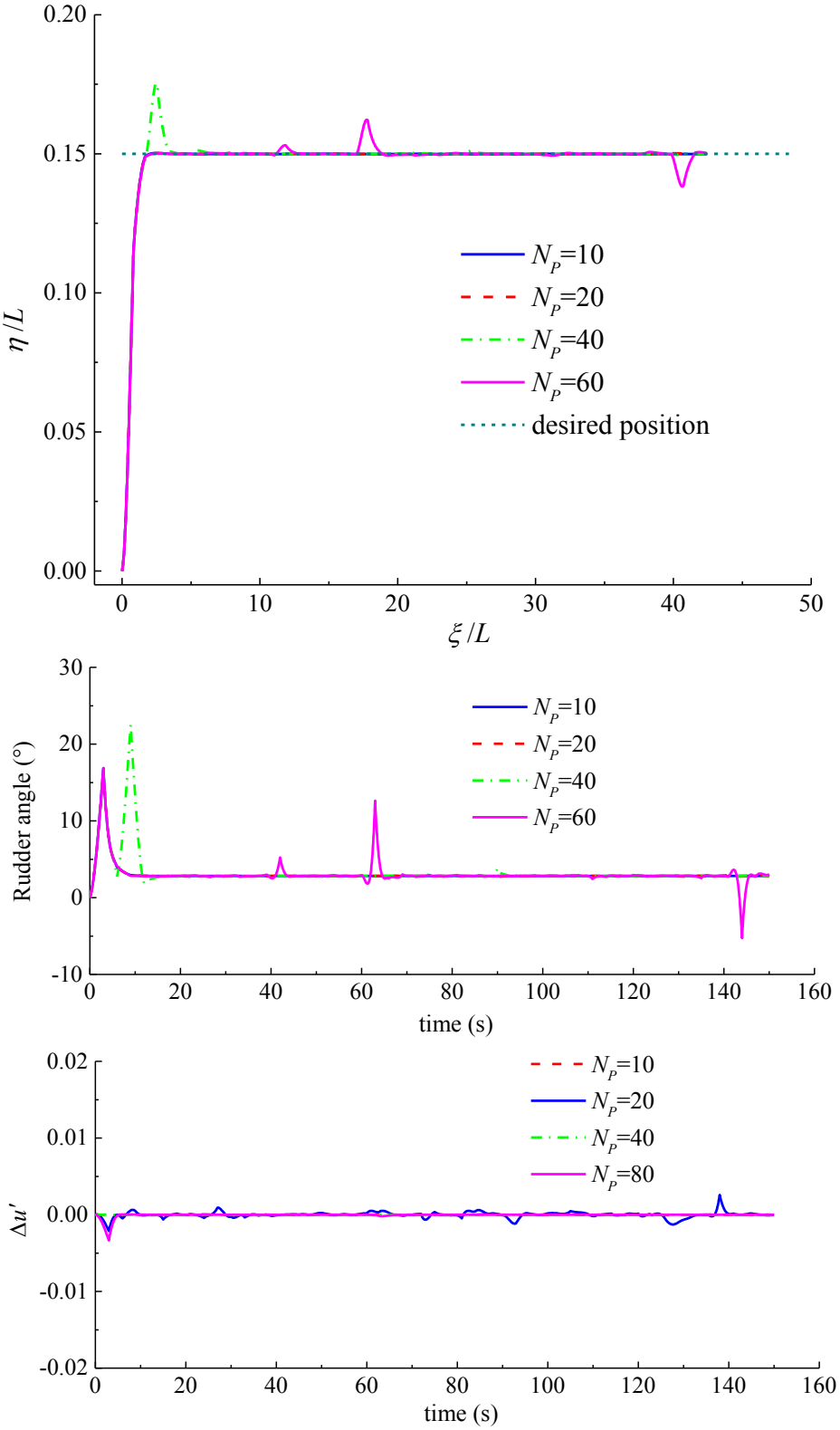

Figure 7. Simulations of the trajectory planning for different prediction horizons.

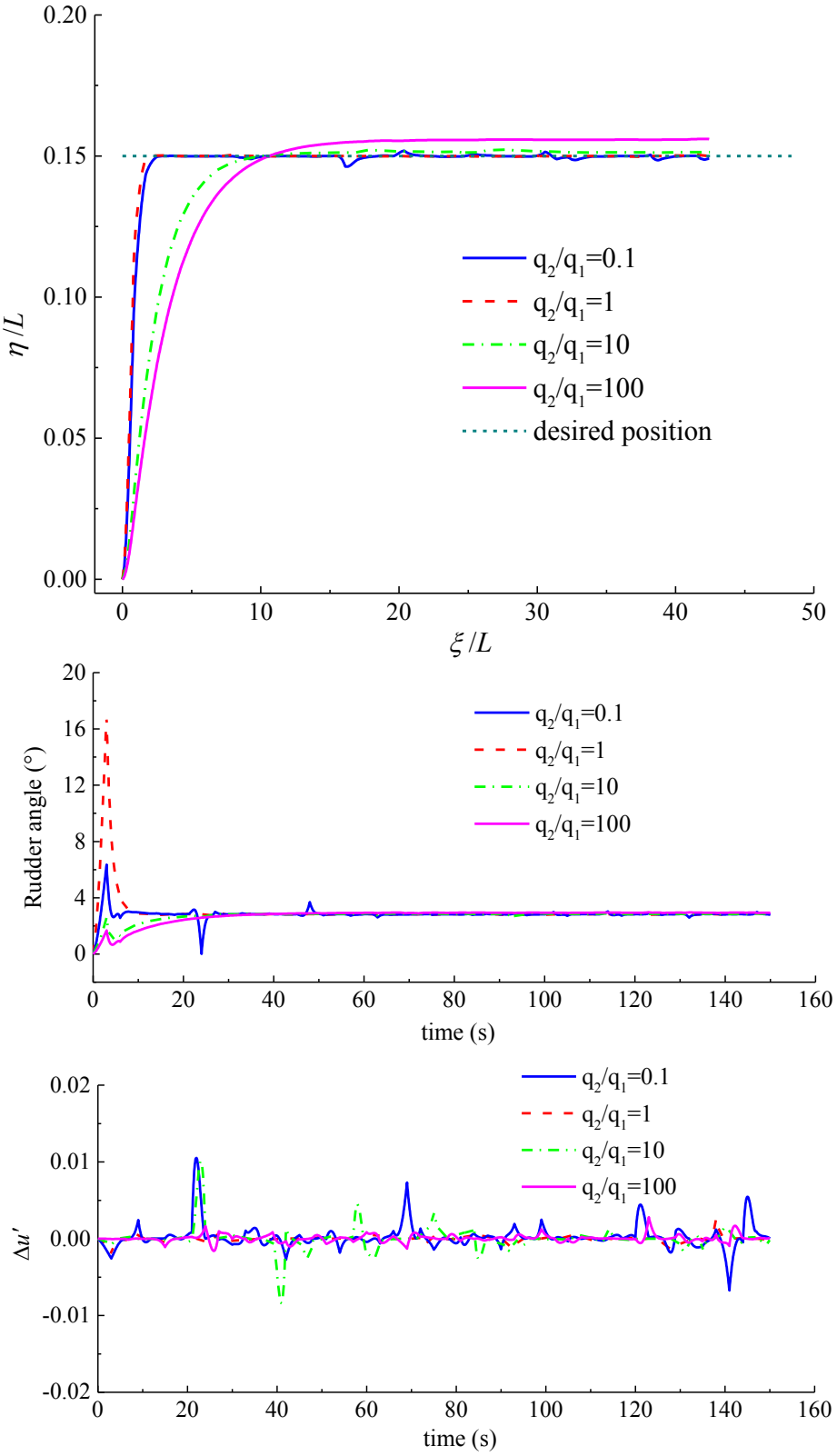

Figure 8. Simulations of the trajectory planning for different ratios between q_1 and q_2.

4.2 Simulation of trajectory under bank effect

The tuned trajectory palnning scheme is further used for situations of ship navigating close to a vertical bank with different ship-bank distances, i.e. h/L=0.35 and h/L=0.25. The combination of rudder deflection and speed variation as multiple input control (which is denoted as Multi-input in Figure 9) is compared with the performance of rudder-only controller (as Single-input in Figure 9). It shows that the favourable prediction horizon and weighting matrices chosen for multiple input system also work for the single rudder case. Comparison of the steady state error of η/L indicates that the multiple input control scheme can guide the ship to the desired position more precisely than the scheme using rudder only. This will partly prove that the speed variation input has a positive effect on improving the control process. It is noticeable from the control input plot in Figure 9 that due to the offset-free scheme, there will be nonzero steady rudder angle and speed reduction to overcome the bank induced forces.

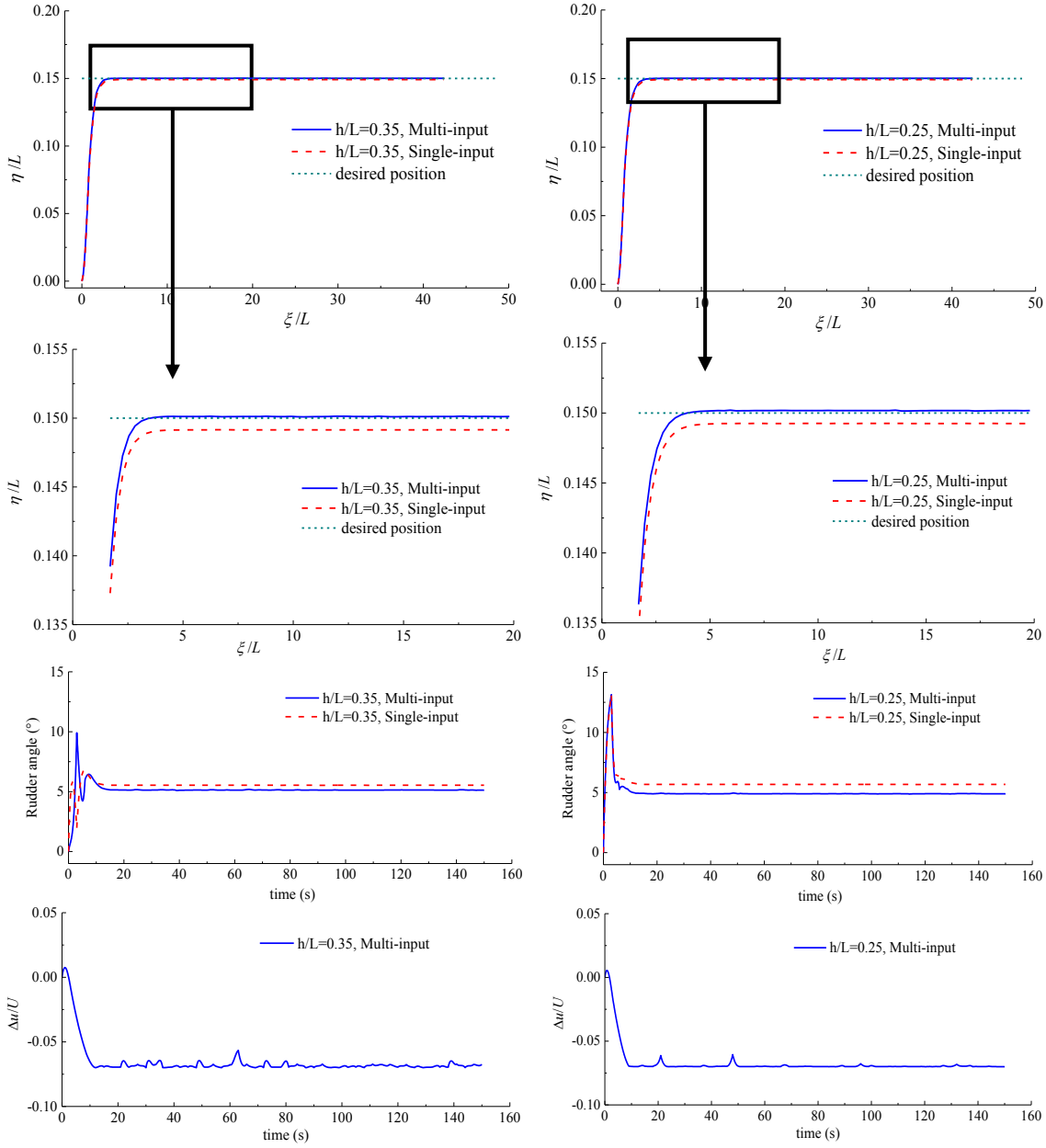

Figure 9. Simulations of the trajectory planning in close proximity to a bank.

5. Conclusions

A brief review of research works on shipping safety management as well as ship path control in restricted water areas is made. The paper focuses on the ship trajectory planning problem considering the influence of bank effect. A linear maneuvering model including the hydrodynamic components of bank induced forces is introduced and transformed to state equations for the design of control system. The experimental approach to obtain the asymmetric derivatives that represent the ship-bank interaction hydrodynamic force is detailed. Then, a trajectory planning controller based on MPC scheme is developed, and

a offsetfree scheme where the unstable error dynamics are first stabilized by an LQR controller through feedback is proposed to account for a steady control input to overcome the disturbance from bank induced forces. The proposed controller is tuned first to obtain the suitable prediction horizon and weighting matrices for ideal performance and then further used in simulations of different ship-bank distances. The advantage of taking speed variation as the second control input is demonstrated in that the steady state errors under bank induced forces can be reduced. The feasibility of the offset-free MPC scheme in trajectory planning for ship proceeding close to a bank is also proved.

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References

Li. S.Y., Meng, Q., Qu. X.B. 2012. "An overview of maritime waterway quantitative risk assessment models." *Risk Analysis* 32(3): 496-512.

Fowler, T.G., Sørgard, E. 2000. "Modeling ship transportation risk." *Risk Analysis*, 20(2):225-244.

Trucco, P., Cagno, E., Ruggeri, F., Grande, O. 2008. "A Bayesian Belief Network modelling of organizational factors in risk analysis: A case study in maritime transportation." *Reliability Engineering & System Safety*, 93(6): 845-856.

Merrick, J.R.W. and van Dorp, J.R. 2006. "Speaking the truth in maritime risk assessment." *Risk Analysis*, 26(1): 223-237.

Li, H. B., Hao, Y. L., Yu, H. Y. 2010. "Risk Assessment Model of Ship Integrated Navigation System Based on Fuzzy Artificial Neural Network." *International Conference on Computational* Intelligence *and Security, Cis 2010*, Nanning, China. Vol.12, 425-428.

Zhang, B.G., Gan, L.X., Ma, L.L., Luo, X.M. 2012. "Risk Assessment of the Main Channel Navigation Environmental of Lianyungang Port Based on Fuzzy Comprehensive Assessment." *Port Engineering Technology*, 47(5): 11-14.

Wu, Y. and Hu, H. 2014. "Channel safety assessment in ship navigation based on fuzzy logic model." *Transportation Research Board 93rd Annual Meeting*. Washington, DC, USA.

Gucma, L. and Pietrzykowski, Z. 2006. "Ship manoeuvring in restricted areas: an attempt to quantify dangerous situations using a probabilistic-fuzzy method." *Journal of Navigation*, 59(2): 251-262.

Inoue, K., Usami, S., Sera, W. 1993. "Risk evaluation of collision avoidance in restricted water (in Japanese)." *Journal of Japan Institute of Navigation*, 89: 187-195.

Miele, A. and Wang, T. 2006. "Optimal trajectories and guidance schemes for ship collision avoidance." *Journal of Optimization Theory & Applications*, 129(1): 1-21.

Wang, N., Tan, Y., Liu, S. 2011. "Ship Domain Identification Using Fast and Accurate Online Self-organizing Parsimonious Fuzzy Neural Networks." *Proceedings of the 30th Chinese Control Conference*, Yantai, China, 5271–5276.

Hasegawa, K. and Yamazaki, M. 2013. “Qualitative and Quantitative Analysis of Congested Marine Traffic Environment – An Application Using Marine Traffic Simulation System.” *International Journal on Marine Navigation and Safety of Sea Transportation*, 7(2): 179-184.

Mou, J. M., Tak, C. V. D., Han, L. 2010. “Study on collision avoidance in busy waterways by using AIS data.” *Ocean Engineering*, 37(5–6): 483-490.

Miyake, R., Fukuto, J., Hasegawa, K. 2015. “Procedure for marine traffic simulation with AIS data.” *TransNav the International Journal on Marine Navigation & Safety of Sea Transportation*, 9(1): 59-66.

Norrbin, N. H. 1974. “Bank effects on a ship moving through a short dredged channel.” *Proceedings of the 10th Symposium on Naval Hydrodynamics,* Cambridge, USA, 71−87.

Ch’ng, P. W., Doctors, L. J., Renilson, M. R.1993. “A method of calculating the ship-bank interaction forces and moments in restricted water.” *International Shipbuilding Progress*, 40(421): 7−23.

Fujino, M. 1968. “Studies on manoeuvrability of ships in restricted waters.” *Selected Papers Journal of Society of Naval Architecture of Japan*. 124: 51-72.

Sano, M., Yasukawa, H., Hata, H. 2014. Directional stability of a ship in close proximity to channel wall, Journal of Marine Science and Technology, 19(4): 376-393.

Parsons, M. G. and Cuong, H. T. 1980. Adaptive path control of surface ships in restricted waters. University of Michigan.

Rios-Neto, A. and Cruz, J. D. 1985. “A stochastic rudder control law for ship path-following autopilots.” *Automatica*, 21(4): 371-384.

Papoulias, F. A. and Healey, A. J. 1992. “Path control of surface ships using sliding modes.” *Journal of Ship Research*, 36(2): 141-153.

Zhang, R., Chen, Y., Sun, Z. and Sun, F. 2000. “Path control of a surface ship in restricted waters using sliding mode.” *IEEE Transactions on Control Systems Technology*, 8(4): 722-732.

Thomas BS, Sclavounos PD. 2007. “Optimal Control Theory Applied to Ship Maneuvering in Restricted Waters.” *Journal of Engineering Mathematics*. 58(1): 301-315.

Djouani, K. and Hamam, Y. 1995. “Minimum time-energy trajectory planning for automatic ship berthing.” *IEEE Journal of Oceanic Engineering*, 20(1): 4-12.

Szłapczyński, R. 2013. “Evolutionary sets of safe ship trajectories with speed reduction manoeuvres within traffic separation schemes.” *Polish Maritime Research*, 21(1): 20-27.

Li, Z., Sun, J. and Oh, S. 2010. “Handling roll constraints for path following of marine surface vessels using coordinated rudder and propulsion control.” *American Control Conference*, 6010-6015.

Feng P. Y., Sun J. and Ma N. 2013. “Path following of marine surface vessels using bow and aft rudders in wave fields.” *Control Applications in Marine Systems*, 9(1): 120-125.

Mucha P., el Moctar O. 2013. “Ship-Bank interaction of a large tanker and related control problems.” *Proceedings of the 32nd ASME International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2013)*, Nantes, France.

Trade Facilitation in the WTO Context

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1. What is trade facilitation?

In an ideal world, cross-border trade would be conducted without any restrictions. However, in reality, international trade faces many obstacles created by governments. Trade costs associated with transportation charges, documentation requirements and delay in clearance at the national border are becoming as important as traditional measures for trade restriction like tariffs and quantitative restrictions. Easier movement of goods and services enhances competitiveness of the export sector and fosters technology transfer through imports and foreign direct investment. Increasing awareness of those trade-related transactions costs has called for multilateral rule-making and regional or plurilateral coordination regarding trade facilitation.

2. Why is it important?

The Trade Facilitation Agreement (TFA) is the first multilateral trade agreement to be concluded since the WTO was established in 1995. The negotiations were finally concluded at the Bali Ministerial Meeting in 2013 and the agreement is awaiting ratification by the two-thirds of the WTO membership (currently at 164), in accordance with Article X:3 of the Marrakesh Agreement Establishing the World Trade Organization. So far, 92 WTO Members have ratified the agreement. Once it enters into force, the Agreement is expected to reduce total trade costs by more than 14 per cent for low-income countries and more than 13 per cent for upper middle-income countries by streamlining the flow of trade across borders. *

Despite the call for more open trade by world leaders at the G7 and G20 Summits, trade negotiations at the multilateral level in Geneva has been stagnant. The Doha Round, which started in 2001, is not going to be concluded soon. As a result, some countries have shifted their focus on regional or plurilateral initiatives such as the Trans-Pacific Partnership (TPP) and the Transatlantic Trade and Investment Initiative (TTIP), but these initiatives are also facing difficulties of their own.

In view of this situation, the success of the TFA is one of the few bright spots in the global trade agenda today. Thus, at the Ise-Shima G7 Summit in May 2016, the leaders stated: “We welcome the successful conclusion of the Nairobi Ministerial Conference, and in order to solidify our achieved outcomes in the recent Ministerial Conferences, call for a swift entry into force of the Trade Facilitation Agreement (TFA) by the end of 2016 and its full implementation.” **

* *Trade Facilitation Agreement: Easing the flow of goods across borders* (WTO, 2015).

** G7 Ise-Shima Leaders' Declaration, G7 Ise-Shima Summit, 26-27 May 2016.

Appendix 1:

AGREEMENT ON TRADE FACILITATION

Preamble

Members,

Having regard to the negotiations launched under the Doha Ministerial Declaration;

Recalling and reaffirming the mandate and principles contained in paragraph 27 of the Doha Ministerial Declaration (WT/MIN(01)/DEC/1) and in Annex D of the Decision of the Doha Work Programme adopted by the General Council on 1 August 2004 (WT/L/579), as well as in paragraph 33 of and Annex E to the Hong Kong Ministerial Declaration (WT/MIN(05)/DEC);

Desiring to clarify and improve relevant aspects of Articles V, VIII and X of the GATT 1994 with a view to further expediting the movement, release and clearance of goods, including goods in transit;

Recognizing the particular needs of developing and especially least-developed country Members and desiring to enhance assistance and support for capacity building in this area;

Recognizing the need for effective cooperation among Members on trade facilitation and customs compliance issues;

Hereby *agree* as follows:

SECTION I

ARTICLE 1: PUBLICATION AND AVAILABILITY OF INFORMATION

1 Publication

1.1 Each Member shall promptly publish the following information in a non-discriminatory and easily accessible manner in order to enable governments, traders, and other interested parties to become acquainted with them:

(a) procedures for importation, exportation, and transit (including port, airport, and other entry-point procedures), and required forms and documents;

(b) applied rates of duties and taxes of any kind imposed on or in connection with importation or exportation;

(c) fees and charges imposed by or for governmental agencies on or in connection with importation, exportation or transit;

(d) rules for the classification or valuation of products for customs purposes;

(e) laws, regulations, and administrative rulings of general application relating to rules of origin;

(f) import, export or transit restrictions or prohibitions;

(g) penalty provisions for breaches of import, export, or transit formalities;

(h) procedures for appeal or review;

(i) agreements or parts thereof with any country or countries relating to importation, exportation, or transit; and

(j) procedures relating to the administration of tariff quotas.

1.2 Nothing in these provisions shall be construed as requiring the publication or provision of information other than in the language of the Member except as stated in paragraph 2.2.

2 Information Available Through Internet

2.1 Each Member shall make available, and update to the extent possible and as appropriate, the following through the internet:

(a) a description[1] of its procedures for importation, exportation, and transit, including procedures for appeal or review, that informs governments, traders, and other interested parties of the practical steps needed for importation, exportation, and transit;

(b) the forms and documents required for importation into, exportation from, or transit through the territory of that Member;

(c) contact information on its enquiry point(s).

2.2 Whenever practicable, the description referred to in subparagraph 2.1(a) shall also be made available in one of the official languages of the WTO.

2.3 Members are encouraged to make available further trade-related information through the internet, including relevant trade-related legislation and other items

[1] Each Member has the discretion to state on its website the legal limitations of this description.

referred to in paragraph 1.1.

3 Enquiry Points

3.1 Each Member shall, within its available resources, establish or maintain one or more enquiry points to answer reasonable enquiries of governments, traders, and other interested parties on matters covered by paragraph 1.1 and to provide the required forms and documents referred to in subparagraph 1.1(a).

3.2 Members of a customs union or involved in regional integration may establish or maintain common enquiry points at the regional level to satisfy the requirement of paragraph 3.1 for common procedures.

3.3 Members are encouraged not to require the payment of a fee for answering enquiries and providing required forms and documents. If any, Members shall limit the amount of their fees and charges to the approximate cost of services rendered.

3.4 The enquiry points shall answer enquiries and provide the forms and documents within a reasonable time period set by each Member, which may vary depending on the nature or complexity of the request.

4 Notification

Each Member shall notify the Committee on Trade Facilitation established under paragraph 1.1 of Article 23 (referred to in this Agreement as the "Committee") of:

(a) the official place(s) where the items in subparagraphs 1.1(a) to (j) have been published;

(b) the Uniform Resource Locators of website(s) referred to in paragraph 2.1; and

(c) the contact information of the enquiry points referred to in paragraph 3.1.

ARTICLE 2: OPPORTUNITY TO COMMENT, INFORMATION BEFORE ENTRY INTO FORCE, AND CONSULTATIONS

1 Opportunity to Comment and Information before Entry into Force

1.1 Each Member shall, to the extent practicable and in a manner consistent with its domestic law and legal system, provide opportunities and an appropriate time period to traders and other interested parties to comment on the proposed introduction or amendment of laws and regulations of general application related to the movement, release, and clearance of goods, including goods in transit.

1.2 Each Member shall, to the extent practicable and in a manner consistent with its

domestic law and legal system, ensure that new or amended laws and regulations of general application related to the movement, release, and clearance of goods, including goods in transit, are published or information on them made otherwise publicly available, as early as possible before their entry into force, in order to enable traders and other interested parties to become acquainted with them.

1.3 Changes to duty rates or tariff rates, measures that have a relieving effect, measures the effectiveness of which would be undermined as a result of compliance with paragraphs 1.1 or 1.2, measures applied in urgent circumstances, or minor changes to domestic law and legal system are each excluded from paragraphs 1.1 and 1.2.

2 Consultations

Each Member shall, as appropriate, provide for regular consultations between its border agencies and traders or other stakeholders located within its territory.

ARTICLE 3: ADVANCE RULINGS

1. Each Member shall issue an advance ruling in a reasonable, time-bound manner to the applicant that has submitted a written request containing all necessary information. If a Member declines to issue an advance ruling, it shall promptly notify the applicant in writing, setting out the relevant facts and the basis for its decision.

2. A Member may decline to issue an advance ruling to the applicant where the question raised in the application:

   (a) is already pending in the applicant's case before any governmental agency, appellate tribunal, or court; or

   (b) has already been decided by any appellate tribunal or court.

3. The advance ruling shall be valid for a reasonable period of time after its issuance unless the law, facts, or circumstances supporting that ruling have changed.

4. Where the Member revokes, modifies, or invalidates the advance ruling, it shall provide written notice to the applicant setting out the relevant facts and the basis for its decision. Where a Member revokes, modifies, or invalidates advance rulings with retroactive effect, it may only do so where the ruling was based on incomplete, incorrect, false, or misleading information.

5. An advance ruling issued by a Member shall be binding on that Member in respect of the applicant that sought it. The Member may provide that the advance ruling is binding on the applicant.

6. Each Member shall publish, at a minimum:

(a) the requirements for the application for an advance ruling, including information to be provided and the format;

(b) the time period by which it will issue an advance ruling; and

(c) the length of time for which the advance ruling is valid.

7. Each Member shall provide, upon written request of an applicant, a review of the advance ruling or the decision to revoke, modify, or invalidate the advance ruling.[2]

8. Each Member shall endeavour to make publicly available any information on advance rulings which it considers to be of significant interest to other interested parties, taking into account the need to protect commercially confidential information.

9. Definitions and scope:

(a) An advance ruling is a written decision provided by a Member to the applicant prior to the importation of a good covered by the application that sets forth the treatment that the Member shall provide to the good at the time of importation with regard to:

(i) the good's tariff classification; and
(ii) the origin of the good.[3]

(b) In addition to the advance rulings defined in subparagraph (a), Members are encouraged to provide advance rulings on:

(i) the appropriate method or criteria, and the application thereof, to be used for determining the customs value under a particular set of facts;
(ii) the applicability of the Member's requirements for relief or exemption from customs duties;
(iii) the application of the Member's requirements for quotas,

[2] Under this paragraph: (a) a review may, either before or after the ruling has been acted upon, be provided by the official, office, or authority that issued the ruling, a higher or independent administrative authority, or a judicial authority; and (b) a Member is not required to provide the applicant with recourse to paragraph 1 of Article 4.

[3] It is understood that an advance ruling on the origin of a good may be an assessment of origin for the purposes of the Agreement on Rules of Origin where the ruling meets the requirements of this Agreement and the Agreement on Rules of Origin. Likewise, an assessment of origin under the Agreement on Rules of Origin may be an advance ruling on the origin of a good for the purposes of this Agreement where the ruling meets the requirements of both agreements. Members are not required to establish separate arrangements under this provision in addition to those established pursuant to the Agreement on Rules of Origin in relation to the assessment of origin provided that the requirements of this Article are fulfilled.

including tariff quotas; and

(iv) any additional matters for which a Member considers it appropriate to issue an advance ruling.

(c) An applicant is an exporter, importer or any person with a justifiable cause or a representative thereof.

(d) A Member may require that the applicant have legal representation or registration in its territory. To the extent possible, such requirements shall not restrict the categories of persons eligible to apply for advance rulings, with particular consideration for the specific needs of small and medium-sized enterprises. These requirements shall be clear and transparent and not constitute a means of arbitrary or unjustifiable discrimination.

ARTICLE 4: PROCEDURES FOR APPEAL OR REVIEW

1. Each Member shall provide that any person to whom customs issues an administrative decision[4] has the right, within its territory, to:

(a) an administrative appeal to or review by an administrative authority higher than or independent of the official or office that issued the decision;

and/or

(b) a judicial appeal or review of the decision.

2. The legislation of a Member may require that an administrative appeal or review be initiated prior to a judicial appeal or review.

3. Each Member shall ensure that its procedures for appeal or review are carried out in a nondiscriminatory manner.

4. Each Member shall ensure that, in a case where the decision on appeal or review under subparagraph 1(a) is not given either:

(a) within set periods as specified in its laws or regulations; or

(b) without undue delay the petitioner has the right to either further appeal to or further review by the administrative authority or the judicial authority or any

[4] An administrative decision in this Article means a decision with a legal effect that affects the rights and obligations of a specific person in an individual case. It shall be understood that an administrative decision in this Article covers an administrative action within the meaning of Article X of the GATT 1994 or failure to take an administrative action or decision as provided for in a Member's domestic law and legal system. For addressing such failure, Members may maintain an alternative administrative mechanism or judicial recourse to direct the customs authority to promptly issue an administrative decision in place of the right to appeal or review under subparagraph 1(a).

other recourse to the judicial authority.[5]

5. Each Member shall ensure that the person referred to in paragraph 1 is provided with the reasons for the administrative decision so as to enable such a person to have recourse to procedures for appeal or review where necessary.

6. Each Member is encouraged to make the provisions of this Article applicable to an administrative decision issued by a relevant border agency other than customs.

ARTICLE 5: OTHER MEASURES TO ENHANCE IMPARTIALITY, NON-DISCRIMINATION AND TRANSPARENCY

1 Notifications for enhanced controls or inspections

Where a Member adopts or maintains a system of issuing notifications or guidance to its concerned authorities for enhancing the level of controls or inspections at the border in respect of foods, beverages, or feedstuffs covered under the notification or guidance for protecting human, animal, or plant life or health within its territory, the following disciplines shall apply to the manner of their issuance, termination, or suspension:

(a) the Member may, as appropriate, issue the notification or guidance based on risk;

(b) the Member may issue the notification or guidance so that it applies uniformly only to those points of entry where the sanitary and phytosanitary conditions on which the notification or guidance are based apply;

(c) the Member shall promptly terminate or suspend the notification or guidance when circumstances giving rise to it no longer exist, or if changed circumstances can be addressed in a less trade-restrictive manner; and

(d) when the Member decides to terminate or suspend the notification or guidance, it shall, as appropriate, promptly publish the announcement of its termination or suspension in a non-discriminatory and easily accessible manner, or inform the exporting Member or the importer.

2 Detention

A Member shall promptly inform the carrier or importer in case of detention of goods declared for importation, for inspection by customs or any other competent authority.

3 Test Procedures

[5] Nothing in this paragraph shall prevent a Member from recognizing administrative silence on appeal or review as a decision in favor of the petitioner in accordance with its laws and regulations.

3.1 A Member may, upon request, grant an opportunity for a second test in case the first test result of a sample taken upon arrival of goods declared for importation shows an adverse finding.

3.2 A Member shall either publish, in a non-discriminatory and easily accessible manner, the name and address of any laboratory where the test can be carried out or provide this information to the importer when it is granted the opportunity provided under paragraph 3.1.

3.3 A Member shall consider the result of the second test, if any, conducted under paragraph 3.1, for the release and clearance of goods and, if appropriate, may accept the results of such test.

ARTICLE 6: DISCIPLINES ON FEES AND CHARGES IMPOSED ON OR IN CONNECTION WITH IMPORTATION AND EXPORTATION AND PENALTIES

1 General Disciplines on Fees and Charges Imposed on or in Connection with Importation and Exportation

1.1 The provisions of paragraph 1 shall apply to all fees and charges other than import and export duties and other than taxes within the purview of Article III of GATT 1994 imposed by Members on or in connection with the importation or exportation of goods.

1.2 Information on fees and charges shall be published in accordance with Article 1. This information shall include the fees and charges that will be applied, the reason for such fees and charges, the responsible authority and when and how payment is to be made.

1.3 An adequate time period shall be accorded between the publication of new or amended fees and charges and their entry into force, except in urgent circumstances. Such fees and charges shall not be applied until information on them has been published.

1.4 Each Member shall periodically review its fees and charges with a view to reducing their number and diversity, where practicable.

2 Specific disciplines on Fees and Charges for Customs Processing Imposed on or in Connection with Importation and Exportation

Fees and charges for customs processing:

(i) shall be limited in amount to the approximate cost of the services rendered on or in connection with the specific import or export

operation in question; and

(ii) are not required to be linked to a specific import or export operation provided they are levied for services that are closely connected to the customs processing of goods.

3 Penalty Disciplines

3.1 For the purpose of paragraph 3, the term "penalties" shall mean those imposed by a Member's customs administration for a breach of the Member's customs laws, regulations, or procedural requirements.

3.2 Each Member shall ensure that penalties for a breach of a customs law, regulation, or procedural requirement are imposed only on the person(s) responsible for the breach under its laws.

3.3 The penalty imposed shall depend on the facts and circumstances of the case and shall becommensurate with the degree and severity of the breach.

3.4 Each Member shall ensure that it maintains measures to avoid:

(a) conflicts of interest in the assessment and collection of penalties and duties; and

(b) creating an incentive for the assessment or collection of a penalty that is inconsistent with paragraph 3.3.

3.5 Each Member shall ensure that when a penalty is imposed for a breach of customs laws, regulations, or procedural requirements, an explanation in writing is provided to the person(s) upon whom the penalty is imposed specifying the nature of the breach and the applicable law, regulation or procedure under which the amount or range of penalty for the breach has been prescribed.

3.6 When a person voluntarily discloses to a Member's customs administration the circumstances of a breach of a customs law, regulation, or procedural requirement prior to the discovery of the breach by the customs administration, the Member is encouraged to, where appropriate, consider this fact as a potential mitigating factor when establishing a penalty for that person.

3.7 The provisions of this paragraph shall apply to the penalties on traffic in transit referred to in paragraph 3.1.

ARTICLE 7: RELEASE AND CLEARANCE OF GOODS

1 Pre-arrival Processing

1.1 Each Member shall adopt or maintain procedures allowing for the submission of

import documentation and other required information, including manifests, in order to begin processing prior to the arrival of goods with a view to expediting the release of goods upon arrival.

1.2 Each Member shall, as appropriate, provide for advance lodging of documents in electronic format for pre-arrival processing of such documents.

2 Electronic Payment

Each Member shall, to the extent practicable, adopt or maintain procedures allowing the option of electronic payment for duties, taxes, fees, and charges collected by customs incurred upon importation and exportation.

3 Separation of Release from Final Determination of Customs Duties, Taxes, Fees and Charges

3.1 Each Member shall adopt or maintain procedures allowing the release of goods prior to the final determination of customs duties, taxes, fees, and charges, if such a determination is not done prior to, or upon arrival, or as rapidly as possible after arrival and provided that all other regulatory requirements have been met.

3.2 As a condition for such release, a Member may require:

(a) payment of customs duties, taxes, fees, and charges determined prior to or upon arrival of goods and a guarantee for any amount not yet determined in the form of a surety, a deposit, or another appropriate instrument provided for in its laws and regulations; or

(b) a guarantee in the form of a surety, a deposit, or another appropriate instrument provided for in its laws and regulations.

3.3 Such guarantee shall not be greater than the amount the Member requires to ensure payment of customs duties, taxes, fees, and charges ultimately due for the goods covered by the guarantee.

3.4 In cases where an offence requiring imposition of monetary penalties or fines has been detected, a guarantee may be required for the penalties and fines that may be imposed.

3.5 The guarantee as set out in paragraphs 3.2 and 3.4 shall be discharged when it is no longer required.

3.6 Nothing in these provisions shall affect the right of a Member to examine, detain, seize or confiscate or deal with the goods in any manner not otherwise inconsistent with the Member's WTO rights and obligations.

4 Risk Management

4.1 Each Member shall, to the extent possible, adopt or maintain a risk management system for customs control.

4.2 Each Member shall design and apply risk management in a manner as to avoid arbitrary or unjustifiable discrimination, or a disguised restriction on international trade.

4.3 Each Member shall concentrate customs control and, to the extent possible other relevant border controls, on high-risk consignments and expedite the release of low-risk consignments. A Member also may select, on a random basis, consignments for such controls as part of its risk management.

4.4 Each Member shall base risk management on an assessment of risk through appropriate selectivity criteria. Such selectivity criteria may include, inter alia, the Harmonized System code, nature and description of the goods, country of origin, country from which the goods were shipped, value of the goods, compliance record of traders, and type of means of transport.

5 Post-clearance Audit

5.1 With a view to expediting the release of goods, each Member shall adopt or maintain post-clearance audit to ensure compliance with customs and other related laws and regulations.

5.2 Each Member shall select a person or a consignment for post-clearance audit in a risk-based manner, which may include appropriate selectivity criteria. Each Member shall conduct post-clearance audits in a transparent manner. Where the person is involved in the audit process and conclusive results have been achieved the Member shall, without delay, notify the person whose record is audited of the results, the person's rights and obligations, and the reasons for the results.

5.3 The information obtained in post-clearance audit may be used in further administrative or judicial proceedings.

5.4 Members shall, wherever practicable, use the result of post-clearance audit in applying risk management.

6 Establishment and Publication of Average Release Times

6.1 Members are encouraged to measure and publish their average release time of goods periodically and in a consistent manner, using tools such as, *inter alia*, the Time Release Study of the World Customs Organization (referred to in this Agreement as the "WCO").[6]

[6] Each Member may determine the scope and methodology of such average release time measurement in accordance with its needs and capacity.

6.2 Members are encouraged to share with the Committee their experiences in measuring average release times, including methodologies used, bottlenecks identified, and any resulting effects on efficiency.

7 Trade Facilitation Measures for Authorized Operators

7.1 Each Member shall provide additional trade facilitation measures related to import, export, or transit formalities and procedures, pursuant to paragraph 7.3, to operators who meet specified criteria, hereinafter called authorized operators. Alternatively, a Member may offer such trade facilitation measures through customs procedures generally available to all operators and is not required to establish a separate scheme.

7.2 The specified criteria to qualify as an authorized operator shall be related to compliance, or the risk of non-compliance, with requirements specified in a Member's laws, regulations or procedures.

(a) Such criteria, which shall be published, may include:

(i) an appropriate record of compliance with customs and other related laws and regulations;

(ii) a system of managing records to allow for necessary internal controls;

(iii) financial solvency, including, where appropriate, provision of a sufficient security or guarantee; and

(iv) supply chain security.

(b) Such criteria shall not:

(i) be designed or applied so as to afford or create arbitrary or unjustifiable discrimination between operators where the same conditions prevail; and

(ii) to the extent possible, restrict the participation of small and medium-sized enterprises.

7.3 The trade facilitation measures provided pursuant to paragraph 7.1 shall include at least three of the following measures:[7]

(a) low documentary and data requirements, as appropriate;

[7] A measure listed in subparagraphs 7.3 (a) to (g) will be deemed to be provided to authorized operators if it is generally available to all operators.

(b) low rate of physical inspections and examinations, as appropriate;

(c) rapid release time, as appropriate;

(d) deferred payment of duties, taxes, fees, and charges;

(e) use of comprehensive guarantees or reduced guarantees;

(f) a single customs declaration for all imports or exports in a given period; and

(g) clearance of goods at the premises of the authorized operator or another place authorized by customs.

7.4 Members are encouraged to develop authorized operator schemes on the basis of international standards, where such standards exist, except when such standards would be an inappropriate or ineffective means for the fulfilment of the legitimate objectives pursued.

7.4 In order to enhance the trade facilitation measures provided to operators, Members shall afford to other Members the possibility of negotiating mutual recognition of authorized operator schemes.

7.5 Members shall exchange relevant information within the Committee about authorized operator schemes in force.

8 Expedited Shipments

8.1 Each Member shall adopt or maintain procedures allowing for the expedited release of at least those goods entered through air cargo facilities to persons who apply for such treatment, while maintaining customs control.[8] If a Member employs criteria[9] limiting who may apply, the Member may, in published criteria, require that the applicant shall, as conditions for qualifying for the application of the treatment described in paragraph 8.2 to its expedited shipments:

(a) provide adequate infrastructure and payment of customs expenses related to processing of expedited shipments in cases where the applicant fulfils the Member's requirements for such processing to be performed at a dedicated facility;

(b) submit in advance of the arrival of an expedited shipment the information necessary for the release;

[8] In cases where a Member has an existing procedure that provides the treatment in paragraph 8.2, this provision does not require that Member to introduce separate expedited release procedures.

[9] Such application criteria, if any, shall be in addition to the Member's requirements for operating with respect to all goods or shipments entered through air cargo facilities.

(c) be assessed fees limited in amount to the approximate cost of services rendered in providing the treatment described in paragraph 8.2;

(d) maintain a high degree of control over expedited shipments through the use of internal security, logistics, and tracking technology from pick-up to delivery;

(e) provide expedited shipment from pick-up to delivery;

(f) assume liability for payment of all customs duties, taxes, fees, and charges to the customs authority for the goods;

(g) have a good record of compliance with customs and other related laws and regulations;

(h) comply with other conditions directly related to the effective enforcement of the Member's laws, regulations, and procedural requirements, that specifically relate to providing the treatment described in paragraph 8.2.

8.2 Subject to paragraphs 8.1 and 8.3, Members shall:

(a) minimize the documentation required for the release of expedited shipments in accordance with paragraph 1 of Article 10 and, to the extent possible, provide for release based on a single submission of information on certain shipments;

(b) provide for expedited shipments to be released under normal circumstances as rapidly as possible after arrival, provided the information required for release has been submitted;

(c) endeavour to apply the treatment in subparagraphs (a) and (b) to shipments of any weight or value recognizing that a Member is permitted to require additional entry procedures, including declarations and supporting documentation and payment of duties and taxes, and to limit such treatment based on the type of good, provided the treatment is not limited to low value goods such as documents; and

(d) provide, to the extent possible, for a *de minimis* shipment value or dutiable amount for which customs duties and taxes will not be collected, aside from certain prescribed goods. Internal taxes, such as value added taxes and excise taxes, applied to imports consistently with Article III of the GATT 1994 are not subject to this provision.

8.3 Nothing in paragraphs 8.1 and 8.2 shall affect the right of a Member to examine, detain, seize, confiscate or refuse entry of goods, or to carry out post-clearance

audits, including in connection with the use of risk management systems. Further, nothing in paragraphs 8.1 and 8.2 shall prevent a Member from requiring, as a condition for release, the submission of additional information and the fulfilment of non-automatic licensing requirements.

9 Perishable Goods[10]

9.1 With a view to preventing avoidable loss or deterioration of perishable goods, and provided that all regulatory requirements have been met, each Member shall provide for the release of perishable goods:

(a) under normal circumstances within the shortest possible time; and

(b) in exceptional circumstances where it would be appropriate to do so, outside the business hours of customs and other relevant authorities.

9.2 Each Member shall give appropriate priority to perishable goods when scheduling any examinations that may be required.

9.3 Each Member shall either arrange or allow an importer to arrange for the proper storage of perishable goods pending their release. The Member may require that any storage facilities arranged by the importer have been approved or designated by its relevant authorities. The movement of the goods to those storage facilities, including authorizations for the operator moving the goods, may be subject to the approval, where required, of the relevant authorities. The Member shall, where practicable and consistent with domestic legislation, upon the request of the importer, provide for any procedures necessary for release to take place at those storage facilities.

9.4 In cases of significant delay in the release of perishable goods, and upon written request, the importing Member shall, to the extent practicable, provide a communication on the reasons for the delay.

ARTICLE 8: BORDER AGENCY COOPERATION

1. Each Member shall ensure that its authorities and agencies responsible for border controls and procedures dealing with the importation, exportation, and transit of goods cooperate with one another and coordinate their activities in order to facilitate trade.

2. Each Member shall, to the extent possible and practicable, cooperate on mutually agreed terms with other Members with whom it shares a common border with a view to coordinating procedures at border crossings to facilitate cross-border trade. Such cooperation and coordination may include:

[10] For the purposes of this provision, perishable goods are goods that rapidly decay due to their natural characteristics, in particular in the absence of appropriate storage conditions.

(a) alignment of working days and hours;

(b) alignment of procedures and formalities;

(c) development and sharing of common facilities;

(d) joint controls;

(e) establishment of one stop border post control.

ARTICLE 9: MOVEMENT OF GOODS INTENDED FOR IMPORT UNDER CUSTOMS CONTROL

Each Member shall, to the extent practicable, and provided all regulatory requirements are met, allow goods intended for import to be moved within its territory under customs control from a customs office of entry to another customs office in its territory from where the goods would be released or cleared.

ARTICLE 10: FORMALITIES CONNECTED WITH IMPORTATION, EXPORTATION AND TRANSIT

1 Formalities and Documentation Requirements

1.1 With a view to minimizing the incidence and complexity of import, export, and transit formalities and to decreasing and simplifying import, export, and transit documentation requirements and taking into account the legitimate policy objectives and other factors such as changed circumstances, relevant new information, business practices, availability of techniques and technology, international best practices, and inputs from interested parties, each Member shall review such formalities and documentation requirements and, based on the results of the review, ensure, as appropriate, that such formalities and documentation requirements are:

(a) adopted and/or applied with a view to a rapid release and clearance of goods, particularly perishable goods;

(b) adopted and/or applied in a manner that aims at reducing the time and cost of compliance for traders and operators;

(c) the least trade restrictive measure chosen where two or more alternative measures are reasonably available for fulfilling the policy objective or objectives in question;

and

(d) not maintained, including parts thereof, if no longer required.

1.2 The Committee shall develop procedures for the sharing by Members of relevant information and best practices, as appropriate.

2 Acceptance of Copies

2.1 Each Member shall, where appropriate, endeavour to accept paper or electronic copies of supporting documents required for import, export, or transit formalities.

2.2 Where a government agency of a Member already holds the original of such a document, any other agency of that Member shall accept a paper or electronic copy, where applicable, from the agency holding the original in lieu of the original document.

2.3 A Member shall not require an original or copy of export declarations submitted to the customs authorities of the exporting Member as a requirement for importation.[11]

3 Use of International Standards

3.1 Members are encouraged to use relevant international standards or parts thereof as a basis for their import, export, or transit formalities and procedures, except as otherwise provided for in this Agreement.

3.2 Members are encouraged to take part, within the limits of their resources, in the preparation and periodic review of relevant international standards by appropriate international organizations.

3.3 The Committee shall develop procedures for the sharing by Members of relevant information, and best practices, on the implementation of international standards, as appropriate. The Committee may also invite relevant international organizations to discuss their work on international standards. As appropriate, the Committee may identify specific standards that are of particular value to Members.

4 Single Window

4.1 Members shall endeavour to establish or maintain a single window, enabling traders to submit documentation and/or data requirements for importation, exportation, or transit of goods through a single entry point to the participating authorities or agencies. After the examination by the participating authorities or agencies of the documentation and/or data, the results shall be notified to the applicants through the single window in a timely manner.

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[11] Nothing in this paragraph precludes a Member from requiring documents such as certificates, permits or licenses as a requirement for the importation of controlled or regulated goods.

4.2 In cases where documentation and/or data requirements have already been received through the single window, the same documentation and/or data requirements shall not be requested by participating authorities or agencies except in urgent circumstances and other limited exceptions which are made public.

4.3 Members shall notify the Committee of the details of operation of the single window.

4.4 Members shall, to the extent possible and practicable, use information technology to support the single window.

5 Preshipment Inspection

5.1 Members shall not require the use of preshipment inspections in relation to tariff classification and customs valuation.

5.2 Without prejudice to the rights of Members to use other types of preshipment inspection not covered by paragraph 5.1, Members are encouraged not to introduce or apply new requirements regarding their use.[12]

6 Use of Customs Brokers

6.1 Without prejudice to the important policy concerns of some Members that currently maintain a special role for customs brokers, from the entry into force of this Agreement Members shall not introduce the mandatory use of customs brokers.

6.2 Each Member shall notify the Committee and publish its measures on the use of customs brokers. Any subsequent modifications thereof shall be notified and published promptly.

6.3 With regard to the licensing of customs brokers, Members shall apply rules that are transparent and objective.

7 Common Border Procedures and Uniform Documentation Requirements

7.1 Each Member shall, subject to paragraph 7.2, apply common customs procedures and uniform documentation requirements for release and clearance of goods throughout its territory.

7.2 Nothing in this Article shall prevent a Member from:

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[12] This paragraph refers to preshipment inspections covered by the Agreement on Preshipment Inspection, and does not preclude preshipment inspections for sanitary and phytosanitary purposes.

(a) differentiating its procedures and documentation requirements based on the nature and type of goods, or their means of transport;

(b) differentiating its procedures and documentation requirements for goods based on risk management;

(c) differentiating its procedures and documentation requirements to provide total or partial exemption from import duties or taxes;

(d) applying electronic filing or processing; or

(e) differentiating its procedures and documentation requirements in a manner consistent with the Agreement on the Application of Sanitary and Phytosanitary Measures.

8 Rejected Goods

8.1 Where goods presented for import are rejected by the competent authority of a Member on account of their failure to meet prescribed sanitary or phytosanitary regulations or technical regulations, the Member shall, subject to and consistent with its laws and regulations, allow the importer to re-consign or to return the rejected goods to the exporter or another person designated by the exporter.

8.2 When such an option under paragraph 8.1 is given and the importer fails to exercise it within a reasonable period of time, the competent authority may take a different course of action to deal with such non-compliant goods.

9 Temporary Admission of Goods and Inward and Outward Processing

9.1 Temporary Admission of Goods

Each Member shall allow, as provided for in its laws and regulations, goods to be brought into its customs territory conditionally relieved, totally or partially, from payment of import duties and taxes if such goods are brought into its customs territory for a specific purpose, are intended for re-exportation within a specific period, and have not undergone any change except normal depreciation and wastage due to the use made of them.

9.2 Inward and Outward Processing

(a) Each Member shall allow, as provided for in its laws and regulations, inward and outward processing of goods. Goods allowed for outward processing may be reimported with total or partial exemption from import duties and taxes in accordance with the Member's laws and regulations.

(b) For the purposes of this Article, the term "inward processing" means the customs procedure under which certain goods can be brought into a Member’s customs territory conditionally relieved, totally or partially, from

payment of import duties and taxes, or eligible for duty drawback, on the basis that such goods are intended for manufacturing, processing, or repair and subsequent exportation.

(c) For the purposes of this Article, the term "outward processing" means the customs procedure under which goods which are in free circulation in a Member's customs territory may be temporarily exported for manufacturing, processing, or repair abroad and then re-imported.

ARTICLE 11: FREEDOM OF TRANSIT

1. Any regulations or formalities in connection with traffic in transit imposed by a Member shall not be:

   (a) maintained if the circumstances or objectives giving rise to their adoption no longer exist or if the changed circumstances or objectives can be addressed in a reasonably available less trade-restrictive manner;

   (b) applied in a manner that would constitute a disguised restriction on traffic in transit.

2. Traffic in transit shall not be conditioned upon collection of any fees or charges imposed in respect of transit, except the charges for transportation or those commensurate with administrative expenses entailed by transit or with the cost of services rendered.

3. Members shall not seek, take, or maintain any voluntary restraints or any other similar measures on traffic in transit. This is without prejudice to existing and future national regulations, bilateral or multilateral arrangements related to regulating transport, consistent with WTO rules.

4. Each Member shall accord to products which will be in transit through the territory of any other Member treatment no less favourable than that which would be accorded to such products if they were being transported from their place of origin to their destination without going through the territory of such other Member.

5. Members are encouraged to make available, where practicable, physically separate infrastructure (such as lanes, berths and similar) for traffic in transit.

6. Formalities, documentation requirements, and customs controls in connection with traffic in transit shall not be more burdensome than necessary to:

   (a) identify the goods; and

   (b) ensure fulfilment of transit requirements.

7. Once goods have been put under a transit procedure and have been authorized to proceed from the point of origination in a Member's territory, they will not be subject to any customs charges nor unnecessary delays or restrictions until they conclude their transit at the point of destination within the Member's territory.

8. Members shall not apply technical regulations and conformity assessment procedures within the meaning of the Agreement on Technical Barriers to Trade to goods in transit.

9. Members shall allow and provide for advance filing and processing of transit documentation and data prior to the arrival of goods.

10. Once traffic in transit has reached the customs office where it exits the territory of a Member, that office shall promptly terminate the transit operation if transit requirements have been met.

11. Where a Member requires a guarantee in the form of a surety, deposit or other appropriate monetary or non-monetary[13] instrument for traffic in transit, such guarantee shall be limited to ensuring that requirements arising from such traffic in transit are fulfilled.

12. Once the Member has determined that its transit requirements have been satisfied, the guarantee shall be discharged without delay.

13. Each Member shall, in a manner consistent with its laws and regulations, allow comprehensive guarantees which include multiple transactions for same operators or renewal of guarantees without discharge for subsequent consignments.

14. Each Member shall make publicly available the relevant information it uses to set the guarantee, including single transaction and, where applicable, multiple transaction guarantee.

15. Each Member may require the use of customs convoys or customs escorts for traffic in transit only in circumstances presenting high risks or when compliance with customs laws and regulations cannot be ensured through the use of guarantees. General rules applicable to customs convoys or customs escorts shall be published in accordance with Article 1.

16. Members shall endeavour to cooperate and coordinate with one another with a view to enhancing freedom of transit. Such cooperation and coordination may include, but is not limited to, an understanding on:
    (a) charges;

[13] Nothing in this provision shall preclude a Member from maintaining existing procedures whereby the means of transport can be used as a guarantee for traffic in transit.

(b) formalities and legal requirements; and

(c) the practical operation of transit regimes.

17. Each Member shall endeavour to appoint a national transit coordinator to which all enquiries and proposals by other Members relating to the good functioning of transit operations can be addressed.

ARTICLE 12: CUSTOMS COOPERATION

1 Measures Promoting Compliance and Cooperation

1.1 Members agree on the importance of ensuring that traders are aware of their compliance obligations, encouraging voluntary compliance to allow importers to self-correct without penalty in appropriate circumstances, and applying compliance measures to initiate stronger measures for non-compliant traders.[14]

1.2 Members are encouraged to share information on best practices in managing customs compliance, including through the Committee. Members are encouraged to cooperate in technical guidance or assistance and support for capacity building for the purposes of administering compliance measures and enhancing their effectiveness.

2 Exchange of Information

2.1 Upon request and subject to the provisions of this Article, Members shall exchange the information set out in subparagraphs 6.1(b) and/or (c) for the purpose of verifying an import or export declaration in identified cases where there are reasonable grounds to doubt the truth or accuracy of the declaration.

2.2 Each Member shall notify the Committee of the details of its contact point for the exchange of this information.

3 Verification

A Member shall make a request for information only after it has conducted appropriate verification procedures of an import or export declaration and after it has inspected the available relevant documentation.

4 Request

4.1 The requesting Member shall provide the requested Member with a written request, through paper or electronic means in a mutually agreed official language of the WTO or other mutually agreed language, including:

[14] Such activity has the overall objective of lowering the frequency of non-compliance, and consequently reducing the need for exchange of information in pursuit of enforcement.

(a) the matter at issue including, where appropriate and available, the number identifying the export declaration corresponding to the import declaration in question;

(b) the purpose for which the requesting Member is seeking the information or documents, along with the names and contact details of the persons to whom the request relates, if known;

(c) where required by the requested Member, confirmation [15] of the verification where appropriate;

(d) the specific information or documents requested;

(e) the identity of the originating office making the request;

(f) reference to provisions of the requesting Member's domestic law and legal system that govern the collection, protection, use, disclosure, retention, and disposal of confidential information and personal data.

4.2 If the requesting Member is not in a position to comply with any of the subparagraphs of paragraph 4.1, it shall specify this in the request.

5 Protection and Confidentiality

5.1 The requesting Member shall, subject to paragraph 5.2:

(a) hold all information or documents provided by the requested Member strictly in confidence and grant at least the same level of such protection and confidentiality as that provided under the domestic law and legal system of the requested Member as described by it under subparagraphs 6.1(b) or (c);

(b) provide information or documents only to the customs authorities dealing with the matter at issue and use the information or documents solely for the purpose stated in the request unless the requested Member agrees otherwise in writing;

(c) not disclose the information or documents without the specific written permission of the requested Member;

(d) not use any unverified information or documents from the requested Member as the deciding factor towards alleviating the doubt in any

[15] This may include pertinent information on the verification conducted under paragraph 3. Such information shall be subject to the level of protection and confidentiality specified by the Member conducting the verification.

given circumstance;

(e) respect any case-specific conditions set out by the requested Member regarding retention and disposal of confidential information or documents and personal data; and

(f) upon request, inform the requested Member of any decisions and actions taken on the matter as a result of the information or documents provided.

5.2 A requesting Member may be unable under its domestic law and legal system to comply with any of the subparagraphs of paragraph 5.1. If so, the requesting Member shall specify this in the request.

5.3 The requested Member shall treat any request and verification information received under paragraph 4 with at least the same level of protection and confidentiality accorded by the requested Member to its own similar information.

6 Provision of Information

6.1 Subject to the provisions of this Article, the requested Member shall promptly:

(a) respond in writing, through paper or electronic means;

(b) provide the specific information as set out in the import or export declaration, or the declaration, to the extent it is available, along with a description of the level of protection and confidentiality required of the requesting Member;

(c) if requested, provide the specific information as set out in the following documents, or the documents, submitted in support of the import or export declaration, to the extent it is available: commercial invoice, packing list, certificate of origin and bill of lading, in the form in which these were filed, whether paper or electronic, along with a description of the level of protection and confidentiality required of the requesting Member;

(d) confirm that the documents provided are true copies;

(e) provide the information or otherwise respond to the request, to the extent possible, within 90 days from the date of the request.

6.2 The requested Member may require, under its domestic law and legal system, an assurance prior to the provision of information that the specific information will not be used as evidence in criminal investigations, judicial proceedings, or in non-customs proceedings without the specific written permission of the requested Member. If the requesting Member is not in a position to comply with

this requirement, it should specify this to the requested Member.

7 Postponement or Refusal of a Request

7.1 A requested Member may postpone or refuse part or all of a request to provide information, and shall inform the requesting Member of the reasons for doing so, where:

(a) it would be contrary to the public interest as reflected in the domestic law and legal system of the requested Member;

(b) its domestic law and legal system prevents the release of the information. In such a case it shall provide the requesting Member with a copy of the relevant, specific reference;

(c) the provision of the information would impede law enforcement or otherwise interfere with an on-going administrative or judicial investigation, prosecution or proceeding;

(d) the consent of the importer or exporter is required by its domestic law and legal system that govern the collection, protection, use, disclosure, retention, and disposal of confidential information or personal data and that consent is not given; or

(e) the request for information is received after the expiration of the legal requirement of the requested Member for the retention of documents.

7.2 In the circumstances of paragraphs 4.2, 5.2, or 6.2, execution of such a request shall be at the discretion of the requested Member.

8 Reciprocity

If the requesting Member is of the opinion that it would be unable to comply with a similar request if it was made by the requested Member, or if it has not yet implemented this Article, it shall state that fact in its request. Execution of such a request shall be at the discretion of the requested Member.

9 Administrative Burden

9.1 The requesting Member shall take into account the associated resource and cost implications for the requested Member in responding to requests for information. The requesting Member shall consider the proportionality between its fiscal interest in pursuing its request and the efforts to be made by the requested Member in providing the information.

9.2 If a requested Member receives an unmanageable number of requests for information or a request for information of unmanageable scope from one or

more requesting Member(s) and is unable to meet such requests within a reasonable time, it may request one or more of the requesting Member(s) to prioritize with a view to agreeing on a practical limit within its resource constraints. In the absence of a mutually-agreed approach, the execution of such requests shall be at the discretion of the requested Member based on the results of its own prioritization.

10 Limitations

A requested Member shall not be required to:

(a) modify the format of its import or export declarations or procedures;

(b) call for documents other than those submitted with the import or export declaration as specified in subparagraph 6.1(c);

(c) initiate enquiries to obtain the information;

(d) modify the period of retention of such information;

(e) introduce paper documentation where electronic format has already been introduced;

(f) translate the information;

(g) verify the accuracy of the information; or

(h) provide information that would prejudice the legitimate commercial interests of particular enterprises, public or private.

11 Unauthorized Use or Disclosure

11.1 In the event of any breach of the conditions of use or disclosure of information exchanged under this Article, the requesting Member that received the information shall promptly communicate the details of such unauthorized use or disclosure to the requested Member that provided the information and:

(a) take necessary measures to remedy the breach;

(b) take necessary measures to prevent any future breach; and

(c) notify the requested Member of the measures taken under subparagraphs (a) and (b).

11.2 The requested Member may suspend its obligations to the requesting Member under this Article until the measures set out in paragraph 11.1 have been taken.

12 Bilateral and Regional Agreements

12.1 Nothing in this Article shall prevent a Member from entering into or maintaining a bilateral, plurilateral, or regional agreement for sharing or exchange of customs information and data, including on a secure and rapid basis such as on an automatic basis or in advance of the arrival of the consignment.

12.2 Nothing in this Article shall be construed as altering or affecting a Member's rights or obligations under such bilateral, plurilateral, or regional agreements, or as governing the exchange of customs information and data under such other agreements.

SECTION II

SPECIAL AND DIFFERENTIAL TREATMENT PROVISIONS FOR DEVELOPING COUNTRY MEMBERS AND LEAST-DEVELOPED COUNTRY MEMBERS

ARTICLE 13: GENERAL PRINCIPLES

1. The provisions contained in Articles 1 to 12 of this Agreement shall be implemented by developing and least-developed country Members in accordance with this Section, which is based on the modalities agreed in Annex D of the July 2004 Framework Agreement (WT/L/579) and in paragraph 33 of and Annex E to the Hong Kong Ministerial Declaration (WT/MIN(05)/DEC).

2. Assistance and support for capacity building[16] should be provided to help developing and least-developed country Members implement the provisions of this Agreement, in accordance with their nature and scope. The extent and the timing of implementation of the provisions of this Agreement shall be related to the implementation capacities of developing and least-developed country Members. Where a developing or least-developed country Member continues to lack the necessary capacity, implementation of the provision(s) concerned will not be required until implementation capacity has been acquired.

3. Least-developed country Members will only be required to undertake commitments to the extent consistent with their individual development, financial and trade needs or their administrative and institutional capabilities.

4. These principles shall be applied through the provisions set out in Section II.

ARTICLE 14: CATEGORIES OF PROVISIONS

1. There are three categories of provisions:

   (a) Category A contains provisions that a developing country Member or a least-developed country Member designates for implementation upon entry into force of this Agreement, or in the case of a least-developed country Member within one year after entry into force, as provided in Article 15.

   (b) Category B contains provisions that a developing country Member or a least-developed country Member designates for implementation on a date after a transitional period of time following the entry into force of

[16] For the purposes of this Agreement, "assistance and support for capacity building" may take the form of technical, financial, or any other mutually agreed form of assistance provided.

this Agreement, as provided in Article 16.

(c) Category C contains provisions that a developing country Member or a least-developed country Member designates for implementation on a date after a transitional period of time following the entry into force of this Agreement and requiring the acquisition of implementation capacity through the provision of assistance and support for capacity building, as provided for in Article 16.

2. Each developing country and least-developed country Member shall self-designate, on an individual basis, the provisions it is including under each of the Categories A, B and C.

ARTICLE 15: NOTIFICATION AND IMPLEMENTATION OF CATEGORY A

1. Upon entry into force of this Agreement, each developing country Member shall implement its Category A commitments. Those commitments designated under Category A will thereby be made an integral part of this Agreement.

2. A least-developed country Member may notify the Committee of the provisions it has designated in Category A for up to one year after entry into force of this Agreement. Each least-developed country Member's commitments designated under Category A will thereby be made an integral part of this Agreement.

ARTICLE 16: NOTIFICATION OF DEFINITIVE DATES FOR IMPLEMENTATION OF CATEGORY B AND CATEGORY C

1. With respect to the provisions that a developing country Member has not designated in Category A, the Member may delay implementation in accordance with the process set out in this Article.

Developing Country Member Category B

(a) Upon entry into force of this Agreement, each developing country Member shall notify the Committee of the provisions that it has designated in Category B and their corresponding indicative dates for implementation.[17]

(b) No later than one year after entry into force of this Agreement, each developing country Member shall notify the Committee of its definitive dates for implementation of the provisions it has designated in Category B. If a developing country Member, before this deadline, believes it requires additional time to notify its definitive dates, the Member may

[17] Notifications submitted may also include such further information as the notifying Member deems appropriate. Members are encouraged to provide information on the domestic agency or entity responsible for implementation.

request that the Committee extend the period sufficient to notify its dates.

Developing Country Member Category C

(c) Upon entry into force of this Agreement, each developing country Member shall notifythe Committee of the provisions that it has designated in Category C and their corresponding indicative dates for implementation. For transparency purposes, notifications submitted shall include information on the assistance and support for capacity building that the Member requires in order to implement.[18]

(d) Within one year after entry into force of this Agreement, developing country Members and relevant donor Members, taking into account any existing arrangements already in place, notifications pursuant to paragraph 1 of Article 22 and information submitted pursuant to subparagraph (c) above, shall provide information to the Committee on the arrangements maintained or entered into that are necessary to provide assistance and support for capacity building to enable implementation of Category C.[19] The participating developing country Member shall promptly inform the Committee of such arrangements. The Committee shall also invite non-Member donors to provide information on existing or concluded arrangements.

(d) Within 18 months from the date of the provision of the information stipulated in subparagraph (d), donor Members and respective developing country Members shall inform the Committee of the progress in the provision of assistance and support for capacity building. Each developing country Member shall, at the same time, notify its list of definitive dates for implementation.

2. With respect to those provisions that a least-developed country Member has not designated under Category A, least-developed country Members may delay implementation in accordance with the process set forth in this Article.

Least-Developed Country Member Category B

(a) No later than one year after entry into force of this Agreement, a least-developed country Member shall notify the Committee of its Category B provisions and may notify their corresponding indicative dates for implementation of these provisions, taking into account maximum flexibilities for least-developed country Members.

[18] Members may also include information on national trade facilitation implementation plans or projects, the domestic agency or entity responsible for implementation, and the donors with which the Member may have an arrangement in place to provide assistance.

[19] Such arrangements will be on mutually agreed terms, either bilaterally or through appropriate international organizations, consistent with paragraph 3 of Article 21.

(b) No later than two years after the notification date stipulated under subparagraph (a) above, each least-developed country Member shall notify the Committee to confirm designations of provisions and notify its dates for implementation. If a least-developed country Member, before this deadline, believes it requires additional time to notify its definitive dates, the Member may request that the Committee extend the period sufficiently to notify its dates.

Least-Developed Country Member Category C

(c) For transparency purposes and to facilitate arrangements with donors, one year after entry into force of this Agreement, each least-developed country Member shall notify the Committee of the provisions it has designated in Category C, taking into account maximum flexibilities for least-developed country Members.

(d) One year after the date stipulated in subparagraph (c) above, least-developed country Members shall notify information on assistance and support for capacity building that the Member requires in order to implement.[20]

(e) No later than two years after the notification under subparagraph (d) above, least-developed country Members and relevant donor Members, taking into account information submitted pursuant to subparagraph (d) above, shall provide information to the Committee on the arrangements maintained or entered into that are necessary to provide assistance and support for capacity building to enable implementation of Category C.[21] The participating least-developed country Member shall promptly inform the Committee of such arrangements. The least-developed country Member shall, at the same time, notify indicative dates for implementation of corresponding Category C commitments covered by the assistance and support arrangements. The Committee shall also invite non-Member donors to provide information on existing and concluded arrangements.

(f) No later than 18 months from the date of the provision of the information stipulated in subparagraph (e), relevant donor Members and respective least-developed country Members shall inform the Committee of the progress in the provision of assistance and support for capacity building. Each least-developed country Member shall, at the same time, notify the Committee of its list of definitive dates for

[20] Members may also include information on national trade facilitation implementation plans or projects, the domestic agency or entity responsible for implementation, and the donors with which the Member may have an arrangement in place to provide assistance.

[21] Such arrangements will be on mutually agreed terms, either bilaterally or through appropriate international organizations, consistent with paragraph 3 of Article 21.

implementation.

3. Developing country Members and least-developed country Members experiencing difficulties in submitting definitive dates for implementation within the deadlines set out in paragraphs 1 and 2 because of the lack of donor support or lack of progress in the provision of assistance and support for capacity building should notify the Committee as early as possible prior to the expiration of those deadlines. Members agree to cooperate to assist in addressing such difficulties, taking into account the particular circumstances and special problems facing the Member concerned. The Committee shall, as appropriate, take action to address the difficulties including, where necessary, by extending the deadlines for the Member concerned to notify its definitive dates.

4. Three months before the deadline stipulated in subparagraphs 1(b) or (e), or in the case of a least-developed country Member, subparagraphs 2(b) or (f), the Secretariat shall remind a Member if that Member has not notified a definitive date for implementation of provisions that it has designated in Category B or C. If the Member does not invoke paragraph 3, or in the case of developing country Member subparagraph 1(b), or in the case of a least-developed country Member subparagraph 2(b), to extend the deadline and still does not notify a definitive date for implementation, the Member shall implement the provisions within one year after the deadline stipulated in subparagraphs 1(b) or (e), or in the case of a least-developed country Member, subparagraphs 2(b) or (f), or extended by paragraph 3.

5. No later than 60 days after the dates for notification of definitive dates for implementation of Category B and Category C provisions in accordance with paragraphs 1, 2, or 3, the Committee shall take note of the annexes containing each Member's definitive dates for implementation of Category B and Category C provisions, including any dates set under paragraph 4, thereby making these annexes an integral part of this Agreement.

ARTICLE 17: EARLY WARNING MECHANISM: EXTENSION OF IMPLEMENTATION DATES FOR PROVISIONS IN CATEGORIES B AND C

1.

(a) A developing country Member or least-developed country Member that considers itself to be experiencing difficulty in implementing a provision that it has designated in Category B or Category C by the definitive date established under subparagraphs 1(b) or (e) of Article 16, or in the case of a least-developed country Member subparagraphs 2(b) or (f) of Article 16, should notify the Committee. Developing country Members shall notify the Committee no later than 120 days before the expiration of the implementation date. Least-developed country Members shall notify the Committee no later than 90 days before such date.

(b) The notification to the Committee shall indicate the new date by which the developing country Member or least-developed country Member expects to be able to implement the provision concerned. The notification shall also indicate the reasons for the expected delay in implementation. Such reasons may include the need for assistance and support for capacity building not earlier anticipated or additional assistance and support to help build capacity.

2. Where a developing country Member's request for additional time for implementation does not exceed 18 months or a least-developed country Member's request for additional time does not exceed 3 years, the requesting Member is entitled to such additional time without any further action by the Committee.

3. Where a developing country or least-developed country Member considers that it requires a first extension longer than that provided for in paragraph 2 or a second or any subsequent extension, it shall submit to the Committee a request for an extension containing the information described in subparagraph 1(b) no later than 120 days in respect of a developing country Member and 90 days in respect of a least-developed country Member before the expiration of the original definitive implementation date or that date as subsequently extended.

4. The Committee shall give sympathetic consideration to granting requests for extension taking into account the specific circumstances of the Member submitting the request. These circumstances may include difficulties and delays in obtaining assistance and support for capacity building.

ARTICLE 18: IMPLEMENTATION OF CATEGORY B AND CATEGORY C

1. In accordance with paragraph 2 of Article 13, if a developing country Member or a least-developed country Member, having fulfilled the procedures set forth in paragraphs 1 or 2 of Article 16 and in Article 17, and where an extension requested has not been granted or where the developing country Member or least-developed country Member otherwise experiences unforeseen circumstances that prevent an extension being granted under Article 17, self-assesses that its capacity to implement a provision under Category C continues to be lacking, that Member shall notify the Committee of its inability to implement the relevant provision.

2. The Committee shall establish an Expert Group immediately, and in any case no later than 60 days after the Committee receives the notification from the relevant developing country Member or least-developed country Member. The Expert Group will examine the issue and make a recommendation to the Committee within 120 days of its composition.

3. The Expert Group shall be composed of five independent persons that are highly

qualified in the fields of trade facilitation and assistance and support for capacity building. The composition of the Expert Group shall ensure balance between nationals from developing and developed country Members. Where a least-developed country Member is involved, the Expert Group shall include at least one national from a least-developed country Member. If the Committee cannot agree on the composition of the Expert Group within 20 days of its establishment, the Director-General, in consultation with the chair of the Committee, shall determine the composition of the Expert Group in accordance with the terms of this paragraph.

4. The Expert Group shall consider the Member's self-assessment of lack of capacity and shall make a recommendation to the Committee. When considering the Expert Group's recommendation concerning a least-developed country Member, the Committee shall, as appropriate, take action that will facilitate the acquisition of sustainable implementation capacity.

5. The Member shall not be subject to proceedings under the Dispute Settlement Understanding on this issue from the time the developing country Member notifies the Committee of its inability to implement the relevant provision until the first meeting of the Committee after it receives the recommendation of the Expert Group. At that meeting, the Committee shall consider the recommendation of the Expert Group. For a least-developed country Member, the proceedings under the Dispute Settlement Understanding shall not apply to the respective provision from the date of notification to the Committee of its inability to implement the provision until the Committee makes a decision on the issue, or within 24 months after the date of the first Committee meeting set out above, whichever is earlier.

6. Where a least-developed country Member loses its ability to implement a Category C commitment, it may inform the Committee and follow the procedures set out in this Article.

ARTICLE 19: SHIFTING BETWEEN CATEGORIES B AND C

1. Developing country Members and least-developed country Members who have notified provisions under Categories B and C may shift provisions between such categories through the submission of a notification to the Committee. Where a Member proposes to shift a provision from Category B to Category C, the Member shall provide information on the assistance and support required to build capacity.

2. In the event that additional time is required to implement a provision shifted from Category B to Category C, the Member may:

   (a) use the provisions of Article 17, including the opportunity for an automatic extension;

or

(b) request an examination by the Committee of the Member's request for extra time to implement the provision and, if necessary, for assistance and support for capacity building, including the possibility of a review and recommendation by the Expert Group under Article 18;

or

(c) in the case of a least-developed country Member, any new implementation date of more than four years after the original date notified under Category B shall require approval by the Committee. In addition, a least-developed country Member shall continue to have recourse to Article 17. It is understood that assistance and support for capacity building is required for a least-developed country Member so shifting.

ARTICLE 20: GRACE PERIOD FOR THE APPLICATION OF THE UNDERSTANDING ON RULES AND PROCEDURES GOVERNING THE SETTLEMENT OF DISPUTES

1. For a period of two years after entry into force of this Agreement, the provisions of Articles XXII and XXIII of GATT 1994 as elaborated and applied by the Understanding on Rules and Procedures Governing the Settlement of Disputes shall not apply to the settlement of disputes against a developing country Member concerning any provision that the Member has designated in Category A.

2. For a period of six years after entry into force of this Agreement, the provisions of Articles XXII and XXIII of GATT 1994 as elaborated and applied by the Understanding on Rules and Procedures Governing the Settlement of Disputes shall not apply to the settlement of disputes against a least-developed country Member concerning any provision that the Member has designated in Category A.

3. For a period of eight years after implementation of a provision under Category B or C by a least-developed country Member, the provisions of Articles XXII and XXIII of GATT 1994 as elaborated and applied by the Understanding on Rules and Procedures Governing the Settlement of Disputes shall not apply to the settlement of disputes against that least-developed country Member concerning that provision.

4. Notwithstanding the grace period for the application of the Understanding on Rules and Procedures Governing the Settlement of Disputes, before making a request for consultations pursuant to Articles XXII or XXIII of GATT 1994, and at all stages of dispute settlement procedures with regard to a measure of a least-developed country Member, a Member shall give particular consideration to the special situation of least-developed country Members. In this regard, Members

shall exercise due restraint in raising matters under the Understanding on Rules and Procedures Governing the Settlement of Disputes involving least-developed country Members.

5. Each Member shall, upon request, during the grace period allowed under this Article, provide adequate opportunity to other Members for discussion with respect to any issue relating to the implementation of this Agreement.

ARTICLE 21: PROVISION OF ASSISTANCE AND SUPPORT FOR CAPACITY BUILDING

1. Donor Members agree to facilitate the provision of assistance and support for capacity building to developing country and least-developed country Members on mutually agreed terms either bilaterally or through the appropriate international organizations. The objective is to assist developing country and least-developed country Members to implement the provisions of Section I of this Agreement.

2. Given the special needs of least-developed country Members, targeted assistance and support should be provided to the least-developed country Members so as to help them build sustainable capacity to implement their commitments. Through the relevant development cooperation mechanisms and consistent with the principles of technical assistance and support for capacity building as referred to in paragraph 3, development partners shall endeavour to provide assistance and support for capacity building in this area in a way that does not compromise existing development priorities.

3. Members shall endeavour to apply the following principles for providing assistance and support for capacity building with regard to the implementation of this Agreement:

   (a) take account of the overall developmental framework of recipient countries and regions and, where relevant and appropriate, ongoing reform and technical assistance programs;

   (b) include, where relevant and appropriate, activities to address regional and sub-regional challenges and promote regional and sub-regional integration;

   (c) ensure that ongoing trade facilitation reform activities of the private sector are factored into assistance activities;

   (d) promote coordination between and among Members and other relevant institutions, including regional economic communities, to ensure maximum effectiveness of and results from this assistance. To this end:

(i) coordination, primarily in the country or region where the assistance is to be provided, between partner Members and donors and among bilateral and

multilateral donors should aim to avoid overlap and duplication in assistance programs and inconsistencies in reform activities through close coordination of technical assistance and capacity building interventions;

(ii) for least-developed country Members, the Enhanced Integrated Framework for trade-related assistance for the least-developed countries should be a part of this coordination process; and

(iii) Members should also promote internal coordination between their trade and development officials, both in capitals and in Geneva, in the implementation of this Agreement and technical assistance.

(e) encourage use of existing in-country and regional coordination structures such as roundtables and consultative groups to coordinate and monitor implementation activities; and

(f) encourage developing country Members to provide capacity building to other developing and least-developed country Members and consider supporting such activities, where possible.

4. The Committee shall hold at least one dedicated session per year to:

(a) discuss any problems regarding implementation of provisions or sub-parts of provisions of this Agreement;

(b) review progress in the provision of assistance and support for capacity building to support the implementation of the Agreement, including any developing or least-developed country Members not receiving adequate assistance and support for capacity building;

(c) share experiences and information on ongoing assistance and support for capacity building and implementation programs, including challenges and successes;

(d) review donor notifications as set forth in Article 22; and

(e) review the operation of paragraph 2.

ARTICLE 22: INFORMATION ON ASSISTANCE AND SUPPORT FOR CAPACITY BUILDING TO BE SUBMITTED TO THE COMMITTEE

1. To provide transparency to developing country Members and least-developed country Members on the provision of assistance and support for capacity building for implementation of Section I, each donor Member assisting developing country Members and least-developed country Members with the

implementation of this Agreement shall submit to the Committee, at entry into force of this Agreement and annually thereafter, the following information on its assistance and support for capacity building that was disbursed in the preceding 12 months and, where available, that is committed in the next 12 months[22]:

(a) a description of the assistance and support for capacity building;

(b) the status and amount committed/disbursed;

(c) procedures for disbursement of the assistance and support;

(d) the beneficiary Member or, where necessary, the region; and

(e) the implementing agency in the Member providing assistance and support.

The information shall be provided in the format specified in Annex 1. In the case of Organisation for Economic Co-operation and Development (referred to in this Agreement as the "OECD") Members, the information submitted can be based on relevant information from the OECD Creditor Reporting System. Developing country Members declaring themselves in a position to provide assistance and support for capacity building are encouraged to provide the information above.

2. Donor Members assisting developing country Members and least-developed country Members shall submit to the Committee:

(a) contact points of their agencies responsible for providing assistance and support for capacity building related to the implementation of Section I of this Agreement including, where practicable, information on such contact points within the country or region where the assistance and support is to be provided; and

(b) information on the process and mechanisms for requesting assistance and support for capacity building.

Developing country Members declaring themselves in a position to provide assistance and support are encouraged to provide the information above.

3. Developing country Members and least-developed country Members intending to avail themselves of trade facilitation-related assistance and support for capacity building shall submit to the Committee information on contact point(s) of the office(s) responsible for coordinating and prioritizing such assistance and support.

[22] The information provided will reflect the demand driven nature of the provision of assistance and support for capacity building.

4. Members may provide the information referred to in paragraphs 2 and 3 through internet references and shall update the information as necessary. The Secretariat shall make all such information publicly available.

5. The Committee shall invite relevant international and regional organizations (such as the International Monetary Fund, the OECD, the United Nations Conference on Trade and Development, the WCO, United Nations Regional Commissions, the World Bank, or their subsidiary bodies, and regional development banks) and other agencies of cooperation to provide information referred to in paragraphs 1, 2, and 4.

SECTION III

INSTITUTIONAL ARRANGEMENTS AND FINAL PROVISIONS

ARTICLE 23: INSTITUTIONAL ARRANGEMENTS

1 Committee on Trade Facilitation

1.1 A Committee on Trade Facilitation is hereby established.

1.2 The Committee shall be open for participation by all Members and shall elect its own Chairperson. The Committee shall meet as needed and envisaged by the relevant provisions of this Agreement, but no less than once a year, for the purpose of affording Members the opportunity to consult on any matters related to the operation of this Agreement or the furtherance of its objectives. The Committee shall carry out such responsibilities as assigned to it under this Agreement or by the Members. The Committee shall establish its own rules of procedure.

1.3 The Committee may establish such subsidiary bodies as may be required. All such bodies shall report to the Committee.

1.4 The Committee shall develop procedures for the sharing by Members of relevant information and best practices as appropriate.

1.5 The Committee shall maintain close contact with other international organizations in the field of trade facilitation, such as the WCO, with the objective of securing the best available advice for the implementation and administration of this Agreement and in order to ensure that unnecessary duplication of effort is avoided. To this end, the Committee may invite representatives of such organizations or their subsidiary bodies to:

(a) attend meetings of the Committee; and

(b) discuss specific matters related to the implementation of this Agreement.

1.6 The Committee shall review the operation and implementation of this Agreement four years from its entry into force, and periodically thereafter.

1.7 Members are encouraged to raise before the Committee questions relating to issues on the implementation and application of this Agreement.

1.8 The Committee shall encourage and facilitate ad hoc discussions among Members on specific issues under this Agreement with a view to reaching a mutually satisfactory solution promptly.

2 National Committee on Trade Facilitation

Each Member shall establish and/or maintain a national committee on trade facilitation or designate an existing mechanism to facilitate both domestic coordination and implementation of the provisions of this Agreement.

ARTICLE 24: FINAL PROVISIONS

1. For the purpose of this Agreement, the term "Member" is deemed to include the competent authority of that Member.

2. All provisions of this Agreement are binding on all Members.

3. Members shall implement this Agreement from the date of its entry into force. Developing country Members and least-developed country Members that choose to use the provisions of Section II shall implement this Agreement in accordance with Section II.

4. A Member which accepts this Agreement after its entry into force shall implement its Category B and C commitments counting the relevant periods from the date this Agreement enters into force.

5. Members of a customs union or a regional economic arrangement may adopt regional approaches to assist in the implementation of their obligations under this Agreement including through the establishment and use of regional bodies.

6. Notwithstanding the general interpretative note to Annex 1A to the Marrakesh Agreement Establishing the World Trade Organization, nothing in this Agreement shall be construed as diminishing the obligations of Members under the GATT 1994. In addition, nothing in this Agreement shall be construed as diminishing the rights and obligations of Members under the Agreement on Technical Barriers to Trade and the Agreement on the Application of Sanitary and Phytosanitary Measures.

7. All exceptions and exemptions[23] under the GATT 1994 shall apply to the provisions of this Agreement. Waivers applicable to the GATT 1994 or any part thereof, granted according to Article IX:3 and Article IX:4 of the Marrakesh Agreement Establishing the World Trade Organization and any amendments thereto as of the date of entry into force of this Agreement, shall apply to the provisions of this Agreement.

8. The provisions of Articles XXII and XXIII of GATT 1994 as elaborated and applied by the Dispute Settlement Understanding shall apply to consultations and the settlement of disputes under this Agreement, except as otherwise

[23] This includes Articles V:7 and X:1 of the GATT 1994 and the *Ad* note to Article VIII of the GATT 1994.

specifically provided for in this Agreement.

9. Reservations may not be entered in respect of any of the provisions of this Agreement without the consent of the other Members.

10. The Category A commitments of developing country Members and least-developed country Members annexed to this Agreement in accordance with paragraphs 1 and 2 of Article 15 shall constitute an integral part of this Agreement.

11. The Category B and C commitments of developing country Members and least-developed country Members taken note of by the Committee and annexed to this Agreement pursuant to paragraph 5 of Article 16 shall constitute an integral part of this Agreement.

ANNEX 1: FORMAT FOR NOTIFICATION UNDER PARAGRAPH 1 OF ARTICLE 22

Donor Member:
Period covered by the notification:

Description of the technical and financial assistance and capacity building resources	Status and amount committed/disbursed	Beneficiary country/ Region (where necessary)	The implementing agency in the Member providing assistance	Procedures for disbursement of the assistance

Appendix 2:

Doha Ministerial Declaration (adopted on 14 November 2001)

TRADE FACILITATION

27. Recognizing the case for further expediting the movement, release and clearance of goods, including goods in transit, and the need for enhanced technical assistance and capacity building in this area, we agree that negotiations will take place after the Fifth Session of the Ministerial Conference on the basis of a decision to be taken, by explicit consensus, at that Session on modalities of negotiations. In the period until the Fifth Session, the Council for Trade in Goods shall review and as appropriate, clarify and improve relevant aspects of Articles V, VIII and X of the GATT 1994 and identify the trade facilitation needs and priorities of Members, in particular developing and least-developed countries. We commit ourselves to ensuring adequate technical assistance and support for capacity building in this area.

Appendix 3:

Decision of the Doha Work Programme (WT/L/579) Annex D

Modalities for Negotiations on Trade Facilitation

1. Negotiations shall aim to clarify and improve relevant aspects of Articles V, VIII and X of the GATT 1994 with a view to further expediting the movement, release and clearance of goods, including goods in transit (4). Negotiations shall also aim at enhancing technical assistance and support for capacity building in this area. The negotiations shall further aim at provisions for effective cooperation between customs or any other appropriate authorities on trade facilitation and customs compliance issues.

2. The results of the negotiations shall take fully into account the principle of special and differential treatment for developing and least-developed countries. Members recognize that this principle should extend beyond the granting of traditional transition periods for implementing commitments. In particular, the extent and the timing of entering into commitments shall be related to the implementation capacities of developing and least-developed Members. It is further agreed that those Members would not be obliged to undertake investments in infrastructure projects beyond their means.

3. Least-developed country Members will only be required to undertake commitments to the extent consistent with their individual development, financial and trade needs or their administrative and institutional capabilities.

4. As an integral part of the negotiations, Members shall seek to identify their trade facilitation needs and priorities, particularly those of developing and least-developed countries, and shall also address the concerns of developing and least-developed countries related to cost implications of proposed measures.

5. It is recognized that the provision of technical assistance and support for capacity building is vital for developing and least-developed countries to enable them to fully participate in and benefit from the negotiations. Members, in particular developed countries, therefore commit themselves to adequately ensure such support and assistance during the negotiations.

6. Support and assistance should also be provided to help developing and least-developed countries implement the commitments resulting from the negotiations, in accordance with their nature and scope. In this context, it is recognized that negotiations could lead to certain commitments whose implementation would require support for infrastructure development on the part of some Members. In these limited cases, developed-country Members will make every effort to ensure support and assistance directly related to the nature and scope of the commitments in order to allow implementation. It is understood, however, that in cases where required support and assistance for such infrastructure is not forthcoming, and where a developing or least-developed Member continues to lack the necessary capacity, implementation will not be required. While every effort will be made to ensure the necessary support and assistance, it is understood that the commitments by developed countries to provide such support are not open-ended.

7. Members agree to review the effectiveness of the support and assistance provided and its ability to support the implementation of the results of the negotiations.

8. In order to make technical assistance and capacity building more effective and operational and to ensure better coherence, Members shall invite relevant international organizations, including the IMF, OECD, UNCTAD, WCO and the World Bank to undertake a collaborative effort in this regard.

9. Due account shall be taken of the relevant work of the WCO and other relevant international organizations in this area.

10. Paragraphs 45-51 of the Doha Ministerial Declaration shall apply to these negotiations. At its first meeting after the July session of the General Council, the Trade Negotiations Committee shall establish a Negotiating Group on Trade Facilitation and appoint its Chair. The first meeting of the Negotiating Group shall agree on a work plan and schedule of meetings.

Appendix 4:

Hong Kong Ministerial Declaration (adopted on 18 December 2005)

33. We recall and reaffirm the mandate and modalities for negotiations on Trade Facilitation contained in Annex D of the Decision adopted by the General Council on 1 August 2004. We note with appreciation the report of the Negotiating Group, attached in Annex E to this document, and the comments made by our delegations on that report as reflected in document TN/TF/M/11. We endorse the recommendations contained in paragraphs 3, 4, 5, 6 and 7 of the report.

Annex E: Trade Facilitation

Report by the Negotiating Group on Trade Facilitation to the TNC

1. Since its establishment on 12 October 2004, the Negotiating Group on Trade Facilitation met eleven times to carry out work under the mandate contained in Annex D of the Decision adopted by the General Council on 1 August 2004. The negotiations are benefiting from the fact that the mandate allows for the central development dimension of the Doha negotiations to be addressed directly through the widely acknowledged benefits of trade facilitation reforms for all WTO Members, the enhancement of trade facilitation capacity in developing countries and LDCs, and provisions on special and differential treatment (S&DT) that provide flexibility. Based on the Group's Work Plan (TN/TF/1), Members contributed to the agreed agenda of the Group, tabling 60 written submissions sponsored by more than 100 delegations. Members appreciate the transparent and inclusive manner in which the negotiations are being conducted.

2. Good progress has been made in all areas covered by the mandate, through both verbal and written contributions by Members. A considerable part of the Negotiating Group's meetings has been spent on addressing the negotiating objective of improving and clarifying relevant aspects of GATT Articles V, VIII and X, on which about 40 written submissions1 have been tabled by Members representing the full spectrum of the WTO's Membership. Through discussions on these submissions and related questions and answers (JOB(05)/222), Members have advanced their understanding of the measures in question and are working towards common ground on many aspects of this part of the negotiating mandate. Many of these submissions also covered the negotiating objective of enhancing technical assistance and support for capacity building on trade facilitation, as well as the practical application of the principle of S&DT. The Group also discussed other valuable submissions dedicated to these issues2. Advances have also been made on the objective of arriving at provisions for effective cooperation between customs or any other appropriate authorities on trade facilitation and customs compliance issues, where two written proposals have been discussed3. Members have also made valuable contributions on the identification of trade facilitation needs and priorities, development aspects, cost implications and inter-agency cooperation4.

3. Valuable input has been provided by a number of Members in the form of national experience papers5 describing national trade facilitation reform processes. In appreciation of the value to developing countries and LDCs of this aspect of the negotiations, the Negotiating Group recommends that Members be encouraged to continue this information sharing exercise.

4. Building on the progress made in the negotiations so far, and with a view to developing a set of multilateral commitments on all elements of the mandate, the Negotiating Group recommends that it continue to intensify its negotiations on the basis of Members' proposals, as reflected currently in document TN/TF/W/43/Rev.4, and any new proposals to be presented. Without prejudice to individual Member's positions on individual proposals, a list of (I) proposed measures to improve and clarify GATT Articles

V, VIII and X; (II) proposed provisions for effective cooperation between customs and other authorities on trade facilitation and customs compliance; and, (III) cross-cutting submissions; is provided below to facilitate further negotiations. In carrying out this work and in tabling further proposals, Members should be mindful of the overall deadline for finishing the negotiations and the resulting need to move into focused drafting mode early enough after the Sixth Ministerial Conference so as to allow for a timely conclusion of text-based negotiations on all aspects of the mandate.

5. Work needs to continue and broaden on the process of identifying individual Member's trade facilitation needs and priorities, and the cost implications of possible measures. The Negotiating Group recommends that relevant international organizations be invited to continue to assist Members in this process, recognizing the important contributions being made by them already, and be encouraged to continue and intensify their work more generally in support of the negotiations.

6. In light of the vital importance of technical assistance and capacity building to allow developing countries and LDCs to fully participate in and benefit from the negotiations, the Negotiating Group recommends that the commitments in Annex D's mandate in this area be reaffirmed, reinforced and made operational in a timely manner. To bring the negotiations to a successful conclusion, special attention needs to be paid to support for technical assistance and capacity building that will allow developing counties and LDCs to participate effectively in the negotiations, and to technical assistance and capacity building to implement the results of the negotiations that is precise, effective and operational, and reflects the trade facilitation needs and priorities of developing countries and LDCs. Recognizing the valuable assistance already being provided in this area, the Negotiating Group recommends that Members, in particular developed ones, continue to intensify their support in a comprehensive manner and on a long-term and sustainable basis, backed by secure funding.

7. The Negotiating Group also recommends that it deepen and intensify its negotiations on the issue of S&DT, with a view to arriving at S&DT provisions that are precise, effective and operational and that allow for necessary flexibility in implementing the results of the negotiations. Reaffirming the linkages among the elements of Annex D, the Negotiating Group recommends that further negotiations on S&DT build on input presented by Members in the context of measures related to GATT Articles V, VIII and X and in their proposals of a cross-cutting nature on S&DT.

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