The selection of the International Port Design Standards applicable for Indonesia

I W Dyah1* and Fuddoly1
1 Department of Civil Engineering, Institut Teknologi Sepuluh Nopember (ITS), ITS Campus, Keputih, Sukolilo, Surabaya, East Java, Indonesia 60111

*Corresponding author’s email: dyah@ce.its.ac.id

Abstract. As of today, almost all the engineer, experts, and student in Indonesia face confusion and edginess concerning designing of Port Infrastructure, mainly due to the absence of a design Standards legally valid for domestic purpose. On the other hand, several standards or guide lines or codes are available and internationally recognized and applied in many places for many years solely without unaffiliated standards. 3 (three) International standards are selected for evaluation to be thoroughly adapted to the Design Standards of Indonesia are British Standards (BS 6349), the German Standards (EAU 2004), and the Standards Design Criteria for Port and Harbor in Japan (OCDI, 2009). The criteria applied during evaluation and selection process based on the observation output from about 300 selected projects within Indonesia. Finally, the British Standards proved to give the best matched for the condition of Indonesia.

1. Introduction
Indonesia controls 1,905,000 km² area with two-thirds consist of sea water and the number of islands reach about 16,000. Variations of islands size and spread of port functions for each points considered exceptional by any standards. Here, Port variation in all cases wide open to be grouped or make a simple categorization. It reflects a high the demand for new port as well as maintaining the available port over the coast of Indonesia

Some drawbacks often found in the field of port infrastructure in Indonesia are:

a) The design used mixed or unknown Standards of design without legal consequences.
b) Procurement process implements incorrect procedures.
c) The life of the structure is very short.
d) The construction considered made of low workmanship as well as the materials.
e) Ignorance to the maintenance works

The design phase considered as source and lead to further distortions. Pertinent to the availability of valid Standard related to government regulation considered urgent. The implementation and connection to the legal basis from any digressions requires immediate actions.

As of today, lack of discussion and research concerning the standard applicable particularly to Indonesia. The comparison study on the port design standard using International code of practice for jetty or other port structure in Indonesia are few or almost none.

There are several standards for Port Design and planning valid internationally. The designer, engineer and university students in Indonesia most frequently apply 3 (three) standards of Port Design specifically the British Standards, the German Standards, and the Japan Standards. Therefore these standards selected and recommended as the best candidate to be the Indonesian Standards. The selection will be
based on some key criteria. And each criteria is selected based on the observation and research output from more than 300 port project locations scattered all over Indonesia covering various function of terminal as well as type of structure particularly jetty, breakwater, dredging and reclamation.

The criteria will be weighted based on level of urgency and the extent of the impact to the output of the design or to the finished structure. The score of each criteria split in to four (4) due to the relatively broad and general overview given to each criteria. The worst situation or insufficient receives score 1, moderate (sufficient but not complete) earn score of 2, Good or complete will earn score of 3, and the Best means complete and easy to follow will earn 4. Recommendation will be withdrawn considering the highest weight-score from each standards.

2. Purpose and benefit of the research
The purpose of the research are to give idea on the necessity of Indonesia Standard for Port Design to be prepared as soon as possible and accelerate the implementation with legal basis elaborate government regulations or ministerial regulation or published as special book of Indonesian Standards for Port.

The benefit will more in effect to the implementation of the use of the Standards. We can expect for the design to be more accountable, to open more opportunity to the involvement of other expertise, and especially in the field of education will direct the course material straight to the Standards.

3. The Selection Criteria
As previously mentioned, there will be three (3) standards to be evaluated here are:
1) “British Standards - Maritime Structures”, BS 6349 part 1 to 8 (abbreviated as BS 6349).
2) “Recommendations of the Committee for Waterfront Structures, Harbours and Waterways”, EAU 2004 (abbreviated as EAU 2004).
3) “Technical Standards for Port and Harbor Facilities in Japan”, OCDI, 2009 (abbreviated as OCDI, 2009).

The criteria to be applied for the selection of the standards is chosen based on the most significant requirement for designing of Port facilities in Indonesia especially considering the weakness or the problem appear in Indonesia. Priority scale put on to weight the criteria as follows:
1) The overall coverage and detail guidance
   The overall coverage and detail guidance considered essential for any standards to give clear guidelines to the users. It shall consist of the various possibility of type of structure and the future change. The extensive interrelation to other standards or guide lines bring positive merit. Certain detail of directions considered advantageous to most user in Indonesia especially to reduce disputes.
   The weight for this case is 25.

2) The design procedures and the load patterns
   This criteria regarded as deliberately crucial to be adopted in the Standards of Port Design in Indonesia. It is due to the fact that mostly during design the port facilities, that designer faced with the dilemma to follow or to freely apply certain design Standards without legal basis. The liability to any options
   As well as the load patterns, several experts and designer meet the conflict to other standards applicable widely in design structure in Indonesia. Confusion of the designer often occur concerning The confusing application of several different standards lead to several problems concerning inefficiency of the structure, over or under design, the load pattern shall be adopted in strictly in accordance to the Standards individually.
   The weight for this case is 20.

3) The construction life time and the safety factors
   As the most susceptible elements found on the structure in the sea environment, the age of the port structure in average reach about 12 years. The actual design life time mostly unknown but
about 20% stated for 30 years. The reality of the structure shows difference to the expected life span from the feasibility study.
The weight for this case is 20.

4) The formula to calculate the all structure components
The confusion and uncertainty as well as the topic of discussion and criticism occur to about 90% of the design. And the case of failure or subject of findings of audit institutions. Most cases deal with problem the use of Standards applicable of other structures state suitability only for certain type of structure (including building and bridge) other than port or sea water environment. Some standards did not covering all part of the structure in the terminal or other coastal structures. The weight for this case is 20.

5) The Monitoring and inspections
The monitoring or supervision and the inspection phase determine the quality, time and cost of construction in Indonesia. 60% of the port projects face with detention problems. Tracing the root of this obstacle shows due to unavailability of explicit and literally exact phrase as well as inconsistency of the monitoring and inspections documents. Evaluation shall examining the detail and overage of the guideline for monitoring and inspection to be performed during construction phase. The weight for this case is 15.

4. The Evaluation of the Standards
Each criteria rated and evaluated concerning the suitability of the standards to the environment and to the common practice of the society of designer in Indonesia. Each criteria will be juxtaposed to each Standards, 15 points of review has been thoroughly examined to meet the best score. Evaluation mainly focused to the suitability of the standards on the environment and to the common practice of the society of designer here are as follows:

The overall coverage and detail guidance
a) BS 6349
This Standards regularly overviewed and revised adapting the latest information and development in area of knowledge. This is a multi-part document divided into the following parts:
1. Part 1 Maritime structures. General criteria
   Part 1-1 Maritime works. General. Code of practice for planning and design for operations
   Part 1-2 Maritime works. General. Code of practice for assessment of actions
   Part 1-3 Maritime works. General. Code of practice for geotechnical design
   Part 1-4 Maritime works. General. Code of practice for materials
2. Part 2 Maritime structures. Design of quay walls, jetties and dolphins
3. Part 3 Maritime structures. Design of dry docks, locks, slipways and shipbuilding berths, ship lifts and dock and lock gates
4. Part 4 Maritime structures. Design of fendering and mooring systems
5. Part 5 Maritime structures. Code of practice for dredging and land reclamation
6. Part 6 Maritime structures. Design of inshore moorings and floating structures
7. Part 7 Maritime structures. Guide to the design and construction of breakwaters
8. Part 8 Maritime structures. Code of practice for the design of Ro-Ro ramps, linkspans and walkways
The scope and coverage of this Standards comprise of 90% of the type of structure to protect coast and port operation.
The score given to this standards is 4.

b) EAU, 2004
This Standard rarely overviewed and revised. And the document comes in one thick book. The latest version published in 2005 as 8th edition to EAU, 2004.
Table of contents of the document shows the coverage of the guidance to the demand on the port infrastructure as follows:
1. Statical calculations
2. Subsoil
3. Active and passive earth pressures
4. Overall stability, foundation failure and sliding
5. Water levels, water pressure, drainage
6. Ship dimensions and loads on waterfront structures
7. Configuration of cross-section and equipment for waterfront structures
8. Earthwork and dredging
9. Sheet piling structures
10. Anchor piles and anchors
11. Waterfront structures, quays and superstructures of concrete
12. Piled structures
13. Embankments
14. Dolphins
15. Experience with waterfront structures
16. Monitoring and inspection of waterfront structures in seaports

The scope and coverage of this Standards comprise of 80% of the type of structure to protect coast and port operation with document systematic referring to the basic knowledge mix with structure function. This systematic less familiar to most designer in Indonesia with the tendency to approach based on package of works to be tendered such as Jetty works, Dredging works, etcetera.

The score given to this standards is 3.

c) OCDI, 2009
This standard provides a single thick document of 1028 pages, with systematic as follows:
Part I: General
Part II: Actions and Material Strength Requirements
Part III: Facilities
Each part give comment or explain all matter in detail covering almost 85% port facilities.
The reference adopting various countries design Standards.
The score given to this standards is 3.

The design procedures and the load patterns

a) BS 6349
The most common type of port structure in Indonesia is Jetty. In this design standards, introduced as suspended deck structures various configuration of pile foundation, see Figure 1 and Figure 2. The bridge between berth and land side introduced as trestle which is commonly term for such part.
The type of structure as in Figure 1 bring to flexible type of structure to allow rather substantial deformation when extensive horizontal force working on. On the other hand Figure 2 gives rigid structure to resist large horizontal force.
Both type of jetty or berth structure extensively adopted in Indonesia reach about 70% of total type of structure as observed.

The design procedure in systematical order is not available but sequence of discussion in sub chapter lead to design procedure. The sub chapter started with selection concerning type of structure, type of pile foundation, type of upper structure, design method, loadings, design of sub structure (pile) and structure tolerances. In sub chapter 8.10.1, shows configuration principle for the pile to withstand the upper loading to cause on pile deformation. Limited value of deformation recommended to adjoin the capacity of the elastic deformations of the pile.

The load working on the structure classified as:

i. Self weight and imposed load
ii. Horizontal actions
iii. Environmental actions

The load scale determined in conjunction to other British Standard. Load combination inter related to load safety factor calculated based on probability of event. Generally loading grouped into normal situation, extreme situations, and temporary load. Detail factor linked to the load is tabulated incorporate almost the entire possibility of load type and the occurrence of load to take place.

It is concluded that guidance on load is thorough and complete.

The score given to this standards is 4.
b) EAU, 2004

The calculation procedure step by step is not available for overall structure. In the case of Jetty introduced as *General Pile-founded Structures (R 157)*. The design procedure available of each part of the structure such pile foundation, beam and slab.

EAU, 2004 discuss quite extensive about structure of Free-standing, high pile-founded structures, Statical System and Calculation, including Structural Advice. Clear recommendation concerning the pile position can not be found but simply that joint to each beam required pile support.

Complete guidance found related to general guide to determine beam for crane position, longitudinal beam as well as the lateral beam or portal including position of beam for fender and bollard. The suggested typical structure of pier or jetty as in **Figure 3**.

![Figure 3](image)

**Figure 3.** Example of port pier system using reinforced cement concrete or RCC and concrete piles [11].

Safety factor partially applicable for load categorized into three (3) cases including:
- Load case 1 for load due to active soil
- Load case 2 for load due to scouring, water pressure difference, water suction passing through vessel, active pressure of extra ordinary soil load, bollard pull and fender pressure, and temporary load during construction phase.
- Load case 3 considered equal to load case 2 with additional load for the possibility of drainage failure, unexpected wave forces and possible over load precious unpredicted.

Multiplier factor to load cases categorized as partial safety factor. Another multiplication applied the load factor for the overall structure with relatively low number.

The score given to this standards is 3.

c) OCDI, 2009

OCDI, 2009, introduced the term of jetty similar to breakwater. The Jetty as common practice in Indonesia grouped as Open-type wharves, see “Part VIII Mooring Facilities”. 2 type of structure for berthing a vessel are the open-type wharves on vertical piles and the open-type wharves with coupled raking piles, see **Figure 4**.

Compared to 80% of jetty structure configuration found in the 400 locations, rather obvious difference can be directly recognized especially the use of low vertical wall or gravity wall along the shore and the absence of trestle.
Design procedure and the flow chart for open-type wharves on vertical available in detail explaining step by step the process including the loop or control as required at certain step.

The load is grouped into vertical and horizontal load and described in detail. The load variety considered sufficient and covers the entire possible loads. However, it is found that regarding the load due to cargo stacked on the berth, as common practice in Indonesia, ignored.

The load factor as part of safety factor separated into 3 types are permanent load, variable load, and accidental load. The scale factor presented in a table and simply straight appointed as a set of load combination.

The score given to this standards is 3.

The construction life time and the safety factors

The determination of the structure age or life span shall take into account the feasibility of the project and the benefit generated by the purpose or the role of the port to the industry. The stretch especially in the reduction regime of service time most probable bring to loss of profit. The use of Standard or guidelines expected to help maintain the design life time or age of the structure. Safety factor (F) principally to obtain the Resistance capacity (R) of the material as part of the structure higher than the forces working on the material or the Solicitation part (S). The fraction of R to S is the safety factor. By exaggeration of each side both R and S still has to lead R/S ≥ F. When R and S each applying the safety factor it may lead to extra safe condition.

a) BS 6349

Recommendation of construction life time is 50 years with consequences in several parts as follows:

i. Factor of the running time to the safety of the structure considering fatigue loading, corrosion, marine growth and reduction to soil capacity.

ii. Probability level applied in boundary number for the design and in determining the return period or recurrence interval.

iii. Economic feasibility of the project and the future development.

Practical recommendations available in this Standard concerning the vehicle or equipment load shall adjust to the latest technology progress during the life time of the construction. The wave forces, tide and current shall apply maximum magnitude during the life time. Safety factor related to the life time has been applied at the calculation of factor of fatigue, durability including the equation preferably to be used, one example shown in BS 6349 Part 1 sub chapter 39 and section 7.
Conclusion concerning the life time of the structure has been comprehensively discussed in BS 6349. The application of life time also applied in the material requirement. The use of this Standard estimated to maintain the structure aged as designed.

The theory behind safety factor introduced in BS 6349 considered unclear. The safety factor mixed in some parts with the life time of structure. The safety factor clearly stated in the load combinations.

The safety factor explain in part 1 and 2 considered relatively detail. The safety refers to the action measure both during construction as well as operational such as fire fighting, road access in emergency stage, emergency response and the safety equipment including the requirement of speed-of-approach monitoring aids. The deformation limit given with limit value.

The safety factor considered less thorough and need more focus to the structure. The safety factor applicable for load combination, and the structure life time considered complete.

The score given to this standards is 3.

b) EAU, 2004

The construction life time applied to the pile concerning corrosion prevention as long as 60 years. For RCC in conjunction to the density of the concrete, type of cement, thickness of concrete decking suggested for 50 years. The structure continuously monitored yield to service life computed starting from the date of operation.

Average service life of the structure at several buildings discussed in R 46, it shows that port structure shorter in life time compare to buildings and better maintenance, and revitalization in regular basis including deepening and spare parts change.

The principle to determine safety factor is based on the stochastic approach to determine the probability of the Resistance (R) value and the Solicitation (S) value.

The structure failure as the result of exceeded value of the limit state or known as Limit State 1 (LS 1), in the form of failure at the foundation or the building. The exceedance to the limit state of the serviceability known as Limit State 2 (LS 2) in the form of over in deformation. F taken based on experience and adopt the Erope Code. Partial safety factor still applicable specific structure such as quaywall or wharf.

The safety factor for the Bearing Capacity applicable by assuming each pile as Individual pile. And partial safety factor for loads is separated in 3 Load Cases as LC 1, LC 2, and LC 3 using Ultimate Limit State (ULS).

The application of load factor in load combination depends on safety level, load combination and the load cases. The F for individual pile in LC 1, LC 2, LC 3 each yield to 1.4, 1.2, and 1.1. For jetty, the load cases suggested only of LC 2.

Deformation and fatigue of the structure give less impact.

The safety factor application considered quite clear.

The score given to this standards is 4.

c) OCDI, 2009

In Part II, the structure life time suggested to be determined considering functional operability of the facilities, economic value, functional role to the society, and physical characteristic. Encounter probability is elaborated to compares with life time and the recurrence interval.

The material selection determined apply the structural life time. The life time also connected to the earthquake calculation (see 2.2 as in OCDI, 2009) and damage level of the structure (see 5.3 in OCDI, 2009).
Safety to the structure based on empirical approach. The boundary value considered as the best approach at the limit state separated into ultimate limit state, serviceability limit state, and the fatigue limit state.

Partial safety factor as in the material factor, load factor, structural analysis factor (the number factor), and the structural factor.

The deformation problems more for the deformation at the foundation not at the state limit of the structure.

The safety factor has been thoroughly examined but unclear about the basic assumption.

The score given to this standards is 3.

**The formula to calculate the structure components**

The approach to the equation or formula applicable to the design help significantly to reduced the design error.

a) BS 6349

The Standards provide complete equation and formula connected to different series of Standard. The equation for technical calculation in conjunction to the bearing capacity (for example) mentioned in separate Standards. Equation related to the life time of construction is available in the same document of BS6349. Most equation related to the port design presented in separate standards.

The score given to this standards is 4.

b) EAU, 2004

The formula and equation available in one book, especially to the basic computation and the safety factors. Technical equation on bearing capacity and deep foundation is available in the separate document. The limit value for each part did not clearly stated.

The score given to this standards is 3.

c) OCDI, 2009

The formula available at limited application but covering extended topics. For example bearing capacity calculation limited to certain type of soil but extensively cover detail of corrosion prevention.

The equation for waterways layout available in complete.

The score given to this standards is 4.

**The Monitoring and inspections**

a) BS 6349

The *supervision* discussed in one with the structure as well as part of the structure for example point 52 and 59. No specific quantity concerning the volume or time to be supervised. *Monitoring* mean at the supervision during construction to certain part of the project for example the foundation issue such as land slides.

Time and time interval of supervision and monitoring not specifically determined.

The score given to this standards is 3.
b) EAU, 2004

This Standards include the construction methods and inspection during construction phase, including the monitoring procedure as in R 193.

Dimension of each part, loading and safety factor focused on the wharf structure as in 6.2.1, R 118, R 209, R 86.

Inspection during construction to check the entire movement of the structure especially:
- Alignment
- Leveling
- And deflections.

Monitoring proceed during construction for fabrication component of the structure such as in 8.1.8.4 and in R 195.

Some pint in inspection and monitoring work explained in complete including the record, report and inspection interval.

The score given to this standards is 4.

c) OCDI, 2009

Monitoring recommended for some parts of the structure. For example the pile joints shall be in lien with inspection works. Monitoring suggested for the entire reclamation works. The inspection suggested periodically done during maintenance phase. No guideline concerning supervision to the entire works, inspection periodically applicable for lighting and other small facility.

The score given to this standards is 4.

5. Conclusion and Recommendation

Conclusion to the three Standard as presented in Table 1 shows that the British Standard gives the best conformity for Indonesian Standard.

| Criteria                                | BS 6349 | EAU, 2004 | OCDI, 2009 |
|-----------------------------------------|---------|-----------|------------|
| The overall coverage and detail guidance | 25 x 4  | 25 x 3    | 25 x 3     |
| The design procedures and the load patterns | 20 x 4  | 20 x 3    | 20 x 3     |
| The construction life time and the safety factors | 20 x 3  | 20 x 4    | 20 x 3     |
| The formula to calculate the all structure components | 20 x 4  | 20 x 3    | 20 x 4     |
| The Monitoring and inspections         | 15 x 3  | 15 x 4    | 15 x 4     |
| Total                                  | 365     | 335       | 335        |

Recommendation concerning further detail shall be focused to British Standard.

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