Curtin University

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42nd AUBEA CONFERENCE 2018

Australasian Universities Building Education Association (AUBEA)

EDUCATING BUILDING PROFESSIONALS FOR THE FUTURE IN THE GLOBALISED WORLD

INNOVATION

VOLUME 1

Editors:
Associate Professor Khoa Do
Associate Professor Monty Sutrisna
Mr Barry Cooper-Cooke
Dr Oluwole (Alfred) Olatunji

AUBEA

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26 - 28 September 2018

Singapore

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ACKNOWLEDGEMENTS

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Vice Dean (Academic), School of Design and Environment, National University Singapore

Professor Peter Newman
John Curtin Distinguished Professor, School of Design & the Built Environment,Curtin

Professor Low Sui Pheng
Professor School of Design and Environment, National University Singapore

Professor Robert Amor
Head of Department, Dept. of Computer Science, University of Auckland

Scientific Committee

Full papers accepted for publishing in the Conference Proceedings are subject to a blind peer review process. The 2018 Conference Committee gratefully acknowledges the generous work of the reviewers, who provide constructive and invaluable feedback within tight time frames to ensure the high standard of published papers. A full list of scientific committee is published on page x.

PREFACE

PROFESSOR CHRIS MORAN

Deputy Vice-Chancellor, Research

Over the last decade, Curtin University has grown from a research-capable university dominated by teaching into an innovative university increasingly recognised for research excellence. We have capitalised on our strong foundations of technical and applied research. We have used our relationships with key industry and Government partners to build impactful research collaborations. But equally important to our success has been our emphasis on innovation, knowledge-sharing and translating research into tangible benefits for society.

The benefits of this hard work and focus are there for all to see. Curtin now ranks in the top 1% of universities worldwide. This year, we were ranked 181st in the world in the Academic Rankings for World Universities. Ten years ago, we hadn't cracked the Top 500.

But we are not content to rest there. Looking forward, our Research Strategy seeks to position Curtin as a strong technical and translation university. To do this, we must excel at connecting the university to the external environment to deliver value. We must continue to innovate and be agile in a time of digital disruption, rapid technological change and globalisation.

Innovation is more than just ways of doing, it is also ways of being - being flexible; being opportunistic; being collaborative; being agile; being ready; and being willing to take calculated risks.

Curtin is proud to support the Australasian Universities Building Education Association (AUBEA) as it continues to prepare building professionals for a rewarding career in an increasingly global industry. Innovation is an important part of this preparation, providing resilience in the face of significant challenges; opportunities in disruption; and success through collaboration. By linking Sustainability, Innovation and Technology, the 2018 AUBEA Conference weaves together elements of the vision, principles, practices and tools that can help sculpt the building professionals of tomorrow.

Congratulations to the Conference Organising Committee, Scientific Committee, Stream Experts, and Conference Convenors on pulling together a quality program for this, the 42nd Annual AUBEA Conference.

FOREWORD FROM THE CHAIR

ASSOCIATE PROFESSOR MONTY SUTRISNA

Chair of AUBEA 2018 Conference

It is with great delight I am writing this introduction for AUBEA 2018 Conference proceeding. Throughout the long history from its formation in 1975, AUBEA has been convening annual conferences successfully. This 42nd AUBEA conference, however, is the first AUBEA conference held in the Asia region. This represents the recognition of the significant roles played by the Asian region in the global building industry and building education. As soon as we received the mandate to host this conference, the organising committee immediately considered Singapore as a potential venue for the conference. Singapore as a place has inspired us to articulate the theme of this conference as: "Educating Building Professionals for the Future: Innovation, Technology and Sustainability in the Globalised Market". The theme embodies characteristics, challenges and opportunities facing the building education sector at the current time and beyond. We all know that the very nature of our building education sector calls for in-depth collaboration between industry and academia to educate building professionals fit for the future. Industry and academia are shaping the future of the profession together and it is highly celebrated in this conference through the selection of the prominent keynotes and stream experts, as well as the highly interactive conference programme.

I would like to take this opportunity to show my gratitude to my colleagues in the organising committee who have been working very hard to make this conference a reality. On behalf of the organising committee, I would also like to thank the AUBEA Council for entrusting us with the mandate to host the conference and also to show appreciation to the sponsors and partners of this conference that has supported the conference. We also would like to acknowledge the important contribution from the scientific reviewers who have been generously donating their time to review abstracts and full papers submitted to this conference to ensure the quality of the papers accepted, as well as the session chairs who are instrumental to the success of the delivery of the paper presentation sessions.

Last but not least, it is our aim to recognise excellence. Therefore, the organising committee have also set up various scholarships and awards in this conference. We have set up the AUBEA 2018 conference to provide a conducive environment and a platform for industry and academia to further collaborate in educating building professionals for the future. On behalf of the organising committee I would like to thank delegates for joining us in this celebration of learning and participating in this exciting conference.

KEYNOTE SPEAKERS

MR PHIL LAZARUS

Architect | MBA
Digital Practice Leader,
Aurecon | Asia

Keynote Address
Bring Ideas to Life through Applied Technology in Engineering

Mr Phil Lazarus is an American Architect with over 20 years of experience leveraging the power of BIM on behalf of architects, engineers, contractors and clients. Involved with Singapore's largest developments since 2006, Phil has been leading the charge in promoting technology based innovation throughout Asia.In his current role as Aurecon's Digital Practice Leader, Phil oversees the activities of over 200 digital engineering staff. He leads Aurecon's Singapore-based Centre of Digital Excellence; exporting best practices for Digital Implementation to operations in Hong Kong, Thailand, Vietnam, China, and Indonesia.

PROF WILLIE TAN

Head, Department of Building I National University of Singapore

Keynote Address
Educating for the future in Construction: An institutional perspective

Professor Willie Tan is Head of Department, Department of Building, School of Design and Environment (SDE), National University of Singapore (NUS). He was the Program Director of the MSc(Project Management) program (2003-13) and Co-Director of the Center for Project Management and Construction Law (2005-7). He is an editorial board member of the International Journal of Project Management and Infrastructure Asset Management, among others. Professionally, he has chaired visit panels for Project Management Institute's (PMI) Global Accreditation Center to accreditate university programs in project management. He has served as a consultant in project management and infrastructure development in many countries in Asia and the Middle East.

MR JOHN ANDERSON

Executive General Manager | John Holland's South East Asia

Keynote Address
Construction Industry in the Globalised Market

Mr John Anderson is the Executive General Manager for John Holland's South East Asia business region and has more than 20 years' engineering experience gained through his work in Vietnam, Indochina, Sudan, Hong Kong, Singapore, Australia and Indonesia. His engineering experience includes civil and building construction, marine construction, environmental protection, structural-steel work, traffic management, viaduct construction, land/marine-foundation works, and planning and overall site coordination.

CONFERENCE THEMES

Educating Building Professional for the Future in the Globalised World

The overarching theme of the 2018 AUBEA Conference is 'Educating Building Professionals for the Future in the Globalised World' in recognition of the multiple and complex demands placed on assessment in higher education. Some of these challenges are long standing, such as those relating to continuously synchronising education and industry practice. Other challenges are emerging as national priorities, funding arrangements and policy frameworks change.

The THREE streams:
1. Innovation
2. Technology
3. Sustainability

Stream Experts

Professor Joseph Ooi,
Vice Dean (Academic), School of Design and Environment, National University Singapore

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John Curtin Distinguished Professor, School of Design & the Built Environment,Curtin

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Professor School of Design and Environment, National University Singapore

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Head of Department, Dept. of Computer Science, University of Auckland

Mr Barry Copper-Cooke

Dr Oluwole (Alfred) Olatunji

Leads, INNOVATION Stream
Curtin University, Australia

Innovation and Science Australia (ISA) indicated in the Australia 2030 "Prosperity Through Innovation" report that innovation was "fresh thinking that creates value". It went on to state, "Australia is in a $1.6 trillion global innovation race" and identified five imperatives for action by government. At the centre of these imperatives was culture and ambition, surrounded by government, industry, education and research and development. While there is not the space to go into the finer detail of each of these imperatives it is clear that the participants at the 42nd AUBEA conference have a vested interest in each of these imperative in whatever part of the globe they are located.

The breadth of the papers presented is wide covering a vast array of subjects that pivot around the central theme of innovation. Performance in any industry is important and none more so than the construction industry, where none performance can come with high liquidated damages. One paper looks at the effect of cultural diversity on project performance, with a focus on its contribution to project success. On a similar theme of culture, the re-purposing of surveillance cameras is investigated, with the suggestion that they may be used to support urban densification in a sustainable way. The push for the densification of our cities cannot happen if the cost of construction is high, this then poses a challenge to industry to perform better and increase productivity while maintaining quality and keeping consumer costs at an affordable rate. One paper looks at the drivers and barriers to innovation along with identifying how government and industry can drive more innovations to achieve significant productivity performance. From an industry perspective teams of people are at the heart of a construction organisation and to get students work ready is one of the primary focuses of education establishments. Two papers look at both these perspectives one focused on educating work-ready students and the other reports on student's teamwork experiences during online study. This, I would suggest, is an important piece of work considering that more and more universities around the world are looking to delivering their courses on-line. How does this approach effect two important components of effective teamwork, communication and collaboration? I trust you will enjoy your time at the 42nd AUBEA conference hosted by Curtin in Singapore, a place that has proven to be innovative, technological and sustainable when it comes to construction and the built environment.

Dr Ahmed Hammad

Dr Chamila Ramanayaka

Leads, TECHNOLOGY Stream
Curtin University, Australia

Throughout history, the creativity and capacity of people's imagination have been main drivers in the theorisation of technology implemented in our daily lives. In today's age, technology integration within the built environment has reached a highly influential level that shapes the overall interaction of people with buildings that are surrounding them. Technology has also meant that the capacity for educating building professionals for the future has advanced to an exceptional level, permitting the dynamics of an evolving industry to be rapidly transferred to its key players.

In the context of the built environment, technology plays a significant role in defining the overall systems that are opening new avenues in integration of the built and human environments: from real-time data that is instantly generated, and which enables constant analysis of implemented strategies, to the use of artificial intelligence to automate essential functions within the built environment through enhanced pattern recognition. The 42nd Australasian Universities Building Education Association (AUBEA) Conference aims to showcase the novel approaches that are implemented for integrating technology within the built environment, with focus on its adoption to further enhance the education of professionals in the field. It is through exhibiting and sharing of the most recent advances in technology integration within the built environment that we envisage an enhanced sector that is capable of bridging human behaviour with its surrounding built environment worldwide. The "technology stream" of AUBEA this year hence provides a pivotal exploration and deep insight into future applications of intelligent technology in the built environment, helping to further ignite the adoption of effective technology within the field. Please join us for this unique experience in Singapore!

Dr Emil Jonescu

Dr Atiq Zaman

Leads, SUSTAINABILITY Stream
Curtin University, Australia

In its broadest terms, the definition of 'sustainability' has been in a perpetual state of refinement since its inception some 40 years ago. It is generally accepted to be the ability to preserve, sustain and balance healthy environmental, economic and social systems, on an international scale. Next to this, exponential population growth and shifts to urban environments necessitates a sustainably-responsible demand for construction and densification of cities. Construction has the capacity to make a critical impact on global the sustainability agenda given that buildings in the first world contribute to more than forty percent of energy consumption over their lifetime. When we consider production of raw materials, construction, operation, maintenance and decommissioning—densification and as a consequence—construction (of cities) provides significant opportunities for sustainable development of built environments and infrastructure. For our survival, it is incumbent upon built environment professionals to research, debate and converge around robust and honest discussion, in unity. The Sustainability stream at the 2018 AUBEA Conference aspires to this, and considers aspects such as design, construction technology, monitoring, standards and management of buildings; materials, products and technology performance; energy, resource efficiency, and processes in building; operation and maintenance; stakeholder engagement; health, safety and working conditions; innovative financing models; infrastructure, urban fabric and architecture; adaptive reuse; and information management. In the spirit of professionalism and friendship we look forward to, and trust that you will be equally rewarded, with the academic and industry contributions from the many delegates from across the globe.

GENERAL INFORMATION

Conference plenary venue
The conference will take place principally in the Ramada Hotel.

Registration
Delegates can register from 08:00 am on Thursday, September 27. The registration desk is located in the foyer of the Ramada Hotel.
The registration desk will be staffed throughout the conference to take general enquiries.

Presenter support
Presenters are asked to be in their designated room 5 minutes prior to the start of the session in their stream in order to load and check any files they require and to confer with the session chair.

For everyone's benefit
To ensure everyone's enjoyment of this event, please:

- Remember to turn off your mobile phones or set 'silent mode';
- Arrive on time for sessions;
- If you are presenting, keep to time limits and follow directions of the session chair; and
- Ask us if you have any questions or if you need assistance.

Assistance
Please don't hesitate to ask Curtin conference staff or volunteers. Conference helpers are readily identifiable by their red coloured lanyards.

Meals
Full registration includes lunch, morning & afternoon tea and the conference dinner. Walk-in Single day registrations include lunch, morning & afternoon tea and the conference dinner on the 27 September or site visit on 28 September.

Tea, coffee and lunches will be served in the foyer of the Ramada Hotel.

The conference dinner will be held at the Ramada Hotel, with a reception commencing at 07:00 pm. If you travel independently to the venue, ensure you arrive in time to allow all guests to be seated by 06:45 pm.

Dress: Business Smart.

Proceedings
The website www.aubea2018.com.au will maintain an electronic copy of the proceedings.
These conference proceedings (including abstracts and program) will also be supplied on USB to delegates on registration.

Photography
Curtin University will be photographing various parts of this conference. Your image and/or contributions may be photographed and used in printed or electronic publications as part of the conference archive and for educational purposes. If you have any concerns about this, please contact staff at the registration desk on the day.
the day.

Feedback
Please use the evaluation forms in your conference bag to provide us with feedback and suggestions for improving the next AUBEA conference. These will be collected on Friday, 28 September 2018.

We also welcome your input at the registration desk at any time.

EDITORIAL

This section contains the abstracts and full papers presented at the conference. On behalf of the conference committee, we would like to acknowledge and thank the delegates that submitted papers for consideration under the conference themes of Innovation,Technology and Sustainability. Table 1 below shows the number of submissions and outcomes in each category.

Table below: AUBEA 2018: Submissions and outcomes

Submission Format	Abstracts Received	Full Papers Received	Final outcomes (total)
Papers (Innovation)	46	36	27
Papers (Technology)	26	31	28
Papers (Sustainability)	30	35	34
Total	**102**	**102**	**89**

Full papers identified as 'Full Paper – Peer Reviewed' in the Conference Proceedings have undergone a blind peer review process, with de-identified feedback and suggestions for revisions provided to authors. All submissions were also reviewed by members of the conference committee review panel. We gratefully acknowledge the generous work of the reviewers, a national and international group of colleagues who contributed their time and expertise to provide review commentary, including constructive and valuable feedback for all submissions.

These proceedings are published by Curtin University under ISBN 978-0-9871831-3-2 (Print) & ISBN 978-0-9871831-6-3 (e-Book). We hope that this collection of papers will make a positive contribution to the ongoing discussion about those challenging issues that lie at the heart of assessment.

Disclaimer

The papers published in this Conference Program have been reviewed, edited and proofread to the best of our ability within the timeframe permitted. We acknowledge that there may be further proofing errors.

Editorial Committee

Associate Professor Khoa Do (Volumes 1, 2 & 3)
Associate Professor Monty Sutrisna (Volumes 1, 2 & 3)
Mr Barry Cooper-Cooke (Volume 1)
Dr Oluwole (Alfred) Olatunji (Volume 1)
Dr Ahmed Hammad (Volume 2)
Dr Chamila Ramanayaka (Volume 2)
Dr Emil Jonescu (Volume 3)
Dr Atiq Zaman (Volume 3)

SCIENTIFIC COMMITTEE

42nd AUBEA Conference 2018: Educating Building Professionals for the Future in the Globalised World

TABLE OF CONTENTS

LIST OF FULL PAPERS I PEERED REVIEWED I INNOVATION - BOOK 1

Page Number

Page Number

Risk Allocation for Indonesia's Performance Based Contract (PBC) for Road Rehabilitation and Maintenance Project

Deni Setiawan[1], Reini Wirahadikusumah[2], Krishna S. Pribadi[3], Harun Al Rasyid Lubis[4]

[1,2,3&4]Civil Engineering, Institut Teknologi Bandung, INDONESIA

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Abstract:

Performance Based Contract for road maintenance is an effort to improve the traditional method. In Indonesia, PBC has been applied on several road rehabilitation and maintenance project. Unfortunately, the implementation of PBC in Indonesia has many problem and needs to develop in several aspects. Experience in some PBC pilot projects (especially in Pantura Lane Road), contractors must bear vehicle load which exceeds the capacity (overloading vehicle) risks and natural disasters that are beyond the control of the contractor. The allocation of risk between project owner and contractor in a PBC contract plays an important role for the success of the project. It should be based on a proper assessment of the involved risks and choosing the party best able to manage them. The purpose of this research is to develop Indonesia's PBC for road rehabilitation and maintenance project based on fair risk allocation. The study took samples in several national roads in Pantura Lane Road. Risk allocation algorithm proposed by Martin Barnes (1983) is applied to determine the best able party to manage the risk by considering magnitude and cost of each risk factor. The results show that the risk of natural disasters and overloading vehicle risk should not bear by the contractors. Force Majeure risk should be allocated to the owner by creating an addendum contract for recovery works with unit price payment mechanism. If the contractor still bear overloading risk, then the owner must facilitate actual traffic volume data and actual total weight data for engineering designing process.

Keywords:

Risk, performance, contract, roads, maintenance

1 Introduction

Indonesia's Government agencies Directorate General of Highway (DGH) are starting to see the benefits of using contracts in which a contractor is responsible for both the construction and maintenance of roadways. In handling the road condition, DGH conducts road management activities such as: periodic maintenance activities and increased structure (betterment). Basically, road maintenance activities are to maintain the condition and level of service of the road, so that they obtain the minimum total costs of transport and has a longer service age. Maintenance of roads according to the World Bank (1998) is a process for optimizing the performance of the road network throughout the year, aiming to keep these roads still function to serve the economic needs of society throughout the year and reduce vehicle operating costs. Generally, national road maintenance work uses a traditional contract with the method of delivery Design-Bid-Build (DBB).

The characteristics of DBB delivery method are the contract for design work and construction work separately conducted, while routine maintenance work is usually done by inhouse management. Other characteristics, are traditional contract using unit price, and requires technical specifications that have been set by the owner. PBC is an approach that holds contracts with delivery methods Design-Build-Operate-Maintain (DBOM). At the PBC, design work, construction, through maintenance contracts are integrated into a single package and only to one contractor. This new contracting scheme allocates higher risk to the contractor, but at the same time opens up opportunities to reduce the cost of achieving the specified standards as a result of implementing new technologies, materials, processes and innovative management strategies (Zietlow 2001). PBC uses lump sum fixed price and applies incentives and disincentives in the payment mechanism. With the mechanism as mentioned above, PCB diverts a significant risk to the contractor. In Indonesia, The World Bank recommendations, the Ministry of Public Works have implemented two PBC pilot projects in 2011, the Pantura Section Demak-Trengguli (7.68 kilometers) in Central Java Province and Section Ciasem-Pamanukan (18.5 kilometers) in West Java Province. Both sections are categorized as national roads. The contract duration for both projects is four years. In 2012, Ministry of Finance to agree on allocating four more PBC projects with 7 (seven) year contract duration. These are: section Semarang-Bawen, West Java (22 kilometers), contract period: 2012-2018, section Bojonegoro-Padangan, East Java (11 kilometers), contract period: 2012-2018, section Padangan-Ngawi, East Java (10.70 kilometers), contract period: 2012-2018, and section Sei Hanyu-Tb. Lahung, Central Kalimantan (50.60 kilometers), contract period: 2013-2020.

PBC for road maintenance project is becoming popular and many road authorities are trying to introduce PBC in their countries. Pilot project of PBC is needed before it is fully introduced to measure the feasibility, capability, cost and quality of work and establish a relationship between the contractor and the road authority (World Bank, 2012). The road authority should try to address these needs during the pilot project. Moreover, the literature review and analysis of this research has identified issues that related to the risks. In this study, the risk of road maintenance work projects under PBC scheme is defined as uncertain events or conditions which have a negative impact on project objectives, that is increased cost of the project. List of the risks obtained through literature study of various references. The purpose of this research is to develop Indonesia's PBC for road rehabilitation and maintenance project based on fair risk allocation. The study took samples in several national roads in Pantura Lane Road. Risk allocation algorithm proposed by Martin Barnes (1983) is applied to determine the best able party to manage the risk by considering magnitude and cost of each risk factor.

2 Literature Review

All construction projects are unique and have their own risks. Such projects involve a number of parties concerned, starting with the owner, contractor, designer, suppliers, and others. All parties involved in a project inevitably carry certain risks. Risk can be defined as a hazard, a probability of it to occur and the potential of losses and resulting gains (Turskis et al, 2012). Risk can be defined as a difference of actual and expected results. Risks can be managed, reduced, transferred or accepted, but it cannot be ignored (Lam et al, 2007). Risk in the construction and maintenance industry has increased with project size and cost. One might even say that today construction is mainly risk management. Risks are found throughout all phases of a project and vary greatly according to the type of construction, the contracts involved, and the type of delivery system. To be successful, the organization should be committed to addressing the management of risk proactively and consistently throughout the project (PMI, 2004). Risk management process usually consists of four stages: risk identification, risk analysis, selection and monitoring of risk management techniques to the consequences of risk. The implementation phase of construction started after the owner and the contractor sign a construction contract. The purpose of construction contract agreement is to allocate the rights, responsibilities and risks between the parties. Construction business is a business with high risks, such as financial risks, political risk, security risk and risk at the time of execution which to be managed and handled by contractors. From the moment that the decision to begin design is taken until the new facility is in use, the owner is uncertain about the outcome of the project. Performance Based Contracts (PBC) is defined as the type of contract in which payment is made if the contractor meets the performance indicators that have been agreed in the contract. Performance Based Contracts focused on outcome (what), compared to how the work is done (how). Therefore, in terms of risk allocation, PBC is a contract that allocates a greater risk to the contractor (Zietlow, 2004), (Stankevich, 2014). The provisions contained in the contract should clearly define "new role" of the project owners and contractors. The parties involved would have to clearly identify all potential risks and allocate it to the party best able to manage it, for example: how to allocate risk in predicting traffic growth and how to allocate the risk of unexpected costs that are beyond the control of the contractor.

2.1 Risk Identification

In spite of the many types of possible risks in Indonesia's PBC, there are mainly three types of risks that are presented on any infrastructure project.

1. Design risks: these risks relate to the problems during the design phase that are associated with cost overruns.
2. Construction risks: these risks relate to the problems during the construction phase that are associated with cost overruns.
3. Maintenance risks: these risks relate to the problems during the maintenance phase that are associated with cost overruns.

2.2 Risk analysis

In order to carry out effective risk assessment, it is important to do a qualitative evaluation in order to determine the probability of occurrence and the level of impact of each risk. In 2014, Susanti et al identified the risks present in road maintenance PBC projects in Indonesia. They surveyed PBS piloting project in Indonesia, asking for the probability of occurrence, level of impact and some missed risks. This study uses qualitative assessments to determine priorities or levels of risk significance. Qualitative assessment includes an assessment of the probability of the occurrence of risk and the impact of risk on increasing project costs.

2.3 Risk Allocation

Regarding the risk allocation, Martin Barnes proposed a methodology. In the specific case of the PBC, the parties (public sector and private sector) should to determine the amount of risk willing to take according to their expected return. This risk allocation was showed as a Risk-allocation algorithm based on probability distribution. A probability distribution is the best set of data by which to measure risks. For many risks, the distribution is approximately normal and can be defined by its mean value and standard deviation. The standard deviation is a measure of the width of the distribution. The principle suggested is that externally arising risks should not be allocated to the contractor as he would charge too much for carrying them. Risk-allocation algorithm proposed by Martin Barnes has six step:

42nd AUBEA Conference 2018: Educating Building Professionals for the Future in the Globalised World

1. Prepare a list of the unrelated risks that have to be carried by one or other of the parties.
2. Identify the risks that are predominantly outside the contractor's control. Allocate these to the client and remove them from the list.
3. Rank the list in order of magnitude (measured as the standard deviation of cost uncertainty).
4. Add the risks (taking the square root of the sum of the squares), working from the largest first and noting the cumulative total. Stop when the cumulative total levels out.
5. If the cumulative total exceeds a tolerable threshold (Perhaps 10% of the estimated cost), consider what steps could be taken either to reduce each risk or to share it between the two parties (e.g. by using ground reference conditions). Go back to step 3 and continue.
6. If the cumulative total is less than the threshold, allocate the remaining large risks and ail the small risks to the contractor.

3 Research Methodology

Research methodology adopted in this paper is a mixed "quantitative and qualitative" method. Quantitative approach to get risks dominant. However, this paper's research design is solely a quantitative approach that includes: (1) the quantification of the risk costs through a cost breakdown structure (CBS); (2) Monte Carlo Simulation to get risk cost standard deviation, and (3) Risk-allocation that adopted Martin Barnes's algorithm; The first step was to identify risks in PBC projects. This was done primarily through literature review. A comprehensive list of 32 risks was developed based on previous studies (shown at Table 2). Questionnaire was developed to get the risk factors from contractors perceptions. The respondents were asked to choose between very low, low, moderate, high and very high. The second question refers to the impact on project cost once the risk event occurs. The qualitative research includes expert interviews to validate risk identification and assist with the selection of the most significant/dominant risks. Risk probability scale and risk impact scale shown at Table 1. For risk allocation model, PBC pilot project at Ciasem-Pamanukan was selected as case study. The contract cost IDR 97,406,765,972.24. The cumulative total exceeds a tolerable threshold **is** 10% of the contract cost: IDR 9,740,676,597.224.

Table 1 Risk probability Scale and Risk Impact Scale

Risk Probability Assessment	Explanation	Risk Impact Assessment	Explanation
1	Occur once in 10-15 years	1	The loss is less than 5% of the contract price
2	Occur once in 5-10 years	2	Losses between 5.1-10% of the contract price
3	Occur once in 2-5 years	3	Losses between 10.1-15% of the contract price
4	Occur once in 1-2 years	4	Losses between 15.1-20% of the contract price
5	Occurs throughout the contract	5	The loss is more than 20.1% of the contract price

After receiving the P and I scores for every risk on the shortlist, the risk severity scores on which a risk can be assessed were calculated. Severity (S) is calculated as a product of both probability and impact as in the following equation:

$$S = P \times I$$

A Pareto analysis was made for the identification of the definitive risks for being evaluated through the PBC's contractors interview. All phase of research methodology shown at Figure 1.

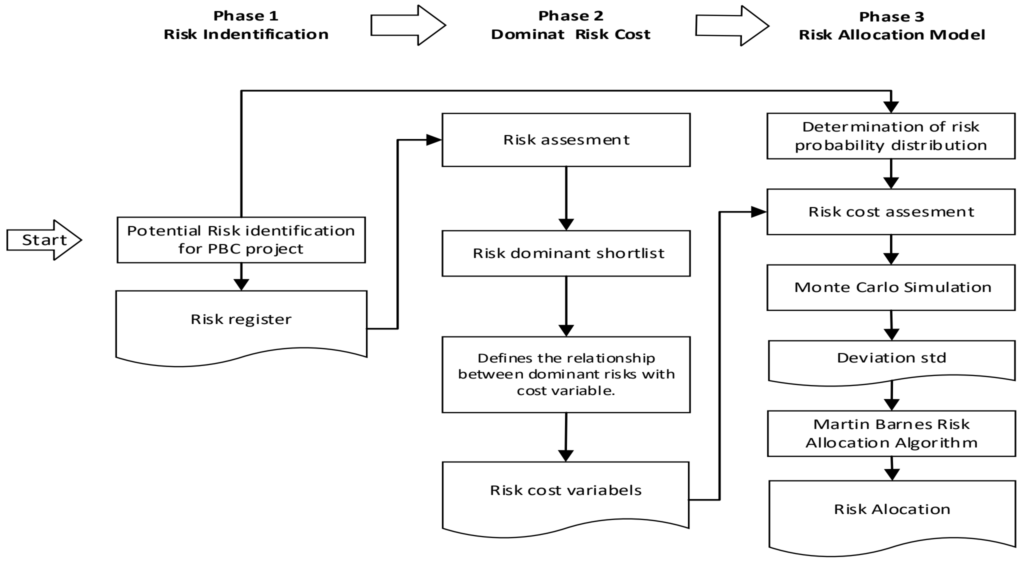

Figure 1 Research Methodology

4 Findings and Discussion

4.1 Risk Selection

Risk Breakdown Structure (RBS) was utilized to identify the risks at different stages of design, construction and maintenance phases. Some previous researchers have conducted a study on risk identification on Performance Based Contracts (Haas, et al,2001; Pidwerbesky, B.D., 2004; Hyman., 2009; Mousavi et al, 2011, Zhu et al, 2011; Zietlow, G., 2013, Andhika et al, 2014, Susanti et al , 2014)). Table 2 shows a list of the various risks that could potentially occur at PBC road work projects.

Table 2 Risk Breakdown Structure

No	Risk Event	Risk Code	Risk Weight
A	**Design Phase**		
1	Increased costs due to design change	A1	29
2	Increased costs due to design errors	A2	29
B	**Construction Phase**		
1	The project stalled due to changes in policy	B1	10
2	Cost changes due to rework to meet road performance standards	B2	35
3	Increased costs due to the scope and amount of work can not be predicted	B3	42
4	Losses due to price estimation error	B4	38
5	Disputes with contractors that have an impact on the delay in the construction process	B5	12
6	Changes in working methods caused by the lack of environmental documents	B6	31
7	Theft of materials and equipment	B7	14
8	Rework activities due to the weak ability of subcontractors	B8	20
9	Cost change due to work implementation errors	B9	33
C	**Maintenance Phase**		
1	Losses due to natural disasters (floods , landslides , etc.)	C1	30
2	Losses due to unavailability of materials, equipment , and labor	C2	18
3	Increased costs due to fluctuations in currency exchange rates	C3	36
4	Disputes due to the weak ability of supervisors	C4	22
5	Schedule delayed due to weather conditions	C5	28
6	Losses due to work accident	C6	5
7	The dispute caused by lack of understanding of the contractual agreement	C7	15
8	Late payments to contractors	C8	34
9	The increasing volume traffic and overloading	C9	110
10	The delay in the project due to the strife caused by the unclear legal framework	C10	9
11	Cessation of the project due to conflicts related to the legality	C11	6
12	Losses due to price estimation error	C12	26
13	Late payments due to work packages that are not included in the priority handling	C13	29
14	Late payments due to the budget that are not available or is available but less	C14	30
15	Contractor's Financial failure	C15	18
16	Costs for security payment	C16	10
17	Blockage of drainage channels due to market	C17	16
18	Losses due to price escalation	C18	34
19	Theft of materials and equipment	C19	14
20	Cessation of schedule due to strike	C20	5
21	Disputes due to performance measurement that does not reflect the performance requirements	C21	10

4.2 Risk dominant selected

The Pareto chart was made through a weight assignment to get risk dominant short list as shown in Figure 2

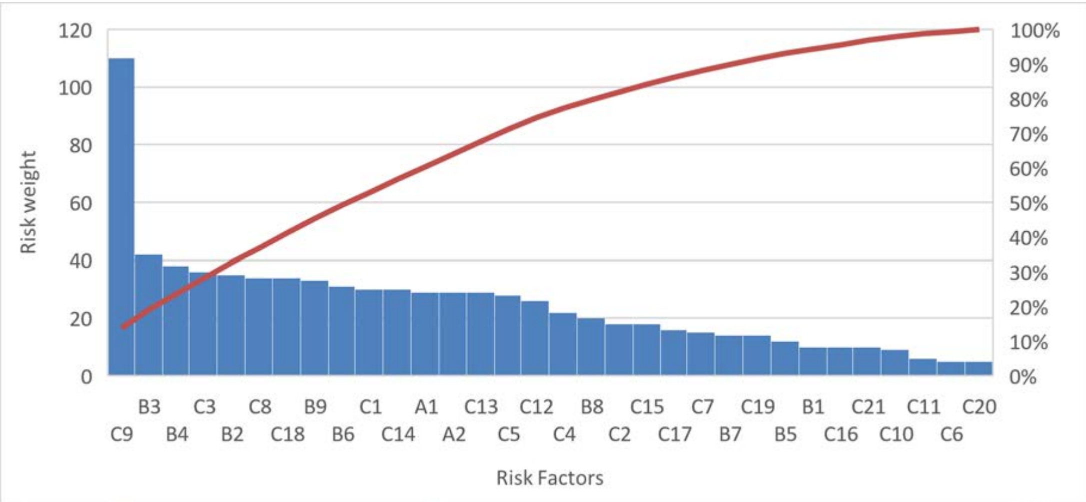

Figure 2 Risk Dominant

4.3. Risk Allocation

4.3.1 Risk Cost Calculation

Monte Carlo Simulation process is done with the help of @Risk software. As described, the distribution used is a triangular distribution. The minimum value, most likely value and the maximum value obtained from the respondents are then simulated to obtain the standard deviation value of each risk cost. The simulation result of standard deviation value from the three case studies can be seen in Table 3.

Tabel 3 Risk Cost Standard Deviation

No	Risk Event	Cost Standard Deviation (Rp)
1	The increasing volume traffic and overloading	2,062,387,000.00
2	Increased costs due to the scope and amount of work can not be predicted	676,733,600.00
3	Increased costs due to fluctuations in currency exchange rates	138,002,800.00
4	Cost changes due to rework to meet road performance standards	891,826,900.00
5	Late payments to contractors	273,830,000.00
6	Losses due to price escalation	137,050,400.00
7	Cost change due to work implementation errors	678,723,200.00
8	Changes in working methods caused by the lack of environmental documents	363,162,600.00
9	Losses due to natural disasters (floods , landslides , etc.)	1,371,411,000.00
10	Late payments due to the budget that are not available or is available but less	136,603,500.00
11	Increased costs due to design change	10,241,560.00
12	Increased costs due to design errors	10,382,690.00
13	Late payments due to work packages that are not included in the priority handling	136,987,700.00
14	Schedule delayed due to weather conditions	13,701,000.00
15	Losses due to price estimation error	138,006,900.00
16	Disputes due to the weak ability of supervisors	68,277,230.00
17	Rework activities due to the weak ability of subcontractors	1,136,039,000.00

4.3.2 Risk Allocation Algorithm

The default risk values are then sorted from the largest to the smallest. The greater the standard deviation value then indicates a large uncertainty value. The standard deviation value of each of these risks is then cumulative and the maximum limit value is assumed to bear the risk. For that, then in this study developed the amount of maximum limit value borne by the contractor. The risk allocation based on Martin Barnes Algorithm show in Table 4.

Table 4 Risk Allocation Process based on Martin Barnes Risk Allocation

No	Risk Event	Cost Standard Deviation	Square Root Sum of The Squares	Cumulative All Risks Allocated to Contractors	Cumulative Cost if C9 Allocated to Owner	Cumulative Cost if C1 Allocated to Owner
1	The increasing volume traffic and overloading	2,062,387,000.00	3,073,274,054.03	3,073,274,054.03		
2	Losses due to natural disasters (floods , landslides , etc.)	1,371,411,000.00	2,278,502,419.01	5,351,776,473.04	2,278,502,419.01	
3	Rework activities due to the weak ability of subcontractors	1,136,039,000.00	1,819,561,799.59	7,171,338,272.63	4,098,064,218.59	1,819,561,799.59
4	Cost changes due to rework to meet road performance standards	891,826,900.00	1,421,344,621.47	8,592,682,894.10	5,519,408,840.07	3,240,906,421.06
5	Cost change due to work implementation errors	678,723,200.00	1,106,736,334.19	9,699,419,228.30	6,626,145,174.26	4,347,642,755.25
6	Increased costs due to the scope and amount of work can not be predicted	676,733,600.00	874,185,410.09	10,573,604,638.38	7,500,330,584.35	5,221,828,165.34
7	Changes in working methods caused by the lack of environmental documents	363,162,600.00	553,382,115.57	11,126,986,753.96	8,053,712,699.92	5,775,210,280.91
8	Late payments to contractors	273,830,000.00	417,546,035.55	11,544,532,789.50	8,471,258,735.47	6,192,756,316.46
9	Losses due to price estimation error	138,006,900.00	315,217,104.39	11,859,749,893.89	8,786,475,839.86	6,507,973,420.85
10	Increased costs due to fluctuations in currency exchange rates	138,002,800.00	283,400,632.41	12,143,150,526.30	9,069,876,472.27	6,791,374,053.26
11	Losses due to price escalation	137,050,400.00	247,530,090.38	12,390,680,616.68	9,317,406,562.65	7,038,904,143.64

No	Risk Event	Cost Standard Deviation	Square Root Sum of The Squares	Cumulative All Risks Allocated to Contractors	Cumulative Cost if C9 Allocated to Owner	Cumulative Cost if C1 Allocated to Owner
12	Late payments due to work packages that are not included in the priority handling	136,987,700.00	206,126,983.93	12,596,807,600.61	9,523,533,546.58	7,245,031,127.57
13	Late payments due to the budget that are not available or is available but less	136,603,500.00	154,021,763.24	12,750,829,363.86	9,677,555,309.82	7,399,052,890.81
14	Disputes due to the weak ability of supervisors	68,277,230.00	71,149,050.17	12,821,978,414.03	9,748,704,359.99	7,470,201,940.99
15	Schedule delayed due to weather conditions	13,701,000.00	20,010,177.51	12,841,988,591.54	9,768,714,537.50	7,490,212,118.49
16	Increased costs due to design errors	10,382,690.00	14,583,888.47	12,856,572,480.01	9,783,298,425.97	7,504,796,006.96
17	Increased costs due to design change	10,241,560.00	10,241,560.00	12,866,814,040.01	9,793,539,985.97	7,515,037,566.96
			Cumulative Cost	**12,866,814,040.01**	**9,793,539,985.97**	**7,515,037,566.96**

The modeling results indicate that there are two risk factors that have an adverse impact and are beyond the contractor's ability to manage them. They are: risk of vehicle overloading and risk of natural disasters, both of them must allocate to the Owner party (Road authorities).

5 Conclusion

Contractor party based on experience managing risk of course if burdened risk that is outside his control will raise the price as compensation to accept those risks. The benefits of risk allocation certainly allocate risks to those who have better capability in handling such risks at a lower cost. There are two risk factors that, if not allocated to those with more ability to manage, are the risk of overloading vehicles and natural disasters. Based on calculation of Barnes risk allocation algorithm: if contractors must bear all of risk then the cumulative risk cost more than 10% of the estimated cost (beyond contractors capability). By allocate the risk of overloading vehicles and natural disasters to the owner party the result show that the cumulative under 10% of the estimated cost. In fact, the owner party has capability to control the risk of overloading by regulation force, if the contractor still bear overloading risk, then the owner must facilitate actual traffic volume data and actual total weight data for engineering designing process. These risks depend on the government regulations and stability, but these risks have to be assumed by the private sector. Therefore, the government responsibility is to provide the most stable conditions such as traffic condition and limitation of overloading for the project development. The literature review showed that there are many types of risk that can be present in a PBC project. It was remarkable the comparison done between the literature review about risks and the Indonesia PBC's projects risk, because it show the differences between the international context and the Indonesia context.

Future research must be focused on each type of risk needs to be deepened (to see more direct potential consequences), sharpened (to ensure the accuracy of risk financing on

financial variables) and comprehensively verified (to increase validity). Limitations in the amount of data and respondents will certainly have an impact on determining distribution. This study uses triangular distribution as an approach. While the proposed Martin Barnes algorithm sets the normal distribution as a reference. For this reason, a comprehensive study is needed on determining the probability distribution for the Monte Carlo simulation process.

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