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THE IMPLEMENTATION OF DESIGN FOR MANUFACTURING AND ASSEMBLY (DfMA) IN INDONESIAN CONSTRUCTION INDUSTRY: MAJOR BARRIERS AND DRIVING FACTORS

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Abstract

Construction industry is a crucial sector of a country's economy, but faces continuing problems such as low productivity, labor intensity, and fragmented processes. Design for Manufacturing and Assembly (DfMA) has been identified as an important strategy for solving this problem. Despite its potential, the adoption of DfMA in Indonesian construction industry has been slow. Therefore, this study aimed to (1) investigate barriers to the adoption of DfMA and (2) propose effective drivers to promote the adoption of DfMA. To achieve these objectives, a comprehensive literature review and structured interviews were conducted with DfMA experts. A questionnaire survey was then carried out with 100 respondents, and after applying purposive sampling criteria, 71 respondents were considered eligible. Following this discussion, the primary data was analyzed using descriptive and inferential statistics. The collected data was processed using structural equation modelling (SEM) application known as SMARTPLS. The result showed that the main obstacle faced was the organizational mindset, while the most effective strategy was the contribution and support of the government. This study provided a better understanding of the constraints faced and driving factors that could be considered effective by industry practitioners. Additionally, there was an expectation that the results of this exploration would be an important starting point for developing a roadmap to encourage the wider adoption of DfMA in construction industry in Indonesia.

Keywords: design for manufacturing and assembly, DfMA, prefabrication, manufacturing, off-site construction, construction innovation

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INTRODUCTION

Low productivity and efficiency are a major and a critical problem in construction industry. To solve this problem, prefabricated systems was introduced. According to (Assad, El-Adaway, Hastak, & LaScola, 2021), off-site construction can help reduce costs, and time, improve quality, and eventually increase productivity.

The major cause of problem in construction industry is lack of communication and cooperation, as well as inadequate knowledge and experience (Nabi & El-Adaway, 2021) among stakeholders. Construction industry suffers from poor organization, productivity, complicated requirements, low profit margins, inadequate communication, and limited talent development (Tung et al. 2021). However, to overcome these problems, several countries have introduced DfMA and the important role in increasing the productivity of construction industry (Tan et al., 2020). The application of DfMA principles in prefabrication can encourage optimal design, manufacturing, and assembly processes. This processes often lead to cost and time savings, impact product quality, and customer satisfaction (Lu et al., 2021) (Abd Razak, Khoiry, Badaruzzaman, & Hussain, 2022).

Several developed countries such as UK, Singapore, and Hong Kong have recognized the benefits of DfMA in construction. As a result, local government authorities and professional bodies in these countries have introduced guidelines to practitioners in construction industry (Tan et al., 2020). These countries are currently leaders in the application of DfMA principles in construction industry (Langston & Zhang, 2021). Despite the advantages of DfMA, many other countries have been slow to adopt these principles. There is also a lack of study connecting DfMA principles to construction industry (Jiang, Mao, Hou, & Tan, 2018). For instance, the application of DfMA principles in Singaporean industry still encounters resistance from private sector, with only 11.2% of the prefabrication usage being recorded in 2001 (Gao, Low, & Nair, Design for Manufacturing and Assembly (DfMA): A preliminary study of factors influencing its adoption in Singapore, 2018). To address this issue, studies have suggested exploring the factors influencing the adoption of DfMA. Understanding these factors could assist in developing strategies to promote effective private-sector participation.

None of the discussions above are specific to Indonesian construction industry from preliminary studies on DfMA adoption. Knowledge gaps concerning barriers and strategies for implementing DfMA, particularly in the country's construction industry. Therefore, this preliminary study aims to explore the major factors that can hinder and encourage the adoption of DfMA principles in construction in Indonesia. The results of the study are expected to be an important starting point for developing a roadmap to inspire the wider adoption of DfMA, specifically in construction in the country.

LITERATURE REVIEW

Issues of Prefabrication Systems

Construction industry performs an important role in the economy of a country, but still has problems with low productivity (Ma, Chan, Li, Zhang, & Xiong, 2020). To address this issue, innovative methods have been developed, namely, prefabricated construction.

According to Nawi et al. (2019), construction industry cannot fully use the potential of prefabricated construction. Despite its positive effect, the industry still faces issues with project delay and cost overruns. This observation is supported by empirical data from prefabrication projects conducted by contractors in Indonesia, as shown in Table 1. An analysis of data in Table 1 showed that the projects still experience problems with timely completion, even though these projects have implemented prefabricated construction.

Table 1 : List of Projects Performance Using Prefabricated Systems

Project Name	Prefabricated Construction	Project Performance
Living Plaza	Yes	1 month late
South 78 Office	Yes	Completed on time
Apartment Royal Tajur	Yes	Completed on time
Tokyo Riverside Apartment T5	Yes	Completed 2 months earlier
DTP Center	Yes	4 months late
Ecohome Apartments	Yes	3 months late
Aeropolis Residence	Yes	4 months late
Living Plaza 328	Yes	3 months late
Tokyo Riverside Apartment T6	Yes	Completed 2 months earlier
Serpong Garden Apartments	Yes	Completed on time
West Senayan Apartments	Yes	Completed on time
Mall Boxies 123	Yes	2 months late
Midtown Apartments	Yes	2 months late
Vivere Office	Yes	1 month late
Osaka Apartments	Yes	Completed on time

A question arises, when prefabricated construction has been implemented, which is known for its speed of delivery, why are these projects still delayed? The same question is also found in Malaysian construction industry, although implementing industrialized building systems (IBS) is still not able to meet the demands of stakeholders (Abd Razak, Khoiry, Badaruzzaman, & Hussain, 2022).

Structured literature review has revealed that issues relating to time and costs often arise from poor communication and cooperation (Nabi & El-Adaway, 2021), as well as lack of knowledge and experience among major stakeholders

(Hyun, Kim, & Kim, 2022). This finding is further supported by a report from KPMG April 2016), which cautions that off-site manufacturing alone will not solve the challenges facing construction industry. Therefore, process needs to be combined with an incorporated design.

DfMA

Description of DfMA Principles

DfMA originates from manufacturing industry and is hailed as a powerful solution to overcome problems in the Architecture, Engineering, and Construction (AEC) industry, such as cost overruns, project delays, and low productivity (Lu et al., 2021). According to Lu et al. (2021), DfMA is still in its early stages in AEC industry, and practice largely applies guidelines and strategies from manufacturing industry. Similarly, DfMA studies have been initiated in construction industry, as shown in Table 2.

Table 2: Previous Studies

Authors	Years of Publication	Study Objectives
S. Gao, S. P. Low, and K. Nair	2018	Exploring factors influencing the adoption of DfMA to better understand the strategies required to promote effective private sector participation in construction industry in Singapore.
K. Chen and W. Lu	2018	Reports a case study of the successful application of DfMA-oriented design method to CWS in a commercial building in Wuhan, China.
S. Gao, R. Jin, and W. Lu	2020	Critically review the concepts and principles of DfMA, and propose major strategies for better implementation of DfMA in construction industry.
C. Langston and W. Zhang	2021	Identify barriers to implementing DfMA in construction industry in Australia.
W. Lu *et al*	2021	Review the development of DfMA in manufacturing and the status quo in construction, and clarify its similarities and differences to other concepts.
Abd Razak et al	2022	Identify the main benefits, inhibiting factors, and supporting factors of DfMA in construction industry in Malaysia.

DFMA is a principle for optimizing design (best design concept) and assembly, through the methods of Design for Manufacturing (DfM) and Design for Assembly (DfA). Following the discussion, these methods help designers optimize prefabricated building design and reduce conflicts between different disciplines at construction stage, by incorporating professional knowledge and information from the other phases into design stage. Based on DfMA principles, more detailed and comprehensive project information will be available at the outset because the contribution of major stakeholders such as designers, engineers, suppliers, and contractors occurs early in design process. Such collaboration can help to identify and address potential risks in manufacturing and construction phases (Bogue, 2012). According to (Langston & Zhang, 2021) DfMA will be a promising strategy for the future of construction industry. This is because DfMA offers several benefits such as fast project delivery, improved quality control, worker safety, and reduced on-site waste.

Barriers to the Adoption of DfMA

DfMA in construction is an innovative concept adopted from manufacturing sector. However, the benefits alone are not sufficient to convince industry to adopt the concept. Several barriers hinder broader application of DfMA, and these challenges need to be addressed. Through a structured literature review, 15 potential barriers to the adoption of DfMA have been identified, as shown in Table 3.

Table 3: Potential barriers to the adoption of DfMA in construction industry

Code	Barriers	Description	References
B01	Resistance to change	The new process brought by DfMA requires stakeholders to change the way from conventional design, production, and construction to be more collaborative following DfMA principles. The process is not always easy for stakeholders to adjust to new processes which can create resistance to major changes and will be barriers to DfMA adoption.	Lu et al. 2021
B02	Higher initial cost	DfMA principles will trigger higher initial costs, for example, to set up factories and warehouses for DfMA components, staff training, technology investment, and others. Therefore, the traditional construction methodology remains the preferred choice as developers or contractors resist the adoption of DfMA due to perceived higher initial costs.	Langston & Zhang. 2021; Gao et al. 2018; Gao et al. 2020
B03	Community mindset	Stakeholders are conservative and lack the mindset to accept new products, technologies, and methodologies.	Langston & Zhang. 2021
B04	Opposition from trade unions	The implementation of DfMA brings increased efficiency and productivity, but it also raises concerns about potential job losses, particularly for on-site laborers. Unions oppose the use of DfMA because of unwillingness to allow job cuts. The resistance from the trade unions could be one of the challenges in DfMA adoption.	Langston & Zhang. 2021

Code	Barriers	Description	References
B05	There is business politics	Contractors and subcontractors usually have long-term agreements with large organizations that dominate the market for traditional construction materials. In this case, contractors and subcontractors are not willing to violate the agreement to adopt DfMA.	Langston & Zhang. 2021
B06	There is no incentive support from the Government	The government has not given attention and support in the form of incentives to support the implementation of DfMA.	Langston & Zhang. 2021
B07	There are no regulations from the Government	The government has not yet issued regulations or policies for the application of DfMA principles to certain building or infrastructure criteria.	Langston & Zhang. 2021
B08	There are no guidelines and standards	The government or related institutions have not created relevant standards and guidelines to encourage and guide the application of DfMA principles in construction industry.	Lu et al. 2021
B09	Technology limitations	The absence of affordable technology will hinder the widespread application of DfMA.	Lu et al. 2021
B10	Low levels of prefabrication in the private sector	The slow progress of DfMA adoption is largely due to resistance and low rates of prefabrication with DfMA principles in the private sector.	Gao et al. 2018
B11	Low demand owner	Project owners are major stakeholders in implementing DfMA because holders have strong control over the decision-making process, low awareness and demand from project owners is an obstacle to implementing DfMA in construction industry.	Gao et al. 2018
B12	Lack of contractor interest	Lack of demand from contractors due to reluctance to invest large amounts at the start to set up factories and procure technology to support the implementation of prefabricated systems with DfMA principles.	Gao et al. 2018
B13	Supply chain management challenges	Difficult to ship large modules from manufacturers which are usually located in big cities and surrounding areas to remote locations (transport challenges).	Langston & Zhang.2021; Gao et al. 2018
B14	Storage location constraints	Limited project location raises challenges for prefabricated module placement, which led to the project team being reluctant to adopt prefabrication.	Gao et al. 2018

Code	Barriers	Description	References
B15	Longer design process	Design process with more complex DfMA principles will cause a longer design process, which can reduce stakeholder interest in implementing DfMA.	Abd Razak et al. 2020

Drivers to the Adoption of DfMA

Construction industry in various countries have recognized the potential of DfMA to improve the delivery of prefabricated projects. Therefore, accelerated efforts to encourage the adoption of DfMA have attracted the attention of several explorers. Through a structured literature review, eight strategies are identified that could encourage the adoption of DfMA, as shown in Table 4.

Table 4: Possible drivers for the adoption of DfMA in construction industry

Code	Drivers	Description	References
D01	Financial incentives	Encouraging the adoption of DfMA in prefabrication processes through financial incentives (such as interest-free financing) etc., could be the right strategy to encourage industry to move towards better adoption.	Gao et al. 2018
D02	There are government regulations	Regulations issued by government agencies urge that the level of prefabrication with DfMA principle in AEC industry be increased.	Gao et al. 2018
D03	Promotion from the government	Promotion from government agencies related to prefabrication technology will generate attention, awareness, knowledge, interest, and action in construction industry.	Gao et al. 2018; Langston & Zhang. 2021
D04	Guidelines and Standards	Guidelines and standards can activate stakeholder attention and interest, hence, it is important for less experienced stakeholders, to regulate DfMA application procedures.	Lu et al. 2021; Gao et al. 2020; Abd Razak et al. 2020
D05	Application of appropriate project delivery	DfMA principles mean that multidisciplinary teams are included from the initial design stage. Only certain procurement methods are possible, e.g. Design-Build or IPD. Moreover, this method is a preferred method which will encourage interest in applying DfMA principles.	Chen et al. 2018; Abd Razak et al. 2020
D06	Increase knowledge	Incorporate DFMA principles in educational curricula, seminar topics etc., to increase knowledge to create awareness and allowing industry players to have an interest in it.	Abd Razak et al. 2020; Lu et al. 2021

Code	Drivers	Description	References
D07	Successful DfMA pilot project	Practitioners are required to be inspired and encouraged by successful examples of DfMA, some stakeholders may wait and observe whether competitors implementing DfMA will receive any real benefits. In addition, a successful DfMA application case will encourage the diffusion of the principle in AEC industry, possibly starting from Government projects first.	Lu et al. 2021
D08	Labor training	Existing workforce training whose capabilities are updated concerning prefabrication systems with DfMA principles can have an impact on opening new job opportunities, which will make major changes in the current structure of construction industry and will activate the interest of AEC industry practitioners.	Langston & Zhang 2021

STUDY METHODOLOGY

The data used in this study were primary data from the respondents' perceptions. To obtain the primary data, a purposive sampling method was used by providing the responders' criteria, including, (1) the respondent had average minimum knowledge of prefabrication and DfMA, (2) the responder had been included in prefabrication project, and (3) the respondent's education was at least a diploma and the people who did not meet these criteria were excluded from the list of respondents. Moreover, the measurement scale referred to Mvududu et al. (2013), using an ordinal measurement scale of 1–5 with a description of the scale which included, 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree. Following this discussion, the type of questionnaire used was a closed direct questionnaire.

The initial data obtained in this study were analyzed using descriptive statistics. Specifically, mean and standard deviation (SD) were calculated to rank the most important variables from respondents' perceptions. Variables with an average score above three were considered important, indicating respondent agreement. This analysis could help in understanding the perception patterns of different stakeholders, acknowledging that each group had different characteristics, interests, and business areas.

Following the initial assessment, inferential statistics, specifically exploratory factor analysis were used to explore the data. The method allowed for the identification of a smaller set of factors that could describe a large number of interrelated variables, enabling interferences about the population based on the sample. The factor analysis process used in this study included, (1) Kaiser–Meyer–Olkin (KMO) and Bartlett Tests, (2) Anti-Image Matrices, (3) Factor

Extraction, and (4) Factor Rotation. In this context, inferential statistics were considered the most appropriate method for generalizing the conclusions of this study.

ANALYSIS AND DISCUSSION

Respondent's profiles

Data were collected using a questionnaire survey with a purposive sampling method to 100 respondents. Subsequently, only 71 responders were considered to meet the criteria for selection. According to Hair, Black, Babin, and Anderson (2013), the minimum limit was 50 samples, as Table 5 showed the 71 profiles of the responders.

Table 5: Respondent's Profiles

Categories	Characteristics	Frequency	Percentage (%)
Organization Type	Clients/developers	7	9.86
	Consultant	11	15.49
	General Contractors	36	50.70
	Supplier	17	23.94
Disciplines of the Organization	Multidisciplinary	20	28.17
	Architecture	9	12.68
	Structure	37	52.11
	Mechanical, electrical, and plumbing	5	7.04
Job role of Respondent	Director	17	23.94
	Team Leader	14	19.72
	Manager	16	22.54
	Engineer	24	33.80
Respondent's years of experience in AEC Industry	<5 years	10	14.08
	5-10 years	20	28.17
	11-15 years	19	26.76
	>15 years	22	30.99
Education of Respondent	Diploma	9	12.68
	Bachelor's Degree	34	47.89
	Master's Degree	20	28.17
	PhD	8	11.27
The level of understanding of pre-fabrication	Excellent	37	52.11
	Good	23	32.39
	Average	11	15.49
The level of understanding of DfMA	Excellent	19	26.76
	Good	27	38.03
	Average	25	35.21

Descriptive Statistic Results

The mean and SD values were used to rank the relevance of the variables based on the perceptions of 71 respondents from various organizations and selected multidisciplinary groups. Based on the respondent's perception of variable B11, the holder's low request to apply DFMA principle was the main obstacle with a mean value of 4.127. Additionally, Table 6 reviewed the results of the descriptive analysis, which showed the level of relevance of barriers to DFMA adoption.

Table 6: Descriptive Statistics of Barriers

Code	Barriers to DFMA Adoption	Means	SD	Rank
B11	Low demand owner	4.127	0.675	1
B13	Supply chain management challenges	4.113	0.934	2
B03	Community mindset	4.014	0.949	3
B08	There were no guidelines and standards	3.972	0.956	4
B01	Resistance to change	3.901	0.958	5
B07	There were no regulations from the government	3.901	0.913	6
B12	Lack of contractor interest	3.845	1.009	7
B09	Technology limitation	3.775	1.136	8
B02	Higher initial cost	3.746	1.092	9
B06	There was no incentive support from the Government	3.718	0.974	10
B10	Low levels of prefabrication in the private sector	3.662	0.985	11
B05	There was business politics	3.507	1.107	12
B14	Storage location constraints	3.493	1.229	13
B15	Longer design process	3.380	1.074	14
B04	Opposition from trade unions	3.352	1.148	15

The driving variable for DfMA adoption, variable D03, was a promotion from the government to introduce DfMA principles to developers and service providers such as general contractors, subcontractors, and consultants. Moreover, encouraging the adoption of DfMA implementation in Indonesian construction industry was the most effective strategy, with a mean value of 4.366.

Table 7: Descriptive Statistics of Drivers

Code	DFMA Adopotion Drivers	Means	SD	Rank
D03	Promotion from the government	4.366	0.681	1
D04	Guidelines and standards	4.310	0.667	2
D07	Successful DfMA pilot project	4.282	0.680	3
D08	Labor training	4.239	0.726	4
D06	Increase knowledge	4.211	0.754	5
D02	There were government regulations	4.197	0.689	6
D01	Financial incentives	4.085	0.671	7
D05	Application of appropriate project delivery	4.042	0.726	8

Factor Analysis Results

From the analysis of factors inhibiting adoption, KMO value was 0.746, with a significance of 0.000, and the anti-image correlation and communality values of all inhibiting variables were above the minimum limit of 0.50. From the best results above, a conclusion could be deduced that the data met the criteria for factor analysis. In addition, Table 8 showed 5 groups of factors that were formed, namely, organizational mindset, low level of stakeholder awareness, technical constraints, supply chain problems, and lack of interest.

Table 8: Rotated Component Matrix of Barriers

Barriers	Variables	Components				
		1	2	3	4	5
Organizational mindset	Community mindset	**0.567**	0.364	0.164	0.247	0.107
	Opposition from trade unions	**0.663**	0.298	0.297	-0.156	-0.040
	There was business politics	**0.766**	0.089	0.242	-0.091	-0.097
	There was no incentive support from the Government	**0.622**	0.112	-0.231	0.233	0.228
	There were no regulations from the Government	**0.676**	-0.018	0.076	0.407	0.371
Low level of stakeholder awareness	There were no guidelines and standards	0.516	**0.593**	0.037	0.307	0.113
	Technology limitations	0.146	**0.788**	0.172	0.177	-0.051
	Low levels of prefabrication in the private sectors	0.029	**0.771**	-0.039	-0.012	0.409
	Low demand owner	0.212	**0.272**	-0.007	0.726	-0.188
	Lack of contractor interest	0.231	**0.745**	0.036	0.221	0.114
Technical contraints	Storage location constraints	0.287	0.257	**0.788**	-0.044	0.072
	Longer design process	0.076	-0.083	**0.754**	0.281	0.08
Supply chain problems	Suply chain management challenges	-0.046	0.213	0.362	**0.653**	0.150
Lack of interest	Resistance to change	0.154	0.157	-0.073	-0.071	**0.735**
	Higher initial cost	-0.006	0.100	0.362	0.068	**0.667**

The driving variable required two rounds of factor analysis because the results of the first factor analysis obtained the value commonalities from variable D01. The variable included financial incentives that did not meet the minimum threshold with a value of 0.267. Therefore, D01 was removed from the list of variables and factor analysis was repeated in the second round.

The results of the second round of factor analysis obtained satisfactory results with anti-image correlation values and communality values above the minimum threshold, with a KMO value of 0.883 and a significance of 0.000.

Following the discussion, Table 9 showed the rotation of factors where there was only one group of factors formed, called government contribution and support.

Table 9: Rotated Component Matrix of Driver Factors

Driver Factors	Variables	Components 1
Government Engagement and Support	Financial incentives	0.742
	There were government regulations	0.790
	Promotion from the government	0.846
	Guidelines and standards	0.721
	Application of appropriate project delivery	0.806
	Increase knowledge	0.816
	Successful DfMA pilot project	0.736

Main Barriers Factor: Organizational Mindset

The application of DfMA in construction industry in Indonesia was relatively new. According to factor analysis result, the main obstacle to the adoption of DFMA in construction industry was organizational mindset, with a variance of 32.8%. Observation showed that construction practitioners were comfortable with conventional methods, rather than switching to more efficient methods.

The new process offered by DfMA application required stakeholders to change way of working, which was originally fragmented from the processes of design, production, and construction, to become more collaborative. According to Lu et al. (2021), the changes were difficult to implement, and the design process was more complex and longer. Due to the complexity, stakeholders have been observed to maintain the conventional methods.

Organizational mindsets were also affected by expensive up-front costs to change the way things work and technology investments. According to (Gao, Jin, and Lu, Design for Manufacture and Assembly in Construction: A Review, 2020), cost components arising from DfMA applications increased capital costs such as costs for setting up factories and storage areas for DfMA components, the requirement for tower cranes with higher capacities to lift DfMA modules, module molding, staff training, and others. Giel and Isa (2011) also explained that expensive initial financing and investment uncertainty were important factors affecting organization's mindset and could lead to resistant to change.

Main Driving Factor: Government Engagement and Support

The main driving factor for the adoption of DfMA in Indonesian construction industry was the participation and support of the country's government agencies, with a variance of 60.981%. Moreover, the government aspect was a stress point in developing countries (Rasoomalinesh et al, 2011)

The transition from conventional, fragmented prefabrication methods to more collaborative with DFMA principles led to higher project capital costs. For example, setting up factories and storage areas for DfMA components, workforce training, technology investment, etc., could be very expensive (Langston & Zhang, 2021) (Gao, Low, & Nair, Design for manufacturing and assembly (DfMA): a preliminary study of factors influencing its adoption in Singapore, 2018) (Gao, Jin, & Lu, Design for Manufacture and Assembly in Construction: a Review, 2020). Consequently, many companies were reluctant to be the first to adopt DfMA technology considering the expenses and risks of uncertainty.

Indonesian government has a crucial role in encouraging the adoption of DFMA in prefabrication process. This could be achieved through financial incentives such as interest-free financing, making policies to include DfMA principles in educational curricula, seminar topics, etc., in order to increase knowledge, create awareness, and allow industry players to be interested in the adopting DfMA.

Gao et al. (2018) investigated the role of Singapore's government in the adoption of DfMA in construction industry. The results showed that support from Singaporean government through policies increased the level of prefabrication through DfMA from 6% to 50%. Additionally, promoting prefabrication through financial incentives, such as interest-free financing could positively impact the successful adoption of DfMA technology in construction industry.

CONCLUSION

In conclusion, the adoption of precast construction was proposed to solve the problem of low productivity in Indonesia's construction industry. However, in reality, construction industry was unable to exploit the full potential of prefabrication systems. This is because several projects in the country that had implemented prefabrication systems still faced problems with cost, time, and quality. The main problem identified in this context was lack of communication and multidisciplinary participation from the start of the project.

DfMA for Indonesian construction industry was still relatively new, hence, there were not many applications. The results of this study showed that the main factor affecting the adoption of DfMA was organizational mindset. Specifically, this mindset assumed that DfMA caused design process to be more complex and longer, leading to cost overruns and investment uncertainty at the start of the project.

To solve these challenges, government contribution, including government regulations and standards, financial support, training, and seminars to increase stakeholders' knowledge and awareness, could perform an important role in encouraging DfMA adoption in Indonesian construction industry. The results are expected to contribute to knowledge in the field of construction project management and as a proposed strategy for the country's government for the wider adoption of DfMA.

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