

# Precast Technology Application Consideration Factors to Building Construction Project Implementation Performance in Banda Aceh

Hafnidar A. Rani

**Abstract**— One of the attempts to improve the efficiency both in term of cost, quality and time the construction sector is the utilization of precast technology (prefabricated). Precast technology application widely improves especially in Indonesia. This is because this technology can reduce the construction cost, produce the better quality, be used for various constructions. This study aims to find out the most dominant factors affecting precast technology application to building construction project in Banda Aceh, and to analyze the relationship and effect between precast technology application factors and building construction project implementation performance in Banda Aceh. This study uses questionnaire distributed to the constructor company of the building sector, starting from M1, M2, and B1 qualifications. Based on the data obtained from Construction Service Development Institution (LPJK) of Aceh Province, the total of constructor companies in 2016 are 39 companies. Because the population is less than 100, so this study uses the population study without sampling. The study result mentions that the most dominant factors affecting precast technology application to building construction project in Banda Aceh is special consideration factor which mean is 4.293. The relationships between precast technology application factors and building construction project implementation performance in Banda Aceh can be explained that all have very high relationship partially with the Pearson Correlation Coefficient Value is between 0.800 – 1.00. Meanwhile for the effect between precast technology application factors and building construction project implementation performance in Banda Aceh can be explained that the most dominant affecting is time consideration factor with the significant value is 0.003. It explains that if time consideration factor is improved, building construction project implementation performance in Banda Aceh will also improve.

**Index Terms**— Precast technology, consideration, performance, construction project.

## I. INTRODUCTION

Construction cost tends to increase from year to year as shows by the observation result during 50 years (1930 – 1980). Compared to manufacturing industry, construction cost is higher above (Larry, and Glen, 1982). One of the factors causing the construction cost can be higher is high salary of the

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F. A. Author is with the National Institute of Standards and Technology, Boulder, CO 80305 USA

S. B. Author was with Rice University, Houston, TX 77005 USA. He is now with the Department of Physics, Colorado State University, Fort Collins, CO 80523 USA

construction worker and the construction process which still using the traditional method. One of the attempts to improve the efficiency both in term of cost, quality and time the construction sector is the utilization of appropriate technology. One of the technologies is precast concrete technology. Precast concrete technology application widely improves especially in Indonesia. This is because this technology can reduce the construction cost, produce the better quality, be used for various constructions.

The most explicit definition of precast concrete is the concrete prepared to be casted, molded and maintained in one place which is not the final destination place. The distance between precast concrete place and project location could be only a few meter, it is because of saving the transportation cost. Or it could be located thousands kilometers, it is because production cost and transportation cost are cheaper. The assembly construction using precast concrete reinforced technology and prestressed concrete technology have become common known in current building construction. In Indonesia, precast concrete technology has been applied in the building, especially in the 1990s to present. For example, the construction of Tanjung Emas Container Port in Semarang using precast system in the upper structure and it can reach the significant time efficiency that the project was finished four months faster than the planning time.

The research which was conducted by [1] mentioned that the total cost used in the development of Rent Simple Flat (Rusunawa) in Keudah Banda Aceh, using 207 columns and the dimensions is 30/50 cm, was 710,630,342.53 IDR using precast method and 675,288,351.59 IDR using conventional method. From the both method, the cost efficiency was 35,34,990.94 IDR. The time period used for precast method was 52 days, while for conventional method was 95 days. The time efficiency obtained from the both methods was 43 days. Thus the required in finishing the column structure construction using precast method is faster 45.26%, but the cost was more expensive 4.97% compared to the conventional method. Based on the study result, it is felt necessary to conduct this research.

## II. LITERATURE STUDY

### A. Precast

[2] mentioned that precast can be defined as the production process of structural or architectural building element in one place or different location where structural or architectural building element will be used. This precast technology can be

applied to various types of materials, one of them is concrete material. Precast concrete is not too different with the common concrete.

[3] mentioned that precast concrete is the concrete beams, columns, lintels (sills above the doors or windows), piles, and parts of the walls and floors molded and partly done in the field or plant before being moved to the position in the structure. When some of the same parts required, precast can be cheaper compared by cast in situ, because it gives the better finishing surface, reduces the concrete shrinkage in the field, and creates the stronger concrete.

### B. Precast Concrete Component Type

[2] mentioned that the product of the precast concrete generally can be categorized into five components as mentioned below.

1. The components for ornament architectural need;
2. The concrete components for the traffic, paving, kerbs;
3. The structural components supporting the loads such as pole, beams, columns, floor plate, sleepers, and pipes;
4. The roof components which must be water resistant and weather resistant; and
5. The concrete brick (adobe).

There are many types of precast concrete components that can be produced in the plant starting from the general component such as beams, columns, plates flooring, cladding, to the specific components to meet the building aesthetic factor. These components are manufactured in various shapes and sizes adjusted to the design planned.

### C. Advantages and Disadvantages of Precast Concrete

[2] mentioned that the significant advantages of precast technology compared to conventional technology can be described below.

1. The project duration become shorter;
2. The material required become decrease such as framework and *scaffolding* reduced significantly;
3. Mass production of precast cause the optimal use of the machine so that the workers needs reduce;
4. Manpower required is less, because the components are made in the plant;
5. The better quality, because precast product manufacture in the plant use constant quality control, a competency system machine use, and the better working environment in the plant; and
6. Construction can be done almost without being affected by the weather, because the components are made in the closed building, and can be heated (in the cold weather), and even the *erection* can be done in the cold season.

But beside the advantages found in the precast technology, there are some disadvantages, such as mentioned below.

1. Transportation, component transportation process need the additional cost for procurement of component lifting tools from transportation tool;
2. Erection, is the process in grouping precast components to one complete part become the strong building; and
3. Connection, is the grouping of concrete and steel material become one main part of reinforced concrete structure.

### D. The Factors of Precast Concrete Technology Application Consideration

[4] mentioned that there are some consideration factors which become potential factors of precast concrete technology application. These consideration factors are mentioned is Table 1.

TABLE 1: THE FACTORS OF PRECAST CONCRETE TECHNOLOGY APPLICATION CONSIDERATION

Variable	Indicator
Cost consideration factor (economic)	The worker required in the field decrease
	The skilled worker required reduce
	No requiring the special maintenance
	Formwork used decrease
	Mould can be used many times
Quality consideration factor	Scaffolding used decrease
	The worker feels comfortable because of working in the ground surface and in the plant
	The weather effect is very small to the worker performance
	The constant quality control
	Computerization quality control technology is more guaranteed
Time consideration factor	The precast concrete surface is better
	More accurate dimension because of the machine using
	The finishing work is more neat
	Constant productivity in the plant
	Precast manufacture is not dependent on the below structure, can done parallel
Special consideration factor	Non-supporting weather in the project location if using conventional method
	The work in the project location is more simple
	The project time planned is short
	Easing the noise pollution because of construction tools in the field.
	The number of local worker which is limited in the project location established
	Project environment condition is cleaner
	The project land available is narrow for the component which is casted in the plant
	The material waste is minimal
	The typical building shape
	The project has the wide area

There are some reasons becoming the considerations of the construction company still using and applying conventional method in the construction project which can be described as below.

1. The high initial investment for precast concrete material procurement;
2. The possibility of components damage during the transportation;
3. Component dimension designed is limited because the limitation of transportation;
4. The limitation of tool capacity used for erection;
5. The connection system is relatively more complex;
6. The difficulty in repairing the damage component , which has been installed;
7. The less experience in handling the project using precast technology;

8. It is required the additional cost for transportation, erection or connection; and
9. It is required the wide land, if the precast component is casted in the project location.

#### E. Performance

[5] stated that the performance is a measure used to measure efficiency and effectiveness of an activity. Performance measurement is the process of calculating the efficiency and effectiveness of an activity.

[6] mentioned that the performance is the work result of the quality and quantity which can be achieved by a person in carrying out the duties and responsibilities given to him.

[7] stated that a company performance measurement are described as follows.

1. The companies can estimate the efficiency of the resources use;
2. The company can plan the realistic future performance targets based on current performance level; and
3. The companies can implement performance improvement strategies based on the distance between the actual performance and the expected performance.

[8] mentioned that ideal characteristics of the performance measurement unit can be mentioned as follow.

1. Describing the customer's needs as well as possible.;
2. Producing the conclusions and recommendations for the management decision;
3. Easy to be understood;
4. Used widely;
5. There is an interpretation;
6. Whether the measurement is available;
7. The measurement result is right; and
8. The economic use.

### III. RESEARCH METHODOLOGY

#### A. Population and Sample

The population is the constructor company of building sector in BG009 sub sector, starting  $M_1$ ,  $M_2$ , and  $B_1$  qualifications registered in LPJK Company of Aceh Province in 2016. Based on the data obtained from LPJK, the total of constructor companies for middle and large qualifications located in Banda Aceh and some companies from outside are 39 companies. Because the population is less than 100, so this study uses the population study without sampling.

#### B. Research Variable

The variables in this study are independent variable (X) consists of precast technology application factors and dependent variable (Y) consists of project implementation performance. The variables used in the questionnaire can be shown in Figure 1.

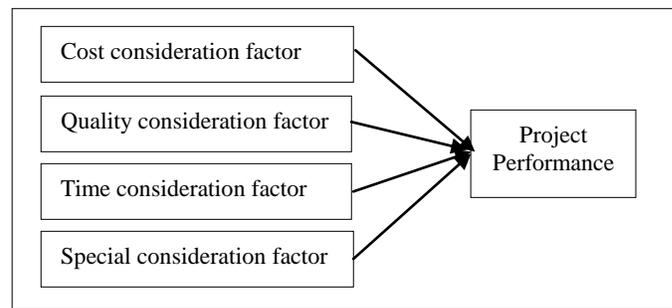


Fig. 1 Research variable

### IV. RESULT

#### A. Reliability Test

The result of reliability test for each variable is summarized in Table 2.

TABLE II TEST OF RELIABILITY

No.	Variable	<i>Cronbach Alpha</i>	Reliability
X1	Cost consideration factor	0.918	Very reliable
X2	Quality consideration factor	0.898	Very reliable
X3	Time consideration factor	0.882	Very reliable
X4	Special consideration factor	0.937	Very reliable
Y	Project Performance	0.963	Very reliable

According to the interval of Alpha coefficient and reliability measurement mentioned in literature study, the cronbach alpha value in the table above is in the interval indicating it is very reliable. Thus the reliability test performed on all of the variables are very reliable, so it can be continued to the data analysis process.

#### B. Descriptive Analysis

The respondent characteristics are constructor companies of building sector in BG009 sub sector, starting  $M_1$ ,  $M_2$ , and  $B_1$  qualifications located in Banda Aceh, with the total is 39 respondents. The characteristic of 39 respondents are summarized in Table 3.

TABLE III RESPONDENT CHARACTERISTIC

No.	Respondent Characteristic	Frequency	Percentage
1	Age		
	a. 20 – 30 Years	7	17.95%
	b. 31 – 40 Years	25	64.10%
	c. 41 – 50 Years	4	10.26%
	d. > 50 Years	3	7.69%
2	Gender		
	a. Male	39	100.00%
	b. Female	-	0.00%
3	Last Education		
	a. High School/Equivalent	2	5.13%
	b. D-III (Diploma)	5	12.82%
	c. S1 (Bachelor)	32	82.05%
	d. S2 (Master)	0	0.00%
	e. S3 (Doctor)	0	0.00%
4	Position		
	a. Director	0	0.00%
	b. Site manager	12	30.77%
	c. Quantity engineer	4	10.26%
	d. Quality engineer	6	15.38%
	e. Field Worker	17	43.59%
5	Experience in construction sector		
	a. 0 – 2 Year	0	0.00%
	b. 3 – 5 Year	0	0.00%
	c. 6 – 8 Year	15	38.46%
	d. > 8 Year	24	61.54%
6	Company Qualification		
	a. M1	24	61.54%
	b. M2	11	28.21%
	c. B1	4	10.26%
7	Precast Technology Application		
	a. Yes	19	48.72%
	b. No	20	51.28%

### C. Mean Value

There are five indicators highly affecting precast technology application consideration in building construction projects in Banda Aceh. Indicator which is are very influential has mean value with interval approaching.

Based on the mean calculation from all indicator mentioned in the above table, the recapitulation mean of each factor of precast technology application consideration can be summarized in Table 4.

TABLE IV MEAN VALUE

No.	Variable	Mean
1	Cost consideration factor	4.168
2	Quality consideration factor	4.172
3	Time consideration factor	4.179
4	Special consideration factor	4.165

### D. Correlation Analysis

Pearson Correlation Coefficient analyzed can be shown in Table 5.

TABLE V CORRELATION ANALYSIS

No.	Variable	Pearson Correlation	Correlation	Sign.< 0.05
1	X1 – Y	0.921	Very high	0.000
2	X2 – Y	0.935	Very high	0.000
3	X3 – Y	0.930	Very high	0.000
4	X4 – Y	0.800	Very high	0.000

### E. Multiple Linear Regression Analysis

The output value can be shown and summarized in Table 6.

TABLE VI MULTIPLE LINEAR REGRESSION ANALYSIS

Variable	Regression coefficient	t <sub>value</sub>	Sign.
Constant	0.660	0.417	0.679
Cost consideration	0.276	2.135	0.040
Quality consideration	0.381	2.700	0.011
Time consideration	0.538	3.193	0.003
Special consideration	0.124	1.657	0.107
F <sub>count</sub> = 121.617			
Sign. = 0.000			
R = 0.967			
R <sup>2</sup> = 0.935			

Based on regression coefficient value shown in Table 6, the multiple linear regression equation model can be shown in the below equation.

$$Y = 0.660 + 0.276X_1 + 0.381X_2 + 0.538X_3 + 0.124X_4$$

### F. F-Test

The value of is obtained through multiple linear regression coefficient output in Table 6, meanwhile the value of F<sub>table</sub> is obtained from the distribution of F table. The value of F<sub>table</sub> can be determined by finding degree of freedom (df) value for numerator (N1) and df for denominator (N2), so that: df (N1) = 3; and df (N2) = 35.

By linking the value df = 3 for the numerator (N1) and df = 35 for the denominator (N2), then the value of F<sub>table</sub> is F<sub>count</sub> obtained 2.87. The F test results obtained from multiple linear regression output for all factors simultaneously can be seen in Table 7.

TABLE 7: F-TEST

No.	Affecting	F <sub>count</sub>	F <sub>table</sub>	Sign.
1	X – Y	121.617	2.87	0.000

Based on the previous table, it is obtained that the value of F<sub>count</sub> > F<sub>table</sub> which is 121.617 > 2.87 and the significance value obtained is 0.000 < 0.05. It means that cost consideration factor, quality consideration factor, time consideration factor, and special consideration factor affecting significantly to the building construction project implementation performance in Banda Aceh simultaneously.

## V. CONCLUSION

There are 4 precast technology application factors in this study including cost consideration factor, quality consideration factor, time consideration factor, and special consideration factor. Through descriptive analysis identified, it is obtained the

highest mean value from time consideration factor which is 4.179. The research conducted by [4] showed that the factor affecting in precast technology application is concrete mold which can be used many times with the average value is 4.306. Meanwhile affecting factor of precast technology refusal is the limitation of component dimension designed because of the limitation of transportation with the average value is 3.694.

The research conducted by [9] showed that the precast concrete technology application in Indonesia is still only small apart of building components such as floor plate, piling, kansteen, fences, plates, columns, beams, architectural ornaments. It is because the ability of producers is very limited and it is not trusted about the connection system grouping the precast concrete components. The successful key in modular system application is in design phase. If the system will be applied, it should be well and carefully planned starting from design, production, transportation, and connection.

Overall, this simple correlation analysis shows that cost consideration factor, quality consideration factor, time consideration factor, and special consideration factor have very high relationship to building construction project implementation performance in Banda Aceh partially, with Pearson correlation coefficients is between 0.800 - 0.100.

Based on multiple regression analysis, it is obtained that the highest value of regression coefficient with the significant value  $< 0.05$  is obtained from cost consideration factor, quality consideration factor, and time consideration factor, the time consideration factor has the regression coefficient value which is 0.538, the quality consideration factor has the regression coefficient value which is 0.381, and the cost consideration factor has the regression coefficient value which is 0.276. it means that if cost consideration factor, quality consideration factor, and time consideration factor improve partially, building construction project implementation performance in Banda Aceh will also improve.

F test shows that precast technology application factors affecting significantly to building construction project implementation performance in Banda Aceh simultaneously, with the value of  $F_{\text{count}} > F_{\text{table}}$  which is  $121.617 > 2.87$  and the significance value obtained is  $0.000 < 0.05$ . It means that all of precast technology application factors simultaneously have the effect to building construction project implementation performance in Banda Aceh.

Based on the results, the value of multiple correlation coefficient (R) obtained is 0.967, it explains the very high relationship. It means that cost consideration factor, quality consideration factor, time consideration factor, and special consideration factor have very high to the building construction project implementation performance in Banda Aceh simultaneously.

Based on the results of regression analysis, the determination coefficient (*Rsquare*) obtained is 0.935. It means that precast technology application factors which consist of cost consideration factor, quality consideration factor, time consideration factor, and special consideration factor give the effect simultaneously as 93.5% to the building construction project implementation performance in Banda Aceh, while the

rest which is 6.5% is affected by other factors which are not examined in this study.

#### ACKNOWLEDGMENT

I, the undersigned below, Dr. Hafnidar A. Rani hereby states that:

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#### REFERENCES

- [1] H. A. Rani, dan Z. Fuadi, Efisiensi dan Efektivitas Pelaksanaan Struktur Kolom Antara Metode Precast dengan Konvensional, , *Jurnal Teknik Sipil*, Fakultas Teknik, Universitas Muhammadiyah Aceh, Volume 8 No. 2, pp 170-183, Februari, Banda Aceh, 2013.
- [2] W. I. Ervianto, Manajemen Proyek Konstruksi, Yogyakarta: Andi Offset, 2005.
- [3] M. G. Scott, Principles of Management Information Systems, Mc. Graw-Hill, 2001.
- [4] E. Agustian, Penerapan Teknologi Beton Pracetak pada Bangunan di Indonesia Ditinjau dari Segi Efisiensi Biaya, Mutu dan Waktu, Universitas Atma Jaya Yogyakarta, 2007.
- [5] S. Patdono, Sistem Pengukuran Kinerja: Sejarah Perkembangan dan Agenda Penelitian ke depan, Proceeding Seminar Nasional Performance Management, Jakarta, 2000.
- [6] A. P. Mangkunegara, Manajemen Sumber Daya Manusia Perusahaan, Bandung: Remaja Rosdakarya, 2001.
- [7] D. J. Sumanth, Productivity Engineering and Management, USA: McGraw-Hill, Inc, 1985.
- [8] I. Fanany, Perancangan Sistem Pengukuran Kinerja pada Perguruan Tinggi dengan Blanced Score Card, Studi Kasus Jurusan Teknik Industri – ITS, Surabaya, 1999.
- [9] W. I. Ervianto, Studi Implementasi Teknologi Beton Pracetak Bagi Bangunan Gedung, National Conference on Prospected Technology, 2007.
- [10] W. I. Ervianto, Teori Aplikasi Manajemen Proyek Konstruksi, Yogyakarta: Salemba Empat, 2004.
- [11] W. I. Ervianto, Studi Implementasi Teknologi Beton Pracetak Bagi Bangunan Gedung, National Conference on Prospected Technology, 2007.
- [12] W. I. Ervianto, Potensi Penggunaan Sistem Modular pada Proyek Konstruksi, *Jurnal Teknik Sipil*, Volume 8 No. 2, pp 170-183, Februari, 2008.
- [13] W. Larry, dan D. Glen, Value Engineering: A Practical Approach for Owners, Designers and Contractor, Van Nostrand Reinhold, New York, 1982.



**Hafnidar A. Rani** was born in Aceh on March 14<sup>th</sup>, 1970. She graduated her Bachelor Degree from Syiah Kuala University as a Civil Engineer in 1995. Then she continued her Master Program in Management Magister of Syiah Kuala University and graduated in 2000. She commenced her doctoral program in Construction Project Management of Universiti Utara Malaysia in 2006 and graduated the program in 2012.

After receiving her bachelor degree, she became the lecturer and teaching in Muhammadiyah Aceh University. Her research interests are in Construction Management, Project Management, Research Methodology, and Probability, Engineering Economic, and Value Engineering.

She has been in her current position as the Dean of Engineering Faculty of Muhammadiyah Aceh University since 2016. She is actively engaged in research especially in the last 5 years and also participating in conferences both national and international. In 2012, she also conducted the research for the community dedication which title was Techniques for Earthquake Resistant House Construction in Coastal Areas. She is also active as the keynote speaker in the seminar both national and international and as the reviewer of some Civil Engineering Journals. Her newest guideline book written is Construction Project Management produced in the beginning of 2016.