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VALUE ENGINEERING BUILDING STRUCTURE WORK ASN PASPAMPRES PUPR PRECAST WITH LEAD RUBBER BEARING POTENTIAL FAULT ZONE

Riyanto Rivky
Universitas Persada Indonesia Y.A. I., Indonesia_Magister Teknik Sipil
Email: riyanrivky2730@gmail.com

ABSTRACT

Life cycle cost (LCC) analysis is a method that can be used to control initial costs and future costs in investing in a project where in this case the use of Lead Rubber Bearing (LRB) technology. The purpose of this study is to analyze the economic value of a building by taking into account the cost of operating the building during the life cycle. Therefore, it is necessary to conduct a study on life cycle cost analysis to find out what costs are contained in the ASN Paspampres, IKN Flat Construction Project and to be able to find out how much costs are incurred starting from the design stage to the age of the building plan that has been determined. The data used are Plan Drawings, Cost Budget Plans (COST BUDGET PLAN) from the project and literature studies that support the research. The estimated cost of replacement and repair in the future is calculated on present value, with an economic life of building construction for 50 years with a simulation of an earthquake occurring only 1 time, assuming 6% interest, assuming an inflation rate of 2.61%, an increase in the price of construction materials and Lead Rubber Bearing (LRB) per year of 0.99%. Life Cycle Cost (LCC) analysis based on 4 system categories is that conventional LCC is greater than precast LCC, conventional LCC + LRB and precast LCC + LRB. Based on the value of Conventional LCC + LRB and Precast LCC + LRB is still more efficient than Conventional LCC and precast LCC, if the earthquake event is below the 12th year for Conventional LCC + LRB and the earthquake event is below 38 years for precast LCC + LRB. The deviation value between conventional LCC + LRB decreases over time until it approaches zero deviation (0) near the 12th year and after that year (12th) the deviation becomes negative. This means that after the 12th year Conventional LCC + LRB is already inefficient compared to Conventional LCC. The deviation value between Precast LCC + LRB decreases over time until it approaches zero deviation (0) near the 38th year and after that year (38th) the deviation becomes negative. This means that after the 38th year Precast LCC + LRB is no longer efficient compared to Conventional LCC.

Keywords: Lead Rubber Bearing (LRB), Life Cycle Cost (LCC), Construction life

INTRODUCTION

One method that can be used to analyze the economic value of a building by considering operating costs throughout the life of the building is Life Cycle Cost (LCC) (Wongkar, Tjakra, & Pratasis, 2016). This method has been known since the mid-1970s and has now been implemented by several States, by large corporations, and government-sponsored projects (Islam, Jollands, & Setunge, 2015). This method is also useful for making decisions based on economic value by considering location, engineering and architectural planning, construction, arrangement, operation to disposal followed by replacement of components or systems during the life span of the building.

Life Cylce Cost has many unexpected variables and because it is related to the future, these variables will be difficult to predict based on current knowledge and tendencies (Nugroho, 2014). Perhaps one way of estimating is to look back and then project these results into the future. Of course, this is the most common method of estimation, which is to analyze old data and organize it with the latest consideration and knowledge. For example, flat roofs can have many problems and are not recommended as a duCost Budget Plan le and trouble-free solution, resulting in lower Life Cycle Costs.

Life Cycle Cost is one of the methods offered in order to calculate costs that are more accurate and more supportive in decision making and can be applied to both manufacturing companies and service companies (Buyung, Pratasis, & Malingkas, 2019). In this study, Life Cylce Cost Calculation was carried out at the stage after project planning. Life Cylce Cost analysis was carried out on structural work at the ASN Paspampres building, the State Capital of Penajam Paser, East Kalimantan. The case study in the research on this building is due to the relocation of the national capital on the island of Kalimantan, precisely in the administrative area of North Penajam Paser Regency, East Kalimantan has been determined by President Joko Widodo. The reason for moving the national capital is due to the small risk of natural disasters, one of which is the earthquake disaster.

There have been many previous researchers looking for various solutions to reduce damage and prevent structural collapse due to earthquakes (Noor, 2014). One of the efforts created for this problem is a based isolated system that can reduce the energy that will hit construction buildings due to earthquakes by using base insulators, one of which is Lead Rubber Bearing (LRB).

Lead Rubber Bearing (LRB) is a type of earthquake protection system consisting of round steel plates and connected with solid rubber (Setiati, Purnomo, & Hardono, 2022). The rubber layer used in LRB serves to absorb earthquake energy, while the steel plate serves to withstand vertical loads. LRB is used as a substitute for bearings in building structures, bridges, and others.

On January 31, 2023, the Government through the Ministry of Public Works and Public Housing (PUPR) together with the Ministry of Economic Affairs has inaugurated a Lead Rubber Bearing (LRB) Factory in the Openwork Area, West Java. Coordinating Minister for Economic Affairs Airlangga Hartanto said, the existence of this factory is in accordance with the direction of the President of the Republic of Indonesia Joko Widodo to encourage the use of domestic products (Farhana, Labdhameirina, & Mediaty, 2022; Sinha & Singh, 2017). The Ministry of PUPR also continues to encourage the use of domestic products in infrastructure development, using products that already have a high Domestic Component Level (TKDN) certificate from the Ministry of Industry

On this basis, one of the researchers conducted research using LRB earthquake damping technology at the ASN Paspampres building because the priority factor of the earthquake also rose so that a technology is needed that can prevent when potential earthquakes and faults occur.

In this study, especially in the use of LRB earthquake damping technology in the ASN Paspampres building, Life Cycle Cost (LCC) analysis will be used in order to determine efficiency and in what year it will be considered inefficient in the use of Lead Rubber Bearing (LRB) earthquake damping / base isolation technology.

RESEARCH METHOD

The research was conducted on the ASN Paspampres Flat Development project. The research method applied is a quantitative descriptive method, which is a process that has a structure and is systematic consisting of several stages. The basic reference for research is in accordance with the background and objectives to be achieved supported by related theories and literature studies. The data used are plan drawings, cost budget plans (COST BUDGET PLAN) (Sila et al., 2023), unit prices of materials and wages as well as specifications for earthquake absorber technology / *Lead Rubber Bearing (LRB)*

The scope in this study, namely :

1. Simulating research on the construction period of buildings in accordance with the age of the building plan based on Government Regulation (PP) no.16 of 2021 "Implementation

Regulations of Law Number 28 of 2002 concerning Buildings" and SNI 1726; 2019 on Earthquake Resistance Planning Procedures for Building and Non-Building Structures

2. Analysis of simulated building damage in accordance with Government Regulation (PP) no.16 of 2021 "Implementation Regulations of Law Number 28 of 2002 concerning Buildings" with three categories of damage conditions, namely Light damage, moderate damage, and heavy damage.
3. Technology is needed that can control earthquakes (Seismic Control), namely the earthquake isolation system used at the base of the building (Foundation) is called base isolation (Base Isolation). The technology system used to dampen earthquake forces due to the location close to the fault zone / fault about +/- 20 m from the building site point using earthquake damping technology / Seismic Base Isolation serves to dampen the movement / vibration of the ground against the potential for earthquake disasters and the potential for fault zones / faults.
4. The value of changes in interest rates and inflation values are taken based on 2023 data in December sourced from Bank Indonesia
5. The maintenance cost of high-rise buildings refers to Government Regulation (PP) no.16 of 2021 "Implementing Regulations of Law Number 28 of 2002 concerning Buildings", namely The maintenance fee as referred to in paragraph (1) is set at a maximum of 2% (two hundredths) of the highest standard price per m2 (square meter) of the current year.
6. The costs calculated in this analysis are the initial cost/value of building construction, building maintenance and replacement of earthquake damping technology every 25 years
7. Analyzing the Investment Cost Value of Building Buildings using Lead Rubber Bearing (LRB) technology on the lower structure and stimulating various conditions of the construction system, especially structures, among others:
    a. 100% Conventional construction method, with Earthquake damage MILD damage (30%)
    b. 100% Prefabricated construction method, with Earthquake damage MILD damaged condition (30%)
    c. Conventional construction method 100% with Lead Rubber Bearing (LRB) with Earthquake damage none (structural work) (0%) + Lead Rubber Bearing (LRB) replacement cost 25 yrs
    d. 100% Precast construction method with Lead Rubber Bearing (LRB), with Earthquake damage none (structural work) (0%) + Lead Rubber Bearing (LRB) replacement cost 25 yrs
8. LCC cost analysis based on Earthquake Event with annual simulation and natural type Lead Rubber Bearing (LRB) replacement cost every 25 years
9. Earthquake events simulated over a construction life of 50 years with only one earthquake occurring.
10. LCC cost analysis based on Earthquake Event with annual simulation and natural type Lead Rubber Bearing (LRB) replacement cost every 25 years.

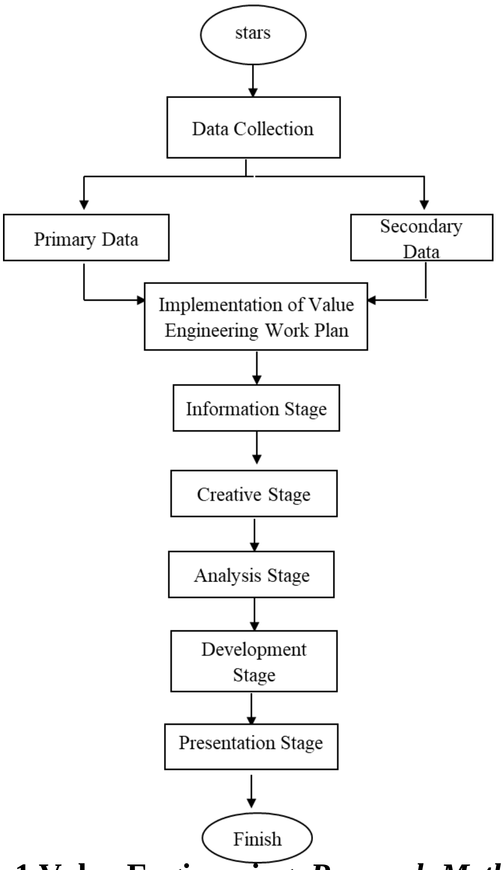


Figure 1 Value Engineering ***Research Methodology Chart***

RESULT AND DISCUSSION

In conducting a Value Engineering study, planning data regarding the construction of the ASN Paspampres Flat building is needed. This data is used as a reference so that it functions and is used later unchanged from the original plan. This existing data will later be used as initial data for value engineering analysis. The project data obtained for processing is as follows :

Building name	: ASN HANKAM-PASPAMPRES Flats
Building location	: Nusantara Capital Region (IKN),
Owner	: Directorate General of Cipta Karya PU-PERA
Consultant	: PT. PENTA CONSULTANT
Building function	: Housing for PASMPAMPRES

Presidential Security Force (Paspampres) Residential Development Activities at KIPP-IKN are designed to be integrated with the Multi-Year Contract (MYC) system FY 2023-2024 amounting to Rp. 1,846,140,000,000, - (one trillion eight hundred forty-six billion one hundred forty million rupiah).

Figure 2. **3D View of ASN Paspampres Flats, IKN**

Figure 3. Concept of Zoning and Intensity of ASN Paspampres IKN

The implementation time of the Integrated Design-Build Construction Work of building construction activities and the Hankam block area at KIPP-IKN is 498 (four hundred and ninety-eight) calendar days or 17 (seventeen) months from the issuance of the Work Start Order (SPMK).

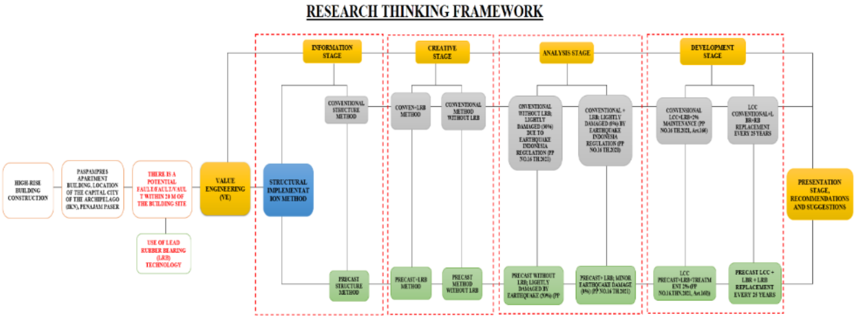


Figure 4. Research Thinking Pattern Framework

This stage will simulate the price of construction work by adding the installation of LRB technology. In the construction of ASN Pasapmpres flats, conventional methods will be used for 4 towers while the remaining 5 towers will be done by precast / precast method. For the COST BUDGET PLAN Analysis stage with the use of LRB, it will be divided into 4 conditions, including: :

1. Cost Budget Plan Conventional Price
2. Cost Budget Plan Prefabricated Price
3. Cost Budget Plan Conventional Price + LRB
4. Cost Budget Plan Prefabricated Price + LRB

In the Cost Budget Plan analysis also includes the value of building maintenance, simulating the value of building damage due to earthquakes refers to the intensity of building damage due to earthquakes and will be calculated annually assuming that every year there will be an earthquake (Ezrahayu, 2021). The use of LRB will also take into account the cost of its replacement every 25 years.

Pareto's Law Testing

Pareto analysis is carried out to determine the highest cost of this project which has the potential to be carried out value engineering analysis. Here are the steps in testing Pareto's law::

1. Sort the job costs from largest to smallest.
2. Sum the total job cost cumulatively
3. Calculating the percentage of the cost of each work.
4. Calculating the cumulative percentage
5. Plotting the cumulative percentage

Table. 1. Pareto Results of ASN Paspampres Flats Structure Work, IKN-Penajam Paser

PARETO ANALYSIS OF ASN PARPAMPRES FLAT IKN LOCATION, PANAJAM PASER-KALTIM

NO	JOB DESCRIPTION	AMOUNT (IDR)	Bobot (%)	CUMULATIVE	CUMULATIVE WEIGHT
1	Architectural Work	56.785.644.898	33,04%	56.785.644.898,04	33%
2	Mechanical Work	41.574.769.460	24,19%	98.360.414.358,04	57%
3	Structure Works	40.291.332.621	23,44%	138.651.746.979,12	81%
4	INFRASTRUCTURE & LANDSCAPE WORK	15.341.150.207	8,92%	153.992.897.186,60	90%
5	MEUBELAIR WORK	10.812.000.000	6,29%	164.804.897.186,60	96%
6	PREPARATION AND PRELIMINARY WORK	4.465.037.750	2,60%	169.269.934.936,79	98%
7	PERIODIC PLANNING AND SUPERVISION WORK	1.948.398.000	1,13%	171.218.332.936,79	100%
8	CONSTRUCTION SAFETY AND MANAGEMENT SYSTEM	675.875.889	0,39%	171.894.208.825,67	100%
a.	Total Bid Price (including profit and incidental costs but excluding VAT)	**171.894.208.825,67**	**100,00%**	**171.894.208.825,67**	
b.	Value Added Tax (VAT) = 11% x (A)	**18.908.362.970,82**			
c.	Total Bid Price Including 11% VAT = (A) + (B)	**190.802.571.796,50**			

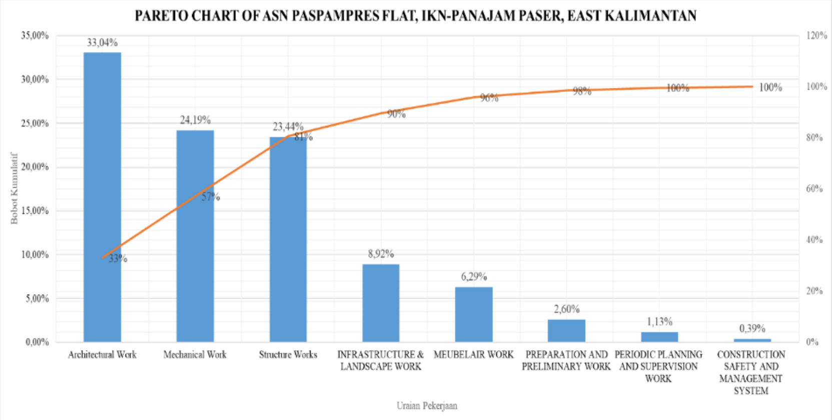


Figure 5 Pareto Results of ASN Paspampres Flat Project, IKN-Penajam Paser

From the pareto results of the entire project, it can be seen that in this project the work that has great weight is Architecture, Mechanical, Electrical & Plumbing work, Structural Work, Infrastructure & Landscape Work, Meubelair Work, Preparatory & Preliminary Work, Periodic Planning and Supervision Work and Construction Management &; Safety System Work. Of the three largest prices, there is a component of the work, there is one job that will be analyzed again using the pareto law, namely in upper structural work. This is because researchers focus more on precast or conventional system methods on the work of the upper structure, namely columns, beams and plates.

Table. 2. Pareto Results of ASN Paspampres Flats Structure Work, IKN-Penajam Paser

PARETO ANALYSIS PEK. PARPAMPRES ASN FLAT STRUCTURE IKN LOCATION, PANAJAM PASER-EAST KALIMANTAN

NO	JOB DESCRIPTION	AMOUNT (IDR)	Bobot (%)	CUMULATIVE	CUMULATIVE WEIGHT
1	Upper Structure Works	29.219.207.602	72,52%	29.219.207.601,82	73%
2	Foundation Work	5.766.287.299	14,31%	34.985.494.901,26	87%
3	Pile Cap Work	2.616.200.633	6,49%	37.601.695.534,64	93%
4	Concrete Wall Work	971.929.714	2,41%	38.573.625.248,78	96%
4	Tie Beam Work	579.796.301	1,44%	39.153.421.549,42	97%
5	Ground work	561.886.051	1,39%	39.715.307.600,31	99%
6	Ground Floor Plate Work	439.029.359	1,09%	40.154.336.959,15	100%
7	Pit Lift Work	136.995.662	0,34%	40.291.332.621,07	100%
a.	Total Bid Price (including profit and incidental costs but excluding VAT)	**40.291.332.621,07**	**100,00%**	**40.291.332.621,07**	
b.	Value Added Tax (VAT) = 11% x (A)	**4.432.046.588,32**			
c.	Total Bid Price Including 11% VAT = (A) + (B)	**44.723.379.209,39**			

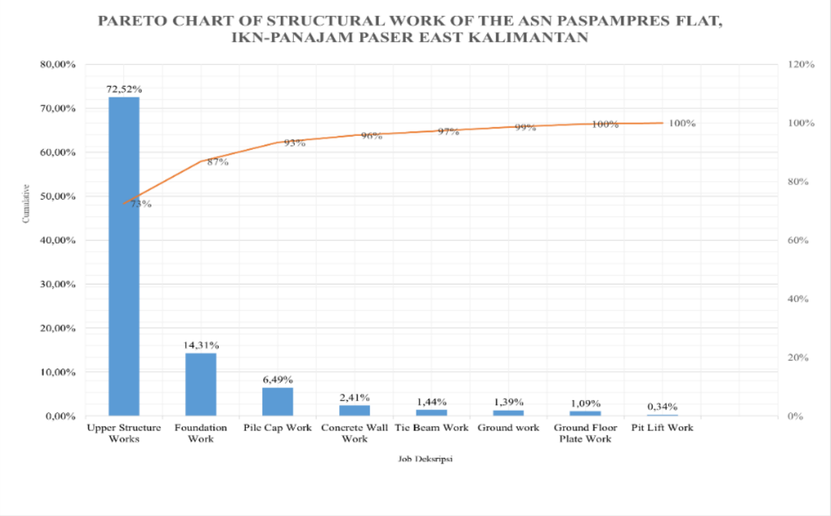


Figure 6. Pareto Diagram of Project Structure Work of ASN Paspampres Flat, IKN-Penajam Paser

From the results of the pareto analysis of structural work, a large weight of work was obtained, namely upper structural work in the construction of ASN Paspampres flats

Function Analysis using Techical Fast Diagram

Function analysis is the main basis in value engineering because it is what distinguishes VE from other savings techniques (Putri, 2019). The function that is determined as the basic reason for the holding of a good or service is called the primary function and will answer the question of what to do? by these goods and services

Table 3. Component Function Analysis

Analysis of Component Functions

Verbs	Nouns	Type of Function
Lead Rubber Bearing	Damper	Primary
Obtaining	Efficient	Primary
Prevent	Damaged	Primary
Receive	Load	Primary
Distributed	Load	Primary
Shrinking	Earthquake	Primary
Shrinking	Deviations	Secondary
Adding to	Building Age	Secondary
Pressing	Cost of Repair	Secondary
Support	Building	Secondary
Reduce	Shocks	Secondary

Based on the identification of functions, a function model is formed, the function model used is a technical FAST diagram. For more details, the relationship between primary functions and secondary functions in the FAST diagram can be seen in the following figure:.

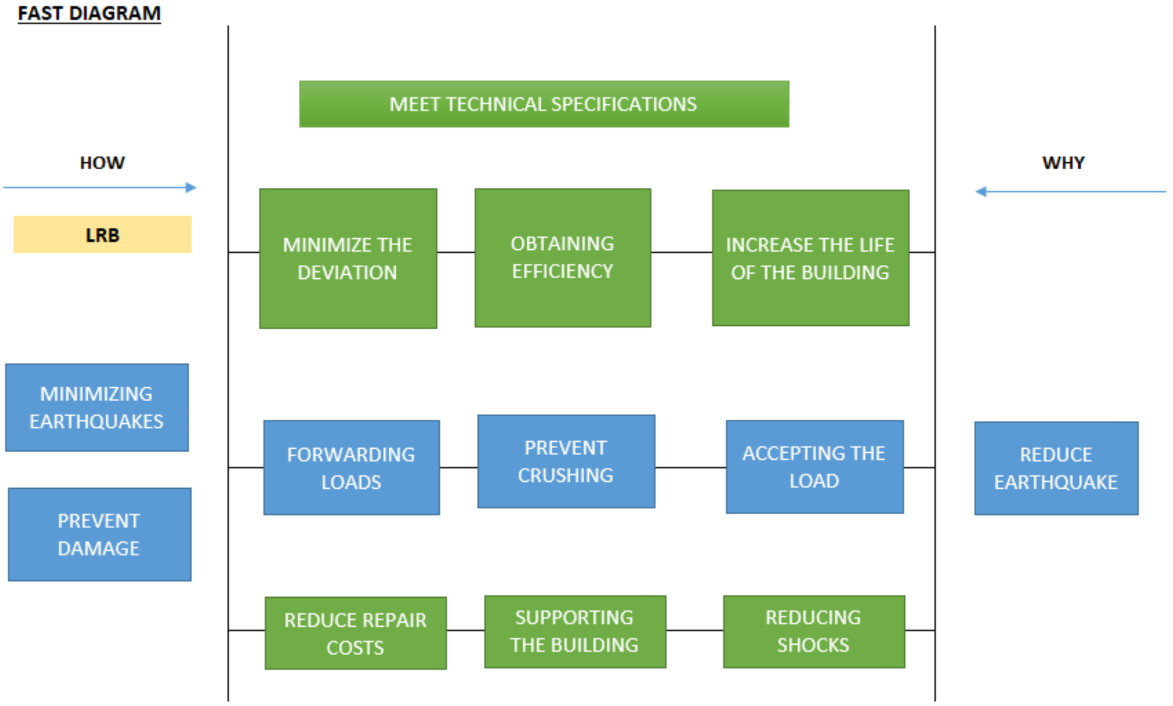


Figure 7. FAST DIAGRAM Lead Rubber Bearing (LRB)

The reasons for conducting a VE analysis on these items are::

a. The location of buildings that are in potential fault zones requires construction technology that can reduce earthquakes and eliminate damage to buildings
b. The huge investment value of the use of Lead Rubber Bearing (LRB) affects the construction value of the ASN Paspampres Project
c. The use of LRB is used in conventional building systems and precast systems
d. Knowing the efficiency of both conventional and precast building systems after using LRB

Information Stage

At this initial stage, efforts are made to obtain as much information as possible relevant to the object of study to be evaluated, where the data and information are processed according to needs at the next stage. The general information required among others is:

1. Project name : ASN PASPAMPRES flats
2. Project location : IKN, Penajam Paser, East Kalimantan
3. Project owner : Inspektorat Cipta Karya PU
4. Building function : Residential
5. Structure Type : Reinforced Concrete Structure
6. Structural system : Moment Bearing Frame System
7. Number of floors : 12 floors
8. Building area : 11.666 m2

Creative Level

At this stage, alternative designs will be raised as a comparison to buildings located in fault zones or faults with the use of LRB (Gur, Mishra, & Chakraborty, 2014). With the emergence of this alternative design, it is hoped that it will create new design opportunities that can streamline prices. Several factors in Multi Criteria Analysis (MCA) Analysis in the Selection of Earthquake Reducer Systems

Table 4. MCA Table for Determination of Earthquake Damper/Base Isolation Used

DESCRIPTION OF THE REVIEW	BOBOT	SCORE	CONVENTIONAL	SCORE	PRECAST	SCORE	CONVENTIONAL +LRB	SCORE	PRECAST+LRB
CONSTRUCTION COSTS	29%	0,51	14,890	1,00	29,412	0,00	0,00	0,49	14,522
IMPLEMENTATION TIME (MONT	29%	0,40	11,765	1,00	29,412	0,00	0,00	0,80	23,529
BUILDING QUALITY	24%	0,00	0,000	0,00	0,000	0,50	11,76	1,00	23,529
EARTHQUAKE DAMAGE REPAIR	18%	0,00	0,000	0,10	1,729	1,00	17,65	1,00	17,647
TOTAL SCORE			26,654		60,553		29,412		79,228
RANGKING			IV		II		III		I

Based on the MCA analysis table above, the type of earthquake absorber used rank 1 is Lead Rubber Bearing (LRB).

Peredam Gempa Lead Rubber Bearing (LRB)

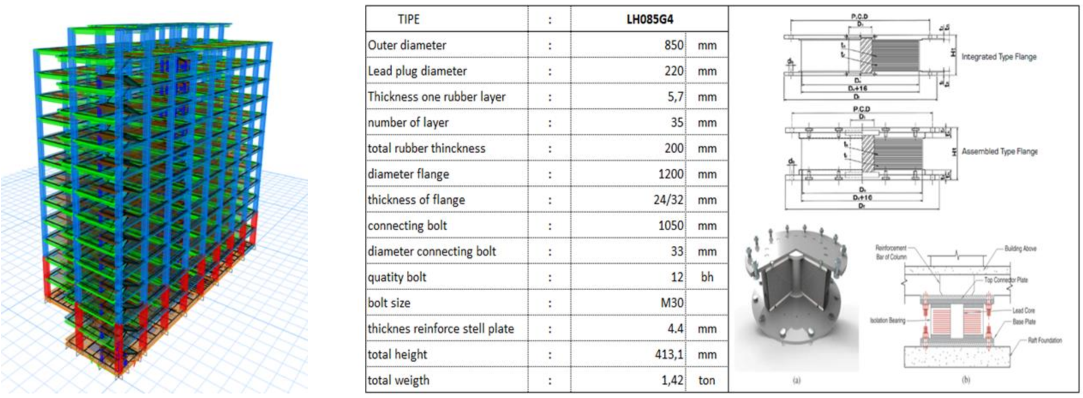
Development implementation system using preprint with the addition of LRB technology. There are several advantages and benefits of using LRB on infrastructure, among others:

a. Absorbs earthquake energy. LRB is able to absorb earthquake energy by means of elastic deformation in rubber. The rubber on the LRB will stretch when an earthquake occurs, so that earthquake energy is absorbed and prevents damage to building structures or bridges.

b. Reduce Damage to Buildings. By using LRB, damage to building structures can be reduced or even avoided. This is because LRB can absorb earthquake energy so that the load on the building structure is reduced. In addition, the use of LRB can also increase the ability of building structures to withstand loads and extend the life of building structures.

c. Ease of repair. If there is damage to the LRB, it can be replaced easily without damaging the structure of the building or bridge. This allows repairing building structures or bridges to be easier and cheaper.

d. Lower cost. LRB allows structures to be built at a lower cost compared to traditional construction. This is because structures with LRB do not require columns and thick walls to withstand the lateral load of the earthquake.
e. DuCost Budget Plan le. LRB has a long service life and can last for more than 50 years with proper maintenance



TIPE	:	LH085G4	
Outer diameter	:	850	mm
Lead plug diameter	:	220	mm
Thickness one rubber layer	:	5,7	mm
number of layer	:	35	mm
total rubber thinckness	:	200	mm
diameter flange	:	1200	mm
thickness of flange	:	24/32	mm
connecting bolt	:	1050	mm
diameter connecting bolt	:	33	mm
quatity bolt	:	12	bh
bolt size	:	M30	
thicknes reinforce stell plate	:	4.4	mm
total height	:	413,1	mm
total weigth	:	1,42	ton

Figure 8.. Lead Rubber Bearing (LRB) Type Used (analytical structure modeling)

Analysis Phase

In the Analysis Stage, researchers will make simulations with 4 categories of building condition types (Nguyen, Reiter, & Rigo, 2014). In materials, it is assumed to experience an increase of 0.99% per year, while LRB is assumed to experience a price increase of 0.99% per year. The percentage of building maintenance costs is taken at 2% referring to the applicable candy.

Table 5. Interest rates and inflation used in the Analysis Phase

KNOWN:	INDEKS		SOURCE
AGE OF BUILDING	50	YEAR	SNI 1726;2019
BUILDING MAINTENANCE	2%	YEAR	PERMEN NO.22/PRT/M/2018; Article 66/PP 16 TH.2021 ARTICLE 160
INTEREST RATES	6%	YEAR	https://finansial.bisnis.com/read/20240118/90/1733524/bunga-deposito-bca-mandiri-bri-dan-bni-terbaru-ada-update-per-17-januari-2024
INFLANSI	2,61%	YEAR	https://www.bi.go.id/id/statistik/indikator/data-inflasi.aspx
MATERIAL PRICE INCREASE	0,99%	YEAR	https://www.bps.go.id/id/pressrelease/2024/01/02/2311/pada-desember-2023--perubahan-indeks-harga-perdagangan-besar--ihpb--umum-nasional-tahun-ke-tahun-sebesar-3-14-persen.html
LRB PRICE INCREASE	0,99%	YEAR	
TKDN	78,75%		Source PT.MAGDA LRB PRODUCT

Table 6: Percentage value of building damage caused by the earthquake

STRUCTURE SYSTEM	CATEGORIES	PROSENTATION	SOURCE
CONVENTIONAL	LIGHTLY DAMAGED	30%	PERMEN NO.22/PRT/M/2018; Article 66/PP 16 TH.2021 ARTICLE 162 Art.7
PRACETAK	LIGHTLY DAMAGED	30%	
CONVENTIONAL + LRB	NOT DAMAGED	0%	
PRACETAK + LRB	NOT DAMAGED	0%	

Table 7. Building Data and LRB Price

BUILDING AREA	13035,6	M2
NUMBER OF FLOORS	12	LAPIS
NUMBER OF COLUMNS/FLOOR	36	Bh
LRB PRICE	Rp 101.276.500	Bh
LRB INSTALLATION FEE	Rp 23.371.500	Bh
LRB REPLACEMENT FEE	Rp 30.382.950	Bh

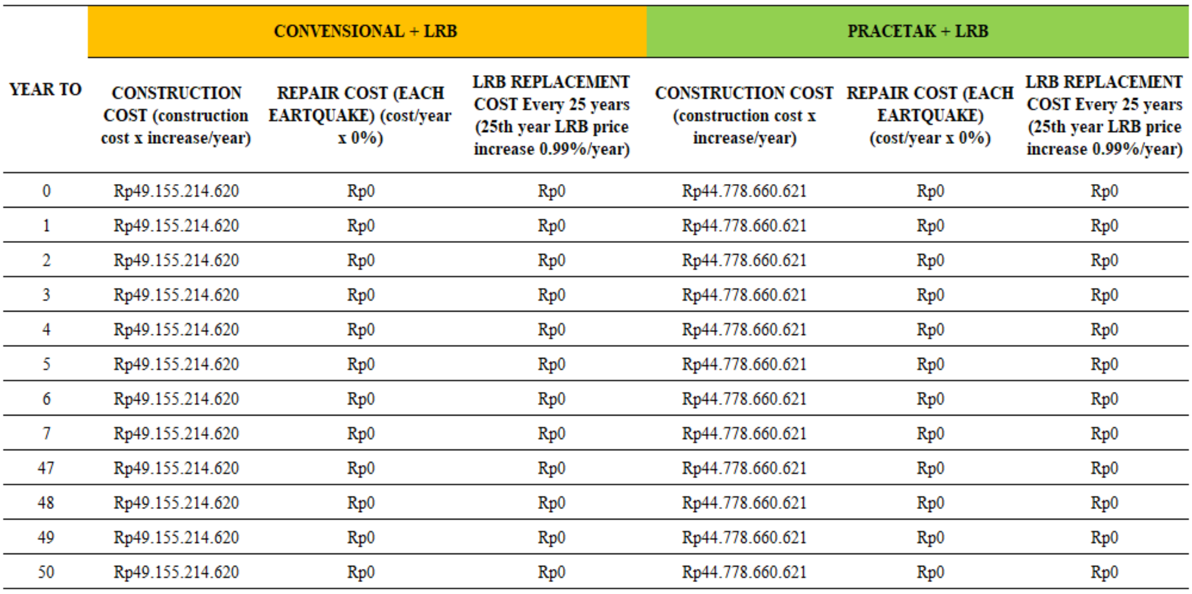
The following is an analysis of the price of ASN Paspampres structural work with various conditions:

Table 8. Calculation of annual repair costs due to earthquakes with minor damage (30%) to conventional structures and precast structures without LRB per year

	CONVENTIONAL		PRACETAK	
YEAR TO	CONSTRUCTION COST (construction cost x increase/year)	REPAIR COST (EACH EARTQUAKE) (cost/year x 30%)	CONSTRUCTION COST (construction cost x increase/year)	REPAIR COST (EACH EARTQUAKE) (cost/year x 30%)
0	Rp44.667.886.620	Rp13.400.365.986	Rp40.291.332.621	Rp12.087.399.786
1	Rp45.110.098.697	Rp13.533.029.609	Rp40.690.216.814	Rp12.207.065.044
2	Rp45.556.688.675	Rp13.667.006.602	Rp41.093.049.960	Rp12.327.914.988
3	Rp46.007.699.892	Rp13.802.309.968	Rp41.499.871.155	Rp12.449.961.347
4	Rp46.463.176.121	Rp13.938.952.836	Rp41.910.719.880	Rp12.573.215.964
5	Rp46.923.161.565	Rp14.076.948.469	Rp42.325.636.006	Rp12.697.690.802
6	Rp47.387.700.864	Rp14.216.310.259	Rp42.744.659.803	Rp12.823.397.941
7	Rp47.856.839.103	Rp14.357.051.731	Rp43.167.831.935	Rp12.950.349.580
47	Rp70.970.668.904	Rp21.291.200.671	Rp64.016.971.555	Rp19.205.091.466
48	Rp71.673.278.527	Rp21.501.983.558	Rp64.650.739.573	Rp19.395.221.872
49	Rp72.382.843.984	Rp21.714.853.195	Rp65.290.781.895	Rp19.587.234.569
50	Rp73.099.434.139	Rp21.929.830.242	Rp65.937.160.636	Rp19.781.148.191

In the table above, the price review of construction costs until year 50, there is an increase in prices based on inflation and interest rates per year.

Table 9. **Calculation of annual repair costs and periodic replacement costs of LRB per 25 years due to earthquakes**



YEAR TO	CONVENSIONAL + LRB			PRACETAK + LRB		
	CONSTRUCTION COST (construction cost x increase/year)	REPAIR COST (EACH EARTQUAKE) (cost/year x 0%)	LRB REPLACEMENT COST Every 25 years (25th year LRB price increase 0.99%/year)	CONSTRUCTION COST (construction cost x increase/year)	REPAIR COST (EACH EARTQUAKE) (cost/year x 0%)	LRB REPLACEMENT COST Every 25 years (25th year LRB price increase 0.99%/year)
0	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
1	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
2	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
3	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
4	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
5	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
6	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
7	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
47	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
48	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
49	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0
50	Rp49.155.214.620	Rp0	Rp0	Rp44.778.660.621	Rp0	Rp0

In the table above the LRB replacement price in the 25th year, at the beginning of the first year the installation cost was Rp. 4,487,328,000 while in the 25th year it became Rp. 5,740,466,621.

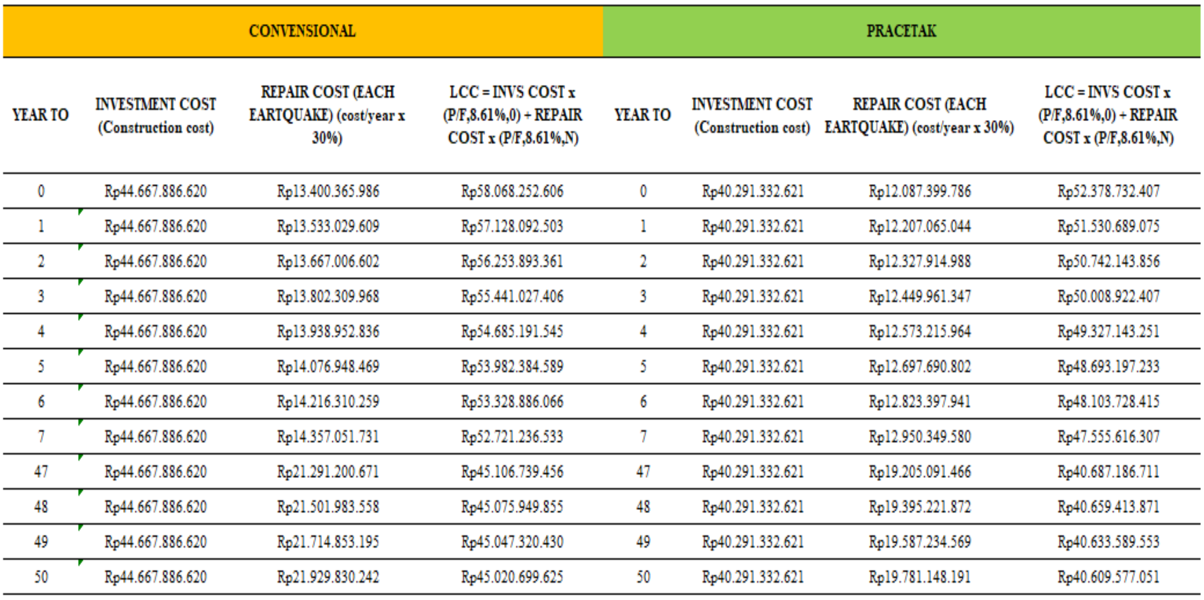
For the Conventional Method System, because the earthquake event cannot be determined with certainty, the LCC value is calculated at each earthquake event from year 0 to year 50. The calculation of LCC at the 1st year earthquake event is as follows:

LCC yr-1 = Initial Cost x (P/F,8.61%,0) + Maintanance Cost year-1 x (P/F,8.61%,1)
= 44.667.886.620 x (1) + 13.400.365.986 x (1)
= 58.068.252.606

For the Prefabricated Method System, since the earthquake event cannot be determined with certainty, the LCC value is calculated for each earthquake event from year 0 to year 50. The LCC calculation for the year 1 earthquake event is as follows:

LCC yr-1 = Initial Cost x (P/F,8.61%,0) + Maintanance Cost year -1 x (P/F,8.61%,1)
= 40.291.332.621 x (1) + 14.150.990.574 x (1)
= 44.065.922.947

Table 10. Life Cycle Cost (LCC) analysis of conventional structural systems with minor damage conditions (30%) without LRB



CONVENSIONAL				PRACETAK			
YEAR TO	INVESTMENT COST (Construction cost)	REPAIR COST (EACH EARTQUAKE) (cost/year x 30%)	LCC = INVS COST x (P/F,8.61%,0) + REPAIR COST x (P/F,8.61%,N)	YEAR TO	INVESTMENT COST (Construction cost)	REPAIR COST (EACH EARTQUAKE) (cost/year x 30%)	LCC = INVS COST x (P/F,8.61%,0) + REPAIR COST x (P/F,8.61%,N)
0	Rp44.667.886.620	Rp13.400.365.986	Rp58.068.252.606	0	Rp40.291.332.621	Rp12.087.399.786	Rp52.378.732.407
1	Rp44.667.886.620	Rp13.533.029.609	Rp57.128.092.503	1	Rp40.291.332.621	Rp12.207.065.044	Rp51.530.689.075
2	Rp44.667.886.620	Rp13.667.006.602	Rp56.253.893.361	2	Rp40.291.332.621	Rp12.327.914.988	Rp50.742.143.856
3	Rp44.667.886.620	Rp13.802.309.968	Rp55.441.027.406	3	Rp40.291.332.621	Rp12.449.961.347	Rp50.008.922.407
4	Rp44.667.886.620	Rp13.938.952.836	Rp54.685.191.545	4	Rp40.291.332.621	Rp12.573.215.964	Rp49.327.143.251
5	Rp44.667.886.620	Rp14.076.948.469	Rp53.982.384.589	5	Rp40.291.332.621	Rp12.697.690.802	Rp48.693.197.233
6	Rp44.667.886.620	Rp14.216.310.259	Rp53.328.886.066	6	Rp40.291.332.621	Rp12.823.397.941	Rp48.103.728.415
7	Rp44.667.886.620	Rp14.357.051.731	Rp52.721.236.533	7	Rp40.291.332.621	Rp12.950.349.580	Rp47.555.616.307
47	Rp44.667.886.620	Rp21.291.200.671	Rp45.106.739.456	47	Rp40.291.332.621	Rp19.205.091.466	Rp40.687.186.711
48	Rp44.667.886.620	Rp21.501.983.558	Rp45.075.949.855	48	Rp40.291.332.621	Rp19.395.221.872	Rp40.659.413.871
49	Rp44.667.886.620	Rp21.714.853.195	Rp45.047.320.430	49	Rp40.291.332.621	Rp19.587.234.569	Rp40.633.589.553
50	Rp44.667.886.620	Rp21.929.830.242	Rp45.020.699.625	50	Rp40.291.332.621	Rp19.781.148.191	Rp40.609.577.051

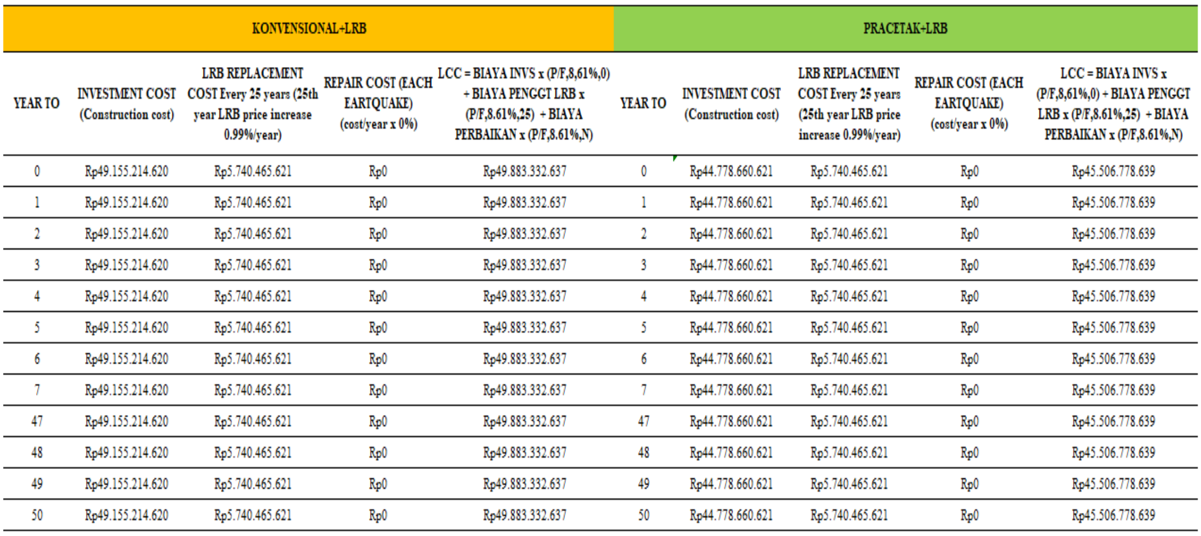
Because the earthquake event cannot be determined with certainty, the LCC value is calculated for each earthquake event from year 0 to year 50. The LCC calculation for the year 1 earthquake event is as follows:

LCC year-1 = Initial Cost x (P/F,8.61%,0) + Replace Cost LRB 25 yr x (F/P,0.99%,25) x (P/F,8.61%,25) + Repair Cost yr-1 x (P/F,8.61%,1)
= 49.155.214.620 x (1) + 5.740.465.621 x (1.2793) x (0.1268) + 0 x (0.9207)
= 49.883.332.637 (Conventional)

Because the earthquake event cannot be determined with certainty, the LCC value is calculated for each earthquake event from year 0 to year 50. The LCC calculation for the year 1 earthquake event is as follows:

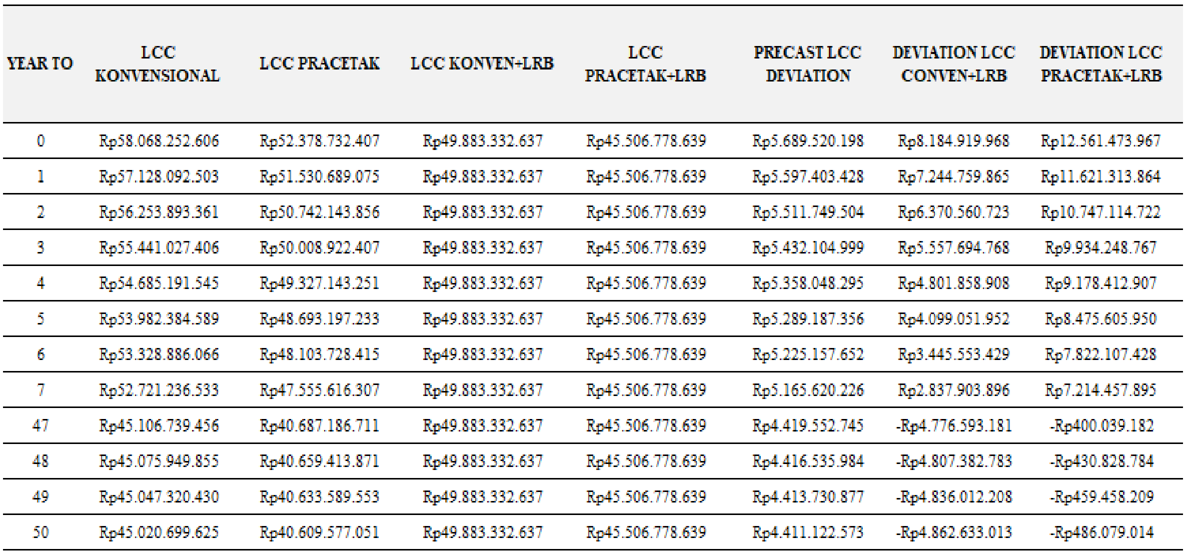
LCC year-1 = Initial Cost x (P/F,8.61%,0) + Replace Cost LRB 25 yr x (F/P,0.99%,25) x (P/F,8.61%,25) + Repair yr-1 x (P/F,8.61%,1)
= 44.778.660.621 x (1) + 5.740.465.621 x (1.2793) x (0.1268) + 0 x (0.9207)
= 45.506.778.639 (Precast)

Table 11. Life Cycle Cost (LCC) analysis on conventional structural systems + LRB with no conditions Minor damage (0%) to structural components + LRB replacement costs per 25 years



KONVENSIONAL+LRB					PRACETAK+LRB				
YEAR TO	INVESTMENT COST (Construction cost)	LRB REPLACEMENT COST Every 25 years (25th year LRB price increase 0.99%/year)	REPAIR COST (EACH EARTQUAKE) (cost/year x 0%)	LCC = BIAYA INVS x (P/F,8,61%,0) + BIAYA PENGGT LRB x (P/F,8.61%,25) + BIAYA PERBAIKAN x (P/F,8.61%,N)	YEAR TO	INVESTMENT COST (Construction cost)	LRB REPLACEMENT COST Every 25 years (25th year LRB price increase 0.99%/year)	REPAIR COST (EACH EARTQUAKE) (cost/year x 0%)	LCC = BIAYA INVS x (P/F,8,61%,0) + BIAYA PENGGT LRB x (P/F,8.61%,25) + BIAYA PERBAIKAN x (P/F,8.61%,N)
0	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	0	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
1	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	1	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
2	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	2	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
3	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	3	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
4	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	4	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
5	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	5	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
6	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	6	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
7	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	7	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
47	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	47	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
48	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	48	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
49	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	49	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639
50	Rp49.155.214.620	Rp5.740.465.621	Rp0	Rp49.883.332.637	50	Rp44.778.660.621	Rp5.740.465.621	Rp0	Rp45.506.778.639

Table 12. Comparison of Life Cycle Cost (LCC) Analysis of various structural systems + their combination and LRB replacement every 25 years



YEAR TO	LCC KONVENSIONAL	LCC PRACETAK	LCC KONVEN+LRB	LCC PRACETAK+LRB	PRECAST LCC DEVIATION	DEVIATION LCC CONVEN+LRB	DEVIATION LCC PRACETAK+LRB
0	Rp58.068.252.606	Rp52.378.732.407	Rp49.883.332.637	Rp45.506.778.639	Rp5.689.520.198	Rp8.184.919.968	Rp12.561.473.967
1	Rp57.128.092.503	Rp51.530.689.075	Rp49.883.332.637	Rp45.506.778.639	Rp5.597.403.428	Rp7.244.759.865	Rp11.621.313.864
2	Rp56.253.893.361	Rp50.742.143.856	Rp49.883.332.637	Rp45.506.778.639	Rp5.511.749.504	Rp6.370.560.723	Rp10.747.114.722
3	Rp55.441.027.406	Rp50.008.922.407	Rp49.883.332.637	Rp45.506.778.639	Rp5.432.104.999	Rp5.557.694.768	Rp9.934.248.767
4	Rp54.685.191.545	Rp49.327.143.251	Rp49.883.332.637	Rp45.506.778.639	Rp5.358.048.295	Rp4.801.858.908	Rp9.178.412.907
5	Rp53.982.384.589	Rp48.693.197.233	Rp49.883.332.637	Rp45.506.778.639	Rp5.289.187.356	Rp4.099.051.952	Rp8.475.605.950
6	Rp53.328.886.066	Rp48.103.728.415	Rp49.883.332.637	Rp45.506.778.639	Rp5.225.157.652	Rp3.445.553.429	Rp7.822.107.428
7	Rp52.721.236.533	Rp47.555.616.307	Rp49.883.332.637	Rp45.506.778.639	Rp5.165.620.226	Rp2.837.903.896	Rp7.214.457.895
47	Rp45.106.739.456	Rp40.687.186.711	Rp49.883.332.637	Rp45.506.778.639	Rp4.419.552.745	-Rp4.776.593.181	-Rp400.039.182
48	Rp45.075.949.855	Rp40.659.413.871	Rp49.883.332.637	Rp45.506.778.639	Rp4.416.535.984	-Rp4.807.382.783	-Rp430.828.784
49	Rp45.047.320.430	Rp40.633.589.553	Rp49.883.332.637	Rp45.506.778.639	Rp4.413.730.877	-Rp4.836.012.208	-Rp459.458.209
50	Rp45.020.699.625	Rp40.609.577.051	Rp49.883.332.637	Rp45.506.778.639	Rp4.411.122.573	-Rp4.862.633.013	-Rp486.079.014

Based on the value of Conventional LCC + LRB and Precast LCC + LRB is still more efficient than Conventional LCC and precast LCC, if the earthquake event is below the 12th year for Conventional LCC + LRB and the earthquake event is below 38 years for precast LCC. The deviation value between conventional LCC + LRB decreases over time until it approaches zero deviation (0) near the 12th year and after that year (12th) the deviation becomes negative. This means that after the 12th year Conventional LCC + LRB is NOT EFFICIENT compared to Conventional LCC (Andaloro, Salomone, Ioppolo, & Andaloro, 2010).

The deviation value between Precast LCC + LRB decreases over time until it approaches zero deviation (0) near the 38th year and after that year (38th) the deviation becomes negative. This means that after the 38th year Prefabricated LCC + LRB is NOT EFFICIENT compared to Conventional LCC.

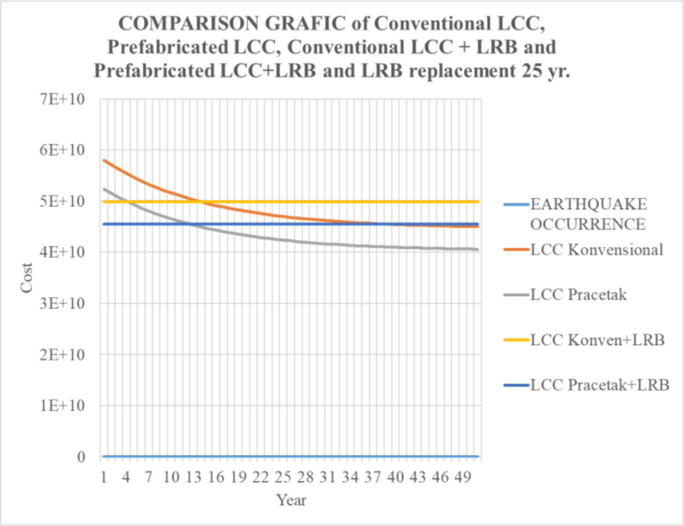


Figure 9. **Conventional LCC Comparison Graphics, PrecastLCC, Conventional LC+LRB, LCC Precast+LRB**

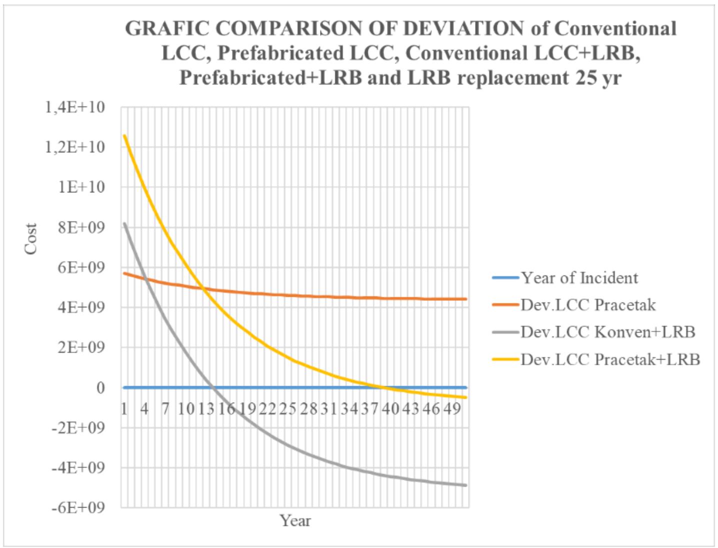


Figure 10. **Comparison Chart of Conventional LCC, Precast LCC, Conventional LCC + LRB, Precast LCC + LRB and their Deviations from Conventional LCC**

Development Stage

In this study, value engineering analysis at the development stage will not analyze value engineering at the development stage because of the lack of data that can be analyzed that is needed in analyzing project data due to the difficulty researchers face in obtaining LRB price certainty. Value engineering analysis is limited to simulating the four categories of development system implementation and comparing the efficiency levels of each LRB use (Kurowski, 2017).

Recommendation and Sugguestion

1. Desain Penggunaan LRB
   The design and type of LRB used are Based on an axial value of 5634.3 kN, type LRB LH085G4 Bridgestone products are used
2. Proposed design alternatives
   Based on the analysis of value engineering, the researcher believes that currently LRB products are getting more and more competitive so that the selection of LRB is most

important based on the value of the weight capacity of the building that will be supported by LRB. The factor of the constituent components of LRB is that rubber must be strong and have a long brittle power so that the ability to absorb or dampen earthquake forces that occur is good.

3. Consideration Policy

   By using value engineering analysis, it is also considered as a background to alternative precast concrete designs as a new design proposal for the use of LRB technology, namely: Location factors close to fault / fault zones

CONCLUSION

Based on a series of Value Engineering analysis of the use of LRB in structural work by simulating various conditions in the ASN Paspampres IKN flat building project, Penajam Paser, East Kalimantan, it can be concluded that:

From the pareto law test, from the Cost Budget Plan data of structural work that structural work is the second largest contributor to funds after arsitketur work among work items as a whole, which is 27%, while the percentage value of comparison of conventional work with precast is 10%.

The ASN Pasapmpres building is located in a POTENTIAL fault zone with a distance of +/- 20 m so that the use of LRB is a must to reduce large earthquake forces and maintain the service life of the building to be long. And this became the basis for identifying the work in VE with several simulations of earthquake damage that occurs each year.

Life Cycle Cost (LCC) analysis based on 4 system categories is that conventional LCC is greater than precast LCC, conventional LCC + LRB and precast LCC + LRB.

In the early stages the value of precast LCC is greater compared to Precast LCC + LRB and at some point it will experience the opposite.

Based on the value of Conventional LCC + LRB and Precast LCC + LRB is still more efficient than Conventional LCC and precast LCC, if the earthquake event is below the 18th year for Conventional LCC + LRB and the earthquake event is below 42 years for precast LCC + LRB.

The deviation value between conventional LCC + LRB decreases over time until it approaches zero deviation (0) near the 12th year and after that year (12th) the deviation becomes negative. This means that after the 12th year Conventional LCC + LRB is already inefficient compared to Conventional LCC.

The deviation value between Precast LCC + LRB decreases over time until it approaches zero deviation (0) near the 38th year and after that year (38th) the deviation becomes negative. This means that after the 38th year Precast LCC + LRB is no longer efficient compared to Conventional LCC

The use of LRB technology in buildings located in fault zones is very effective and efficient, especially in buildings that use a combination of precast structure systems with LRB. LRB's large initial investment value can be covered in the next few years on the use of its buildings with 0% structural damage in the event of an earthquake so that the life of the building and reliability become long.

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