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Re-Design of the Structure of the Batang I Industrial Flats Worker Building Using the Precast Concrete Method

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A R T I C L E I N F O

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A B S T R A C T

The Industrial Workers' Flats, located in the Batang Integrated Industrial Area, are supporting facilities workers use. The building was previously planned using conventional methods. In many cases, demands for fast and efficient construction work often occur, especially in the case of high-rise buildings. The need for multi-storey buildings encourages the need for an economical structural design that can be implemented quickly and efficiently without reducing the stiffness between the components of the building structure. From the explanation above, it is re-planned using the precast concrete method so that the work is neat, precise, and fast. In this planning, the SRPMK system is used. It needs good supervision in precast concrete, especially in joints, because precast joints are not as monolithic as conventional ones. It is necessary to develop precast technology to be more innovative in its use and easier to apply.

1. Introduction

Flats are multi-storey buildings built in an environment divided into functionally structured sections in horizontal and vertical directions. These units can be owned separately, especially for residential areas. Along with the rapid development of the industrial world, these flats were built in the Batang Integrated Industrial Area, which is used for the needs of workers in the industrial area. In many cases, demands for fast and efficient construction work often occur, especially in the case of high-rise buildings. The need for multi-storey buildings encourages the need for an economical structural design that can be carried out quickly and efficiently without reducing the stiffness between building structural components [1].

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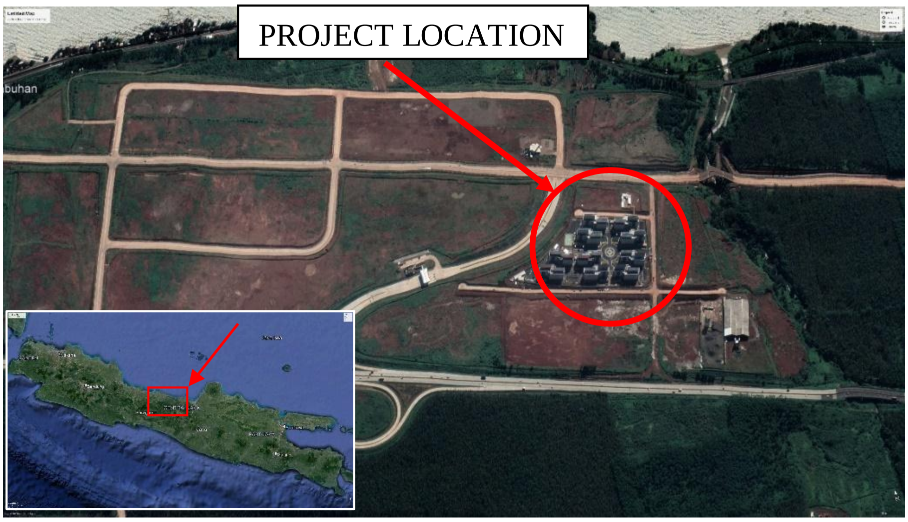
The Batang Package I Industrial Workers' Flats is a building that functions as a vertical residence built in the Batang Integrated Industrial Area. The Batang Paket 1 Industrial Flats is a 5-story structure with a height of 17.5 meters; the building has four towers with a typical type, so it tends to have the same floor plan configuration. This building was built with reinforced concrete using the cast-in-place method, requiring a relatively long processing time. Even in the process, they often pay less attention to accuracy, so the workmanship is not neat and lacks precision. Due to the demands of construction work with neat results but still fast in progress due to the urgent need for the building, it is on that basis that the author will modify the Batang I Industrial Workers' Flats building using the precast concrete method.[2]

As for this re-planning, the structural components that use precast concrete are beams and plates in the main structure only, while other components use the cast-in-place method. The building system used is still the same, namely the Building Frame System. Using the Building Frame System, the vertical loads that occur due to gravity will be received by the frames, while the shear walls will receive the lateral loads that occur due to earthquakes and wind.[3]

2. Research Method

2.1. Research Location

The location for construction of Industrial Workers' Flats is located in Ketanggan Village, Gringsing, Batang. The location of this building is next to the Batang-Semarang toll road and near the beach. More details can be seen in Figure 1.



Source: Google Earth

Figure 1. Project Location

2.2. Data Collection

The data that must be collected is a plan drawing based on the intended use of the building built, its function, and the surrounding environment. This design will be a development benchmark to be implemented. Image data includes plans, views, sectional drawings, and detailed drawings structure to be used for component dimension planning structure. Regulations and other supporting literature as a theoretical basis as well supporters.[3]

3. Description and Technical

The flow used in this plan is to collect data, then calculate the Seismic Design Category determined by the structural risk category reviewed (I-V) and the seismic parameter value of the site where the structure or the building will be constructed (SDS and SDI). KDS value calculation refers to SNI 1726:2019.[4] Then carry out a preliminary design to determine the

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dimensions of the structure with reference to SNI 2847:2019. There are boundary conditions that have been set therein. In the preliminary design, the calculated structure includes roof plates, floor plates, beams, and columns. Then proceed with the calculation of the load, in the calculation of this load, namely the dead load, live load, wind load, and earthquake load. As for determining the dead load, live load, and wind load using SNI 1727:2013 and regulations for earthquake loads using SNI 1726:2019. Then proceed to structural modeling, namely using the help of the ETABS 2016 application and Sp Column and, performing an internal force analysis, then checking the requirements.[5]

4. Results and Discussions

4.1. Preliminary Beam Design

Fy 420 MPa steel quality, the longest span is 600 cm, dimension planning calculation according to SNI 2847:2019 article 9.3.1.

Tall = $h \min \geq \frac{L}{16}$

Wide =$b\ min = 0{,}5 \times h$

The beam multiplier factor (0,4-0,6)

$$h\ min \geq \frac{6000}{16} = 375$$

$$b\ min = 0{,}5 \times 375 = 188$$

All beam dimensions used in this final project are 250x450 cm.

4.2. Preliminary Slab Design

The floor slab is designed with concrete quality specifications of 30 MPa and steel quality of 420 MPa. In this plan, the plates are precast, which then, during installation, is continued with cast overtopping. The plate in this plan uses a roof plate thickness of 125 mm and a floor plate of 130 mm.

4.3. Preliminary Column Design

Column design data, concrete quality is 30 MPa; the strength reduction factor is 0.3, column height is 350 cm, and the longest beam span is 600 cm.

$$\frac{PU}{\Phi \times f'c} = \frac{1086424{,}08}{0{,}3 \times 30} = 120713{,}79\ mm^2$$

$$b = h\ or\ A = h^2 = b^2\ so\ b = \sqrt{A}$$

$$b = \sqrt{120713{,}79}$$

$$b = 347\ mm$$

Column design 50 x 60

The load received by the column:

108642 + (1,4*(0,6 x 0,6 x 3,5 x 5 x 2400)) = 1298104,79

Column Area (A) = $\frac{PU}{\Phi \times f'c} = \frac{1298104}{0{,}3 \times 30} = 144233{,}79\ mm^2$

$$b = \sqrt{144233{,}79}$$

$b = 380\ mm < 600\ mm$ (Fulfil)

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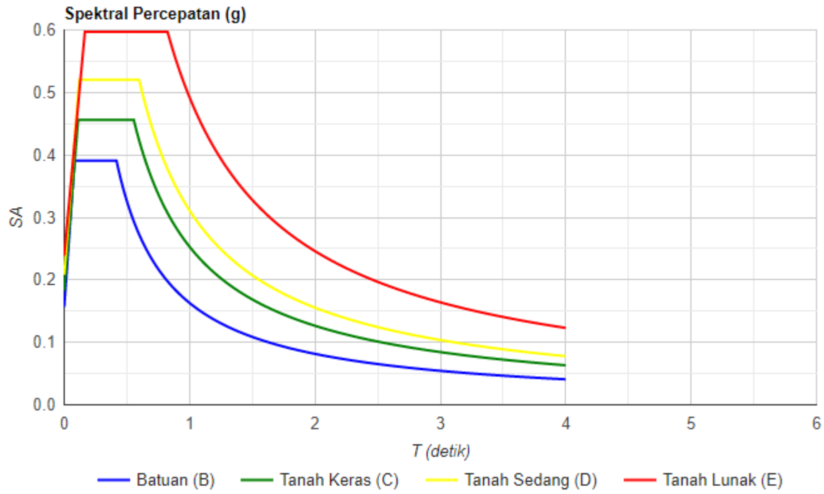
4.4. Calculation of Structure Load

The structural loading includes dead loads and live loads. The dead load itself is the weight of the building, including structural elements and others. While live loads are loads that can be moved at any time, for example, humans. the floor plate load is 1.54 kN/m, the roof plate load is 0.7 kN/m, the wall load is 3.15 kN/m and the ladder load 256 kg/m. Then for the live load of roof floors 0.96 kN/m, corridor floors 4.79 kN/m, stair floors 4.88 kN/m, public spaces 4.79 kN/m, rain loads 0.49 kN/m.[3]

Then there is the earthquake load which can be seen in Figure 2.



Scource: http://rsa.ciptakarya.pu.go.id/2010/

Figure 2. Seismic acceleration results in Ketanggan Village, Gringsing, Batang.

4.5. Floor Slab Reinforcement

The plate modeling is modeled as a thin-shell element that is set (auto mesh) to a maximum of 1 m x 1 m. the structure is modeled as a rigid diagram. The steps to determine the slab reinforcement are by taking the output from the 2016 ETABS application, processing the data in the form of moments, and calculating and determining the reinforcement ratio.[6] the moment that occurs on the roof floor is the moment that occurs on the field, namely M11 (X direction) 4.638 Kn/m M22 (Y direction) 6.051 Kn/m, the moment on the support M11 (X direction) -12.405 Kn/m M22 (Y direction) -10,827. So that the reinforcement is obtained in table 1.

Table 1. Recapitulation of Roof Plate Reinforcement

Plate Reinforcement Data	Plate Type	
	420x600	240x400
Focus reinforcement	D10-150	D10-150
Field reinforcement	D10-150	D10-150

Scource: Documentation of research result, 2023.

Table 2. Recapitulation of floor slab reinforcement 2-5

Plate Reinforcement Data	Plate Type	
	420x600	240x400
Focus reinforcement	D10-100	D10-100
Field reinforcement	D10-100	D10-100

Scource: Documentation of research result, 2023.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

4.6. Modeling of Precast Plates

The half slab is a plate that is cast half of the planned plate thickness, where half of the plate thickness will be conventionally planned; in this final project, precast plate or half slab elements are divided into 17 types, namely as follows:

Table 3. Recapitulation of Half Slab dimensions

Type	**Dimension (mm)**		
	B	**H**	**L**
S1	4000	70	872
S2	4000	70	2100
S3	4000	70	2100
S4	4000	70	872
S5	4000	70	698
S6	4000	70	2100
S7	1900	70	2200
S8	1900	70	2200
S9	4075	70	872
S10	4075	70	2100
S11	4075	70	872
S12	977	70	4200
S13	2100	70	4200
S14	977	70	4200
S15	2800	70	2200
S16	2800	70	1950
S17	666	70	2200

Scource: Documentation of research result, 2023.

4.7. Beam Reinforcement

In the beam reinforcement, the most important thing is to take the internal force from the ETABS application of the internal force that occurs, namely Mu Pedestal (-) 100.889, Mu Pedestal (+) 71.765, Mu Field (-) 144.426, Mu Field (+) 100.264, Vu Support 70, 2218, Vu Field 52.0654 and Vg Support 88.4258. The block has a length of 600 cm and a width of 25 cm and is 45 cm high. From the explanation above, it can be concluded that beam reinforcement is in the following table.

Table 4. Beam Reinforcement Recapitulation

Longitudinal Reinforcement	
Upper Support Longitudinal	4 D19
Centerline Longitudinal	2 D10
Lower Support Longitudinal	4 D19
Upper Court Longitudinal	3 D19
Midfield Longitudinal	2 D10
Lower Field Longitudinal	3 D19
Transfersal Reinforcement	
Focus transfersal	2 D10-75
Field Transfersal	2 D10-100

Scource: Documentation of research result, 2023.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

4.8. Precast Beam Modeling

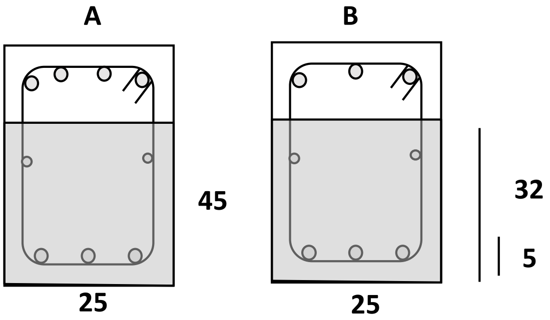


Figure 3. Precast Beams

The picture above illustrates a precast beam which is only partially cast. These elements will be installed together with the precast plate. After casting the precast blocks then waiting 3 days to be installed while waiting is usually carried out in the form of sprinkling water on the precast blocks. Installation of precast beams includes stacking control, lifting control, installation control and monitoring control when scaffolding is removed.[7]

The following is the formula used for precast element control:
+Mx = -Mx = 0,0107 w a2 b
+My = -My = 0,0107 w a b2

4.9. Column Repetition

Column reinforcement is planned using Spcoloum. Column planning data, namely column height 3500 mm, short side of column 500 mm, long side of column 600 mm, 40 mm clean cover, concrete quality 30 Mpa and reinforcement quality 420 Mpa. The stages include checking the axial flexural force, checking the column strength (Mnc) determining the length of the plastic hinge zone, determining the transfersal reinforcement of the plastic hinge zone/support, the confines of the plastic hinge zone and determining the shear strength of the plastic hinge zone.[8]
From the explanation above, the column reinforcement can be concluded in the following table:

Table 5. Column Repetition

Longitudinal Reinforcement	
Longitudinal	16 D22
Transfersal Reinforcement/Pedestal	
Weak axis	4 D13-100
Strong axis	4 D13-100
Transfersal Reinforcement/ Field	
Weak axis	2 D13-100
Strong axis	2 D13-100

Scource: Documentation of research result, 2023.

5. Conclusions and Suggestions

5.1. Conclusions

For precast elements in this plan, namely using precast beams and Half Slab. The use of precast concrete in building projects can save time during project implementation, because using the precast concrete method Scaffolding can be dismantled when precast concrete is 14 days old. Whereas in the conventional method the scaffolding is dismantled at the age of 28

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days of concrete. Work using the precast concrete method is more precise than the conventional method, where precast elements can be controlled before being installed. Using precast concrete is considered neater in terms of work in the field, in the sense that the project environment is more organized and clean.

5.2. Suggestions

After completing this final project, the authors would like to provide suggestions for the use of the precast method in the future, including: It is necessary to properly supervise the use of the precast concrete method, especially in joints because precast concrete joints are not as monolithic as conventional joints. It is necessary to develop precast technology so that it is more innovative and efficient in its use, and easier to apply.

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