PRECAST CONCRETE SLAB OF LIGHTWEIGHT BRICK

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Abstract . The main need for the community is a house with an area of land that can meet the needs of the family. Residential floor can be extended vertically upwards which is a concrete floor slab. This can be fulfilled with a series of lightweight bricks reinforced by plain reinforcement which is a one-way slab floor.The lightweight brick used has dimensions of 10x20x60 (cm) with a compressive strength of 4 MPa fc'. Edge holes of lightweight bricks are used to place BJTP 10 plain bar reinforcement. The minimum space requirement in a simple house usually is 3x3 m2 so the span requirement is about 3m. For slabs dominated by forces in bending so that the test method used is pure bending. The load required from the SNI code is converted into a concentrated load P and then it will be seen that the deflection that occurs does not exceed the applicable provisions. For a span of 3m, the strength of a series of lightweight brick floor plates can meet the requirements as contained in the SNI for buildings, both the load received and the deflection that occurs. A review was also carried out on spans of 1m and 2m. Instant mortar is used for bonding between lightweight bricks and for reinforcement, grouting type instant mortar with 30 Mpa fc' or K300 compressive strength is used. The results of the floor plate strength test for live loads exceed the limit requirements of 1.92 kN/m2 and the deflection that occurs is still below L/240.

Keywords: concrete floor slab, lightweight brick, instant mortar, grouting ,pure bending mom

1. Introduction

The development of technology and information has spread to every level of Indonesian society. The application of civil engineering technology in this case is focused on the works between concrete and reinforcement which is applied to lightweight bricks to become part of the floor slabs of multi-storey houses. The use of reinforced concrete is common in the manufacture of floor slabs with the conventional method of casting in place. The disadvantages of this method is always requires a large amount of formwork self-weight concrete and a relatively long time

M. U. H. Al Rasyid and M. R. Mufid (eds.), *Proceedings of the International Conference on Applied Science and Technology on Engineering Science 2023 (iCAST-ES 2023)*, Advances in Engineering Research 230,
https://doi.org/10.2991/978-94-6463-364-1_23

to complete the project. Other, faster methods, such as using Hebel floor plates, still have weaknesses. Own weight and processing costs are still relatively large. Other methods such as the use of dak keraton as floor slabs still result in relatively large weights.

Lightweight brick is a material that has been widely used by some Indonesian people, even in remote villages to make the walls of their homes. Residential houses generally have a room of about 3x3 m2, and this will be the benchmark for the span of the floor slab. Other criteria are the relatively cheap price, the workmanship being practical and light, and sufficient strength. In general, people need a simple terraced house with relatively low cost and simple technology.

In the work of building a house, of course, several conditions must be met besides strength, namely stiffness. Many models are offered and can be seen on social media such as YouTube. The most basic thing is that this work is the experience and estimation of concrete slab construction field workers regardless of safety, strength, rigidity, and cost factors. The material used is a combination of lightweight steel[1]. Lightweight bricks for floor plates use lightweight steel lath supports and then transfer to lightweight steel rafters at a distance according to the lightweight brick dimensions. There are also angle steel and profile steel such as UNP [2].

The need for housing every year is increasing both multi-story houses and apartments. Concrete material is widely used for the construction of buildings, houses, and even other infrastructure. The mission of developing the application of science and technology in the field of concrete structures will be applied to residential houses by reducing formworks. Conventional methods are still widely used even though the implementation stage requires a relatively long time. For floor slab work, we can use precast lightweight concrete floors, because we can save time and money by not using formworks and waiting time for the normal age of concrete [3]. Concrete floor slabs in multi-story buildings can be made from several parts such as those produced from hebel floor panels. Plates are made per strip with a width of about 60 cm with a length of 2,97m but this plate weighs about 174 kg which is large and the price is relatively high[4].

This panel slab claimed to be super strong and economical. However, until now there has been no support from regulations or industry or research on non-floor models using lightweight bricks. Figure 3.

The author with the results of previous research tries to use concrete panel slabs with a lighter weight for residences with the limitations still referring to terraced houses where the main obstacle is limited space such as size and material mobility.

The use of lightweight concrete is a good thing in making plates because it can reduce the load received by the structure. Reducing loads, especially self-weight, greatly helps multi-story buildings in resistance to earthquake loads.

Lightweight brick technology for the manufacture of concrete panel slabs with a precast system is the result we expect and adds to the development of concrete slab technology in terms of multi-story housing construction which is much needed by the housing sector in Indonesia. Using a lightweight precast floor plate system can speed up the time for carrying out fieldwork, especially for modern minimalists. Another requirement is that due to the workload having a deflection value that cannot be greater than L/240, Structural concrete requirements for buildings [5]. According to the Codes, the minimum live load for designing buildings must be able to carry a live load of 1.92 kN/m2 [6].

If it is formulated for the needs of residential houses, it is how to make floor slabs for residential houses with criteria such as being lightweight, not using scaffolding, relatively short time, and fulfilling factors such as strength, stiffness, and stability.

In this paper, we will briefly discuss making concrete floor slabs for residential houses from a series of lightweight bricks that are reinforced by reinforcement in the top and bottom sections. So it is necessary to obtain the strength of the floor plate (one-way plate path) due to the working load and get the floor plate model in size or dimensions along with the reinforcement.

The use of a precast panel slab is very helpful in increasing the ductility of the plate and has the advantage of a light load because the thickness of the panel slab is small. But it should be avoided to set the transverse superposition surface on the section with the greatest moment. Further research is still needed for this new plate as a composite material with a review of its mechanical properties from various load cases(7).

Researchers have started from high-quality concrete without a manual compaction process. The results obtained were that the addition of silica fume to concrete that was given superplasticizer could increase the strength of steel slag-aggregated concrete but the resulting self-weight was > 2400kg/m3 [8]. Lightweight concrete without cement and sand can produce a lightweight concrete composition but with low compressive strength and is easily penetrated by water. The application of this concrete can be seen in its use in water absorption wells [9]

The lightweight concrete that can be used for structural concrete in the floor plate segment is 20.61MPA concrete quality with dimensions of 25x20x12 (cm) and the weight of each segment is 9kg [10]. Series of lightweight concrete segments with deformed reinforcement to serve as floor slabs but the performance of cellular lightweight concrete due to exposure to high temperature is not discussed in this topic causing a decrease in the compressive strength [11].

Lightweight bricks of the CLC (cellular lightweight concrete) type have a lower compressive strength of 0.68 MPa [12]. The strength of concrete produced from waste of lightweight brick can reach 20 MPa at the age of 28 days [13]. The lightweight brick to be used is 20x10 (cm) in dimension which has a compressive strength of around 4 MPa [14].

When viewed from the science of reinforced concrete, force or strength can be explained through load calculations, internal force analysis, and strength analysis by code. In reinforced concrete, the cooperation in cross-section is that the tensile force is retained by the reinforcement, not by the concrete. The concrete cross-section only withstands the pressure force according to the assumptions used in the cross-sectional analysis . The tension forces must be equal with compression forces [15].

For loading refers to the codes including dead load and live load so that for a width of 20 cm, live load and dead load produce a load factor Qu = 88.24 kN/m' along the span of one-way slabs. For a span L = 0.9 m, the bending moment due to load is 0.125 x 0.8824 x 0.9^2 = 0.089 kNm. The allowable deflection according to codes is L/240 = 900/240 = 3.75 mm.

In the calculation of the internal force on the simple beam, the maximum bending moment is obtained in the middle of the span. The method used is the normal flexural strength test with two loading points. There is no shear force at the mid-span so there is pure bending (Fig.1). For 1-way floor slabs the ratio Ly/Lx > 2.0 and the behavior is the same with single reinforcing beams. The working load, dead load, and live load are transmitted through the reinforcement until the support beam. The relationship between the force in bending and the area of reinforcement through cross-sectional analysis is as follows: $Mn = As * fy * (d-a/2)$.

Load Calculation for Dead Load and Live load, self-weight 100 mm 66.7 kg/m2, from the weight of the ceramic is 24 kg/m2 and also mortar or species 2 cm 42 kg/m2. So dead load QDL = 111.67 kg/m2 and live load QLL = 192 kg/m2. The factored load becomes Qu = 1.2 QDL + 1.6 QLL = 441.2 kg/m2. For width 0.2m, Qu = 0.8824 kN/m', and the bending moment Mu is equal to $1/8$ Qu L^2 = .9927 kNm (with span L = 3m) and nominal moment Mn = Mu/0.9. With effective depth and arm forces of jd = 0.83 d, we get As = 45.689 mm^2. We used BJTP – 10 mm with area is equal to 78.5 mm^2 (OK).

The flexural moment $1/8$ qu L^2 = P/2*a; where a = the shear span or L/3 and we have Qu (equivalent) = 8/6 P/L or P = 3/4 Qu/L. So the concentrated load P can be used as a uniform load Qu = 4/3 P/L.

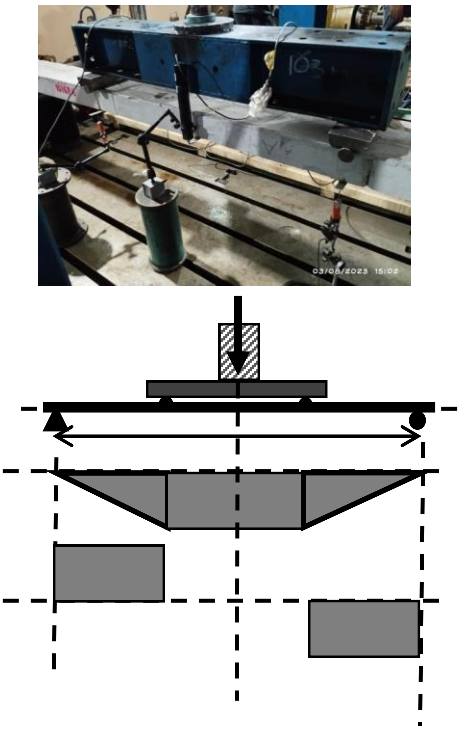

Fig .1. Sketch of Pure Bending Moment

2. Research Method

This research is intended to answer the doubts of some industrial or the public regarding the use of lightweight bricks as concrete slabs rather than as walls. The materials used are lightweight brick with dimensions of 10x20x60 cm, instant mortar, and also BJTP reinforcement. For the supports tools are water pass, twine, wire, and cement spoon.

For spans of 3m use 5 light bricks and 3.6 m spans using 7 lightweight bricks. The tests were carried out at the Jakarta State Polytechnic and the Center for Strength and Structure Technology, Puspiptek Serpong.

The steps taken are:

- Make holes on the edge of lightweight bricks measuring 2x2 cm and arrange the series of lightweight bricks according to the span and connect each other with MU instant mortar adhesive.
- Placing BJTP 10 reinforcement in all holes on the edges and tied by wire. The reinforcement was covered with MU-grouted instant mortar and became the floor plate path.
- Next is the maintenance of a series of lightweight bricks and testing the sequence of bricks as a beam to get the maximum P value and deflection Fig. 2. The inzet picture is the lightweight bricks with edge holes.

Fig .2. Sequence of lightweight bricks

Fig .3. Test object span 3,3m

Fig .4. The collapse of the beam

The beam spans to be discussed are from 0.9m to 3.3m. Test results with variable spans are taken from the average of 3 test objects and presented tabulatedly. The quantities to be assessed are the maximum load and the deflection.

3. Result and Discussion

The test results of the precast concrete slab segments conducted at the PNJ laboratory and the Serpong-Tangerang BRIN-LUK Laboratory are as follows in the table.
To maintain pure bending of the beam, the placement of the load is set at a distance from the support, namely L/3.
The shear span of 3,3m span will be 1,1m Fig. 4.

Furthermore, P (kN) is used as a uniform load based on pure bending moment theory and the resulting deflection is not greater than the allowable L/240..

TABLE I. P-DISPLACEMENTS

Beam Number	Span(m)	Load(kN)	Displacements (mm)
B1	0,9	2,39	1,4
B2	1,8	4.08	4,5
B3	2,7	4,71	6,0
B4	3,3	2,02	4,2

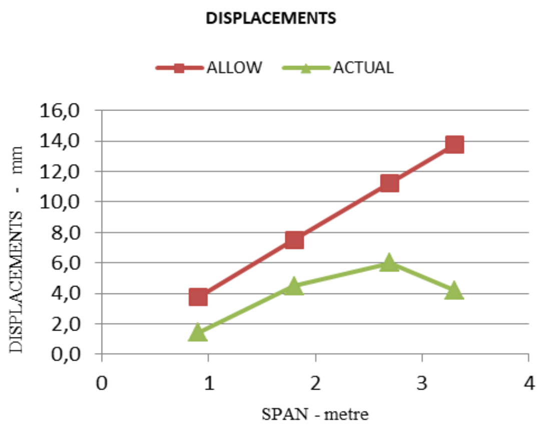

Fig .5. displacement vs span beam

The allowable deflection according to the codes is L/240. The actual deflection that occurred was still under the permit deflection. So the system assembled from the sequence of lightweight bricks fulfills the requirements of the code.

In 3,3 m span of the beam gets a smaller deflection than a span of 3m. This is because the capacity of lightweight concrete with reinforcement has been exceeded so that it crumbles.

Modifications to the results of the deflection on the span of 3 m obtained a deflection of 5.14 mm which is still smaller than the permitted value of L/240 12.5 mm.

Summary of processed test results for uniform loads

TABLE II. UNIFORM LOADS

Beam Number	Span(m)	Load(kN)	Qu equivalent (kN/m)

Beam Number	Span(m)	Load(kN)	Qu equivalent (kN/m)
B1	0,9	2,39	3,55
B2	1,8	4.08	3,02,
B3	2,7	4,71	2,33
B4	3,3	2,02	0,89

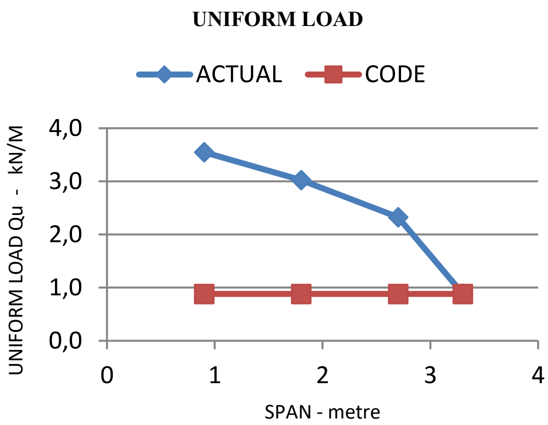

Fig .6. Uniform load vs span beam

Qu equivalent is referring to codes for evenly distributed live load is 1.92kN/m2, so for a width of 20 cm it is equivalent to 0.2 m = 88.24 kg/m'.
The crack load P is being changed to Qu and it can be seen here that the short span has a large Qu load of 3.55 kN/m. For the long span of 3.3 m, the smaller Qu is 0.98 kN/m.The modification for the load on the span of 3 m obtained Qu 1.59 kN/m which is still greater than 0.88 kN/m. From the results obtained in a 3m span, this lightweight brick precast system can still be used as a residential floor plate.
So that the value of the deflection and the load that can be carried is still within the limits permitted by the codes

4. Conclusion

The results of testing a series of lightweight bricks with dimensions of 20x10x60 with fc' 4MPa with span variations between 1 m - 3.3 m, can be concluded as follows:

1. The lightweight brick installation system assembled with instant mortar for P10 reinforcement and between lightweight bricks can be used as a residential floor plate path.
2. The load that is carried exceeds the load required by SNI 2847-2019 regarding the minimum load for buildings, namely the live load of 1.92 kN/m2.

3. The deflection value that occurs from the plate path with a span of up to 3 m does not exceed the limits permitted by SNI 2847 – 2019, namely L/240..

Acknowledgment

On this occasion the author would like to express his deepest gratitude to all those who have helped, especially to the Head of UP2M Jakarta State Polytechnic, who has distributed funds from the Jakarta State Polytechnic and also students of the Civil Engineering Department who have assisted in the implementation process and data collection in the laboratory.

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