IOSR Journal of Engineering (IOSRJEN)
e-ISSN: 2250-3021, **p**-ISSN: 2278-8719
Vol. 3, Issue 2 (Feb. 2013), ||V1|| PP 31-36

Experimental Study of Precast Walls with Variation Type of Opening Due to Vertical and Lateral Static load

Abdalmaged A. Abdala[1], Sri Murni Dewi[2], Achfas Zacoeb[3]
[1](M. Eng. Student, Department of Civil Engineering, Brawijaya University, Indonesia)
[2](Professor, Department of Civil Engineering, Brawijaya University, Indonesia)
[3](Asst. Professor, Department of Civil Engineering, Brawijaya University, Indonesia)

Abstract: The main existing research aim is to carry out an experimental investigation on three types of precast reinforcement walls. The First type of wall is with door opening, the second is wall with a window opening and the third one is solid wall. It is very important to understand the wall behavior in different types, which is known by conducting experimental tests, subsequently the objectives of this experiment is to study the behavior of precast wall in three types, wall capacity, strain behavior, stress in wall and deflection, then understand the effect of openings in the walls. In this experimental study, eighteen specimens of precast wall have been tested, six specimens for each type, three for vertical load and three for horizontal load. The size of specimens was 1000, 1000, and 50 mm. When the theoretical and experimental results have been compared in deflection, it was found that there is a correlation between the deflection and the opening size, where the opening size is increased the deflection increases; on the other hand the load capacity decreases when the opening size increases. In other words the stress is increased when the opening size is increased.

Keywords: *precast concrete, opening, vertical load, lateral load.*

I. INTRODUCTION

The concept of precast (also known as “prefabricated”) construction includes those buildings where the majority of structural components are standardized and produced in plants in a location away from the building, and then transported to the site for assembly. These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost. The main features of this construction process are as follows:

- The division and specialization of the human workforce.
- The use of tools, machinery, and other equipment, usually automated, in the production of standard, interchangeable parts and products.

This type of construction requires a restructuring of the entire conventional construction process to enable interaction between the design phase and production planning in order to improve and speed up the construction. One of the key premises for achieving that objective is to design buildings with a regular configuration in plan and elevation [1].

Many countries used various precast building systems during the second half of the 20th century to provide low-income housing for the growing urban population. They were very popular after the Second World War. In general, precast building systems are more economical when compared to conventional multifamily residential construction (apartment buildings) in many countries.

Precast concrete walls provide an excellent envelope for low-rise commercial and industrial buildings. They are relatively easy to manufacture, structurally efficient, durable, and attractive. In addition, their desirability to the owner and design professionals’ can be increased tremendously if they provide lateral-load resistance [2].

Precast concrete has been successfully used in variety of building structures, and used variety of opening in wall. So that the main reason to concerned on wall with different opening.

II. METHODOLOGY

A. Research design.

This research study the effects of lateral load and gravity load in the precast wall. The Analysis experimental carried out is:

1. The experimental test results will compare with the load in analysis
2. Obtained the maximum load and load at crack initiation.

B. Experimental Test Setting Up.

the load will applied on the specimens in two types vertical and horizontal load every type of precast wall has six specimens three specimens for vertical load and three for horizontal load. Load was applied at the center of the top of wall for vertical concentrated loads and the lateral load in the lateral side at the upper end wall 150 mm from the top and the load applied by using a hydraulic jack and measured by load cell. For each reading a set of reading was taken for load capacity, lateral, failure and displacement.the two supports in vertical load are fixed 10 cm from the edge span of wall and the support are fixed in horizontal wall. Setting up specimen on test machine can be seen in**Fig.1.**

Fig.1 setting up the wall in testingmachine in horizontal load

III. RESULTS AND DISSCUSION

In simple wall flexural testing is done by concentrated load P which put in one point.The wall was applied at the center of the top of wall for vertical concentrated load and the lateral load in the lateral side at the upper end wall 150 mm from the top. The loading stages are using two strips (two strips are equal to 268Kg) on the capacity of proving ring reading-scale is 25 ton, starting from zero to achieve the maximum load of wall.

A. The testing of wall in vertical load.

Based on the simple wall, flexural testing is done by providing a concentrated load P which is put in one point. The wall was applied at the center of the top of wall for vertical concentrated loads and the lateral load in the lateral side at the upper end wall 150 mm from the top **Fig1.**

The data from testing included the maximum load, deflection, and also the stress. The load is obtained from the readings of proving ring, and the deflection is obtained from the reading of dial gauge. From the **TABLE 1** shows that the maximum deflection at the top wall with door is 0.489 mm and wall with window is 0.316 mm, so that is means the wall with small size of opening is more stiffness.

TABLE 1 Comparison the deflection between the types of the wall.

Type of wall	**Average deflecton(mm)**		**load(kg)**
	Bottom	**Top**	
I_V	0.124	0.489	10988
II_V	0.165	0.316	10988
III_V	0.18	…	10988

From the comparison from **Table 1** the maximum deflection at the top wall with door is 0.489 mm and wall with window is 0.316 mm, so that means the wall with small size of opening is more stiffness.

Table 2 shows that the maximum deflection at the bottom dial gage was 0.14 mm, 0.17 mm and 0.2 mm in the type of wall I_V, II_V and III_V respectively. However, from the STAAD PRO analysis the maximum deflection at the same point of load is 0.06, 0.097 and 0.116 for I_V, II_V and III_V respectively. On the other hand, the maximum deflection obtained at the top of opening area for the wall with door in specimens I_V is 0.533 mm and 0.27 from theoretical analysis. Also, the maximum deflection obtained from the experimental result in specimens II_V is 0.347 mm and 0.245 mm from theoretical. Differences in the results of research and theoretical analysis can be caused by the assumptions in the calculation can not be met in the implementation of research in the laboratory, the difference in The characteristic strength of concrete in compression (*f'c*)

TABLE 2 The comparison of maximum deflection between experimental and theoretical analysis in vertical load.

The specimn	Max load (P) kg	Max (△)mm experimental		Max (△)mm theoretical analysis (STAAD)		Relative error %	
		Bottm	Top	Bottm	Top	Bottom	Top
I_{V1}	10988	0.115	0.42	0.06	0.27	90.8	55.5
I_{V2}	10988	0.14	0.516			133.3	91.1
I_{V3}	10988	0.117	0.533			90	97.4
II_{V1}	10988	0.16	0.347	0.097	0.245	64.9	41.6
II_{V2}	10988	0.17	0.324			75.2	32.2
II_{V3}	10988	0.165	0.279			70.1	13.8
III_{V1}	10988	0.2	...	0.116	...	72.4	....
III_{V2}	10988	0.175	....		....	50.8	....
III_{V3}	10988	0.179	....		....	54.3	....

B. The testing of wall in horizontal load

The deflection observation on wall was done at the side of the landscape, on the two spots, one opposite the divider load in three types of wall in the same distance 15cm from the top and also there is one at the 30cm from the bottom in the same side. The Deflection reading on the wall used manual dial gauge tools. The detail of pedestal location, the division of load, and the location of dial gauge can be seen in **figure 1**

From the **Table 3** the average maximum deflection at the top wall with door is 0.480 mm and wall with window is 0.361 mm, moreover the deflection in solid wall is 0.234 mm.

TABLE 4 illustrated those three types of wall at the same load. So as can be seen the strength in type III_H is the biggest in all types because the deflection is the smallest one from top and bottom after that type II_H . wall strength appears to be inversely proportional to the opening size.and that means hollow is effect in strength of wall the hollow increase the strength decrease.

TABLE 3 Comparison the maximum deflection between the types of wall in horizontal load.

Type of wall	Average Deflecton(△)mm		load average(kg)
	Bottom	Top	
I_H	0.18	0.480	4198.66
II_H	0.103	0.361	4645.33
III_H	0.087	0.234	4913.33

TABLE 4 Comparisons the deflection between three types of wall in the same load.

Type of wall	Average Deflecton(△)mm		load average(kg)
	Bottom	Top	
I_H	0.180	0.480	4198.66
II_H	0.087	0.328	4198.66
III_H	0.061	0.173	4198.66

In **TABLE 4** three types of wall at the same load. So as can be seen the strength in type III_H is the biggest in all types because the deflection is the smallest one from top and bottom after that type II_H . wall strength appears to be inversely proportional to the opening size.and that means hollow is effect in strength of wall the hollow increase the strength decrease.

C. Comparison the load capacity between theoretical analysis and result of research in horizontal load.

There are differences in the result between theoretical analysis and research result, this difference because the assumptions that are difficult to apply the theoretical analysis in research in the laboratory so from that the difference will be happen.

In addition, external factors in the implementation of research in the laboratory may also result in differences between theorists and the analysis of research results, such as accuracy of the location and time of testing instrument readings, the precision in the manufacture of test specimens, the conversion factor of the tools, support, and etc. The result of comparison between theoretical analysis and the result of research is that the capacity from the theoretical analysis is 5729 kg, but in the research the average load was in three types of walls (I_H, II_H, and III_H) (4198.66 ,4645.33,4913.33) kg respectively. from the result it is clear that when the size of opening increase the load capacity decrease.

The comparison in **TABLE 5** it can be seen that the maximum deflection at the bottom dial gage was 0.191mm, 0.114 mm and 0.1 mm in the type of wall I_H, II_H and III_H respectively. However, from the theoretical analysis the maximum deflection at the same point of load is 0.098, 0.047 and 0.05 for I_H, II_H and III_H respectively. On the other hand, the maximum deflection obtained at the top of wall with door (I_H) is 0.5 mm and 0.4 mm in specimens wall with window (II_H) as well as in solid wall (III_H) is 0.264mm.

TABLE 5 The comparison of maximum deflection between experimental and theoretical (STAAD PRO) analysisinhorizontalload.

The specimen	Max load (P) kg	Max (Δ)mm experimental		Max (Δ)mm theoretical analysis (STAAD)		Relative error %	
		Bottom	Top	Bottom	Top	Bottom	Top
(I_{H1})	4288	0.191	0.5	0.098	0.373	94.8	34
(I_{H2})	4020	0.171	0.456	0.092	0.349	85.8	30.6
(I_{H3})	4288	0.18	0.485	0.098	0.373	83.6	30
(II_{H1})	4556	0.114	0.4	0.047	0.217	142.5	84
(II_{H2})	4556	0.102	0.35	0.047	0.217	117	61.2
(II_{H3})	4288	0.094	0.335	0.044	0.204	113.6	64.2
(III_{H1})	4824	0.076	0.2	0.047	0.159	61.7	25.7
(III_{H2})	4824	0.086	0.238	0.047	0.159	82.9	49.6
(III_{H3})	5092	0.1	0.264	0.05	0.168	30	57.1

Moreover, from the theoretical analysis the maximum deflection at the same point of load is 0.373 mm, 0.217 mm and 0.168 mm for I_H, II_H and III_H respectively. Differences in the results of research and theoretical analysis can be caused by the assumptions in the calculation can not be met in the implementation of research in the laboratory, such as the difference in the characteristic strength of concrete in compression (*f'c*)

E. Testing the strain

1. Testing the strain in the reinforcement of walls at vertical loading.

Strain on three types of wall can be measured by using strain-gauge steel to represent the behavior of reinforcement at nine specimens of wall, strain gauge installed in I_{V1}, II_{V2} and III_{V3}. Readings were taken at intervals corresponding to the 268kg weight increase in two strips on a scale of proving ring readings. Of readings can be determined with a given load relationship strain that occurred. Chart of load and strain in I_{V1}, I_{V2} and I_{V3} can be seen on the **Fig 2.**

From the **figure 2**The trend in three types of wall are almost the same, can be seen that the strain in all types is linear and the lower strain was 0.000098 mm/mm in type III_V, but we can see that strain in wall with opening is bigger than solid wall and that means when the size of hollow increases the strain increase also.

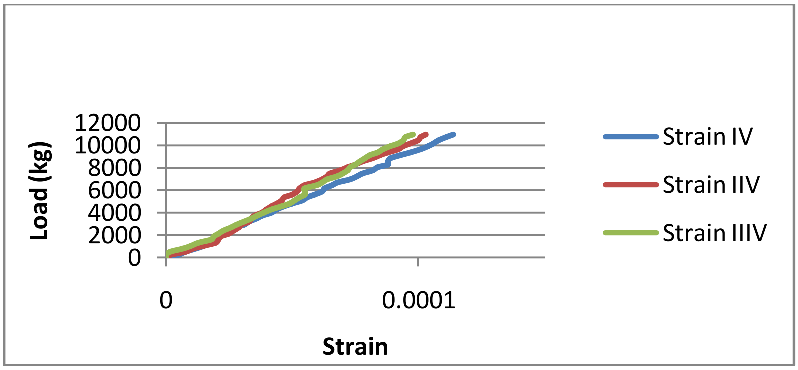

Fig 2 The relation of Load-Strain for vertical loading

2. Testing the strain in the reinforcement of walls at horizontal loading

The **graph 3** illustrated that the relation between strain-load in three types of wall. As can be seen that in the I_H specimen the strain (0.000057) is bigger than types II_H, and III_H. Throughout the comparison the trend have the same curve shape.

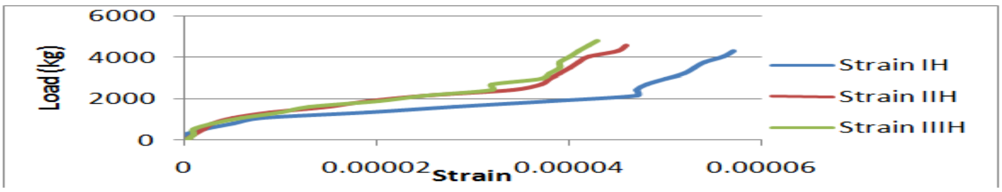

Fig 3 The relation of Load-Strain for horizontal loading

Specimen	Stress (σ) N / mm^2		Specimen	Stress (σ) N / mm^2	
	Experimental	Theoretical		Experimental	Theoretical
I_H	1.45	3.5	I_V	3.67	6.91
II_H	1.17	3.17	II_V	2.62	5.84
III_H	1.09	3.06	III_V	2.49	3.63

TABLE 6 The comparison of the stress in experimental and theoretical in horizontal load.

From **TABLE 6** the stress in theoretical analysis is bigger than the stress in experimental and the bigger stresses are in wall with hollow door. The stress increase when the size of opening increases.

F. Statistical Analysis

To investigate the influence of variations in type of wall performed the statistical analysis in the form of multi-range analysis. The result of statistical analysis is showed on the table (7 and 8).

TABLE 7 Analysis of Variance for a Randomized Complete Block Design at load 10988 kg in vertical load.

Source of variation	Sum of squares	Degree of freedom	Mean square	F_0	F_t table
Treatment A	0	2	0	0	4.46
Error	965889152	6	1609815253	……	
Total	965889152	8	…..	…..	

TABLE 8 Analysis of Variance for a Randomized Complete Block Design at maximum horizontal load.

Source of variation	Sum of squares	Degree of freedom	Mean square	F_0	F_t table
Treatment A	86868.43	2	43434.215	0.0015	4.46
Error	169073736	6	28178956	….	
Total	169160604.4	8	…..	….	

From the **TABLE (8and 9)** can be seen that the significant level is obtained F-Table is 4.46. While F-count on variation of wall is 0 in horizontal load and 0.0015 in vertical load. It can be concluded that the wall type of this variable do not have a significant influence on the maximum load that can be held by wall.

IV. RESULTS AND CONCLUSION

The maximum deflection average in vertical load which has been reached in wall with a hollow door at the top of the opening was 0.489 mm, whereas in the walls with a window it was 0.316 mm and there was no significant effect with different sized opening. In the horizontal load, the maximum deflection average at the bottom was 0.180 mm in walls with a door and was 0.103 mm in walls with a window, which means that whenever the opening size increases, the deflection increases as well. Moreover the strength in the wall increases when the opening size increases. The maximum load average that can be held in horizontal load is 4913.33kg in a solid wall and was 4645.33kg in walls with a window opening, while the maximum load average in walls with door opening was 4198.66 kg, therefore the load capacity is increased when the opening size decreases.

Changing the size of an opening has little effect on load capacity, so all types of wall can used with the same load with no need to consider the opening in the wall.

By comparing be the experimental and theoretical results in deflection, the trend was similar in both. There are differences in the values of deflection. It was higher in the experimental results than in theoretical studies, for all wall types.

REFERENCES

[1] Brzev, S.& Guevara-Perez, T., Precast Concrete http://www.scribd.com/doc/35995777/Precast-Concrete.

[2] Astarlioglu, S.2005. Object Oriente Platform for Seismic Analysis of Precast Concrete Buildings. The Pennsylvania State University: PhD Dissertation.

[3] Yee, A.A 2001. Structural and Economic Benefits of Precast / Prestressed Concrete Construction. PCI JOURNAL

[4] Yee,P.T.L . L., Adan, A.B,. A.,Mirasa , A .K.,&Rahman,A.B.A.(2011).Performance of IBS Precast Concrete Beam-Column Connections Under Earthquake Effects: A Literature Review.American J. of Engineering and Applied Sciences 4 (1): 93-101.

[5] Semelawy, M. 2011.Experimental and NumericalL Development of Anchor-JoOINTED Precast Structural Wall System and Optimum Design of PrestressedSlabsL. Western Ontario University. Phd Dissertation.

[6] Yanez,F. V. Park,R. &Paulay, T.Seismic Behavior of Walls with Irregular Oppenings. Rotterdam. ISBN9054100605.

[7] Mohammed, B.S. Ean. L. W. &Hossain, K.M.A.CFRP Composites for Strengthening of Reinforced Concrete Walls with Openings.International Journal of Engineering Research and Applications, 1, 1841-1852.

[8] Sas, G. Demeter, I. Carolin, A. György, T. N. Stoian, V. and Täljsten, B. 2008. FRP Strength THENED RC Panels with CUT-OUT Openings.

[9] Dewi, S, M.,&Djakfar., 2011. StatistikaDasar, 2[ed]edition. Malang, Indonesia.

[10] American Concrete Institute, 2011. Building Code Requirements for Structural Concrete (ACI 318-11) and Commentary (ACI 318R-11).

[11] Lee,K.M., & Bernal,D., 1997. Reinforced Concrete Design, 3[th]edtion. The McGraw-Hill Companies, ING, New York St Louis San Francisco.