UNIVERSITI TEKNOLOGI MARA

CONFERENCE PROCEEDING

ICITSBE 2012

1ST INTERNATIONAL CONFERENCE ON INNOVATION AND TECHNOLOGY FOR SUSTAINABLE BUILT ENVIRONMENT

16 -17 April 2012

Organized by:
Office of Research and Industrial
Community And Alumni Networking
Universiti Teknologi MARA (Perak) Malaysia
www.perak.uitm.edu.my

PAPER CODE: CT 02

A STUDY ON BENDING CAPACITY OF WALL-SLAB STRUCTURAL SYSTEM BY USING SINGLE LAYER AND DOUBLE LAYER OF REBAR FOR RESIDENTIAL PROJECT

Hooi Min Yee[a] and Siti Isma Hani Ismail[b]
Fakulti Kejuruteraan, Universiti Teknologi MARA (Pulau Pinang),Malaysia.
[a]minyh@ppinang.uitm.edu.my, [b]sitiismai@ppinang.uitm.edu.my

Abstract
Using Industrialised Building Systems (IBS) will address issues such as quality, materials wastage, delays, dirty and hazardous worksites. Wall-slab structural system is in the form of rigidly connected wall slab member.Moment transfer of joint is an important aspect for proper structurally functioning of wall-slab system. The objective of this study is to investigate the effect of reinforcement details in the wall on bending capacity for support stiffness in wall-slab. A total of six wall specimens were tested. Three of these specimens consisted single layer of rebar while another three specimen consisted of double layer of rebar. The size of the wall-slab's specimens is 1000mm in length, 1080mm in width, 1000mm in height and 80mm in thickness. The predicted bending capacity at failure is from 5.36kNm to 7.12kNm, depending on actual concrete cover. The bending capacity at failure for single layered of rebar in wall for specimen 1, 2 and 3 were found to be 3.59kNm, 3.81kNm and 3.15kNm, respectively. The bending capacity at failure for double layered of rebar in wall for specimen 1, 2 and 3 were 5.50kNm, 6.31kNm and 7.00kNm, respectively. Based on the results, specimens consisted of double layered of rebar in wall are found to provide higher bending capacity to the joint of wall-slab structural system compared with single layered of rebar in wall.

Keywords: Industrialised Building Systems (IBS), Bending Capacity , Residential Project

1. Introduction

Moses (2006) has stated that in Malaysia, the implementation of Industrialised Building System (IBS) by using precast concrete elements were introduced since 1966 when the government launched two pilot projects which involves the construction of Tengku Abdul Rahman Flats in Kuala Lumpur (see Fig. 1a) and the Rifle Range Road Flats in Penang (see Fig. 1b). Malaysia's housing policy is gearing toward meeting the objective of ensuring access to adequate and decent shelter to all citizens, particularly the low-income groups. According to Construction Industry Development Council (CIDB) Malasyia, IBS is a construction system which components are manufactured in a factory, on or off site, positioned and assembled into structures with minimal additional site work.

(a) (b)

Fig. 1 (a) Tengku Abdul Rahman Flats in Kuala Lumpur (b) Rifle Range Road Flats in Penang

The key rationale in adopting the Industrialised Building Systems (IBS) concept essentially for housing construction is to enhance the development of low cost housing project for the lower income group in our country. Low Cost Housing is always relates to the effective budgeting by implementing techniques which help in reducing the construction cost through the use of locally available materials along with improved skills and technology without sacrificing the strength, performances and life of the structure. In this case, the most suitable building system to be use is the wall-slab system (see Fig. 2).

In the process of nurturing the industry towards less labour dependent, the government of Malaysia through CIDB, had aggressively promoting the development and usage of new and relevant technologies in the area. Using IBS is seen as the alternatives that can greatly reduce construction time compare to the conventional method.

Fig. 2 Wall-slab system in Malaysia

Suk et al (2008) have stated that since the mid-1980s, approximately 4,160,000 apartments have been built in Korea, and more than 70 % of these apartments were high-rise apartments having 11 floors or more. Wall-slab structural system is a system suitable for use in the field of high-rise building where the main load resisting system is in the form of rigidly connected wall-slab. Fig. 3a shows the wall-slab structural system and Fig. 3b shows basic specimen design.

However, in Malaysia, wet construction method is still widely accepted as a convention and safe option despite incurring higher cost and slow production rate. It is important for Malaysian construction industry to evolve and be ready for the globalization era where by increase of productivity, quality and safety are compulsory and the reduction of cost and construction period must be taken into account. The advantages of using Industrialised Building Systems (IBS) are reduction of unskilled workers, reduce wastage, increase in quality, safer working environment in construction site, reduce construction period, easier site management and it is environmental friendly. Wall-slab system has been widely used in many develop countries as it not only facilitate construction speed but also reduce the construction cost with the use of suitable and repetitive system formwork.

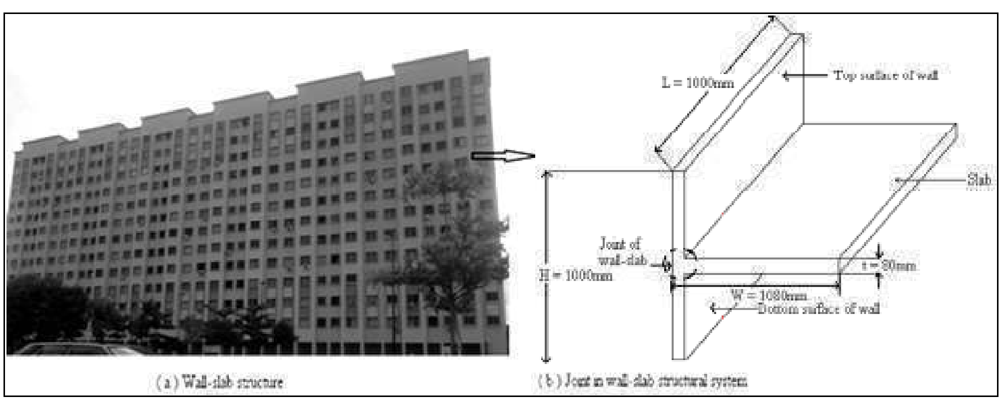

Fig. 3 (a) Wall-slab structural system (b) Basic specimen design

Yeoh (2006) has carried out a comparison between behaviour of wall-slab structural system and using the conventional moment resisting frame. Liu and Abdhassan (2004) have studied the moment-rotation parameters for composite shear tab connections in steel frame buildings.

For wall-slab system, the vertical element i.e. concrete wall is designed to carry the load transfer from slabs. Proper understanding of strength and stiffness of joint is crucial for the design and analysis of wall-slab system. Among the factors, the reinforcement details play an important role, since concrete has negligible tensile strength. This study has been carried out with the objective to understand the effect of reinforcement details in wall part on the strength and stiffness of joint in wall-slab system.

2. Methodology

This research involves mainly experimental carry out in the lab. The following works were involved during the experimental process : determination of suitable scaled down size of joint of wall-slab structural system to be investigated and numbers of sample of joint to be cast, load testing of joint samples, rebar tensile test and concrete cube test. Analysis of wall-slab joint using finite element (FE) software had also been carried out. A total of six specimens were tested. Three specimens consisted single layered of rebars (denoted as 1(S), 2(S) and 3(S)) and another three consisted of double layered of rebars in the wall (denoted as in 1(D), 2(D) and 3(D)). The size of the sample of wall-slab used was length, L = 1000mm, width, W = 1080mm, height, H = 1000mm and thickness, T = 80mm as shown in Fig. 1b The sketch of slab with single and double layers shown in Fig. 4. Two different arrangements of rebars in wall segment have been chosen: single layer and double layer; as shown in Fig. 4a and 4b, respectively. 5mm mild steel bars were used for all the rebars.

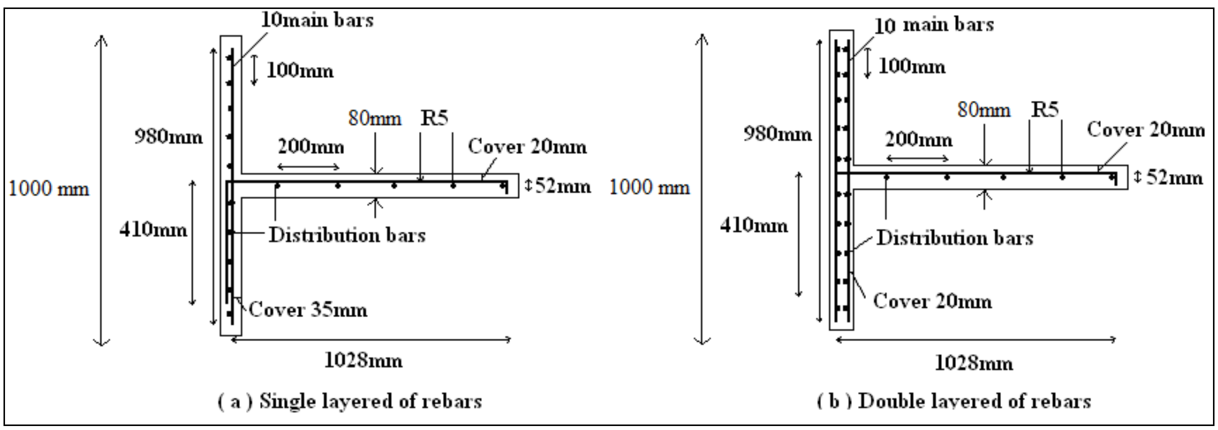

Fig. 4 Details of test specimens

The preparation of the concrete specimens including installation of rebars, preparation of the timber formwork, concrete casting and curing were carried out in the laboratory. The concrete was prepared by the mixer in the lab. The experiment setup is shown in Fig. 5. The specimen was placed by the hydraulic jack that was loaded at a distance of a 580mm from the wall face. The test consisted of two loading cycles. The load was applied gradually in small increment with vertical deflection at A and B recorded. The load applied was measured using a 40kN proof ring. The applied load was halted at load level of 2kN. Then, the specimen was unloaded and recovery of deflection was recorded. After that, the specimen was once again reloaded until the maximum loading was reached. The readings of deflection were taken at every 0.5kN of load increment. Deflection and relevant data at that stage were recorded. The specimen was considered fail when the load was observed to decrease with further increase in deflection.

Fig. 5 Experiment setup

3. Results And Discussion

The six specimens of the test results for bending moment at failure are observed to be less than their corresponding predictions. The actual tensile test results of the three rebars samples were consistent with each other with an average value of 817MPa. The cube test results of the six specimens were also found to be consistent with each other in the range from 22MPa to 26MPa. The actual cover had checked by actual dismantling of one wall-slab specimen and using cover meter on the remaining five samples. Table 1 shows a summary of all the test results, corresponding predictions based on BS 8110 (1997) and the theoretical based on actual concrete cover of the six specimens.

Table 1: Summary of comparisons with theoretical calculation

Specimen	Bending Moment (kNm) at failure			
	Theoretical (actual concrete cover)	Theoretical	Actual	% Difference
1 (S)	5.84	8.41	3.59	-57.31
2 (S)	6.16	8.41	3.81	-54.70
3 (S)	6.80	8.41	3.15	-62.54
1 (D)	5.36	8.41	5.50	-34.60
2 (D)	7.12	8.41	6.31	-24.97
3 (D)	6.16	8.41	7.00	-16.77

The value of concrete cover will influence the effective depth of tension rebar. For the particular structure stiffness, by increasing the effective depth, it will subsequently reduce the bending capacity. It is due to effective depth, d = thickness - cover - (rebar diameter/2). Specimens with double layered of rebars were found to exhibit higher bending capacity at failure compare to specimens with single layered of rebars. The crack pattern can be seen in Fig. 6. The cracks were observed to be extending and propagating along with the appearance of new cracks.

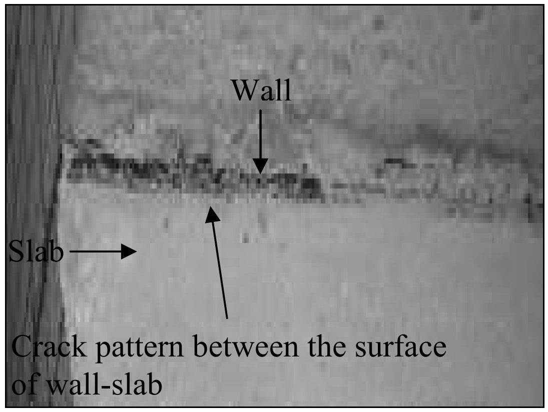

Fig. 6 Crack pattern of specimen 3 (S) at intersection between wall and slab

4. Conclusion

This study also determined that the adoption of this slab and wall form technique in the construction of the low cost high-rise apartments greatly benefit the building industry in various aspects such as reducing the construction cost, better planning and design coordination, speed of construction, minimising manpower on site, better quality construction, environmentally friendly, and improved site safety. Based on experimental results, specimen for the wall consisted double layered of rebars provide higher bending capacity slab compared with single layered of rebars in wall.

References

Moses. S.M. (2006). Cutting Time and Costs with IBS, Property Times, 7th January 2006.

British Standard Institution. (1997). BS 8110 : Part 1 : 1997, Structural Use of Concrete, Part 1. Code of Pratice for Design and Construction. *British Standards Intitution*, 21 & 65.

Liu, J. & Abolhassan, A.A. (2004). Moment-Rotation Parameters for Composite Shear Tab Connections. *Journal of Structural Engineering*, 130, 1371-1379.

Yeoh, S.L. (2006). A Computational Study on Wall-Slab Structural System Considering Floor Slab Flexural Stiffness. *MSc Dissertation*, School of Civil Engineering, Universiti Sains Malaysia.

Suk, C.G., Jung, W.J., Park, H.K., Kim, N.H. and Katsuyama, K. (2008). Application Study of Explosive Demolition for the Wall-Slab Building, *Science and Technology of Energetic Materials*, 69, 51-58.