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STRUCTURAL BEHAVIOR OF THIN RPC WALL PANELS WITH VARYING STEEL REINFORCEMENT AND ASPECT RATIO SUBJECTED TO AXIAL ECCENTRIC UNIFORMLY DISTRIBUTED LOADING

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Abstract: This paper presents experimental study of structural behavior of thin Reactive Powder Concrete (RPC) wall panels subjected to axial eccentric uniformly distributed loading with varying steel reinforcement ratio (ρ) and aspect ratio (AR= H/L). The experimental program included testing of six two-way thin RPC wall panels, fixed at all sides and applying the load axially with eccentricity equal to (t/6). The results indicates that the ultimate strength of the RPC wall panel decreases with increase in AR from (1.25 to 2.00) for panels with H/t = 18.75. The decreasing in ultimate load for RPC wall panels is about 16% and 38.7%, for an increase in AR from 1.25 to 2.0 for panels with ρ = 0.012566, and about 6.38% and 36.2%, for an increase in AR from 1.25 to 2.0 for panels with ρ = 0.007854.The ultimate strength of RPC wall panel increases with an increase of percentage of steel reinforcement ratio (ρ). For an increase in reinforcement ratio from ρ = 0.007854 to ρ = 0.012566 the increase is about (6.4, 4.76 and 2.22) % for walls with AR (1.25, 1.50 and 2.00) respectively. The lateral deflection decrease with the increase of percentage of steel reinforcement ratio from (0.007854 to 0.012566) under two-way in plane loading, When AR= 1.25 the reduction about (1.22 times) and When AR= 2.00 the reduction about (1.11 times). The lateral deflection of RPC wall panels decrease with the increase in aspect ratio.

Keywords: *Concrete Wall, Eccentric Load, Axial Load, Two-way Action, Reactive Powder Concrete, Steel Reinforcement, Aspect Ratio.*

السلوك الإنشائي للألواح الجدارية النحيفة ذات خرسانة المساحيق الفعالة مع اختلاف نسبة حديد التسليح ونسبة العرض إلى الارتفاع المعرضة الى تحميل محوري لامركزي منتشر

الخلاصة: هذا البحث يقدم دراسة تجريبية للسلوك الانشائي للألواح الجدارية النحيفة ذات خرسانة المساحيق الفعالة المعرضة الى تحميل محوري لامركزي موزع بانتظام مع نسب مختلفة من نسبة حديد التسليح (ρ) و نسبة الارتفاع على العرض(Aspect Ratio). البرنامج التجريبي يتضمن فحص ستة نماذج من الألواح الجدارية النحيفة (two-way action) ذات خرسانة المساحيق الفعالة (RPC)، المثبتة بكل الجوانب ويتم تسليط الحمل محوريا مع لا مركزية مساوية الى السمك مقسم على ستة (t/6). النتائج تشير إلى مقاومة الجدران ذات خرسانة المساحيق الفعالة (RPC) تقل مع الزيادة في نسبة الارتفاع على العرض (H/L) من (1.25 الى 2.00)، للجدران مع H/t = 18.75. النقصان في التحمل النهائي لجدران خرسانة المساحيق الفعالة RPC هو حوالي 16٪ و 38.7٪، بزيادة (AR) من 1.25 الى 2.00 للجدران مع ρ = 0.012566، وحوالي 6.38٪ و 36.2٪، بزيادة (AR) من 1.25 الى 2.00 للجدران مع ρ = 0.007854. التحمل الاقصى للجدران ذات خرسانة المساحيق الفعالة RPC يزداد مع زيادة نسبة حديد التسليح (ρ). للزيادة في نسبة حديد التسليح من ρ = 0.007854 إلى ρ = 0.012566 الزيادة حوالي (6.4، 4.76 و 2.22)٪ للجدران مع AR (1.25، 1.50 و 2.00) على التوالي . الازاحة الجانبية تنخفض مع زيادة نسبة حديد التسليح من ρ = 0.007854 إلى ρ = 0.012566 تحت

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تحميل محوري (two-way action) ، عندما AR = 1.25 النقصان حوالي (1.22 مرات) وعندما AR = 2.00 النقصان حوالي (1.11 مرات). والازاحة الجانبية لجدران RPC تنخفض مع زيادة في نسبة العرض إلى الارتفاع.

1. Introduction

Wall is a vertical plate member resisting vertical (in-plane) or lateral loads. Out of plane bearing walls were referred to RC wall panels which were commonly used as load-bearing structural members, braced and laterally supported by the rest of the structure. Bearing concrete walls resisting primarily (in-plane) vertical loads which acting downward on the top of the wall the vertical load may act eccentrically with respect to the wall thickness, causing weak-axis bending [1].Also a wall is defined in the Part 1 of British Code 8110 in 1997, clause 1.3.4.1, as a vertical load-bearing element which its length exceeding 4 times its thickness, this definition identify the walls from a columns [2].

Reactive Powder Concrete (RPC) is one of the newest and most significant developments in concrete technology also known Ultra-High-Performance Concretes (UHPC) it is cementinous composites concrete with superior material properties like highly compressive strength and tensile strength, high modulus of elasticity, extremely high ductility and durability, limited shrinkage, high resistance to corrosion and abrasion and fatigue resistance. The RPC mix which is characterized by dense mix, high cement content, crushed quartz or fine sand (with particle size less than 600 μm), silica fume, contains in most cases steel fibers to decrease its brittleness, new generation of superplasticizers, low w/c ratio (less than 0.2), and no coarse aggregate [3]. RPC has been primarily used in many modern multi-story buildings (tall buildings), bridges (like Pedestrian Bridges and Vehicular Bridges), tunnels, factories, power stations and off-shore structures. It has also been used in shotcrete repair, poles, parking garages, and agricultural applications. [4] Also RPC can be used for security applications, realization that RPC has excellent impact and blast resistance that make it good solutions to protect high security buildings by using wall or roof precast panels. [5]

The main objective of this study is to investigate the structural behavior of thin concrete wall panels supported on all sides with varying steel reinforcement and aspect ratio subjected to axial eccentric uniformly distributed loading, in which eccentricity causes secondary bending moment.

2. Experimental Program

The experimental program of this work includes studying the influence of two parameters on structural behavior of RPC wall panels subjected to axial eccentric compression loads in two–way action by testing six structural models reduced-scale wall panels, these models are divided into two groups, group one of horizontal and vertical steel reinforcement ratio equal to 0.012566 which contain 3 specimens and the second group of $\rho = 0.007854$ which contain 3 specimens. The slenderness ratio for all specimens was (H/t = 18.75), the thickness for all panels is 40 mm. The parameters are:

1. Aspect ratio (AR): The value of aspect ratio (H/L) is (1.25, 1.50 and 2.00).

2. Flexural steel reinforcement ratio (ρ): The selected ratios of horizontal and vertical steel reinforcement are ($\rho = 0.007854$ and $\rho = 0.012566$), and it's above the percent of minimum reinforcement ratio stated by the code of practice (ACI 318-14) (11).

The values of the mechanical properties of RPC, ultimate load capacity, load-deflection relationship and crack patterns are considered the indicators to denote the aims of this study.

3. Construction Materials

3.1. *Cement*

The Iraqi ordinary Portland cement (Mass) type (I) is used in this study.

3.2. *Fine Aggregate*

Extra fine sand, anti-slip aggregate #4 with size (300-600) µm is used for RPC mix.

3.3. *Silica Fume (Densified Microsilica MEYCO (MS 610))*

MEYCO (MS 610) is a mineral additive that is used in RPC mix.

3.4. *High Range Water Reducing Admixture (Superplasticizer S.P.)*

A third generation copolymer-based superplasticizer, designed for the production of RPC mix is used (Glenium 51).

3.5. *Ultra-Fine Steel Fibers (Micro Steel Fiber)*

Ultra-fine steel fibers are used throughout the experimental program. This type of ultra-fine straight steel fibers was manufactured by the Ganzhou Daye Metallic Fibers Co., Ltd, China. Micro steel fiber is the material of Reactive Powder Concrete (RPC). The diameter of the steel fiber is 0.2 mm and its length is 15 mm with aspect ratio (L_f / D_f) = 75.

3.6. *Probuild SB (Epoxy Used)*

In order to avoid any (1 mm or less) gab (if it is found) between tested specimen and the steel frame, an epoxy (Probuild SB) resin is filled inside this gab around the specimen for (7) days curing of epoxy to bracing (control) the fixity of the wall at supports.

3.7. *Steel Bars*

For reinforcement welded wires fabric mesh was used and placed with single layer at the middle of specimen's thickness. These wires were (4mm) in diameter with fy = 720 MPa placed at (50mm) c/c spacing in both directions and (80mm) c/c, with

10mm concrete cover. In addition, a (10mm) steel reinforcement is placed around the wall to strengthen or protect the wall's edges as shown in Figure (1).

4. Wall Specimen Details

Panels are designed as (W x_1 x_2) where:
W: Refers to the word (Wall), x_1: Refers to the type of concrete used (R= RPC).
x_2: Refers to the number of the wall panel within the group.
The details of the wall panels are summarized in Table (1).

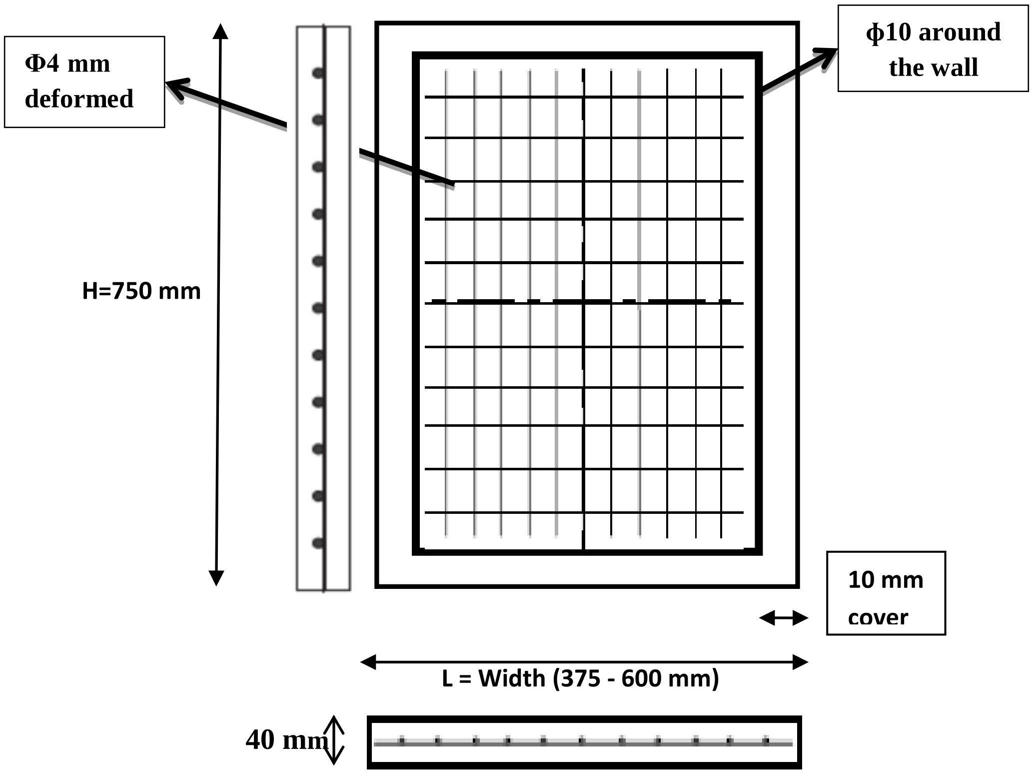

Figure (1): Arrangement of Reinforcement in Panel.

Table (1): The Details of the Wall Panels.

Wall panel	*Dimension (mm)*			*Aspect Ratio (H/L)*	*Wall panel*	*Dimension (mm)*			*Aspect Ratio (H/L)*
	H	**L**	**T**			**H**	**L**	**T**	
WR1	750	600	40	1.25	WR4	750	600	40	1.25
WR2	750	500	40	1.50	WR5	750	500	40	1.5
WR3	750	375	40	2.00	WR6	750	375	40	2

5. Reactive Powder Concrete Mix

Mix Proportions of RPC is shown below:

Table (2): Mix Proportions of RPC.

Cement (C)	*880 kg*	—
Fine Sand (S)	970 kg	—
Silica Fume (SF)	20%	Percent by weight of cementinous
	220 kg	—
Steel Fiber (V_f)	1.5%	Percent of mix volume
	118 kg	—
W/C	0.19	—
G51	7 %	Percent of cementitious materials (cement + silica fume) weight

6. Test Rig Set Up (Frame Used)

The test rig used in this study, the one used by Ganesan, N., et.al [6] with some adjustment for side restraints, in order to make a simple, economical and functional test rig (support simulation), the top and bottom fixed support conditions is simulated by attaching a 32 mm diameter high strength steel rod on a channel of size (C50 mm×3 kg/m) and welded very well. The steel rod should be at on eccentricity t/6. The vertical sides were supported by a channels of 62.25 mm depth and 8 mm thickness.

A rectangular steel belt (5cm width and (55cm, 45cm, 32 cm length respectively)) was welded in an equally spaced along the channel to have interrelated side supports. Along the channel there is a (3- 4) screw {(12mm) in diameter} to have extremity degree of fixity for the wall panel. This operation was made very carefully and with high accuracy to ensure there are no gaps allowed to be within the support and welding. To satisfy the eccentricity when the loading is applied. Details of the supported are shown in Figure (2) and Plate (1 A, B and C). The two I-sections fixed to the test machine by many clamps tightly, top and bottom, and then filling the gap (if it is found) between the wall panels and side supports with epoxy then tightening the screws in the side supports to fixing the panel and put the specimens in the laboratory for seven day for curing of epoxy.

Plate (1) A: Top and Bottom Support.

Plate (1) B: Side Supports.

Plate (1) C: Framed Used.

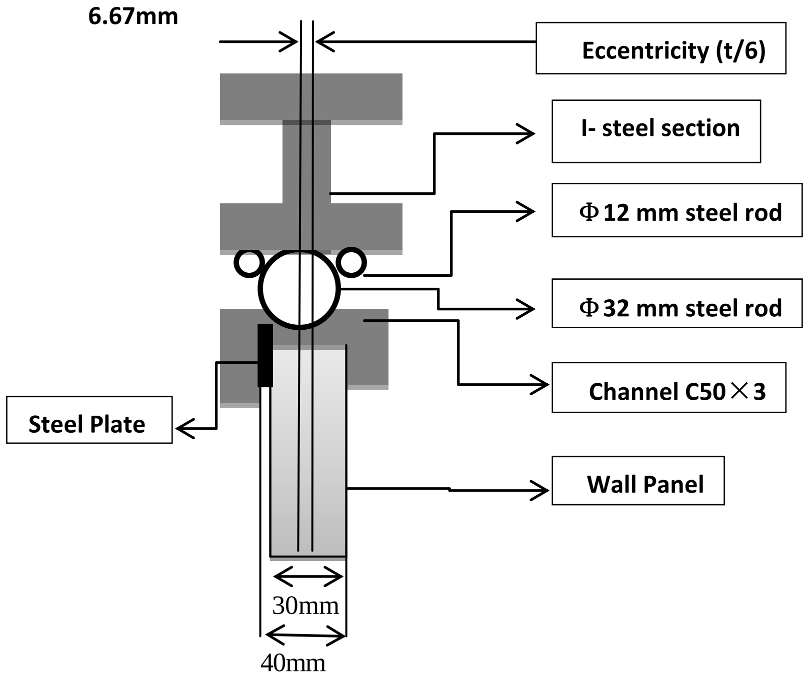

Figure (2): Detail of Supports Used In this Work.

7. Wall Panels Testing Procedure

Before the testing day, the wall is lifted from curing container and the specimens are cleaned, wiped and painted in white color to ensure the crack pattern can be observed easily on wall surfaces and to attain clear visibility of cracks during testing. After the test rig was fixed, the panel is fixed to the top and bottom supports and the wall panels are labeled and accurately placed along the edges of supports.

Leveling the panel to ensure the perpendicularity of the panel the axial load is applied at eccentricity = t/6 from the center of specimens and the dial gages are placed at mid center of the wall panels.

During the test, the applied loads and the corresponding mid-span deflections are recorded using dial gauge of 0.01mm accuracy and 25mm capacity located on the face of the wall panels (in the middle of the tested wall face) .

In the beginning of each test, about (2 kN) is applied to seat the supports and loading system, then the load is released after applying the seating loading, axial compressive loading is applied progressively in increments of (10 kN).

This amount of gradual loading allowed sufficient number of loads and resultant deflections to be taken during the test which gives a realistic idea for the structural behavior of the wall panels.

The ultimate axial load with its corresponding deflections at the center of the wall are observed and recorded, as shown in Plate (2) below.

Plate (2): RPC Wall Panels Before and After the Test.

8. Mechanical Properties of Hardened Concrete

The mechanical properties of RPC mixes are listed in Table (3), the compressive strength *(f_c')* tests were carried out on cylinders (100 x 200) mm in accordance with ASTM-C39-86 [7]. Flexural strength (modulus of rupture) (f_r) tests were carried out on prisms (100x100x400) mm in accordance with ASTM C 78-02 [8].While the indirect tensile strength (splitting tensile strength) (f_{ct}) tests were carried out on cylinders (100 x 200) mm in accordance with ASTM C496-04 [9].

Table (3): Mechanical Properties of Hardened Concrete.

Concrete Type	*Compressive Strength (f_c') MPa*	*Modulus of Rupture (f_r) MPa*	*Splitting Tensile Strength (f_{ct}) MPa*
RPC	120.4	19.4	12.73

9. Test Results

9.1. *Axial Failure Loads and Lateral Deflection for RPC Wall Panels*

The failure loads and lateral deflection for all the panels tested in this paper were presented in this section to study the effects of two parameters aspect ratios (H/L) and steel reinforcement ratio (ρ), on ultimate axial load capacity and lateral deflection of thin RPC wall panels.Table 4 presented the results of axial load of specimens and their corresponding lateral deflection.

Table 4: Results of Axial Load of Specimens and Their Corresponding Lateral Deflection.

Group One	*Experimental Results (kN)*	*Lateral Deflection (mm)*	*Group Two*	*Experimental Results (kN)*	*Lateral Deflection (mm)*
WR1	1500	1.98	WR4	1410	2.42
WR2	1260	1.315	WR5	1320	2.32
WR3	920	1.19	WR6	900	1.32

9.1.1. *Effect of Aspect Ratio (AR) on Ultimate Strength and Lateral Deflection*

It can be noticed from Table 4, Figures (3) and (4):

- The ultimate strength of the RC wall panel decreases with increase in AR from (1.25 to 2.00) for panels with H/t = 18.75.
- The decreasing in ultimate load for RPC wall panels is about 16% and 38.7% , for an increase in AR from 1.25 to 2.0 for panels with ρ = 0.012566.
- The decreasing in ultimate load for RPC wall panels is about 6.38% and 36.2%, for an increase in AR from 1.25 to 2.0 for panels with ρ = 0.007854.
- For RPC wall panels the increase in aspect ratio will result decreasing in the lateral deflection. When AR is increased from 1.25 to 2.00 the reduction in the lateral deflection when ρ = 0.012566 is about (1.66 times), and for an increase of AR from 1.25 to 1.50 the reduction is about (1.51times), also when increase AR from 1.5 to 2.00 the reduction in lateral deflection is about (1.11 times).
- For RPC wall panels when ρ = 0.007854, the increase in AR from 1.25 to 2.00 result in reduction in the lateral deflection, the reduction is about (1.83 times), and for an increase of AR from 1.25 to 1.50 the reduction is about (1.04 times), also when increase AR from 1.5 to 2.0 the reduction in the lateral deflection is about (1.76 times).

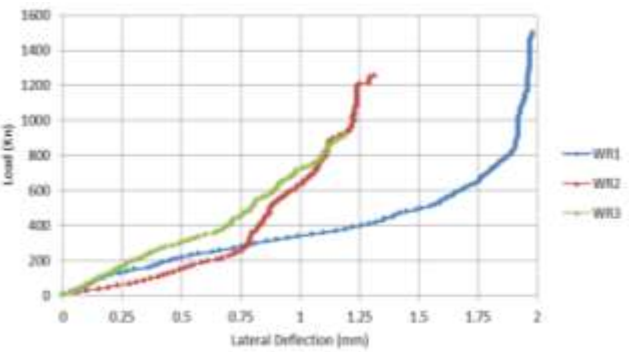

Figure (3): Effect of AR on Load-deflection Behavior for RPC With ρ = 0.012566.

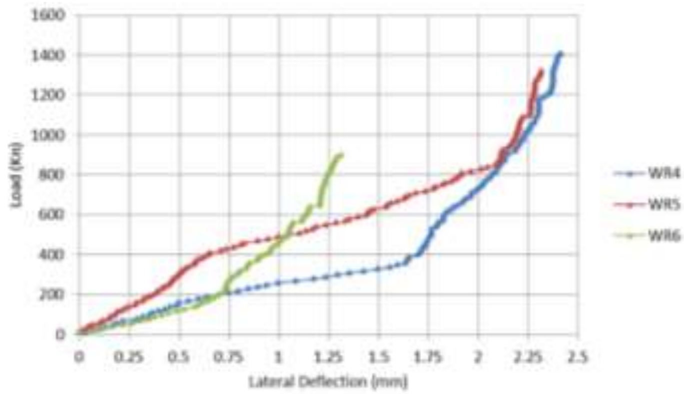

Figure (4): Effect of AR on Load-Deflection Behavior for RPC with ρ = 0.007854.

9.1.2. *Effect of steel reinforcement ratio (ρ) on ultimate strength and lateral deflection*

It can be noticed from Table 4, Figures (5,6 and 7):

- The ultimate strength of wall panel with H/t = 18.75 increases with an increase of percentage of steel reinforcement ratio (ρ).
- For RPC specimens for an increase in reinforcement ratio from ρ = 0.007854 to ρ = 0.012566 the increase in ultimate load is about (6.4, 4.76, 2.22) % for walls with AR (1.25, 1.50, 2.00) respectively. The increase in strength could be because of the two-way bending in which the horizontal and vertical reinforcement resist the bending action. The results shows that changing the percentage of steel reinforcement between (0.007854 to 0.012566) was not increased the strength of the specimens considerably and it was only varied between (2.22 – 6.4) %. This may be attributed to the fact that the steel mesh was carrying a small fraction about 14%, of the total capacity of the panel.[10] However, the effect of steel reinforcement on the ultimate strength of wall panels is still insignificant and need more study work.
- The lateral deflection decrease with the increase of percentage of steel reinforcement ratio under two-way in plane loading.
- When increased steel reinforcement ratio for RPC wall panels from 0.007854 to 0.012566, the lateral deflection reduced as follow:
- When AR= 1.25 the reduction is about (1.22 times).
- When AR= 1.50 the reduction is about (1.76 times).
- When AR= 2.00 the reduction is about (1.11 times).

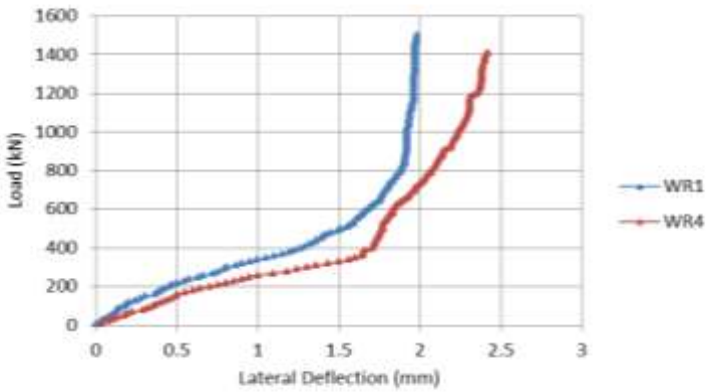

Fig (5): Effect of (ρ) on Load-deflection Behavior with (AR= 1.25).

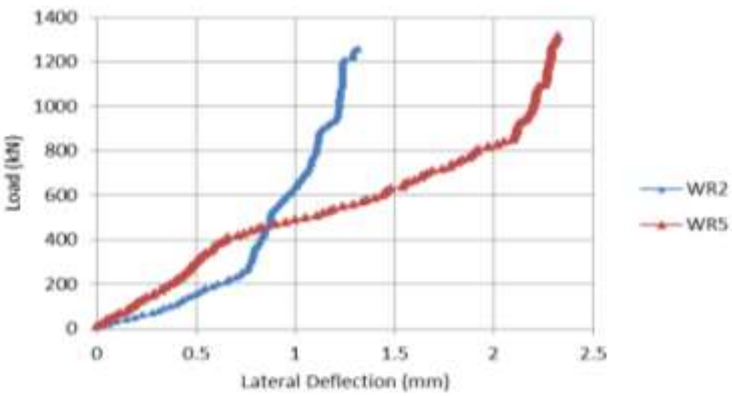

Fig (6): Effect of (ρ) on Load-deflection Behavior with (AR= 1.50).

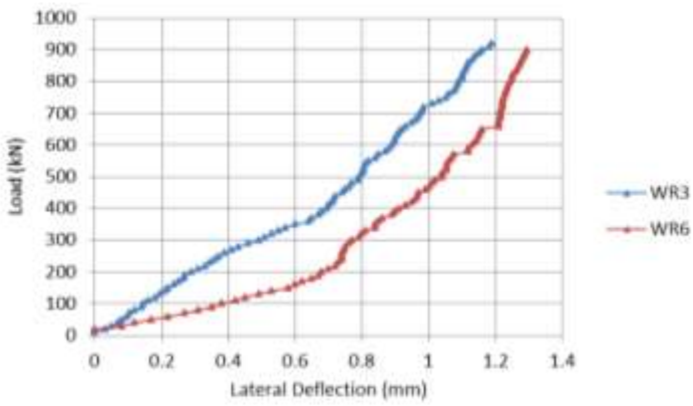

Fig (7) : Effect of (ρ) on Load-deflection Behavior With (AR=2.00).

9.2. *Cracking Patterns for RPC Wall Panels and Failure Mode*

Plates from (2) to (7) shows the crack patterns observed on compression faces and the tension faces of the tested RPC wall panels after failure. All the panels failed by crushing failure mode and the failure was happened suddenly it was abrupt failure and it was happened ,approximately, when reach ultimate load of RPC wall panels with explosive voice of failure. The crack patterns of panels WR1,WR5 and WR6 on the compression face, exhibited non-straight cracks near bottom edges of the panel (crushing) in the region of 1/3 height of the wall. These cracks are horizontal and perpendicular to the loading direction with some fine vertical and inclined cracks on the compression face of the WR1 wall panels and one fine crack on the top edge of WR5. In tension faces one non-straight horizontal main crack appears in the bottom edges of wall panels WR1, WR5 and WR6 with small minor cracks on the tension face of panel WR5.

The crack patterns of WR2 and WR4 on the compression face, exhibited non-straight cracks near top edges of the panels WR2 and WR4 (crushing) in the region of 1/3 height of the wall. These cracks are horizontal and perpendicular to the loading direction, for compression face of WR2 shows a series of horizontal crack along the width of panel (crushing) and some cracks branched from near the top region of the wall WR2 and spread vertically downwards also inclined cracks near the edges of wall WR2 and WR4, for compression face of WR3 one horizontal crack had been formed when the load reached near the ultimate load in the bottom edge of panel also one diagonal crack in the corners of panel, the reason for diagonal cracks is that, some twisting moments occur near the corners, may be caused by the inequality of the edge of the wall, which generates inequality in loading, the holding down of the side edges by the side supports and the application of eccentric loads onto the loading edges, all this may cause torsional cracks.

In the tension faces of panels WR2, WR3 and WR4, horizontal cracks along the width of wall appears in the top edges of wall panels and one fine horizontal crack appear on the bottom edge of WR2. From a comparison of the crack patterns of WR1, WR5 and WR6 and WR2, WR3 and WR4 it is found that WR1, WR 5 and WR6 had the major cracks occurring on the bottom edge, while the cracks for WR2, WR3 and

WR4 occurred at the top of tested wall panels except the compression face of WR3 where the crack in the bottom edge, the failure occurred in these way for all tested panels, may be because this is the most weakness region in the tested wall panels. Thus, it can be observed that as the steel reinforcement increases the number of cracks increases, but the width of cracks and propagation of cracks decreased.

In general for RPC wall panels, there is no cracking occurrence on surface of wall panel except the compression face of panel WR1 and WR2 which have some vertical and inclined cracks along the panel, the wall panels of RPC crushed at top and base of the wall, all panels of RPC failed by crushing mode, this mode of failure because the low slenderness ratio used. The failed of RPC wall panel by crushing with many narrow crack's width this type of failure patterns may be as a result of the improvement in the tensile capacity of the RPC wall panels, which the steel fibers arrest micro cracks and enhance the ductility. This unique cracking mode indicates typical two-way behavior close to the cracking mode of failure of restrained ends and one-way behavior between unsupported edges. In addition, a torsional mode of failure near the corners of some of walls was observed. The torsional failure mode may have contributed to an additional reduction in load capacity. Table (5) describe the cracks of RPC specimens.

Plate (3)A:WR1Compression Face.

Plate (3)B:WR1 Tension Face.

Plate (4)A:WR2Compression Face.

Plate (4)B:WR2 Tension Face.

Plate (5)A: WR3 Compression Face.

Plate (5)B: WR3 Tension Face.

Plate(6)A:WR4 Compression Face.

Plate(6)B:WR4 Tension Face.

Plate(7)A:WR5 Compression Face.

Plate(7)B:WR5 Tension Face.

Plate(8)A:WR6 Compression Face.

Plate(8)B:WR6 Tension Face.

Table (5): Description and Location of Cracks of RPC Specimens.

SAMPLE	***CRACK LOCATION***	***SIDE CRACK***	***SURFACE CRACK***
WR1	Crush at bottom of the wall (Horizontal Crack at (1/3 H) from Bottom)	None	Three surface cracks on the compression face.
WR2	Crush at top of the wall (Horizontal Crack at (1/3 H) from Top)	One horizontal crack at the base of tension face the wall.	Many surface cracks on the compression face.
WR3	Crush at top and bottom of the wall (Horizontal Crack at (1/3 H) from top and Bottom)	One diagonal cracks	None
WR4	Crush at top of the wall (Horizontal Crack at (1/3 H) from Top)	None	None
WR5	Crush at bottom of the wall (Horizontal Crack at (1/3 H) From Bottom)	Crush at top edges of the wall	Two surface cracks on both ten. And comp. face
WR6	Crush at bottom of the wall (Horizontal Crack at (1/3 H) From Bottom)	None	None

10. Conclusions

From the test results of the experimental program the following conclusions are obtained:

1. In general the ultimate strength of the RPC wall panels decreases with increase in AR.
2. From the results of the experimental work it was concluded that the ultimate strength of the wall panel under two-way (in plane) action increases with an increase in vertical and horizontal steel reinforcement.
3. The increase in aspect ratio (H/L) from 1.25 to 2.00 for RPC wall panels result in decreases in the lateral deflection of the concrete wall panels.
4. The increase in reinforcement ratio of the wall panels from ($\rho = 0.007854$ to $\rho = 0.012566$), causes to decrease the lateral deflection of RPC wall panels. The lateral deflection decreases with the increase in the percentage of horizontal and vertical reinforcement indicating considerable improvement in the ductile property.
5. The steel reinforcement ratio did not have an effect on the failure mode for the tested walls, more tests will be needed before a final conclusion can be made for the effect of the steel reinforcement ratio (ρ) on the failure mode.
6. The development of larger number of finer cracks in RPC wall panels indicates a better cracking performance. This behavior will improve the serviceability limit states and durability significantly.

Abbreviations

RPC	Reactive powder concrete.
BS	British Standard
RC	Reinforced Concrete
AR	Aspect Ratio
H	Height of The Wall.
T	Wall Thickness.
L	Wall Length.

11. References

1. Wight, J. k. and Macgregor, J.G., "*Reinforced Concrete Mechanics and Design*", Sixth Edition, 2011, pp.973.
2. British Standards Association, BS 8110: Part 1."*Structural Use of Concrete*", British Standard Institution, 1997.
3. Richard, P. and Cheyrezy, M., "*Composition of Reactive Powder Concrete*", Cement and Concrete Research, Vol. 25, No. 7, 1995, pp. 1501-1511.
4. Luca G. Sorelli, Alberto Meda, and Giovanni A, "*Steel Fiber Concrete Slabs on Ground: A Structural Matter*". Plizzari ACI Structural Journal/July-August ,2006.
5. David, T., "*Bridge Construction Methods*" concrete institute of Australia, Aug. 2007.pp 100-105.

6. Ganesan, N., Abraham, R., Beena, P.R. and Anil, R., "*Influence of Horizontal Reinforcement on Ultra High Performance Concrete Wall Panels under Two way in plane action*", International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May 2013 ISSN 2229-5518.
7. ASTM C39, "*Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*", 2004.
8. ASTM C78-02 "*Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading*" 2002.
9. ASTM C496-04 “*Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens*”,2004.
10. Fahmy, E.H., Shaheen, Y.B., Abou Zeid, M.N. and Gaafar, H., "*Ferrocement Sandwich and Cored Panels For Floor And Wall Construction*", 29th Conference on Our World In Concrete & Structures 25 - 26 August 2004, Singapore.
11. ACI 318-14, "*Building Code Requirements for Structural Concrete and Commentary*", American Concrete Institute, 2014.