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ENERGY DISSIPATION OF REINFORCED CONCRETE SHEAR WALL UNDER IMPACT OF SEISMIC LOADS

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Abstract- Different types of loadings were considered in analysis of buildings such as gravity, wind and seismic loadings based on adapted engineering designer from standard code. In present study, energy dissipation of reinforced concrete shear wall under impact of seismic loads is examined. The adopted variables that considered such as sialic and dynamic loading, height to width ratio of wall, reinforcements ratio and compressive strength. Models are built using finite element method by SAP2000 software. Energy dissipation, displacements and drifts are assessments for each model. The analysis results showed that the three are improvements in reinforced concrete shear wall (RCSWs) energy dissipations due to increase in RCSWs width due to increase whole stiffness become higher so that the displacement reduced and increase in base shear that developed due to the applied seismic load. The enhancement in energy dissipation of models is 33.27, 54.55 and 66.00% (reduce), respectively. RCSWs when the compressive strength of concrete is higher, the energy dissipation also increases, resulting in an increase in the modulus of elasticity of the concrete, so the stiffness of the RCSW becomes greater. The improved energy dissipation is 1.82, 4.63, 8.00 and 19.79% (reduce), respectively. In addition, the increased in reinforcement ratio make the RCSWs more ductile and reduce the energy dissipation. The enhancement in energy dissipation of models with more reinforcement ratio as compared with model less amount of reinforcement is 6.30, 6.85, 14.38 and 22.08% (reduce), respectively.

Keywords: Energy Dissipation, Dynamic Analysis, Seismic Loading, Reinforced Concrete Shear Wall, SAP2000.

1. INTRODUCTION

Analysis methodology relies on loadings type that considered in analysis like static or dynamic. Dynamic loads are a function of time, while static loads are constant and do not vary with time. Shock loads, harmonic loads and cyclic loads are the main dynamic loads acting on structures, depending on building function, building type and location. All standard building codes use reinforced concrete (RC) shear walls. Shear wall design considers both in-plane and out-of-plane loads to determine the thickness of the shear wall and the number of vertical and horizontal reinforcement. Seismic loads depend on the location of the building considered in the design. Earthquake loads as lateral loads analyzed as linear and nonlinear as static or dynamic loads depending on building function, building importance and building location. Energy dissipation (ED) that developed due to applying seismic loadings on the structural buildings depend on the deformations and building ductility.

The ED play an Important parameter on building design under the effect of seismic loading. Energy dissipation in RC shear walls is very important in analysis seismic as it reduces the magnitude of the seismic response, and thus minimizing the ductility and strength requirements of the structure [1]. Energy dissipation mechanism classified as the important parameter for the structural failure resistant performance under earthquakes. M. Abdel-Mooty and H. Hasan, A. Al-Hassan, 2012 [2], studied the energy dissipation in reinforced concrete building due to seismic loadings. Dampers were placed between the reinforced concrete frame and the assembly placed at shaking table, the parameters adapted such as damper type and seismic loadings by analytical and experimental approaches. Results from both approaches indicated that the presence of damper as energy dissipation reduced the structural damage due to applied seismic loadings.

Xiaobin Hu, et al. 2019 [3], explored the behavior seismic of RCSWs within structural building but analyzed separately. Different parameters were considered such as strength compressive concrete, axial compressive load and seismic loadings. analysis results showed that the axial compressive of the wall pier increases make the energy dissipating capacity decreases. Nouri, H. et al, 2016 [4], analyzed the details that based on standard international codes on the performance of shear wall under influence of seismic loadings. Alternatives lateral seismic loadings were applied to investigated the relationship between reinforced concrete shear wall ductility and energy dissipation. Analysis results indicated that in case of low stiffness degradation, loss in capacity of reinforced concrete shear wall due to ductility and high energy. Hamed Hamidi, et. al., 2018 [5], the behavior and strength of RCSW under repeated seismic loadings were studied, taking into account varying levels such as 10, 15 and 20 stories.

Findings indicate that earthquakes resulted in an increase in seismic requirements for the wall but did not lead to structural failure. Additionally, the inclusion of subsequent records brought about a reduction in residual structural displacement. The reliability of structures must take into account the impact of multiple seismic loadings when making a final determination. It was found that the distribution of energy varied depending on the height of the structure, meaning that taller structures may experience a greater contribution from the mass matrix while experiencing decreased contributions from the stiffness matrix. Mohammad Khanmohammadi and Sajad Heydari 2015 [6], Studied the seismic performance of RCSWs by applied systems multiple rocking. Through the analysis of several structures, including buildings measuring 8, 12, and 20 stories tall, a well-established system utilizing energy dissipation devices has been developed to withstand seismic forces. A variety of shear wall rocking systems were examined, in addition to a traditional reinforced concrete shear wall.

The conclusions drawn from analyzing the shear walls of standard reinforced concrete and those with a rocking mechanism showed several advantages. These included improved energy dissipation, reduced deformations, no residual displacements, and an alternative mode of failure. F.S. Latifov and D.S. Ganiyev 2020 [7], studied Wide use of thin-walled constructions or structural elements in mechanical engineering, in transmission systems, in the field of construction does urgent calculation of their dynamical strength characteristics and choice of their optimal variants. The bases of retaining walls are composed of open profile joined cylindrical shells, and their forms are accepted as optimal. An empty system is obtained by replacing massive retaining walls by thin-walled shells. To provide stability of this system, empty parts are filled with soil and this results in savings of concrete. The objective of present work is to evaluate the energy dissipation of RCSW under impact of seismic loads with different parameters such as seismic and dynamic loading, height to width ratio of wall and compressive strength.

2. MODELS DESCRIPTIONS

Various parameters were used in the present work to evaluate the performance of RCSW under seismic loading. The wall aspect ratio, concrete compressive strength and reinforcement ratio are the main parameters. The stress-strain performance for concrete of all grades by apply the Takeda model. Takeda model is adopted for reinforced concrete shear wall based on Takeda model (1970). The adopted stress-strain behavior for the three compressive strength such as 25, 30 and 35 MPa is shown in Figure 1.

The behavior in Stress-strain of reinforcements is shown in Figure 2, in which the reinforcement behaves as linear nearly up to f_y. the portion from f_y to f_u (620 MPa) is nonlinear and then drop down.

Table 1. Parameters of RCSWs models

Model mark	Wall height H (m)	Wall width W (m)	H/W	Compressive strength f_c (MPa)	Rebar's spacing c/c (mm)
W1	3.0	3.0	1.00	25	150
W2	3.0	4.0	0.75	25	150
W3	3.0	5.0	0.60	25	150
W4	3.0	6.0	0.50	25	150
W5	3.0	3.0	1.00	30	150
W6	3.0	4.0	0.75	30	150
W7	3.0	5.0	0.60	30	150
W8	3.0	6.0	0.50	30	150
W9	3.0	3.0	1.00	35	150
W10	3.0	4.0	0.75	35	150
W11	3.0	5.0	0.60	35	150
W12	3.0	6.0	0.50	35	150
W13	3.0	3.0	1.00	25	200
W14	3.0	4.0	0.75	25	200
W15	3.0	5.0	0.60	25	200
W16	3.0	6.0	0.50	25	200
W17	3.0	3.0	1.00	30	200
W18	3.0	4.0	0.75	30	200
W19	3.0	5.0	0.60	30	200
W20	3.0	6.0	0.50	30	200
W21	3.0	3.0	1.00	35	200
W22	3.0	4.0	0.75	35	200
W23	3.0	5.0	0.60	35	200
W24	3.0	6.0	0.50	35	200

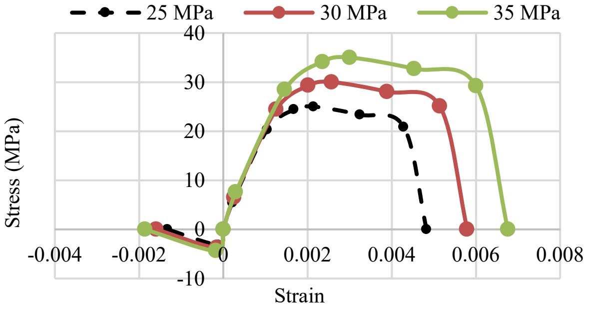

Figure 1. Stress-strain behavior of concrete grade 25, 30 and 35 MPa

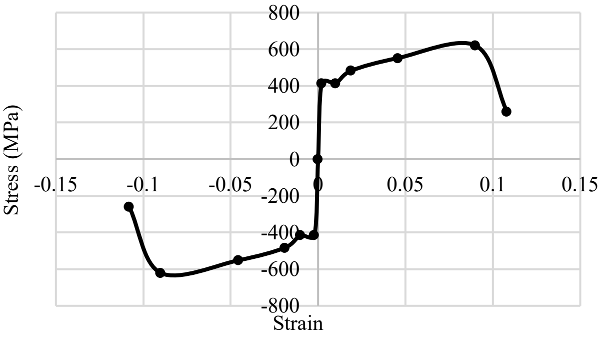

Figure 2. Stress-strain behavior of reinforcements within RCSWs

3. FINITE ELEMENT MODELING

Various techniques were used to simulate the RC shear wall model. Adhesive constraints are used to represent contact surfaces without motion in any direction of the bonded surfaces. The concept of the technique is to merge adjacent nodes so that they become one fully interactive node. A structural model representing RCSW was considered and simulated according to the parameters assumed in this studyAll of RCSWs had been designed in accordance to "ACI-318-2019" [8] below the impact of gravity loadings. The gravity masses and all sorts of seismic masses are taken into account in the evaluation of structural elements. The format concerns of RCSW with one-of-a-kind in top to width ratio, vertical and horizontal ratio and wall thickness with constant boundary situation at the base. The constant at the base symbolizes the raft basis below this kind of structural vertical element. Gravity utilized loadings that is the most important loadings to graph the RCSW based totally on the ASCE-07-2016 [9]. The loadings are switch from the slabs to the RCSW.

In case of linear static seismic loading, the place of such a RCSW in Baghdad hence all seismic elements of Iraq code [10] adopted in present study. Equivalent seismic loading which is used in static linear analysis are calculated using the same response design for nonlinear static analysis (pushover). The individual RCSWs (taking into accounts the presences of slab, loadings and applying diaphragm) is simulated by using finite element method for the RCW analysis with modeling assumptions to build these elements. The layered shell element is used for the analysis of shear walls, the advantage of using shell elements is the ability to model three dimensional RCSW. The shear wall is modeled using multi-layer shell elements that based on the principles of composite material mechanics. The shell element consists of several layers of different thicknesses according to reinforcement diameter with different material mechanical properties that assigned to various layers. The function of the nonlinear RCSWs modeling is to estimate the strength capacity to deform and the corresponding force demand. Table (2), lists the dimensions of RCSWs and mechanical properties for each material.

Table 2. Dimensions of RCSWs and mechanical properties for each material

Thickness Slab above RCSWs (mm)	200	
Height Story (mm), *H*	3000	H/W
Wall Width (mm), *W*	3000	1.00
	4000	0.75
	5000	0.60
	6000	0.50
Thickness wall (mm)	200	
Reinforcement ratio	Vertical "φ16@150" and 200 mm c/c	
	Horizontal "φ16@150" and 200 mm c/c	
Compressive strength of concrete (f_c') (MPa)	25	
	30	
	35	
Poisson's ratio (v)	Concrete 0.2	
	Reinforcement 0.3	
Yielding strength of the steel bars (f_y) (MPa)	413	
Unit weight (γ) (kg/m^3)	Concrete 2400	
	Reinforcement 7850	

4. SUPPORT CONDITION AND LOADS

Support conditions have been corrected for all models representing the foundation type underneath columns and RCSWs is raft foundation. The gravity loads that applied on the slabs of the whole system of reinforced concrete structural building is 3.25 kN/m^2 as super imposed dead load and 2 kN/m^2 [9] as live load assuming that it is a residential building. All proposed load combinations that suggested by"ACI-318-2019" [8] and "ASCE-4-2016" [9] are adopted to evaluate the performance of building and RCSWs. Based on the building's location in Baghdad, lateral loadings such as seismic and wind. Wind load assuming a baseline wind speed VB of 45 m/sec category B and pressure distributions based on floor level height.

5. ANALYSIS RESULTS

The seismic loads applied in the RCSWs produce larger displacements at the top of the share wall that make the drift is maximum at the top of the wall. Drift is the displacement ratio for each level divided by the floor height, so it is dimensionless. Table 3 lists the base shear, drifts and displacements that occurs at the top of the RSCWs in which the drifts and displacements according to the maximum base shear for each model. Figure 3 shows the base shear-displacement variations for one model.

Table 3. Base shear, drift and displacements

Model mark	Base shear (kN)	Drift	Displacement (m)	Time (sec.)
W1	248.1	-0.00163	-0.03912	2.49
W2	300.1803	-0.00152	-0.03648	2.29
W3	434.6541	-8.74E-04	-0.020976	1.78
W4	508.5727	-4.03E-04	-0.00967	2.74
W5	249.65	-0.002	-0.048	2.47
W6	384.58	-0.0015	-0.036	2.27
W7	500.4236	-0.00116	-0.03	2.56
W8	546.358	-4.85E-04	-0.01164	5.05
W9	275.0375	-0.00204	-0.04896	2.46
W10	436.0007	-0.00169	-0.04056	2.27
W11	598.1984	-0.0012	-0.0288	2.56
W12	623.5372	-8.04E-04	-0.02	3.63
W13	201.6059	-0.00215	-0.0516	2.6
W14	283.8168	-7.70E-04	-0.01848	2.24
W15	420.7521	-0.00115	-0.0276	2.57
W16	499.3508	-3.76E-04	-0.00902	2.75
W17	227.6823	-0.0019	-0.0456	2.58
W18	353.4962	-0.00154	-0.03696	2.28
W19	453.0579	-0.00111	-0.02664	2.56
W20	499.6741	-5.87E-04	-0.01409	3.41
W21	267.9586	-0.00141	-0.03384	2.47
W22	409.8381	-0.00169	-0.04056	2.27
W23	542.2337	-0.00117	-0.02808	2.56
W24	583.9753	-5.08E-04	-0.01219	4.11

The listed results that tabulated in Table 3 indicated that increase in wall width the base shear become more that reflects on drifts and displacements. Increase in concrete compressive strength increase in base shear and increase in reinforcement ratio also increase the base shear. The base shear-drift and base shear-displacement same behavior except in values of displacements not in base shear because the drift is displacement at the top of RCSWs divided by the total height of RCSW. The baseline shear displacement ratio are hysteresis loops overlapped with each other to form figure similar to ellipsoid with oblique diagonal pass through origin. Base shear, displacements, and drift values are time dependent. At any specific time, there is specific base shear, displacement, and drift that vary positively and negatively. The displacements and drifts become very small after a time period of more than 12.5 seconds and become very close with each time step that is rounded to zero. Base shear variations with displacement at top for (W1) models shown in Figure 3.

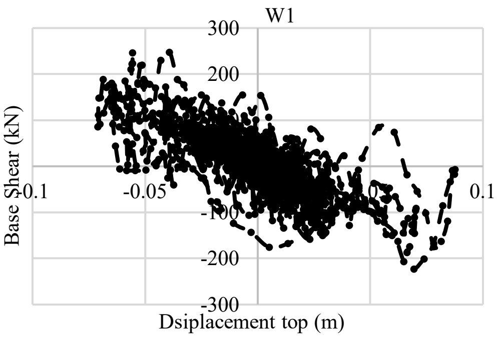

Figure 3. Base shear with displacement for W1

The energy dissipation for all models lists in Table 4. Figures 4 to 6 show the variations of energy dissipation that developed and variations with RCSWs widths, compressive strength and reinforcement ratios. The energy dissipation enhanced when increase in RCSWs width, concrete compressive strength and reinforcement ratio.

Table 4. Energy dissipation for all models

Model mark	W1	W2	W3	W4
Energy dissipation (kN.m)	55.00	36.70	25.00	18.70
Model mark	W5	W6	W7	W8
Energy dissipation (kN.m)	54.00	35.00	23.00	15.00
Model mark	W9	W10	W11	W12
Energy dissipation (kN.m)	52.70	31.80	21.60	13.61
Model mark	W13	W14	W15	W16
Energy dissipation (kN.m)	58.71	38.90	29.20	24.00
Model mark	W17	W18	W19	W20
Energy dissipation (kN.m)	56.03	37.92	26.91	16.47
Model mark	W21	W22	W23	W24
Energy dissipation (kN.m)	57.98	33.85	17.93	15.83

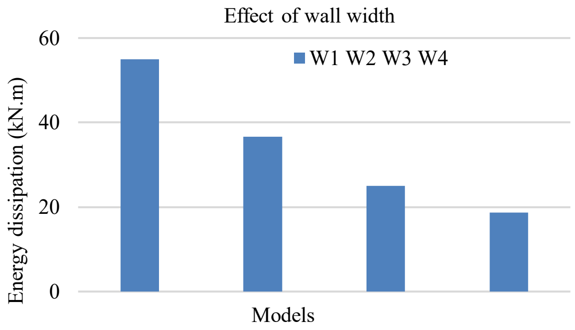

Figure 4. Energy dissipation variations with effect of RCSWs width

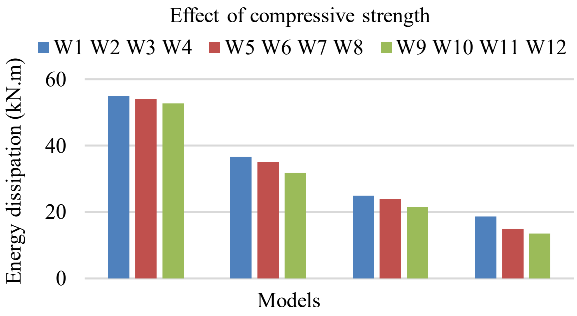

Figure 5. Energy dissipation variations with effect of RCSWs compressive strength

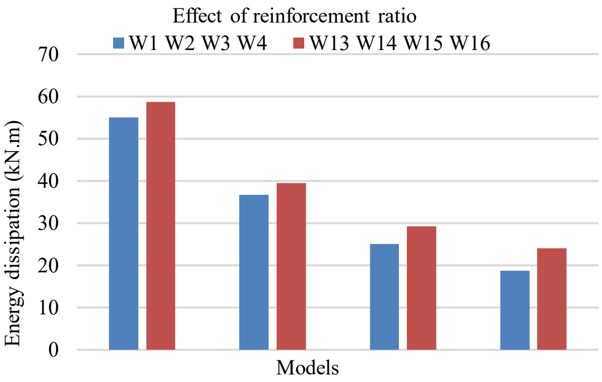

Figure 6. Energy dissipation variations with effect of RCSWs reinforcement ratios

6. PUSHOVER ANALYSIS

Nonlinear static analysis was used as a pushover for all models to compare the findings to those of nonlinear time history (NLTH) analysis. Table 5 compares the base shear and displacements of all models using nonlinear time history and pushover analysis.

Table 5. Comparisons of "base shear" and "displacements" between nonlinear time history and pushover analysis for all models

Model mark	W1	W2	W3
Base shear (kN) NLTH	248.1	300.1803	434.6541
Base shear (kN) Pushover	185	305	425
Displacement (m) NLTH	-0.03912	-0.03648	-0.020976
Displacement (m) Pushover	-0.035	-0.025	-0.016
Model mark	W4	W5	W6
Base shear (kN) NLTH	508.5727	249.65	384.58
Base shear (kN) Pushover	500	215	368
Displacement (m) NLTH	-0.00967	-0.048	-0.036
Displacement (m) Pushover	-0.0085	-0.042	-0.032
Model mark	W7	W8	W9
Base shear (kN) NLTH	500.4236	546.358	275.0375
Base shear (kN) Pushover	550	570	265
Displacement (m) NLTH	-0.03	-0.01164	-0.04896
Displacement (m) Pushover	-0.021	-0.011	-0.042
Model mark	W10	W11	W12
Base shear (kN) NLTH	436.0007	598.1984	623.5372
Base shear (kN) Pushover	427	280	602
Displacement (m) NLTH	-0.04056	-0.0288	-0.02
Displacement (m) Pushover	-0.033	-0.024	-0.015
Model mark	W13	W14	W15
Base shear (kN) NLTH	201.6059	283.8168	420.7521
Base shear (kN) Pushover	185	300	401
Displacement (m) NLTH	-0.0516	-0.01848	-0.0276
Displacement (m) Pushover	-0.045	-0.016	-0.018
Model mark	W16	W17	W18
Base shear (kN) NLTH	499.3508	227.6823	353.4962
Base shear (kN) Pushover	485	206	357
Displacement (m) NLTH	-0.00902	-0.0456	-0.03696
Displacement (m) Pushover	-0.0082	-0.037	-0.026
Model mark	W19	W20	W21
Base shear (kN) NLTH	453.0579	499.6741	267.9586
Base shear (kN) Pushover	450	550	245
Displacement (m) NLTH	-0.02664	-0.01409	-0.03384
Displacement (m) Pushover	-0.023	-0.12	-0.031
Model mark	W22	W23	W24
Base shear (kN) NLTH	409.8381	542.2337	583.9753
Base shear (kN) Pushover	402	510	565
Displacement (m) NLTH	-0.04056	-0.02808	-0.01219
Displacement (m) Pushover	-0.036	-0.023	-0.0108

Base shear and the displacements from pushover analysis nearly close with that of nonlinear time history. Figure 7 shows the effect of RCSWs width on base shear and displacement. When the ratio of height to width less of the RCSW, the displacement become less. Figure 8 shows the impact of compressive strength on base shear and displacement, the increase in compressive strength that lead to decrease in displacements. Figure 9 represent the influence of reinforcement ratio on base shear and displacement, more reinforcement ratio gave less displacement.

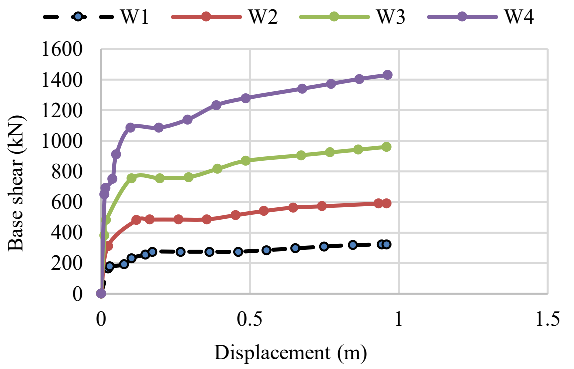

Figure 7. Effect of RCSWs width on base shear and displacement

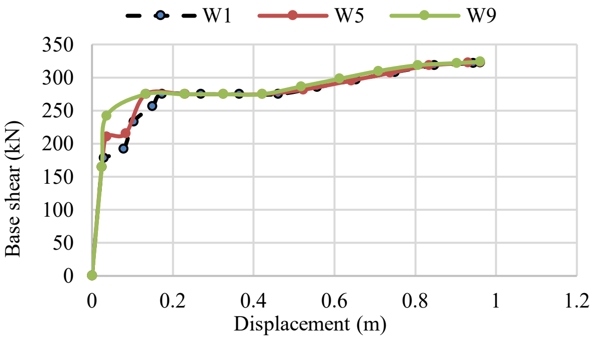

Figure 8. Effect of "compressive strength" on base shear and displacement

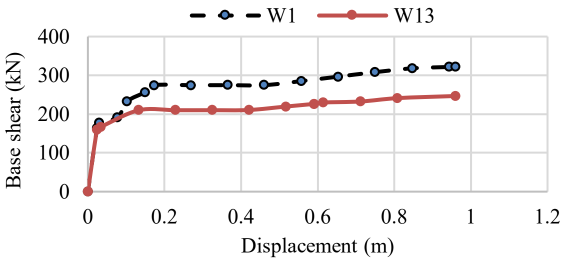

Figure 9. Effect of reinforcement ratio on "base shear" and "displacement"

7. DISCUSSIONS

Analysis results of individual RCSWs indicated that the lateral force bearing capacity of RCSWs has more compressive strength and reinforcement ratio (less rebar's spacing). Increase in compressive strength that is mean increase in modulus of elasticity so that increase in stiffness of RCSW. Increase in rebar's ratio make the RCSW more ductile that is lead to decrease the displacement. The RCSWs hysteresis behavior, energy dissipation and shear strength capacity improved by increase compressive strength of concrete and rebar's ratio but within limits of standard code such as ACI-318-2019. Wall aspect ratios, such as the height-to-width ratio, have an influence on global wall behavior. A decrease in aspect ratio makes the RCSWs more stable, with high stiffness, low displacement, and good energy dissipation. According to the results of finite element analysis, the greater the compressive strength of the concrete used in RCSWs, the higher the in-plane shear load capacity, and RCSWs with a double layer are a suitable practice that gives extra confinement to the concrete wall.

The contribution of shear performance to the top displacement of an RCSW may be insignificant when compared to the concentrated shear at lower stories, which can affect displacement and drift at these stories. Models of RCSWs using a multi-layer shell element model based on composite fabric mechanics, which at once applies the nonlinear performance of the reinforced concrete shear wall detail to the constitutive relations of concrete and steel, have many advantages in explaining the complex nonlinear behaviors. The simulation results demonstrate that the multi-layer shell element model accurately simulates RCSWs. The parameters that adopted that impact on performance of RCSWs summarized as follows.

7.1. Effects of RCSW Width

The effects of RCSWs width on the base shear resistance lists in Table 6, Increase in RCSWs width lead to increase in stiffness of the wall due to increase in moment of inertia of the wall. Increase in wall width make the wall more stable in the direction of seismic loading. The numerical results listed in Tables 6 and (4.9), the maximum increase in base shear in case of RCSW width 6 m.

Table 6. Effects of RCSWs width on the resistance shear

Model mark	W1	W2	W3
% increase in base shear	---	20.99	75.19
Model mark	W4	W5	W6
% increase in base shear	104.99	---	54.05
Model mark	W7	W8	W9
% increase in base shear	100.45	118.85	---
Model mark	W10	W11	W12
% increase in base shear	58.52	117.5	126.71
Model mark	W13	W14	W15
% increase in base shear	---	40.78	108.70
Model mark	W16	W17	W18
% increase in base shear	147.69	---	55.26
Model mark	W19	W20	W21
% increase in base shear	98.99	119.46	---
Model mark	W22	W23	W24
% increase in base shear	52.95	102.36	117.93

7.2. Effects of Concrete Compressive Strength

The effects of RCSWs compressive strength on the base shear resistance and displacements lists in Table 7, Increase in RCSWs compressive strength make the concrete modulus of elasticity more so that the stiffness EI of wall increase. Based on analysis results, the maximum increase in shear base resistance and moment overturning in case of RCSW compressive strength is 35 MPa.

Table 7. Effects of RCSWs compressive strength on the resistance shear and top displacement (based on 25 MPa)

Model mark	W1	W2	W3
% increase in base shear	---	---	---
Model mark	W4	W5	W6
% increase in base shear	---	0.62	28.12
Model mark	W7	W8	W9
% increase in base shear	15.13	7.43	10.86
Model mark	W10	W11	W12
% increase in base shear	45.25	37.63	22.61

7.3. Effects of Reinforcement Ratios

The effects of RCSWs reinforcement ratios on the base shear resistance and displacements lists in Table 8, Increase in RCSWs reinforcement ratio of vertical and horizontal reinforcements increase in RCSWs ductility so that the wall become more resistance to lateral load due to the confinements of reinforcements to the wall. The numerical results showed that the maximum increase in base shear in case of RCSW reinforcement distributed at 150 mm c/c.

Table 8. Effects of RCSWs reinforcement ratios on the resistance shear (compare with models W1 to W12 as 150 mm c/c)

Model mark	W1	W2	W3
% increase in base shear	---	---	---
Model mark	W4	W5	W6
% increase in base shear	---	---	---
Model mark	W7	W8	W9
% increase in base shear	---	---	---
Model mark	W10	W11	W12
% increase in base shear	---	---	---
Model mark	W13	W14	W15
% increase in base shear	18.74	5.45	3.20
Model mark	W16	W17	W18
% increase in base shear	1.81	8.80	8.08
Model mark	W19	W20	W21
% increase in base shear	9.47	8.54	2.57
Model mark	W22	W23	W24
% increase in base shear	6.00	9.36	6.34

7.4 Maximum Displacement Comparisons

Figure 10 to 12 shows the effects of RCSWs width, compressive strength and reinforcement ratio on the displacement based on the level floor. The maximum displacement occurs at the top of the RCSWs. Increase in RCSWs width, compressive strength and reinforcement ratio lead to decrease the displacements due to increase in wall stiffness and confinement that resists the more shear that develop due to seismic loading.

There are improvements in RCSWs energy dissipations due to increase in RCSWs width due to increase in moment of inertia that make the whole stiffness become higher so that the displacement reduced and increase in base shear that developed due to the applied seismic load. The enhancement in energy dissipation of models W2, W3 and W4 compared with model W1 is 33.27, 54.55 and 66.00% (reduce) respectively RCSWs energy dissipation improved also when the compressive strength of concrete greater that cause growth in concrete modulus of elasticity. So that the stiffness of the RCSWs become more.

The enhancement in energy dissipation of models W5, W6, W7 and W8 compared with model W1, W2, W3 and W4 is 1.82, 4.63, 8.00 and 19.79% (reduce), respectively. In addition, the increased in reinforcement ratio make the RCSWs more ductile and reduce the energy dissipation. The enhancement in energy dissipation of models W1, W2, W3 and W4 compared with model W13, W14, W15 and W16 is 6.30, 6.85, 14.38 and 22.08% (reduce), respectively.

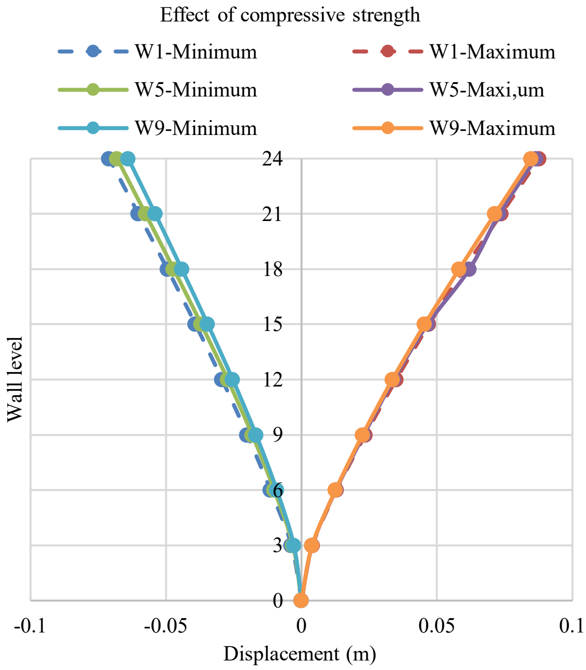

Figure 10. Effect of RCSWs width on the displacements along height

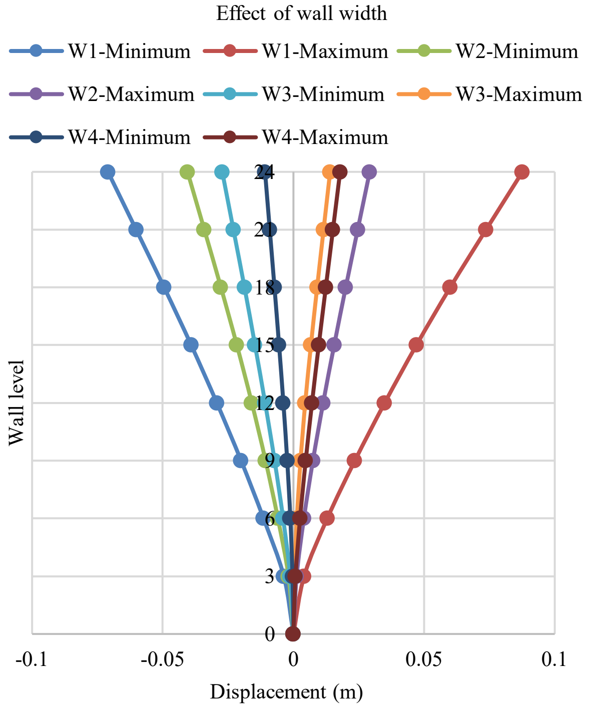

Figure 11. Effect of RCSWs compressive strength on the displacements along height

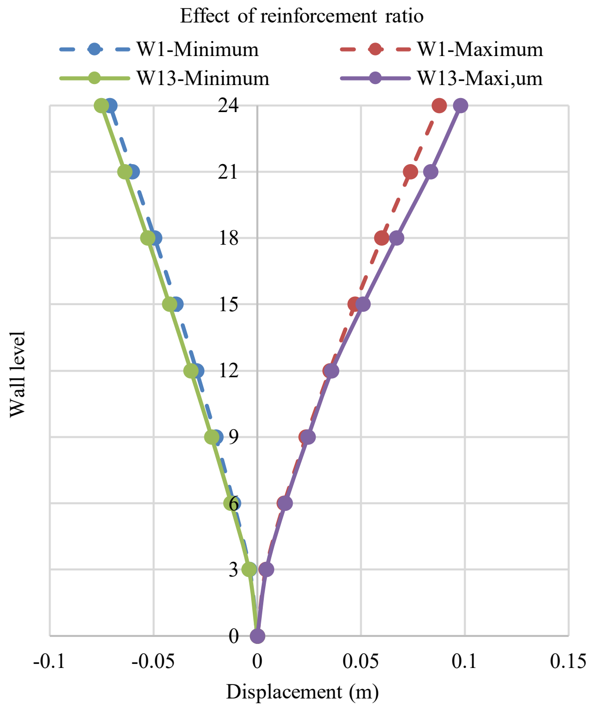

Figure 12. Effect of RCSWs reinforcement on the displacements along height

8. CONCLUSIONS

On the based analysis result the important conclusions can be written as follows:

1. Lateral force bearing capacity of RCSWs with high compressive strength and reinforcement ratio become more. Increase in compressive strength lead to increase in modulus of elasticity so that increase in stiffness of RCSW. Increase in rebar's ratio make the RCSW more ductile.
2. Energy dissipation enhanced and affected by increase compressive strength of concrete and rebar's.
3. Wall aspect ratio is significant impact on the strength of RCSW.
4. Increase in concrete compressive strength of RCSWs gave the higher in-plane shear load.
5. At the pinnacle of the strengthened concrete structure, lies the maximum displacement. Assessing damage levels entails considering the shear wall, which serves as a vital indicator.
6. Shear strength, hysteresis behavior, and energy dissipation are all factors of the RCSWs. By augmenting the compressive strength of concrete, the capacity can be enhanced. Ratio of rebar's.

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