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SEISMIC RESILIENCE PERFORMANCE OF CORRUGATED STEEL SLIT SHEAR WALLS

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Abstract *-The aim of the study is to understand the factors that contribute to the hysteresis behavior of corrugated steel slit shear walls. The study designed several models to investigate the effect of design parameters, including effective corrugation angles, slit number, angle of corrugation, and steel property. The design procedure focused on ensuring that the shear walls exhibit plastic deformations before yielding to increase energy dissipation. The study found that the placement angle, height, number of slits, and spacing of the corrugation significantly influence the seismic performance of the steel corrugated plate shear walls. The analysis revealed that the seismic performance of the shear wall was best when the corrugation was placed at an angle of 90◦. Additionally, the study investigated the effectiveness of splitted slits and found that a combination of full slit and splitted slit improved the performance of the best model. Finally, the study compared the hysteresis behaviors of models with and without slits to understand the impact of slits on the behavior of the shear wall. Overall, the study provides insights into the design parameters that can improve the seismic performance of corrugated steel slit shear walls and highlights the importance of considering hysteresis behavior in the design process.*

Key Words**: corrugated steel plate shear walls, slits, ANSYS, hysteresis behaviour, FEMA**

1. INTRODUCTION

Steel Plate Shear Wall (SPSW) systems have become increasingly important in recent years as a lateral force-resisting system in buildings. They are used in many different countries and building types due to their ability to withstand earthquakes and other lateral forces. Energy dissipation technologies have been developed to mitigate damage in structures during seismic events. These technologies use materials such as steel plates, steel bars, and steel strips to dissipate energy at specific locations in the structure. The steel slit shear wall (SSSW) is a type of metallic damper that has been investigated due to its higher energy dissipation, better ductility, and ease of installation and repair.A steel plate shear wall is composed of a steel infill plate, surrounding boundary beams, and boundary columns. Additional horizontal or vertical stiffeners may be required for stiffened steel shear walls. Corrugated Steel slit Shear Walls (CSPSWs) have become more popular as an efficient lateral force-resisting device due to their improved hysteresis behavior, buckling stability, and higher out-of-plane stiffness compared to flat plates. Shear walls made of Steel Corrugated Plate (SCP) are commonly used in real-world engineering and have high elastic starting stiffness, stable hysteresis properties, and good seismic performance. The angle, height, and spacing of corrugations have a significant impact on the seismic performance of shear walls. Overall, Steel Plate Shear Wall systems and their variants are important components of seismic-resistant building design and construction.

2. LOADING PROTOCOL

Table -1: Cyclic Loading Values

Drift Radian	Drift Percentage(%)	Drift displacement(mm)
0.00375	0.3750	16.88
0.005	0.5000	22.5
0.0075	0.7500	33.75
0.01	1.0000	45
0.015	1.5000	67.5
0.02	2.0000	90
0.03	3.0000	135

0.04	4.0000	180
0.05	5.0000	225
0.06	6.0000	270
0.07	7.0000	315
0.08	8.0000	360
0.09	9.0000	405
0.1	10.000	450
0.11	11.000	495
0.12	12.000	540
0.13	13.000	585
0.14	14.0000	630
0.15	15.000	675
0.16	16.000	720
0.17	17.000	765
0.18	18.000	810
0.19	19.000	855
0.2	20.000	900

Cyclic loading procedure were adopted as displacement controlled incremental cycle loading scheme . Then drift ratios are 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5%, 5.0%, and 6.0% are imposed to the specimens in sequence.displacement provided in the table is applied in cyclic loading as per FEMA.

3. ANALYZED SPECIMEN

According to the different angles between the corrugation of steel shear wall under the conditions of 30◦ , 60◦ , and 90◦ were designed.0◦ were not analyses because the horizontal corrugation is not appropriate for the slits.The steel column of the steel frame of the corrugated steel slit shear wall adopted a rectangular box section.The section size of the rectangular steel column was 500 × 400 × 20 mm, and its height was 4.5 m. The H-shaped steel beam had a section size of 500 × 300 × 20 × 15 mm, and its span was 6 m.

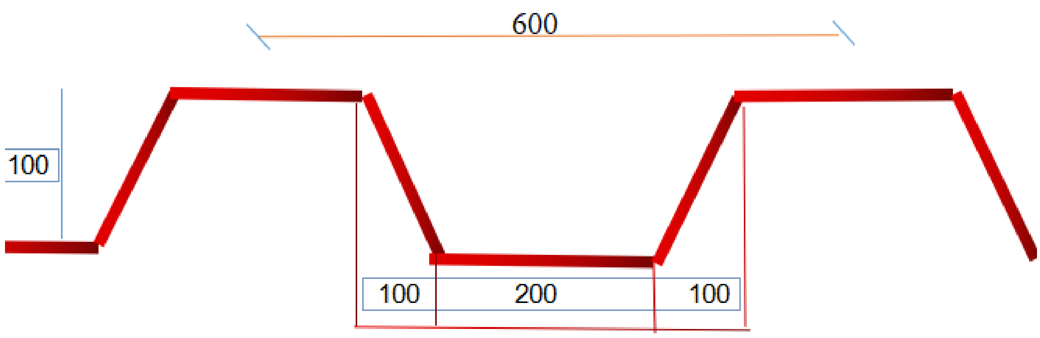

Fig -1: Dimension of Trapezoidal Corrugation

The thickness of the corrugated steel shear walls was 15 mm. The yield strength of the frame column, frame beam, and shear wall was 380 MPa. Perpendicular impact load was applied at the laterally at top of column of frame and 2 supports are provided at top and bottom,CSSSWs have plastic deformations (i.e. energy consumption) before the structure gets into yielding.

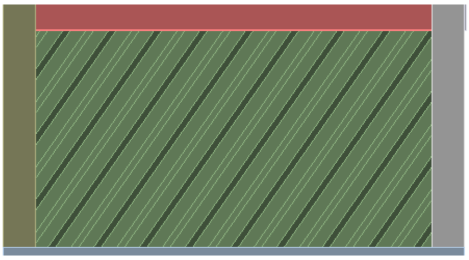

Fig -2:60º Corrugation Angle

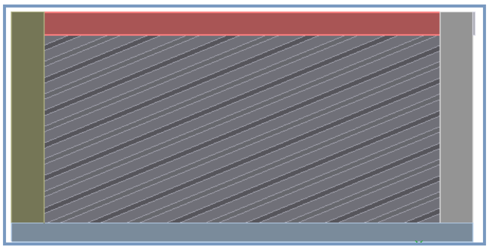

Fig -3:30º Corrugation Angle

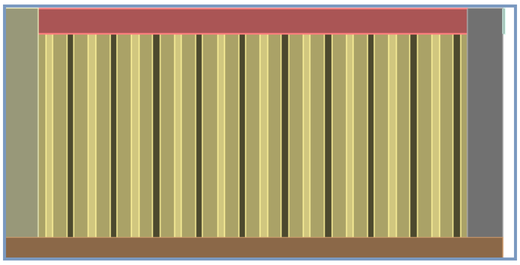

Fig -4:90º Corrugation Angle

The above figure shows three angle of corrugation of steel slit shear walls (30º,60º,90º).0º is not analyzed because it is not appropriate for slit due to the horizontal corrugation, Here analysis proves that 90º is more effective. So the model designed with 90º corrugation angle.

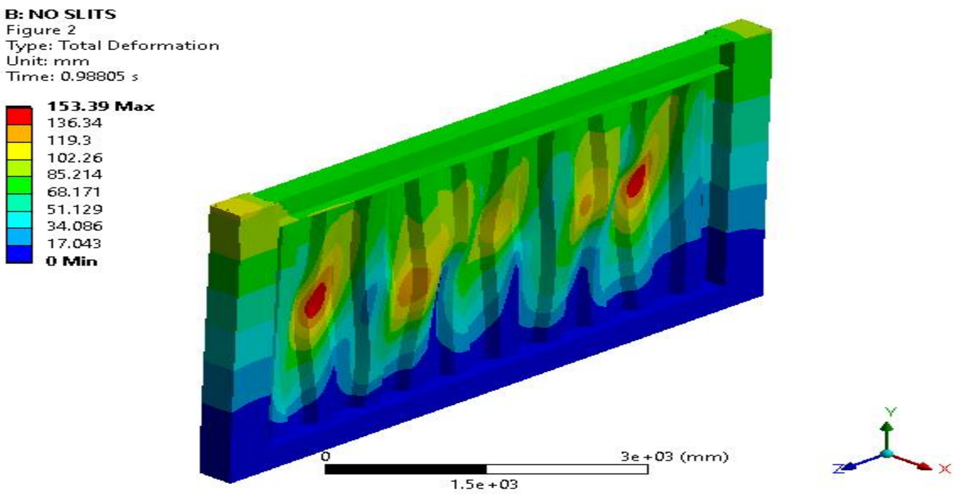

Fig -5:Total Deformation Diagram of Wall without Slit

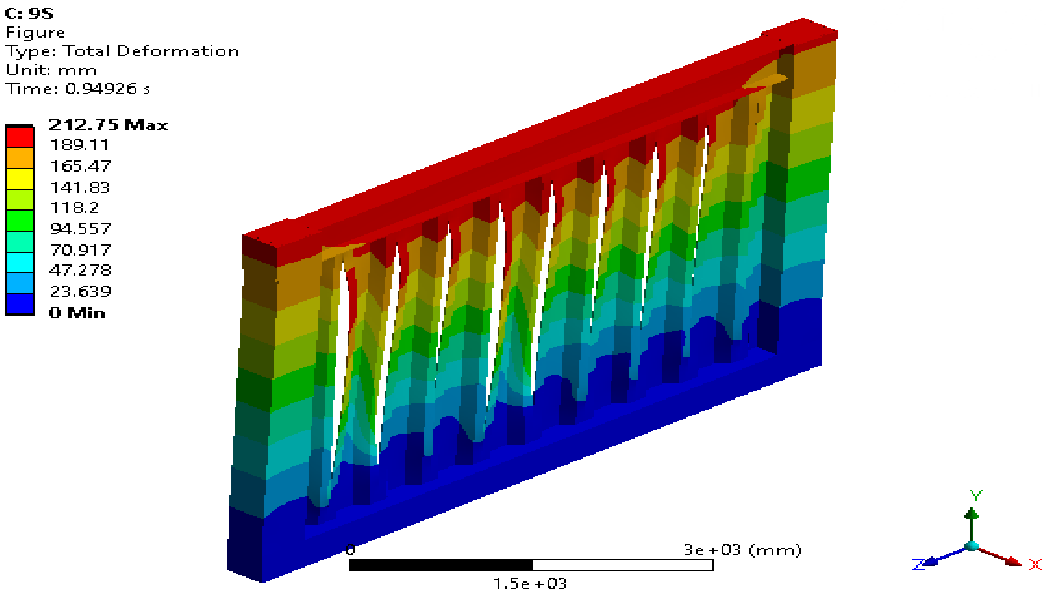

Fig -6: Total Deformation Diagram of Wall with 9 Number of Slits

The above figures shows the total deformation diagrams of wall without slit and wall with nine numbers of slits.The model without slit have the maximum deformation at the center part of wall and the model with nine numbers of slit have maximum deformation at the top end of slit of beam then it reduces up to bottom.in this objective part 10 models are analyzed (model with 1-9 numbers of slit and model without slit).And also different models of 3 to 7 numbers slit models were analyzed.

Table -2: Comparison of Values

Model	Load(kN)	Deformation (mm)	%Decrease in load	Yield displacement	Drift%	Ductility
1Slit	11479	109.26	22.59608901	14.401	2.43	7.59
2Slit	9872.8	156.59	33.42683749	14.502	3.48	10.80
3Slit	9547.2	143.19	35.62238705	14.528	3.18	9.86
4Slit	6792.9	159.01	54.19487525	14.531	3.53	10.94
5Slit	7694	148.57	48.11867835	14.618	3.30	10.16
6Slit	6122.5	152.36	58.71544167	20.826	3.39	7.32
7Slit	5761.7	183.6	61.14834794	14.612	4.08	12.57
8Slit	5014.1	191.6	66.18948076	19.405	4.26	9.87
9Slit	4669.5	159.64	68.51314902	17.927	3.55	8.91
Without Slit	14830	46.924	1	20.98	1.04	2.24

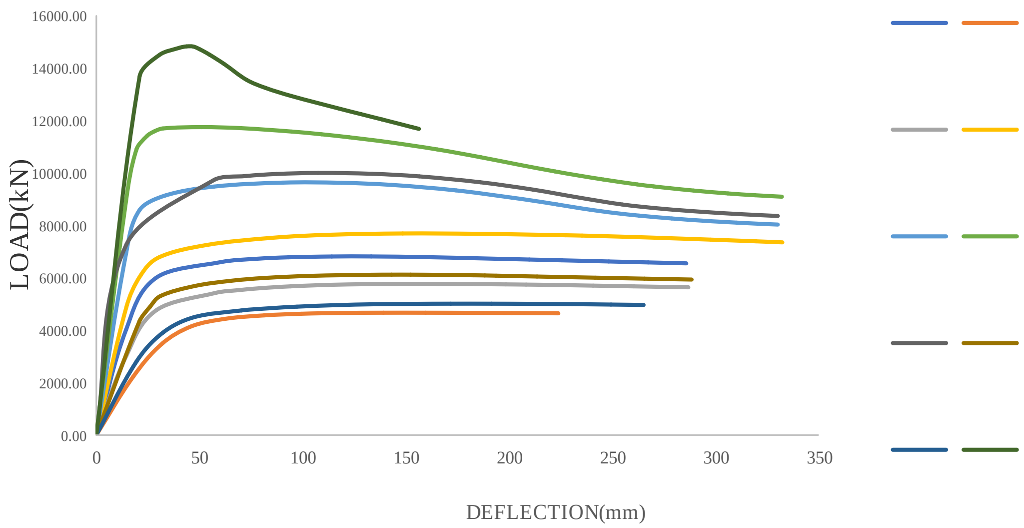

Chart -1: Load vs Deflection Graph

The load-deflection curves can be used to design and optimize structures such as beam columns and bridges. Engineers can use the curve to determine maximum load a structure can withstand before it fails, and adjust the design accordingly. The graph given above shows the load vs displacement graph .after that different models of same number of slits are analyzed. The ductility bar charts of all models are given below.

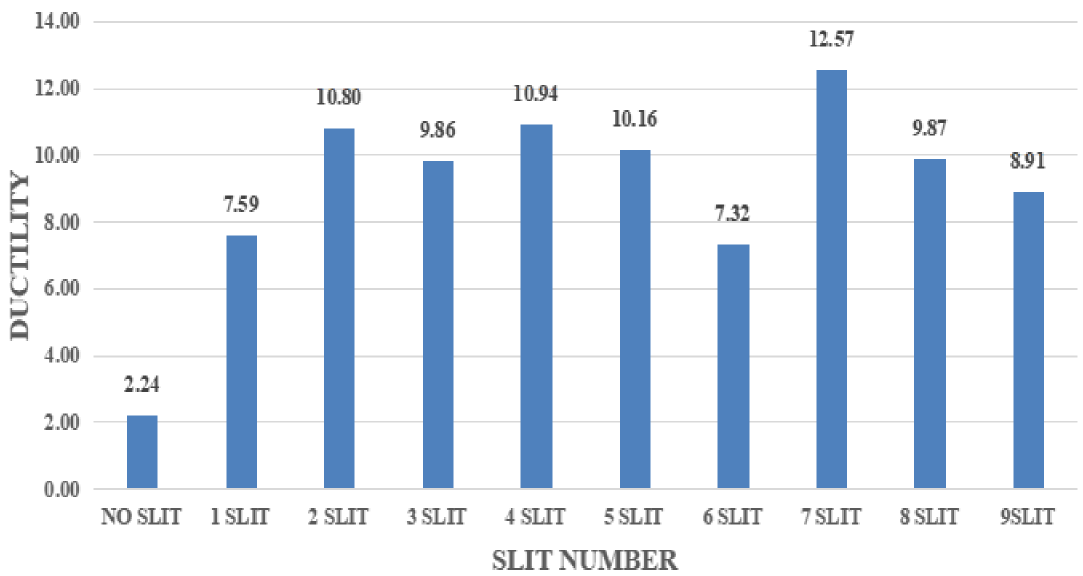

Chart -2:Ductility Bar Chart

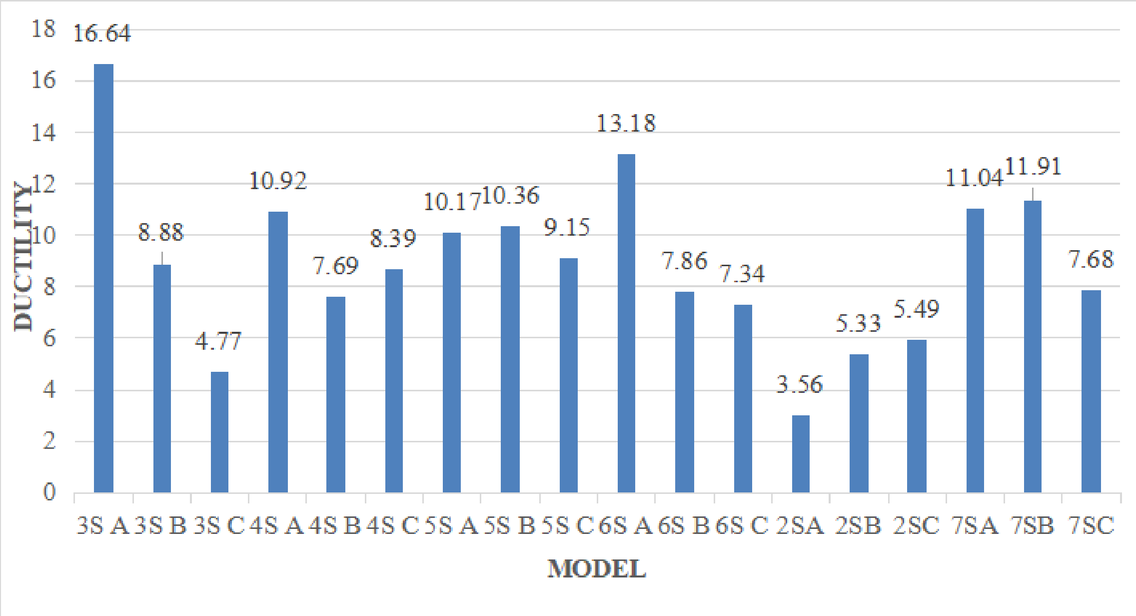

Chart -3 Ductility Bar Chart

Find out the effective model from above models and changed it into three different models. All slits are splitted and Combination of full slit and splitted slit(full slit and both ends and splitted slit at both ends).a full slit is splitted into nine numbers of slits.

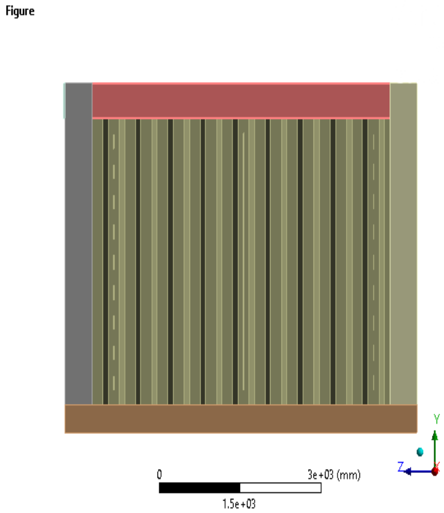

Fig -7: Splitted Slit both Ends

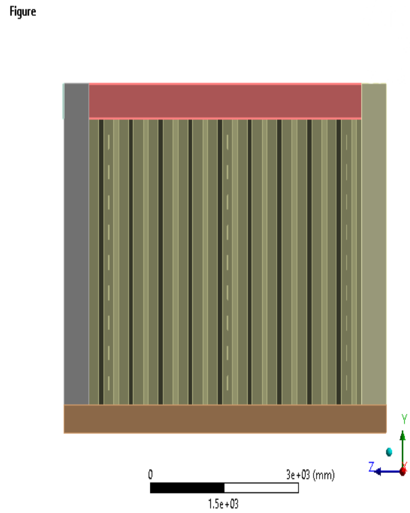

Fig -8: Full Splitted Slit

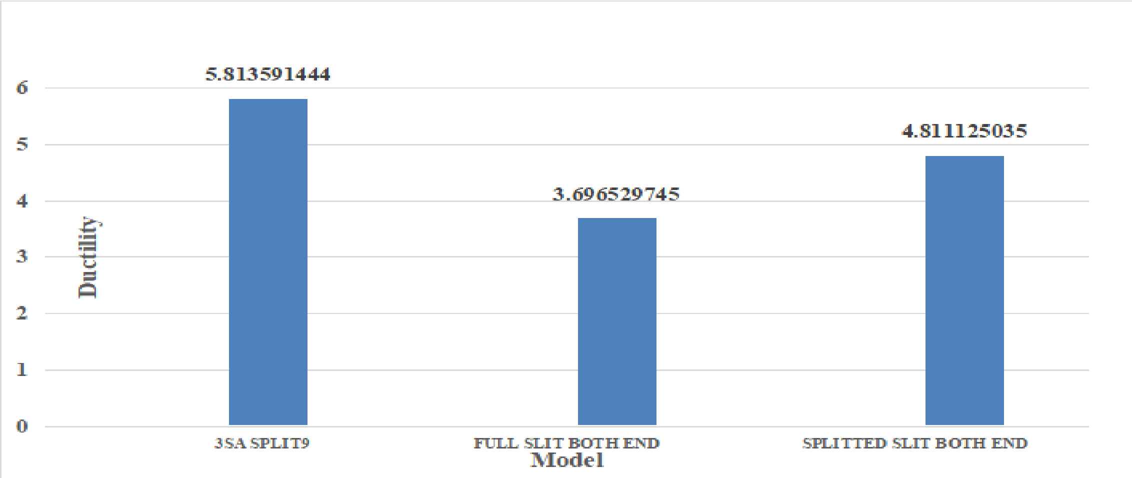

Chart -4: Ductility Bar Chart

Carry cyclic analysis of wall to find energy absorption capacity capacity of corrugated steel slit shear wall .Here three models are selected for comparison .The first one is Wall with out slit. It is selected because the energy absorption capacity of wall without slit is need to know the variation in the values. Then more effective model with slit and model with splitted slit is selected to find energy absorption capacity.

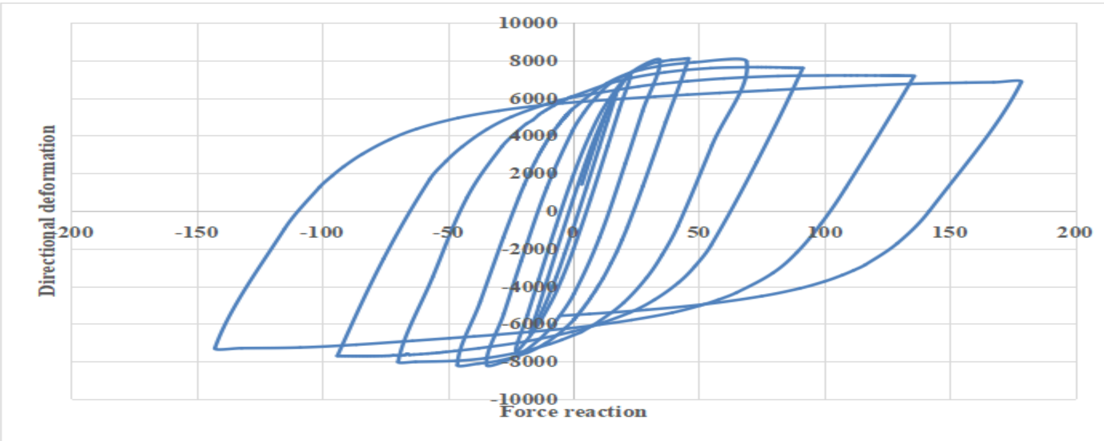

Chart -5 Hysteresis Curve of Wall with 3 Numbers of Slit

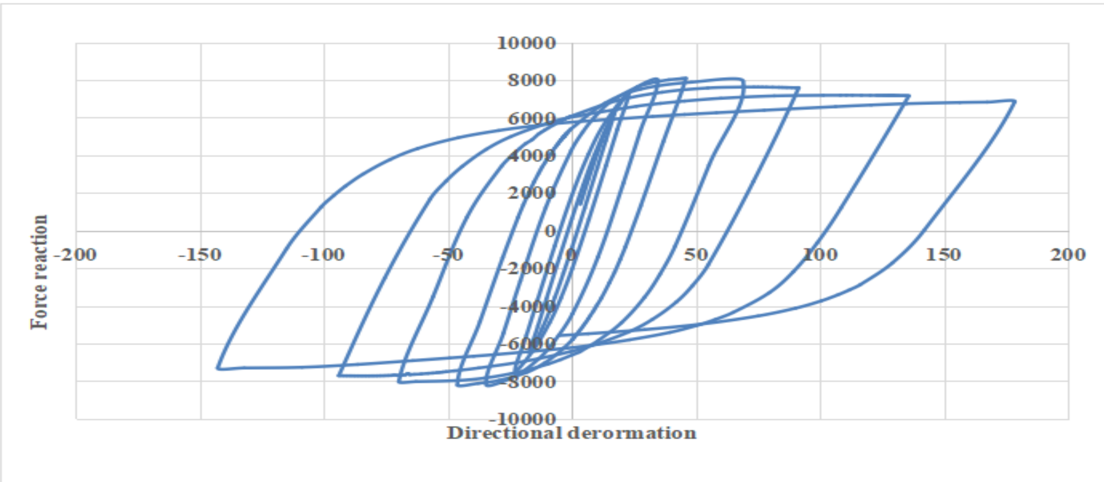

Chart -6 Hysteresis Loop of Wall without Slit

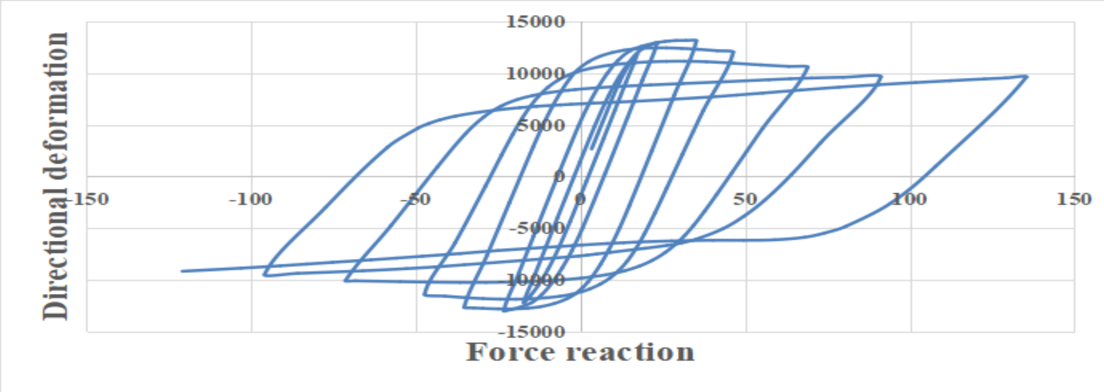

Chart -7 Hysteresis Loop of Model 3SA Splits into 9

Table -3: Energy Absorption Capacity

Model	Energy Absorption Capacity (kJ)
3SA	8181.006926
3SA 9	11638.54321
No slit	3662.593545

The energy absorption capacity is the energy consumption capacity of members under repeated loads.it can reflect non linear mechanical performance of the members or structures. Therefore, energy absorption capacity can be an important index to measure the seismic performance of members. Therefore, under a certain strength guarantee ,if the component has good energy absorption capacity ,it can absorb a large part of seismic energy in the earthquake. Here energy absorption capacity is obtained from the area of loop by using origin software.

4. CONCLUSIONS

1. From the analysis of different models of corrugated steel slit shear walls, it is observed that number of slits is not only a main factor that determine the ductility, ductility as well as energy absorption capacity varies with space between slits and length of slit

2. Corrugation inclination angles of 30◦, 60◦, and 90◦ indicates that the seismic performance of the shear wall is the best when the corrugation inclination angle is 90◦.

3. Model without slit have less energy absorption capacity as well as ductility

4. From the analysis 3sa model (3 slit model with max space) have maximum ductility and 3sa split 9 have maximum energy absorption capacity

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