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Cyclic Behaviour of Double Skin Composite Steel Plate Shear Wall Using Shape Memory Alloy with Various Aspect Ratios

Ms. Aisha V. Fathima[1], Ms. Chaithra S[2]
[1, 2]*Department of Civil Engineering, SNIT Adoor*

Abstract: Shear wall is commonly used in high rise buildings to resist lateral forces. Reinforced concrete shear wall and steel shear wall are the commonly used. Now a days composite shear wall is most popular. Double skin composite shear wall consisting of two steel plates, concrete core, CFST column as boundary members, steel truss connectors, double wave form steel bars connected to steel truss. In this paper steel plate is replaced by shape memory alloy plate and determine the maximum load and total deformation. Cyclic behaviour of double skin composite steel plate shear wall using shape memory alloy with various aspect ratios can be studied using the software ANSYS 2021 R2. SMA plate shear wall provides better performance than in steel plate shear wall.
Keywords: Composite shear wall, Steel truss, Double wave form steel bars, Aspect ratios, Cyclic behaviour.

I. INTRODUCTION

In high-rise buildings, the axial and horizontal forces imposed by wind and earthquakes are commonly resisted by using traditional reinforced concrete shear walls. An increase in the height of a building results in an increase in the axial and lateral forces of the shear walls in that building [6]. Reinforced concrete shear wall is the primary lateral load resisting member in high-rise buildings. The steel-reinforced concrete composite wall, concrete-filled steel tube composite wall, steel plate shear wall, and double skin composite wall have been proposed to improve the performance of the shear wall [3]. Double skin composite steel plate shear wall consisting of dual steel plates, concrete core, two concrete filled steel tubular column as boundary members and double wave form steel bars connected to steel angles. Steel truss can provide strong out-of-plane resistance of the steel plate. Steel plates can be replaced by using shape memory alloy plates. The SMA has received considerable attention for seismic applications due to its self-centering capability, resulting in lower repair costs combined with rapid recovery of normal serviceability after severe earthquakes [1]. Cyclic behaviour of the steel plate composite shear wall and shape memory alloy (SMA) plate composite shear wall with various aspect ratios can be analysed by using the software ANSYS 2021 R2. The models are used to determine the maximum load and deformation of the steel plate composite shear wall and shape memory alloy plate composite shear wall.

II. SHAPE MEMORY ALLOY

SMA are materials capable of undergoing large recoverable strains of about 10% without exhibiting plasticity. SMA have high damping capacity, good control of forces, recentering capability, high fatigue resistance, and the recovery of strains are among the characteristics that have made SMAs an effective material for seismic applications. SMAs were discovered in the 1932 and it was after 1962 that both in-depth research and practical applications of SMAs emerged. The shape memory effect and super elastic effect are known as two unique properties of SMAs. The former property is the capacity to regain the original shape by heating and the latter is related to the ability of recovering large deformations after removal of the external load [10]. SMA has different mechanical characteristics than conventional steel. Nickel Titanium SMA can eliminate about 8% of residual strain during unloading.

III. FINITE ELEMENT MODELLING

Modelling consists of 12 models. Figure 1 to 6 represents steel plate composite shear walls and figure 7 to 12 represents shape memory alloy plate composite shear walls. Modelling was done using the software CATIA V5 convert this model in to step file. The model with different aspect ratios were studied. Steel plate composite shear wall and shape memory alloy plate shear wall having different aspect ratios were taken. Aspect ratios are 2, 1.75, 1.5, 1.25, 1, 0.75. Width of the specimen is 1500mm, total wallthickness is 150mm, thickness of the steel plate is 4mm, size of the steel truss is 40X40X4mm and diameter of the wave form steel bar is 8mm.

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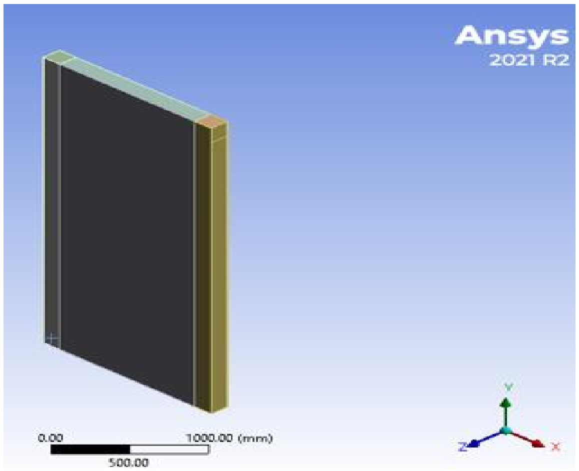

Fig. 1 SPSW1 with AR 2

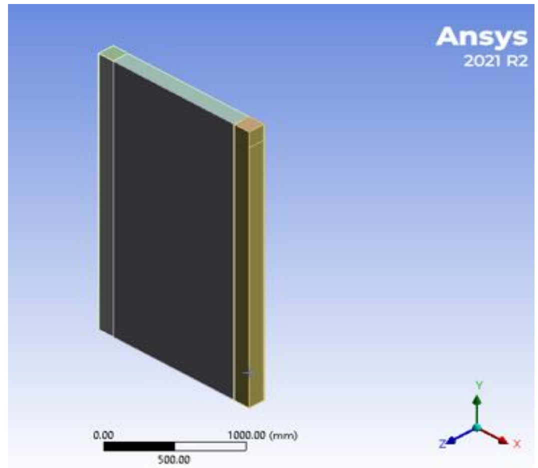

Fig. 2 SPSW2 with AR 1.75

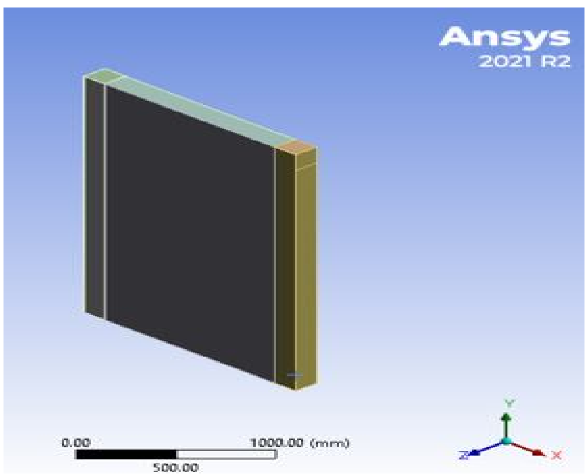

Fig. 3 SPSW3 with AR 1.5

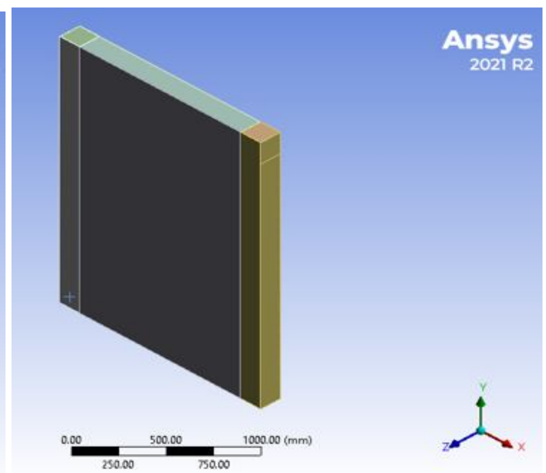

Fig. 4 SPSW4 with AR 1.25

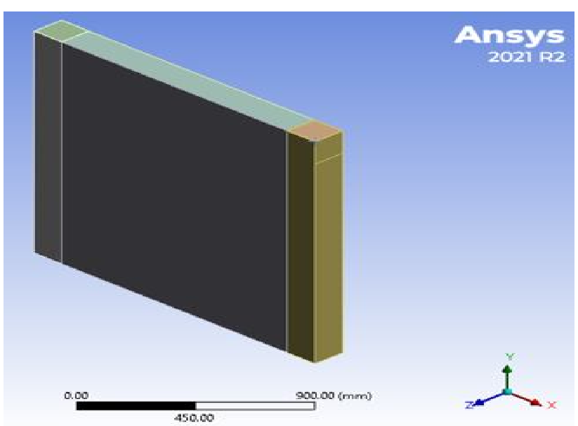

Fig. 5 SPSW5 with AR 1

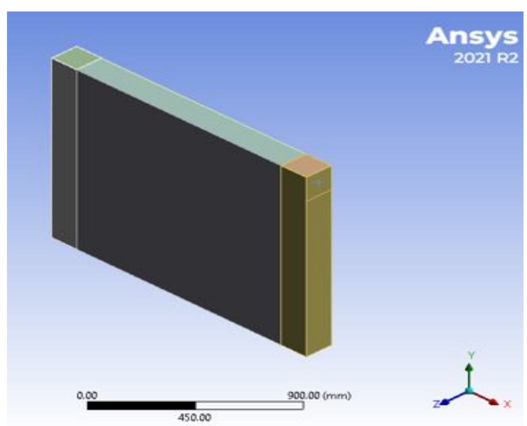

Fig. 6 SPSW1 with AR 0.75

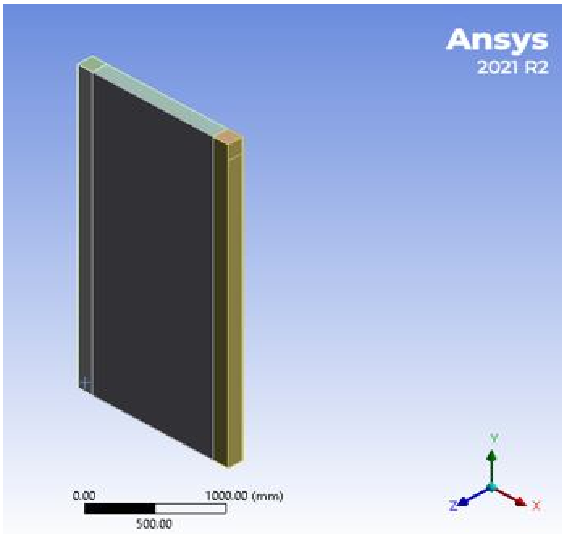

Fig. 7 SMAPSW7 with AR 2

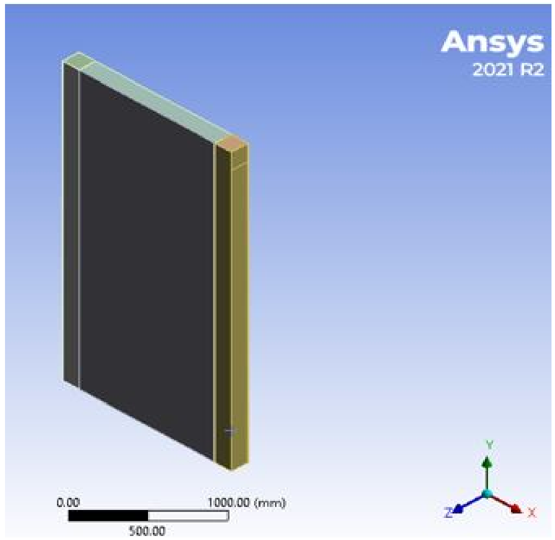

Fig. 8 SMAPSW8 with AR 1.75

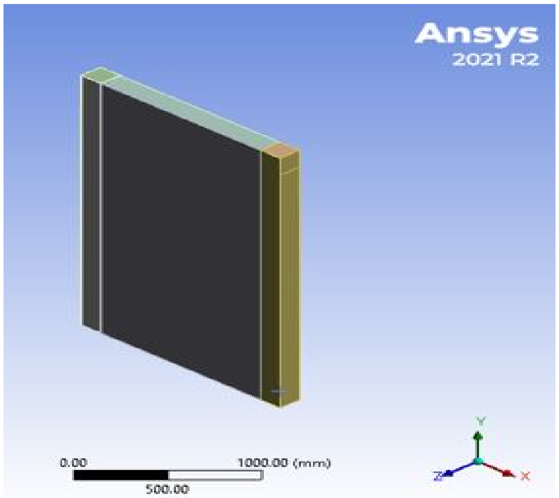

Fig. 9 SMAPSW9 with AR 1.5

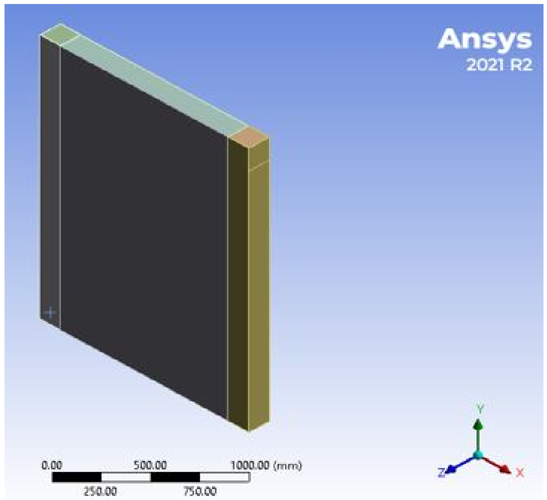

Fig. 10 SMAPSW10 with AR 1.25

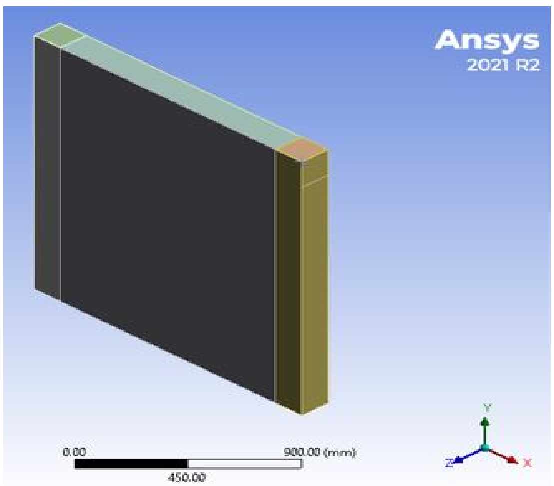

Fig. 11 SMAPSW11 with AR 1

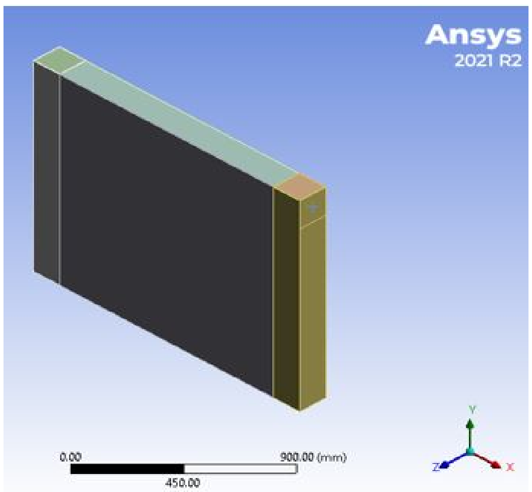

Fig. 12 SMAPSW12 with AR 0.75

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IV. FINITE ELEMENT ANALYSIS

ANSYS 2021 R2 was used for the finite element analysis. Steel, shape memory alloy, concrete is modelled by 3D and vertical bars, zig zag element is modelled by 1D. Solid 185 was used for infilled concrete.

A. Material Properties

Material properties are assigning to the corresponding geometry.

TABLE 1
MATERIAL PROPERTIES

Properties	Steel	Concrete	SMA
Young's modulus	$1.95X10^5$ MPa	21967 MPa	90000 MPa
Poisson's ratio	0.3	0.2	0.3
Density	7850 kg/m^3	2300 kg/m^3	6450 m^3

B. Boundary Conditions

In this analysis bottom of the shear wall is fixed and top end of the shear wall is free. Remote force is applied at the top of the shear wall. Figure 12 represent boundary conditions of the composite shear wall.

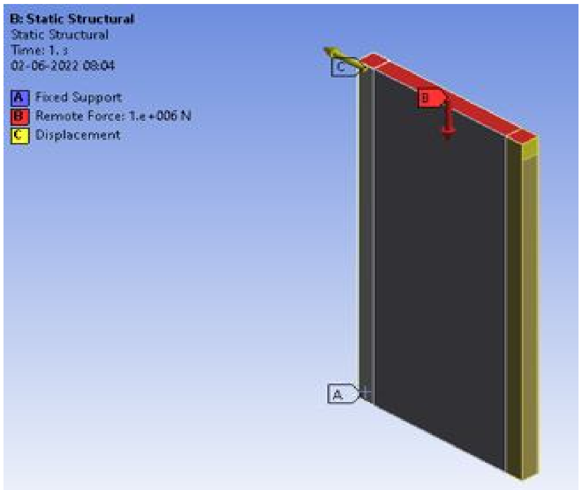

Fig. 13 Boundary conditions

Figure 13 to 24 presents the analysis models of steel plate composite shear walls and shape memory alloy plate composite shear walls with various aspect ratios.

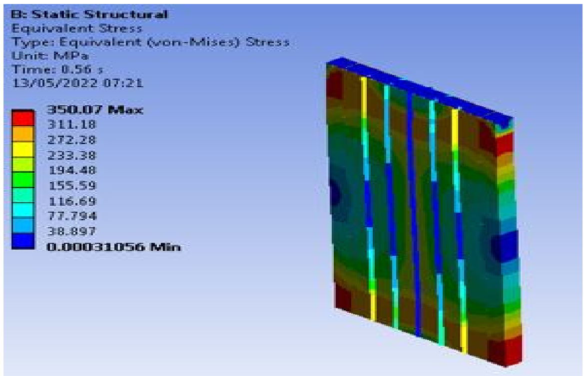

Fig. 14 SPSW1 with AR 2

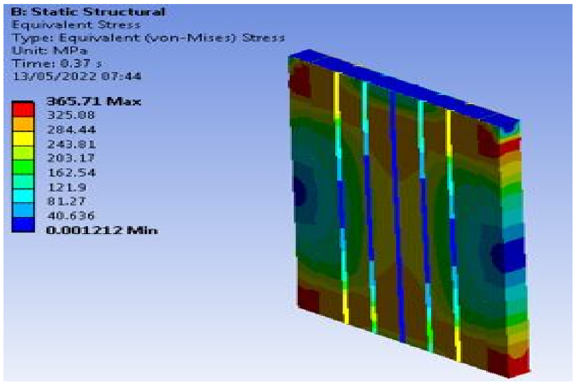

Fig. 15 SPSW2 with AR 1.75

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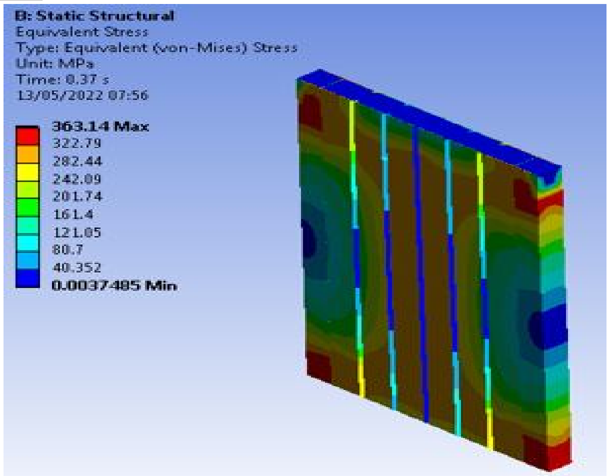

Fig. 16 SPSW3 with AR 1.5

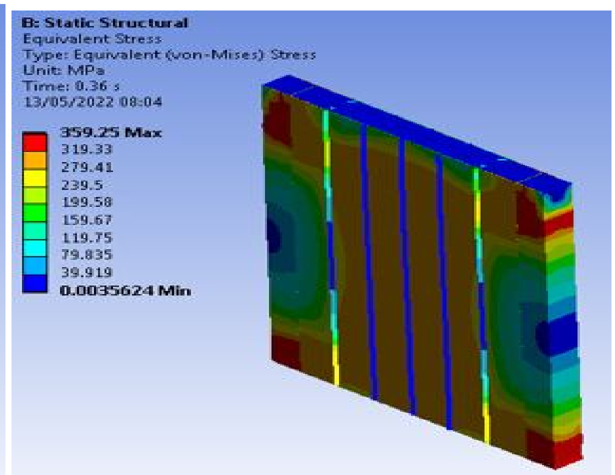

Fig. 17 SPSW4 with AR 1.25

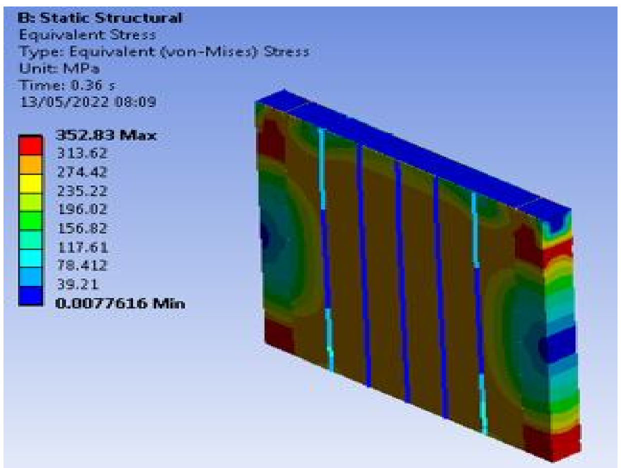

Fig. 18 SPSW5 with AR 1

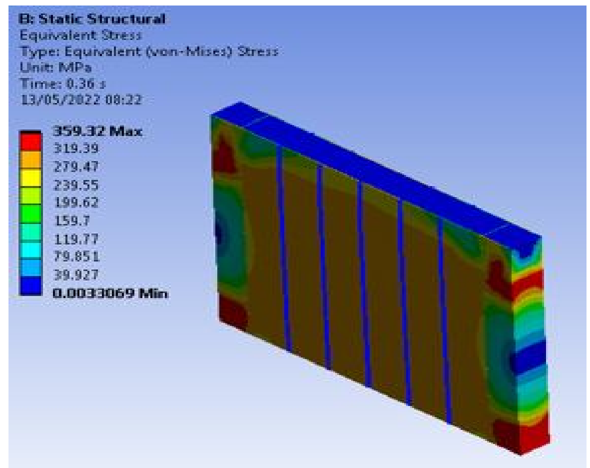

Fig. 19 SPSW6 with AR 0.75

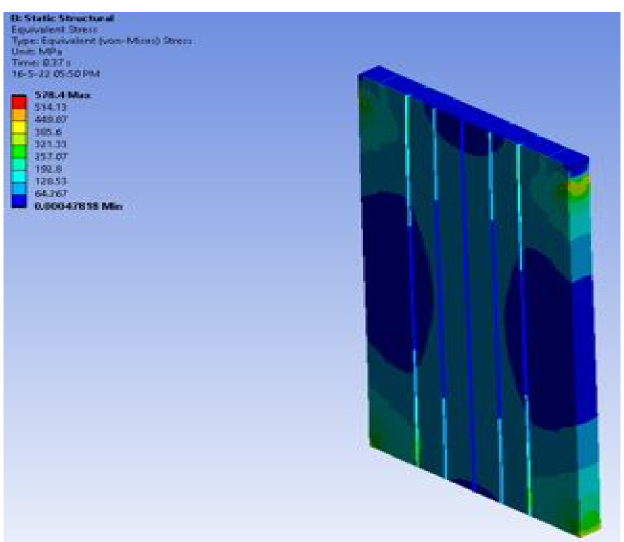

Fig. 20 SMAPSW7 with AR 2

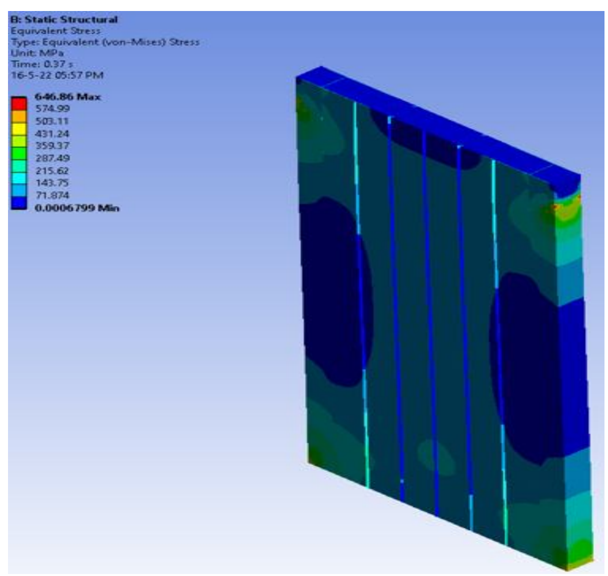

Fig. 21 SMAPSW8 with AR 1.75

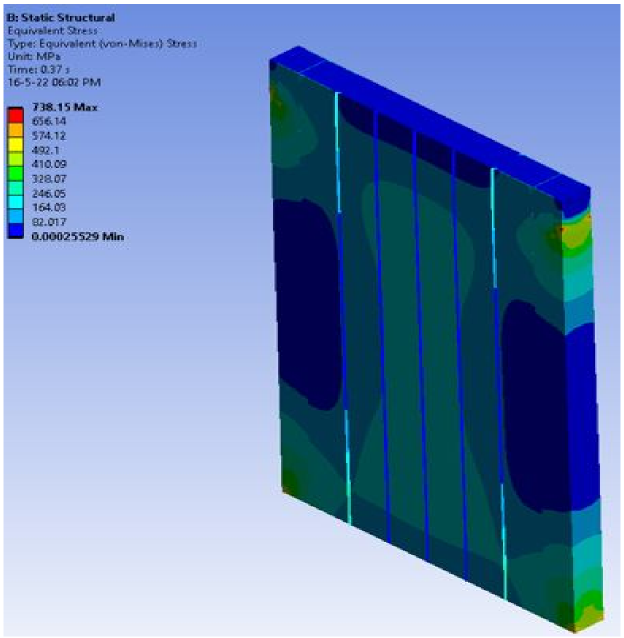

Fig. 22 SMAPSW9 with AR 1.5

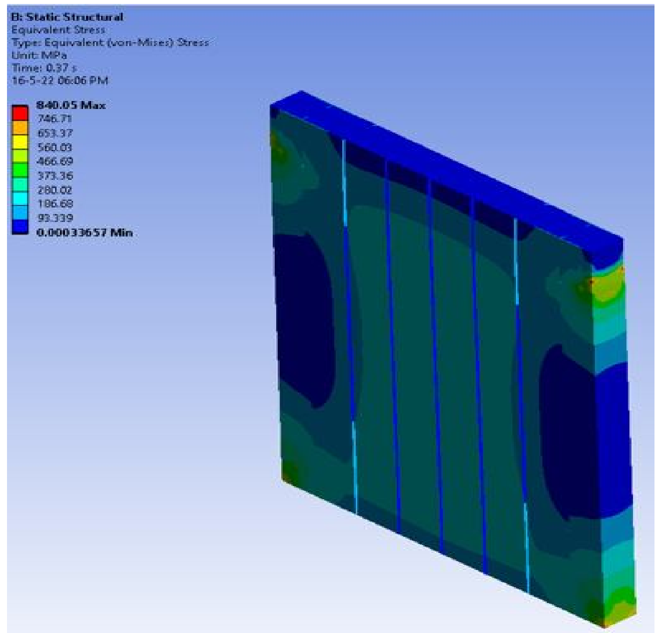

Fig. 23 SMAPSW10 with AR 1.25

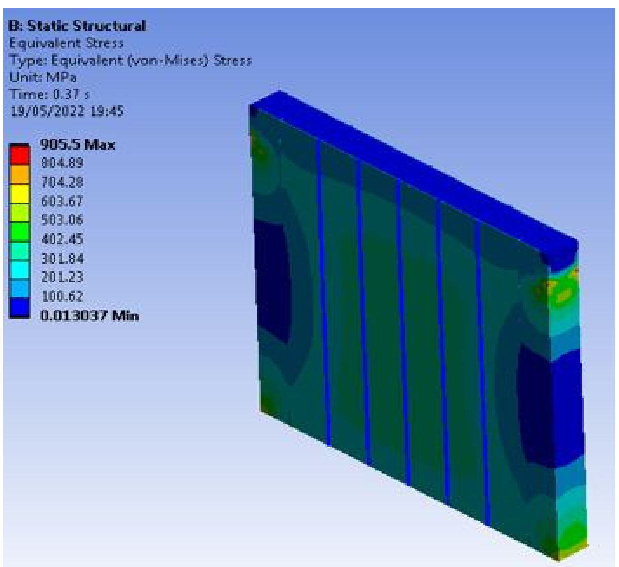

Fig. 24 SMAPSW11 with AR 1

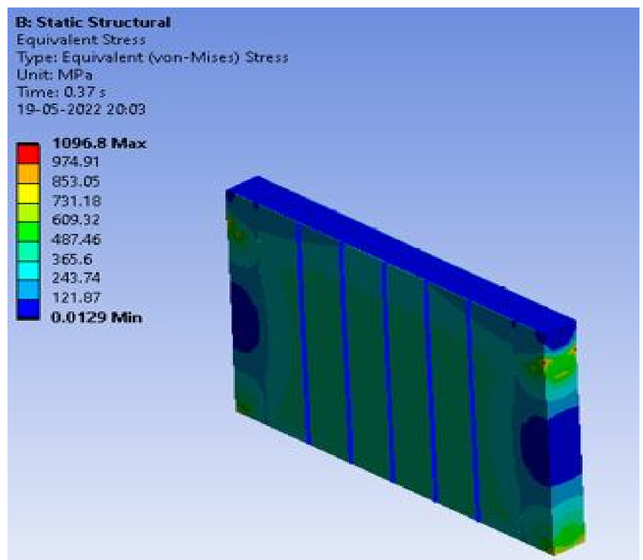

Fig. 25 SMAPSW12 with AR 0.75

C. *Analysis Results*

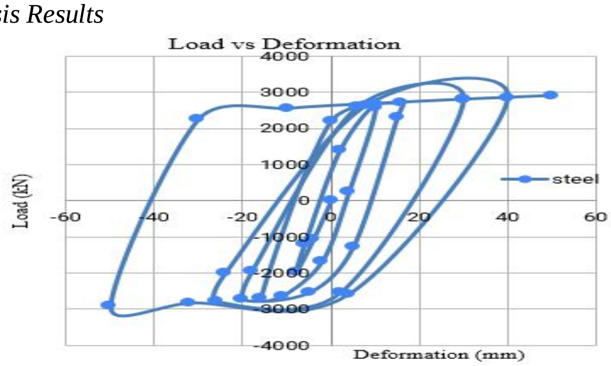

Fig. 26 SPSW1 with AR 2

Fig. 27 SPSW2 with AR 1.75

Fig. 28 SPSW3 with AR 1.5

Fig. 29 SPSW4 with AR 1.25

Fig. 30 SPSW5 with AR 1

Fig. 31 SPSW6 with AR 0.75

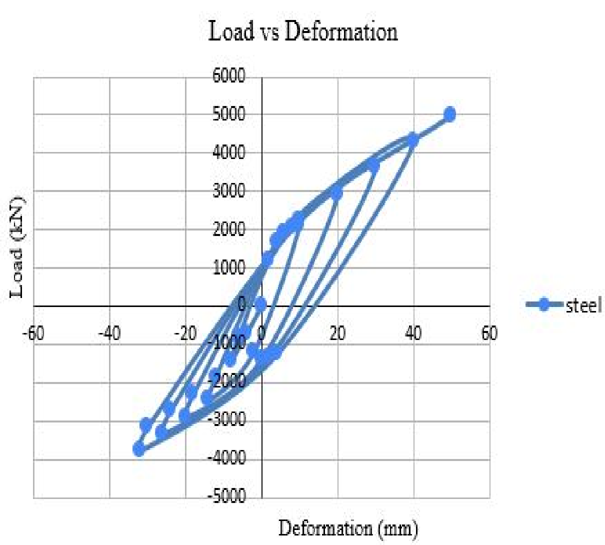

Fig. 32 SMAPSW7 with AR 2

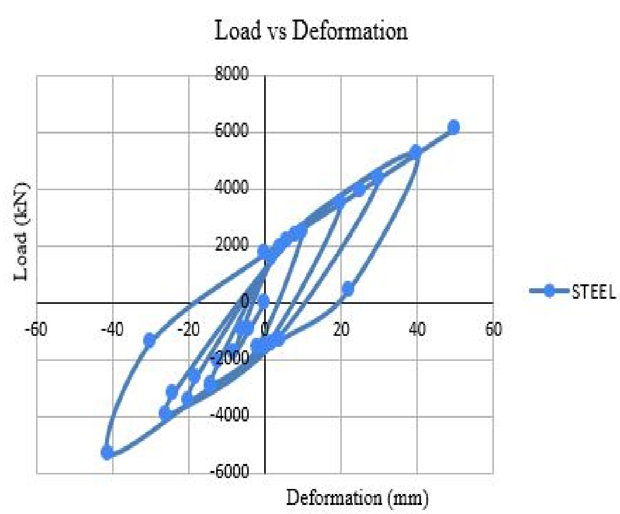

Fig. 33 SMAPSW8 with AR 1.75

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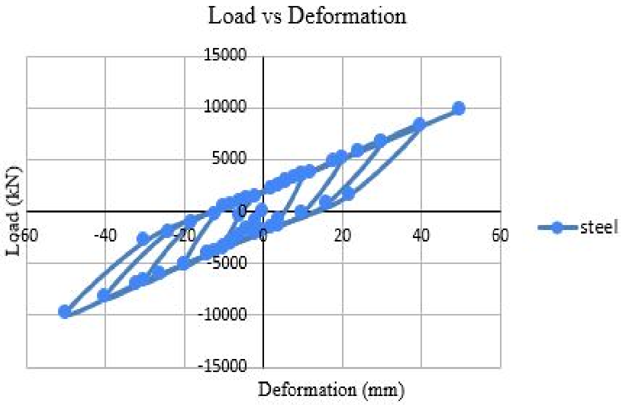

Fig. 34 SMAPSW9 with AR 1.5

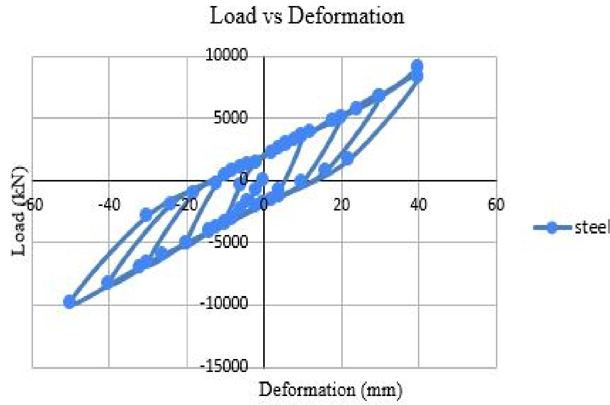

Fig. 35 SMAPSW10 with AR 1.25

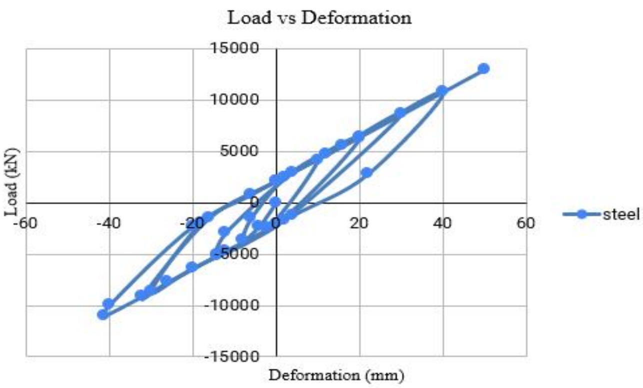

Fig. 36 SMAPSW11 with AR 1

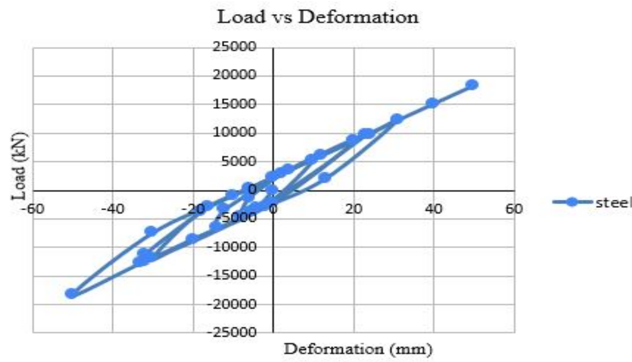

Fig. 37 SMAPSW12 with AR 0.75

V. CONCLUSIONS

In this analysis aspect ratios decreases structure takes more load in both steel plate composite shear wall and shape memory alloy (SMA) plates composite shear wall. Shape memory alloy plate shear wall takes more load than in steel plate shear wall having similar deformation. As aspect ratio 1.25 is better in both steel plate shear wall and shape memory alloy plate shear wall. Comparing composite shear wall with steel plate and shape memory alloy plate shape memory alloy improves the performance in composite shear wall.

VI. ACKNOWLEDGMENT

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