NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY
[IJIERT] ISSN: 2394-3696 Website: ijiert.org
VOLUME 8, ISSUE 12, Dec. -2021

INVESTIGATION OF STEEL SLIT PANEL EFFECT ON MODAL PARAMETERS OF REINFORCED CONCRETE STRUCTURE BY FINITE ELEMENT METHOD

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ABSTRACT

The destructive effects of seismic loads on structures are known. Earthquake engineers have taken many precautions in their building designs to protect and minimize these destructive effects. In this way, many new design and reinforcement methods have been developed against seismic loads. The use of a steel slit panel (SSP) is one of the developed methods. Therefore, in this study, the effects of SSP on dynamic performance in a 5-storey reinforced concrete building model were investigated. For this, two models with and without SSP were created by the finite element method and modal parameters were compared. As a result of the data obtained, it has been observed that the building model makes more balanced displacements, as can be understood from the mode shapes. In addition, the SSP model made the structure more rigid by reducing the periods of the structure. It can be used in SSP prestressed reinforced concrete structures.

Keyword: Steel slit panel, reinforced concrete structure, mode shapes, modal parameters, finite element method

INTRODUCTION

Most of the structures found in earthquake hazardous areas are subject to various destructive effects caused by seismic loads.[1],[2],[3],[4],[5]. Buildings located in seismically active regions are under high risk of severe damages caused by harmful earthquake loads. [6]. In recent years, in the world and our country, the determination of the effect of vibrations on structures and structural behavior has become very important.[7]. The steel slit panel-frame system has emerged to increase the seismic resistance of structures. Compared to other conventional seismic reinforcement elements, it is a system that has just started to be used in the construction industry. Steel slit panels are bolted to beams directly attached to the columns. Steel slit panels are steel sheets with vertical rows of slits that form a series of bending members within the sheet. Steel slit panels are designed to resist all lateral loads, increase the rigidity of the system and provide energy consumption. Steel slit panels help reduce the damage due to earthquake. On the other hand, conventional steel beams are made of steel plates with welded-on joints, which can develop buckling and fracturing in an earthquake. Thus, in order to avoid the above problems, these new steel slit panel (SSP) are preferred for their better performance in seismic areas. It has also been developed that are capable of delivering high amounts of seismic resistance. Other structural systems available in the market, such as concrete slab systems and steel beams and columns are mainly used to provide structural support in structures in earthquake prone areas. In this case, steel SSP will have more flexibility in design. Structures made from steel SSP can perform most tasks, such as horizontal, vertical, lateral and block sectional requirements without suffering from buckling, according to the developers. Although it has a higher load bearing capacity than conventional steel beams and columns, steel SSP need to be designed to be able to withstand the extremely high temperatures involved. Thus, it becomes a complex task to guarantee the structural stability. However, by using good quality SSP, such problems can be avoided. It has been found that for steel SSP, the steel is heated and shaped during a forming process in a steel rolling mill. After the shaping process, the shape and the thickness of the steel can be determined. After the steel is shaped, it is hot rolled into steel sheets and subjected to an automated metallization process. After the metallization process, it is effectively bonded by using a hot dip process. After the bonding process, the SSP has excellent flexibility in shape and weight. In addition, its requirement of support is usually much less than that of traditional steel beams and columns. Structures retrofitted with SSP reduce maintenance costs with a lower coefficient of thermal expansion. SSPs are produced by cutting slits in calculated sizes and numbers into steel plates, the thickness of which is prepared according to the strengthening project. Civil engineers, large bridges, high-rise buildings, offshore platforms, etc. uses SSP in various structures. SSPs are the most suitable system for tall buildings for various reasons. The SSP is designed to withstand major earthquakes and conform to the seismic performance requirements of structures. Wind, temperature differences, etc. it is resistant to environmental influences. Steel slit panel construction is widely used in the construction of new structures as well as in strengthening existing structures in earthquake zones. The use of SSP is due to the following advantages: - Construction costs: SSP is much cheaper than steel beams and columns and is easy to install. In addition, the supporting structures do not have to be designed to allow them to bend during earthquakes. - Superior flexibility: -The reinforced concrete frame and steel beams can become brittle when exposed to severe seismic loads. But with the help of SSP, this risk is virtually eliminated. -It is flexible for use in beams without lateral movements. It also becomes flexible for use in structures with different inclinations, unique flexibility for use in tall structures. - Additive manufacturing: Recent studies show that 3D printing can also produce SSP. This technology can be used for manufacturing lattice-shaped SSP beams, allowing for variations in shape and weight that are not possible with conventional steel slitting. 3D printing has a significant advantage over traditional fabrication methods. It can be used to provide advanced control of beam sizes, dimensional tolerances and levels of flexural compliance, according to the needs of the particular structure. SSP is especially suited for high load bearing structures. It can be used in a variety of configurations. Different SSPs can be combined for better performance. Moreover, in some cases, steel beams and columns can be joined with glass fiber composite SSP. As compared with traditional steel beams and columns, the composite components of SSP elements have been shown to have an exceptional strength to weight ratio, high stiffness and superior thermal resistance. In addition, their stress and strain stiffening characteristics are also very high. The reinforcement can be as little as 2%, which makes it approximately 25% stronger than conventional steel beams and columns. SSP can be used for reinforced concrete structures, for reinforced concrete beams and columns and in reinforced concrete frames.

Researchers have carried out many studies using both the finite element method and the finite element method. There are many studies by the authors using the finite element method before. In this study, studies [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19] on the use of the finite element method were used. In addition, the authors have comparative studies [20], [21], [22], [23], [24], [25] using more than one method, including the finite element method. In these studies, the effect of the finite element method was compared with the operational and experimental modal analysis method. With all this knowledge, this new study has been carried out. Researchers have conducted studies [26], [27], [28], [29], [30] about steel slit panel (SSP).

The aim of this study is to observe the effects of steel slip panel (SSP) contribution to the modal parameters of reinforced concrete structure with the finite element method. For this purpose, a prestressed concrete reinforced structure model was created and a modal analysis of the building model created by the finite element method was carried out.

Description of Model Reinforced Concrete Structure

Model reinforced concrete structure is a 5-storey reinforced concrete building with two spans (5 m) in x and y directions, with a floor height of 3 m. Columns and beams are 35x60 cm, floor thickness is 15 cm. The finite element model (FEM) of the reinforced prestressed concrete structure is given in figure 1.

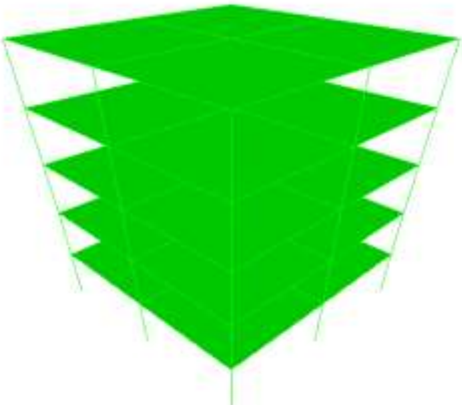

Figure 1: FEM model of reinforced concrete structure

Description of Steel Slit Panel

SSP elements are manufactured from 2.5 mm thick (24 slots) steel. Steel slit panel schematic drawing is given in figure 2. Location of steel slit panel is given in figure 3.

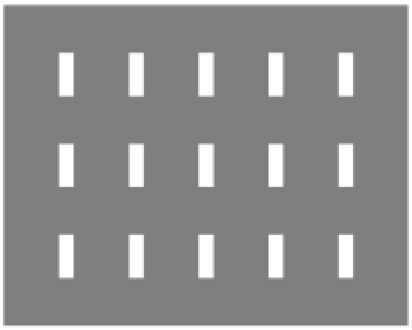

Figure 2: Steel slit panel schematic

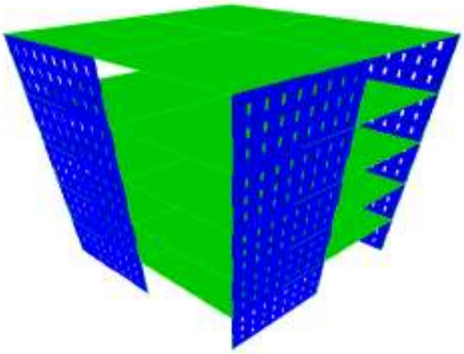

Figure 3: Location of steel slit panel

ANALYSIS AND RESULTS

The structure was first analysed in its current state using SAP2000 with the finite element method, then SSP was added to the frames and the same analysis was repeated and the results were compared.

Results of the Building without SSP

The structure was analysed without adding steel slit panel (SSP) by finite element method. The first 5 modes were taken into account in the analysis. Obtained results are presented in figures 4,5,6,7,8 as periods and mode shapes.

Figure 4: 1. Mode shape (Period = 0.5845 s)

It is seen that Mode 1 is translational mode shape. The period value was obtained as 0.5845 second in mode 1.

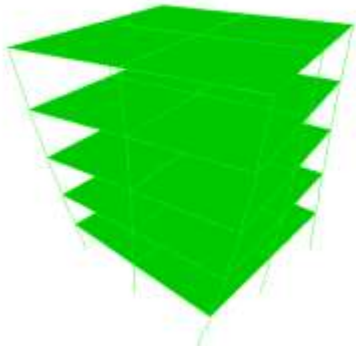

Figure 5: 2. Mode shape (Period = 0.5543 s)

It is seen that Mode 2 is torsional mode shape. The period value was obtained as 0.5543 second in mode 2.

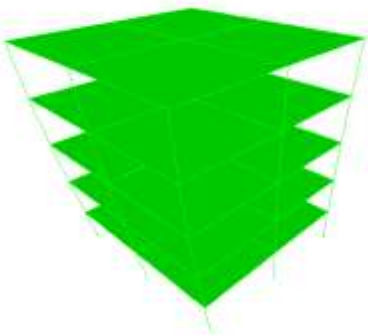

Figure 6: 3. Mode shape (Period = 0.5094 s)

It is seen that Mode 3 is translational mode shape. The period value was obtained as 0.5094 second in mode 3.

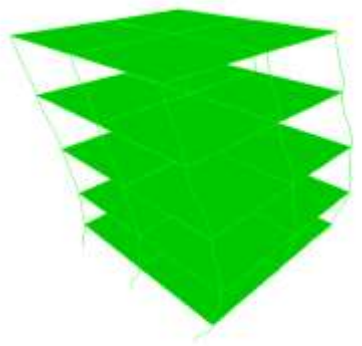

Figure 7: 4. Mode shape (Period = 0.4647 s)

It is seen that Mode 4 is translational mode shape. The period value was obtained as 0.4647 second in mode 4.

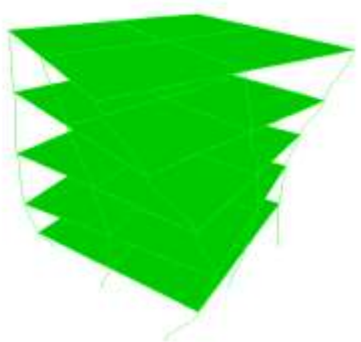

Figure 8: 5. Mode shape (Period = 0.3829 s)

It is seen that Mode 5 is torsional mode shape. The period value was obtained as 0.3829 second in mode 5.

Results of the Building with SSP

The building was analysed with adding steel slit panel (SSP) by finite element method. The first 5 modes were taken into account in the analysis. Obtained results are presented in figures 9,10,11,12,13 as mode shapes.

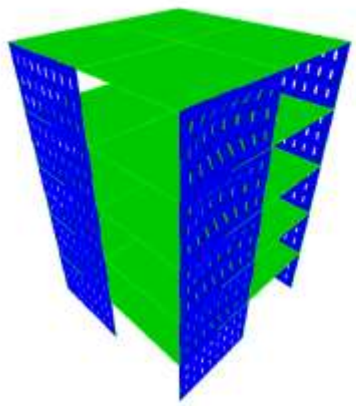

Figure 9: 1. Mode shape (Period = 0.5413 s)

It is seen that Mode 1 is translational mode shape. The period value was obtained as 0.5413 second in mode 1.

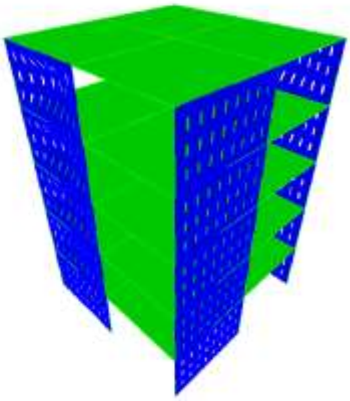

Figure 10: 2. Mode shape (Period = 0.5009 s)

It is seen that Mode 2 is translational mode shape. The period value was obtained as 0.5009 second in mode 2.

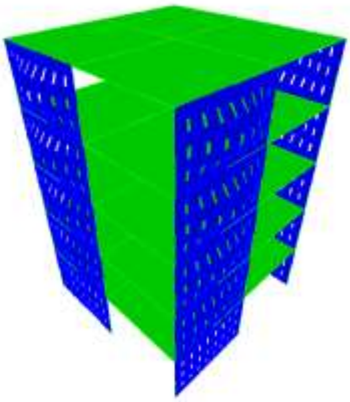

Figure 11: 3. Mode shape (Period = 0.4107 s)

It is seen that Mode 3 is translational mode shape. The period value was obtained as 0.4107 second in mode 3.

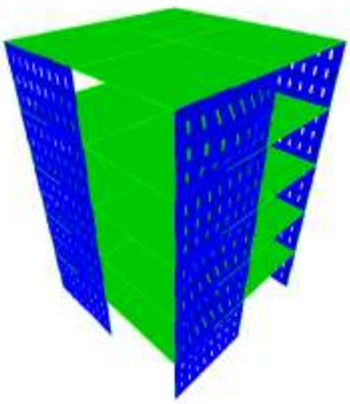

Figure 12: 4. Mode shape (Period = 0.3347 s)

It is seen that Mode 4 is translational mode shape. The period value was obtained as 0.3347 second in mode 4.

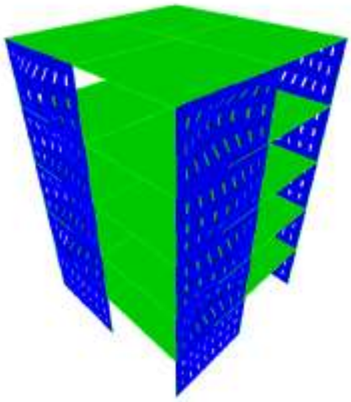

Figure 13: 5. Mode shape (Period = 0.2850 s)

It is seen that Mode 5 is translational mode shape. The period value was obtained as 0.2850 second in mode 5.

The comparison of period and mode shapes of the model with SSP and without SSP model is given in Table 1.

Table 1. Comparison period and mode shapes of without SSP model and with SSP model

Mode	1	2	3	4	5
Without SSP Period (s)	0.5845	0.5543	0.5094	0.4647	0.3829
With SSP Period (s)	0.5413	0.5009	0.4107	0.3347	0.2850
Difference of Period (s)	-0.0432	-0.0534	-0.0987	-0.1300	-0.0979
Difference of Period (%)	16.75	9.63	19.38	27.98	25.57
Without SPP Mode Shapes	Translational	Torsional	Translational	Translational	Torsional
With SPP Mode Shapes	Translational	Translational	Translational	Translational	Translational

CONCLUSIONS

The percentage changes in the parameters of the building are listed below;

In the mode 1, the period difference between non-SSP and SSP status was obtained as -0.0432 s. The effect of SSP reinforcing as a percentage was determined as 16.75%.

In the mode 2, the period difference between non-SSP and SSP status was obtained as -0.0534 s. The effect of SSP reinforcing as a percentage was determined as 9.63%.

In the mode 3, the period difference between non-SSP and SSP status was obtained as -0.0987 s. The effect of SSP reinforcing as a percentage was determined as 19.38%.

In the mode 4, the period difference between non-SSP and SSP status was obtained as -0.1300 s. The effect of SSP reinforcing as a percentage was determined as 27.98%.

In the mode 5, the period difference between non-SSP and SSP status was obtained as -0.0979 s. The effect of SSP reinforcing as a percentage was determined as 25.57%.

As a result of the study, it has been observed that the structure model makes more balanced displacements, as can be understood from the mode shapes. In addition, SSP showed by reducing the period of the structure. Thus, the stiffness increased. In the first mode, it was observed that only about 16.75 percent increase in the period. the period has decreased significantly in all modes. It can be said that the SSP application makes the structure safe by removing it from the resonance range. It can be used in SSP prestressed reinforced concrete structures.

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