

# **COST COMPARISON OF INDUSTRIAL STEEL BUILDING WITH STEEL PLATE SHEAR WALL BY CONSIDERING I-SECTION & CONCRETE FILLED SECTION AS COLUMN SECTIONS**

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**Abstract**-Behavior of structure during earthquake motion depends on distribution of weight, stiffness and strength in both horizontal and vertical planes of building. To reduce the effect of earthquake elements steel plate shear walls are used in the building. These can be used for improving seismic response of buildings. The main role of steel shear wall is to collect lateral forces of earthquake in a building and transfer those forces to the foundation. The web plates in steel shear walls are categorized according to their ability to resist buckling. The web plates can be sufficiently stiffened to preclude buckling and allow the full shear strength of the web to be reached. Shear walls are the walls like vertically aligned structural components which are subjected to lateral loads in their plane. These have proved to be very effective for lateral load resistance particularly in the medium to high-rise buildings. These depending upon the material of construction they may be classified as the RCC and steel shear walls. Steel structures are generally lighter than masonry or RC structures. Lower weight translates to lower seismic forces. Steel structures typically show good ductility, even when they are not specifically designed or detailed for seismic resistance. The beams, columns and the plate together act as the vertical plate girder. The columns act as the flanges, the plate as the web and the beams as the horizontal stiffeners of the plate girder. In present study Steel Industrial building with shear wall is analysed & design on STAAD-PRO. Two types of column sections are used i.e. I-section & Concrete filled section. Cost comparison is done for both the cases & compared with Steel Industrial building with & without shear wall.

**Key Words** : Steel shear wall , Ductility, Seismic Resistance, Shear strength, Plate Girder, I-Section, Concrete filled section

## **General**

Earthquakes are natural phenomena, which cause the ground to shake. Due to earthquake the structure on the ground gets damage or collapse. Earthquake resistant design of structure is a continuing area of research since the earthquake engineering has started not only in India but also in other developed countries. The structure is still damaged due to some or the other reason during earthquakes.

Shear walls are vertical elements of the horizontal force resisting system. Steel shear wall is a lateral load resisting system consisting of vertical steel plate in-fills connected to the surrounding beams and columns and installed in one or more bays along the full height of the structure to form a cantilever wall. The steel plate shear walls are mainly used in multistoried building in the foreign countries such as America, Japan, Canada etc.

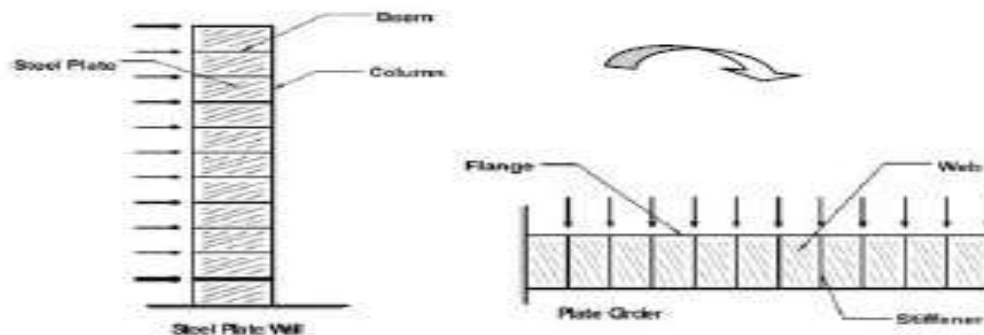
Steel structures have historically performed well in earthquakes, and little loss of life can be attributed to collapse of steel buildings in earthquakes. Many of the highly destructive earthquakes around the world have occurred in areas where there are very few steel structures. Thus, the exposure of steel structures to strong earthquakes has been perhaps somewhat less than other types of construction.

Steel Plate Shear Walls have been used in United States since 1970's. In the early period of development of the steel plate shear walls, they were used for seismic retrofit of low and medium-rise existing hospitals and other structures. These initial shear walls were designed with relatively closely spaced horizontal and vertical stiffeners. In a 51-story high-rise building in San Francisco steel shear walls are used as the primary lateral load resisting system.

Now a days the vital properties of steel are made use of in these lateral load resisting systems in the form of steel shear walls. In general the steel plate shear wall system consists of a steel plate welded or bolted to the surrounding beams and columns on all sides.

### ***Behaviour & mechanism of shear resistance of steel plate shear wall.***

Its behavior is analogous to a vertical "Plate Girder". In this columns acts as a flanges, beams as stiffeners & steel plate as a web.

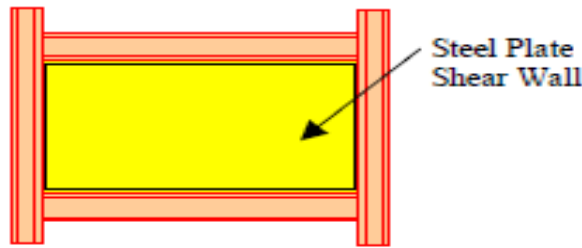


***Figure : Steel Plates Shear Wall and Plate Girder Analogy***

### ***Basic Types of Shear Walls.***

#### ***Un-stiffened steel plate shear walls***

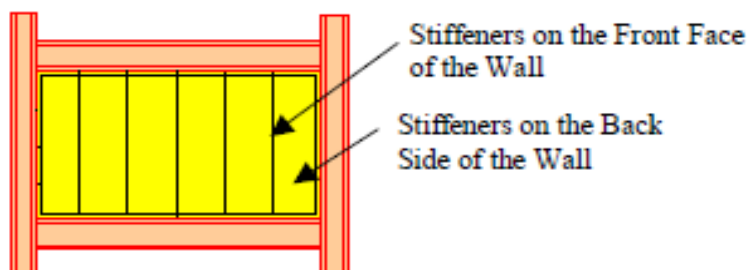
These are latest and more preferred as compared to the other types. These consist of a thin steel plate welded or bolted to the surrounding beams and the columns. There are no stiffeners on the steel plate. This makes it relatively more economical and easy for fitting and handling. Being thin, it buckles at a relatively small lateral force. But after that it shows full strength as well as stiffness.



1. Steel Plate Shear Wall (Unstiffened)

#### ***Stiffened steel plate shear walls***

These consist of a relatively thick steel plate connected to the beams and columns on its periphery. The plate is stiffened by the horizontal and vertical stiffeners running over it. Thus the plate has got relatively higher strength and stiffness before buckling. The buckling is the criteria used for the design of this shear wall. The cost of fabrication of the stiffeners and the extra material cost increases the overall cost of the shear wall. The tension field stresses do not develop in this case. The yielding of plate occurs before the buckling. stiffeners on the steel plate. This makes it relatively more economical and easy for fitting and handling. Being thin, it buckles at a relatively small lateral force. But after that it shows full strength as well as stiffness.



2. Steel Plate Shear Wall (stiffened)

**Table : Difference between RCC and steel shear walls**

	<b>RCC Shear Wall</b>	<b>Steel Shear Wall (SPSW)</b>
Thickness	About 200 mm	About 6,8,10,12 mm
Material	Stiff, brittle	Flexible , ductile
Mechanism of shear resistance	Direct (through internal shear and bending stresses)	Indirect (through diagonal tension)
Internal resistance force	Shear and bending stress	Diagonal tension forces

#### ***Advantages of steel plate shear wall (SPSW)***

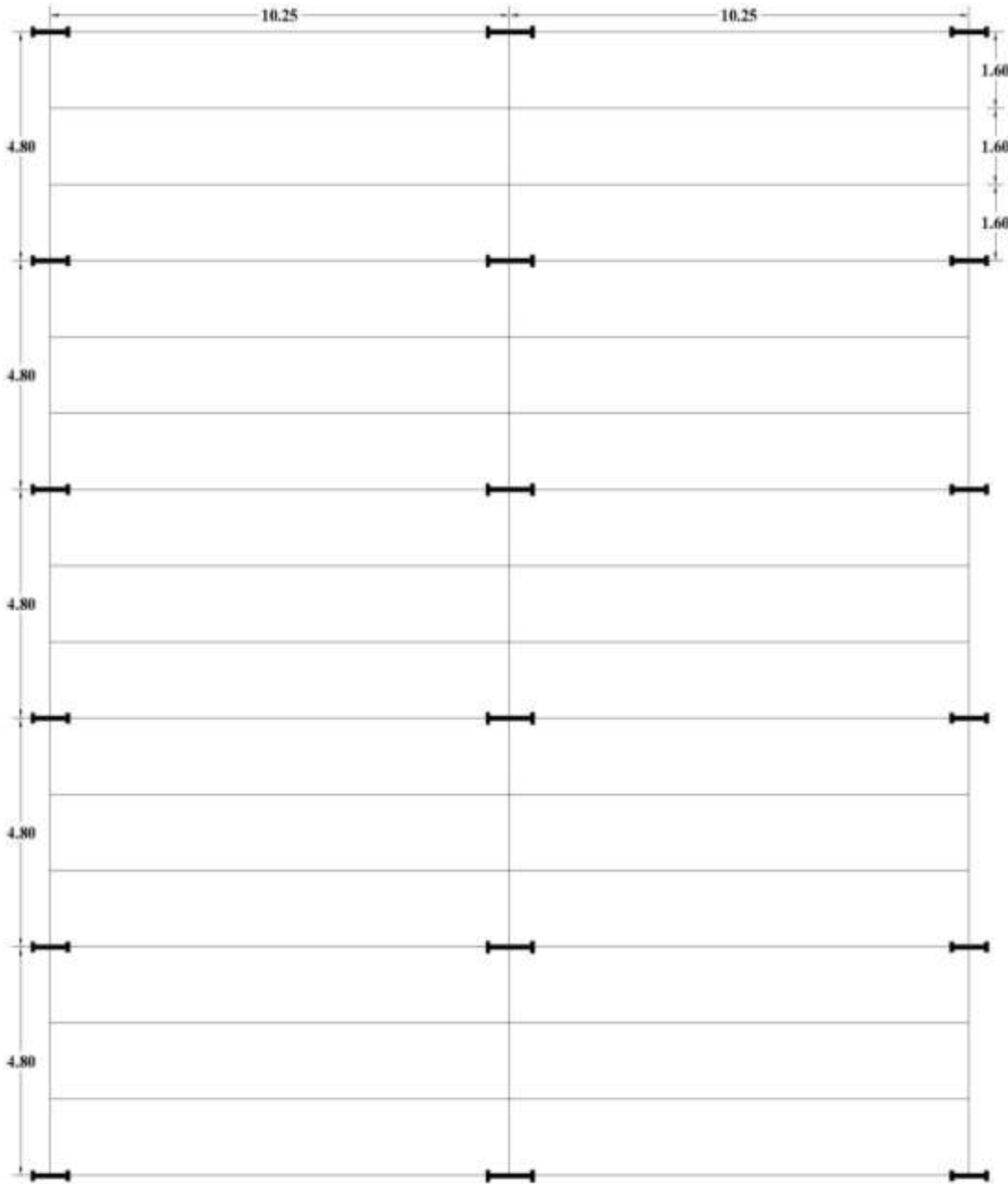
1. Steel shear wall is very efficient and economical lateral load resisting systems.
2. The steel shear wall system has relatively high initial stiffness, thus very effective in limiting the drift.
3. Compared to reinforced concrete shear walls, the steel shear wall is much lighter which can result in less weight to be carried by the columns and foundations as well as less seismic load due to reduced mass of the structure.
4. By using shop-welded, field-bolted steel shear walls, one can speed-up the erection process and reduce the cost of construction, field inspection and quality control resulting in making these systems even more efficient.
5. Due to relatively small thickness of steel plate shear walls compared to reinforced concrete shear walls, from architectural point of view, steel plate shear walls occupy much less space than the equivalent reinforced concrete shear walls. In high-rises, if reinforced concrete shear walls are used, the walls in lower floors become very thick and occupy large area of the floor plan.
6. Compared to reinforced concrete shear walls, steel plate shear walls can be much easier and faster to construct when they are used in seismic retrofit of existing building.
7. Steel plate shear wall systems that can be constructed with shop welded-field bolted elements can make the steel plate shear walls more efficient than the traditional systems. These systems can also be very practical and efficient for cold regions where concrete construction may not be economical under very low temperatures.

#### ***Design of Steel Building With Steel Plate Shear Wall***

The mechanism of shear resistance and its behavior of steel plate shear walls is quite different from that of the RCC shear walls. This is because of the fact that the SPSW system consists of not only the steel plate but along with that the columns and the beams to which steel plate is connected. So the beams and columns affect the overall behavior of the SPSW and vice versa. Steel

plate shear wall is modeled as strip model. Hence to find out the effect of the steel plate shear walls on the steel Industrial building (G+3) with I-section & Concrete filled section as column sections present study is done.

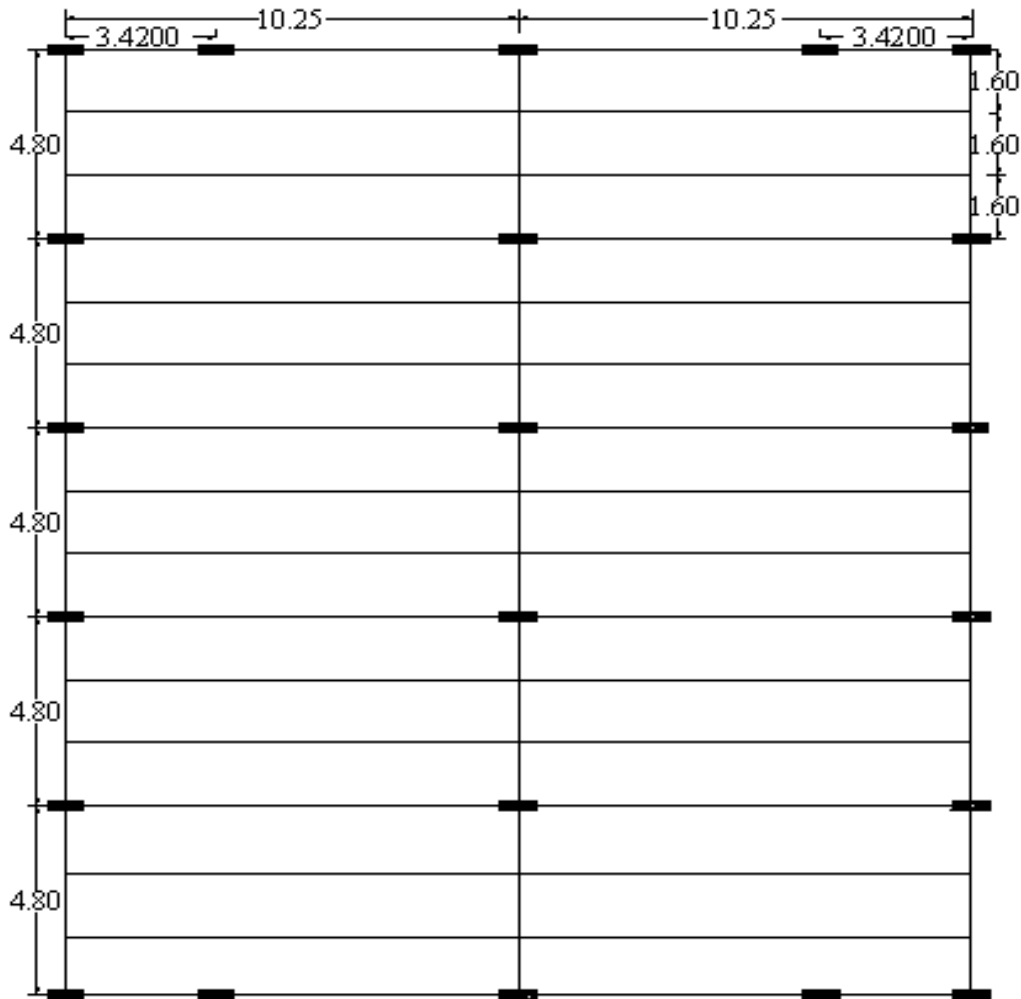
***Steel Industrial Building without Steel Plate Shear Wall (SPSW) with I-section as Columns-***



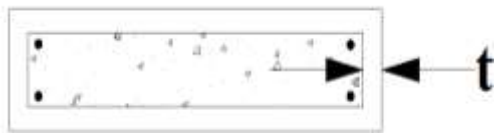
**Plan of steel Industrial Building  
(By using I - section as coloumn)**

***Fig: Plan of Steel Industrial Building without SPSW by using I- section as column***

**Steel Industrial Building with Steel Plate Shear Wall with Concrete filled section as Column**



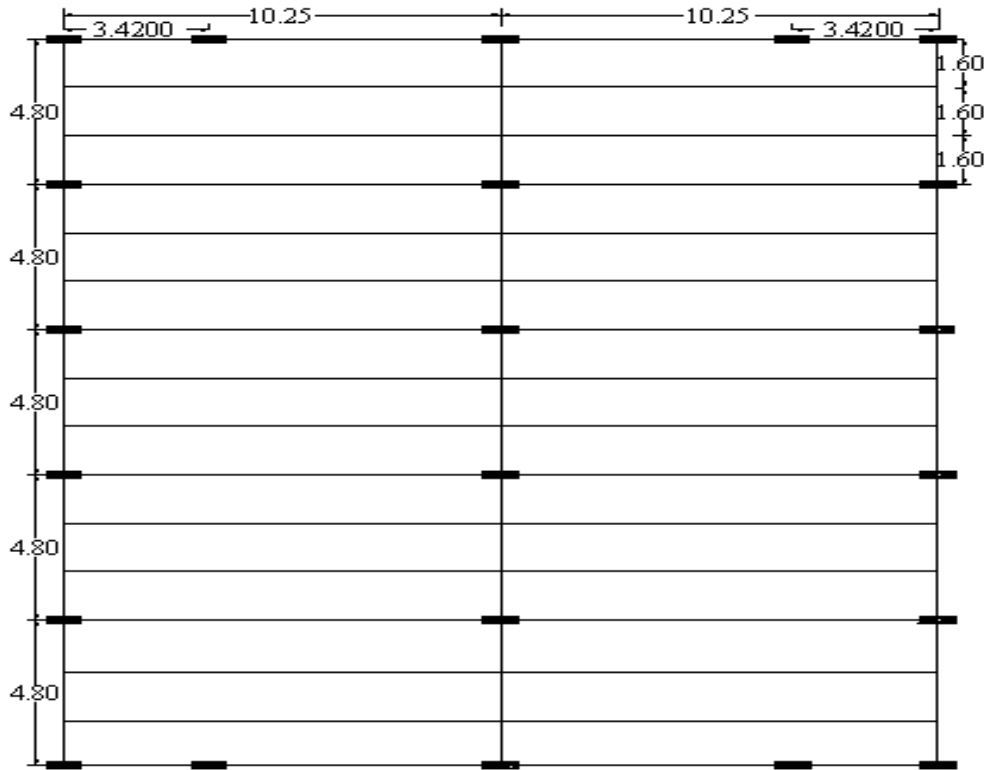
**Plan of steel Industrial Building with Steel Plate Shear wall  
(By using Concrete filled section as coloumn)**



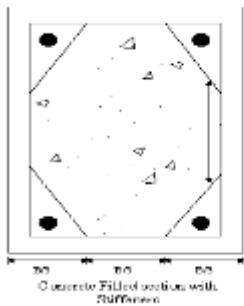
*Typical C/S of Column*

**Fig.: Plan & C/S of Column of Steel Industrial Building with SPSW by using Concrete filled section as column**

**Steel Industrial Building with Steel Plate Shear Wall with Concrete filled section as Column with Stiffeners**



**Plan of steel Industrial Building with Steel Plate Shear wall  
 (By using Concrete filled section as coloumn)**



Stiffeners

C/S of Column

**Fig.:** Plan & C/S of Column of Steel Industrial Building with SPSW by using Concrete filled section as column with stiffeners

**Table :** Cost comparison with & without SPSW

Sr.No.	Type of Steel Building	Cost with SPSW	Cost without SPSW
1.	SPSW with I-section as columns	Rs.1,30,12,800/-	Rs. 1,32,28,000/-
2.	SPSW with Concrete filled section as column	Rs.1,21,52,291/-	Rs. 1,29,47,894/-

3.	SPSW with Concrete filled with stiffeners section as column	Rs.1,17,90,939/-	---
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**Conclusion –**

1. The provision of SPSW is found out to be more economical in Steel Industrial Building with I-section as column.
2. The sizes of inner columns is found out to be smaller in case of steel Industrial building with SPSW than steel industrial building without SPSW by using I-section as column.
3. Cost of steel building with Concrete filled section as column is coming out to be less as compare to Cost of steel building with I-section as column.
4. Steel building with SPSW with Concrete filled section as column is found to be economical compare to Steel building with SPSW with I-section as column.
5. Steel building with SPSW with Concrete filled section as column is found to be economical compare to Steel building without SPSW.
6. Provision of shear wall can reduce the cost of cladding or wall.
7. The steel building with SPSW with concrete filled column with stiffener is found to be economical than steel building with SPSW with concrete filled column without stiffener.
8. Encased I-section is found out to be economical than Concrete filled section with stiffener for medium rise structure. If it is applied for high rise structure reverse may be the case.
9. Because of provision of stiffener, elongated section can be used. Stiffener provides the lateral support.
10. The elastic local buckling of a steel plate can be avoided through an appropriate longitudinal spacing of stiffeners.
11. The steel building with SPSW with concrete filled column with stiffener is found to be economical than steel building with SPSW with I-section as column.

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