

Comparison of steels via SMAW and MIG welding methods under industrial loads

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Abstract: In this study, the deflection and deformation behaviours of IPN80 steel beam and column were investigated under the different industrial loads. Single-sided welds were applied to IPN80 steel beams using shielded metal arc (SMAW) and metal inert gas welding (MIG) method in the form of T-type. After that, the performance of SMAW and MIG welded joints were identified using beam bending test under 500 and 3000 N loads. SMAW and MIG methods were compared with each other to understand the deflection and deformation behaviours of the welded steel structures. Lower deformation and deflection were obtained in MIG welded steel beams. The results show that, steel beams welded MIG method has higher load capacity than SMAW welded ones. MIG welding method is more reliable than the SMAW method for the combining performance and load capacity.

Keywords: metal inert gas welding, shielded metal arc welding, steel beam and column, bending test, deflection.

1. Introduction

Experience shows that steel structures subjected to earthquakes behave well. A ductile behaviour, which provides extended deformation capacity, is generally the better way to resist earthquakes (Agarwal 1992, Hattap et al. 2005, Kayhan et al. 2010, Callister 1993). There are some advantages for steel structures in a seismic zone, namely their flexibility and low weight. Stiffer and heavier structures attract larger forces when an earthquake hits. Steel structures are generally more flexible than other types of structure and lower in weight (Groover 2007, Oates et al. 1998, Black et al. 2008, Deren, 1995). Forces in the structure and its foundations are therefore lower. This reduction of design forces significantly reduces the cost of both the superstructure and foundations of a building. Steel structures are generally light in comparison to those constructed using other materials (Karaduman et al. 2002, Cary 1994, Oguz 1993). The two of the combining methods used in the steel structures are shielded metal arc welding (SMAW) and metal inert gas welding (MIG). SMAW uses a metallic consumable electrode of a proper composition for generating arc between itself and the parent work piece. The molten electrode metal fills the weld gap and joins the work pieces. This is the most popular welding process capable to produce a great variety of welds. The electrodes are coated with a shielding flux of a

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suitable composition. The welding quality of the shielded metal arc welding is determined by the welding parameters including the welding slot forms, electrode diameter, welding current, welding speed, arc length, electrode advance angle, electrode oscillation angle and movement, welding direction and position, etc (Afolabi 2008, Chan et al. 1999, Ates et al. 1999). MIG welding is an arc welding process, in which the weld is shielded by an external gas, like argon, helium, CO₂, argon + Oxygen or other gas mixtures (Salazar et al. 2007, Magasdi et al. 2007). Consumable electrode wire, having chemical composition similar to that of the parent material, is continuously fed from a spool to the arc zone. The arc heats and melts both the work pieces edges and the electrode wire. Structural steel beams used the steel construction can be combined using both welding methods. Steel beams generally carry vertical gravitational forces but can also be used to carry horizontal loads, for example, loads due to an earthquake or wind. The loads carried by a steel beam are transferred to columns or walls, which then transfer the force to adjacent structural compression members. In light frame construction the joists rest on the beam. Steel beams are characterized by their profile, the shape of their cross-section, their length, and their material. One of the most common types of steel beam is the I-beam or wide-flange beam. This is commonly used in steel-frame buildings and bridges. The main goal of the present study is to investigate the deflection and deformation behaviour of IPN80 steel beams welded shielded metal arc and metal inert gas welding methods under the different industrial loads.

2. Experimental study

2.1 Materials

The material used in this study was commercially available (EN 10025: 2004) as a structural steel beam. Hot rolled and round-edged IPN80 steel beams occur geometrical dimensions of $80 \times 42 \times 3.9$ mm and weight of 5,94 kg/m. Chemical content of the IPN80 steel beam (St37-2) was given in Table 1.

The geometrical shape and perspective view of IPN80 steel material were shown in Fig. 1(a) and Fig. 1(b), respectively. Geometrical dimensions of IPN80 steel material in accord with European structural steel standard (EN 10025: 2004) was given in Table 2. Flanges of IPN steel materials are oblique 14% head towards inner surface and body height is higher than beam flanges. IPN steel materials are widely used as girder stem because of body plane loadings in the steel structures.

2.2 Welding applications

Single-sided welds were applied to IPN80 steel beam and column using shielded metal arc and metal inert gas welding method in the form of T-type. Before welding operation, surface of steel beam and column were cleaned using wire brushing and sanding. After that, steel structure was fixed to template for stabilize of axis lines. Afterwards, steel beam and column were welded single-sided using SMAW and MIG method. As shown Fig. 2, it was used two steel materials one of the steel beam and the other steel column for all welding applications. Weld nugget size were measured as 23.2 mm. Six welds were

Table 1 Chemical content of IPN80 steel material (%)

Standard	C	Si	Mn	P	S	Fe
DIN EN 10025-94	0,17	0,4	0,5	0,04	0,05	98,84

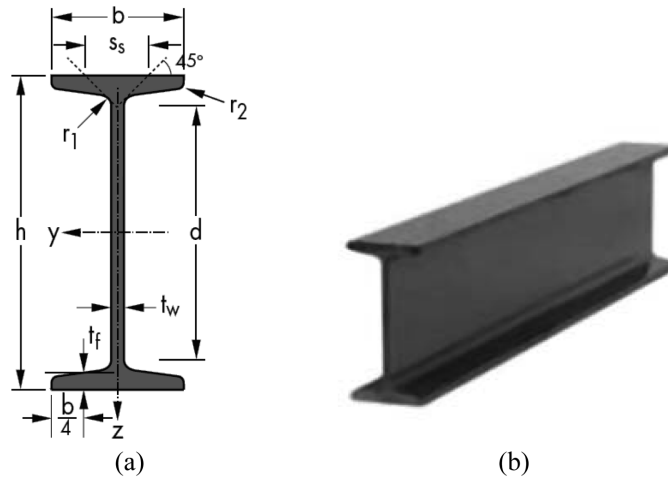


Fig 1. (a) Geometrical shape and (b) perspective view of IPN80 steel material

Table 2 Geometric dimensions of IPN80 steel material

Symbol	G	h	b	t_w	t_f	r_1	r_2	A	d	S_s	A_L	A_G
Value	5,94	80	42	3,9	5,9	3,9	2,3	7,57	59	21,6	0,304	51,09
Unit	kg/m	mm	mm	mm	mm	mm	mm	$\text{mm}^2 \times 10^2$	mm	mm	mm^2/m	m^2/t



Fig 2. Welded steel structure

totally applied to a specimen together with two inner corners and four outer corners. Used welding parameters for SMAW and MIG welding were listed in the Table 3 and Table 4, respectively.

2.3 Beam bending tests

Beam bending tests were applied to steel structure specimens to compare the performance of SMAW and MIG welding. Each test specimen was applied steel beam and steel column, welded each other. Firstly, test specimen was placed in a mould, as shown in Fig. 3(a). Afterwards, having a specimen mould was assembled to tensile/compression testing device (Schenck Trebel) which has load capacity of 50 tones, as shown in Fig. (3b). Also, a comparator was fixed to tensile/compression testing device for deflection measurement of steel beam. In the beam test, while steel column was fixed to all directions, top ends of steel beam was applied to load (-Y) direction through a high strength steel cylinder has

Table 3 Shielded metal arc welding parameters

Parameter type	Values and comments
Welding machine	ESAB LHF 400
Material	IPN80 steel beam/column
Number of material	2
Cleaning of surfaces	Wire brushing and sanding
Electrode type	Rutile shielded metal electrode
Electrode diameter	3,25 mm
Welding current	110 Ampere
Welding speed	4 mm/sec
Arc length	1,6 mm
Polarization	Straight polarity, electrode (-)

Table 4 MIG welding parameters

Parameter type	Values and comments
Welding machine	ESAB C 280
Material	IPN80 steel beam/column
Number of material	2
Cleaning of surfaces	Wire brushing and sanding
Wire type	Flux cored welding wire
Wire diameter	0,8 mm
Wire speed	4,2 m/min
Welding current	100 Ampere
Welding speed	6,5 mm/sec
Shielding gas	88Ar + 10CO ₂ + 2O ₂
Arc length	1,2 mm
Polarization	Straight polarity, wire (-)

diameter of 50 mm. Direction of load and boundary conditions were shown in Fig. 3(c). It was applied to each steel structure specimen six different industrial loads of 500, 1000, 1500, 2000, 2500 and 3000 N. After loading, deflection values occurred top ends of steel beam were measured using the comparator. Deflection values reported in the test are the average of at least three specimens. After that, the deflection values of the welded structure were evaluated and the performance of the two methods was compared each other.

3. Results and discussion

Deflection values depending on the load in the bending test were listed in Table 5. Furthermore, the comparison of steel structure welded SMAW and MIG methods was also given in Table 5.

Fig. 4 represents the deflection curve of steel specimen joined with MIG welding method depending on the different loads. In the curve, the deflection values of steel beam were increased gradually with the increment of load. The deflection values of the steel beam consists of a small amount under the lower

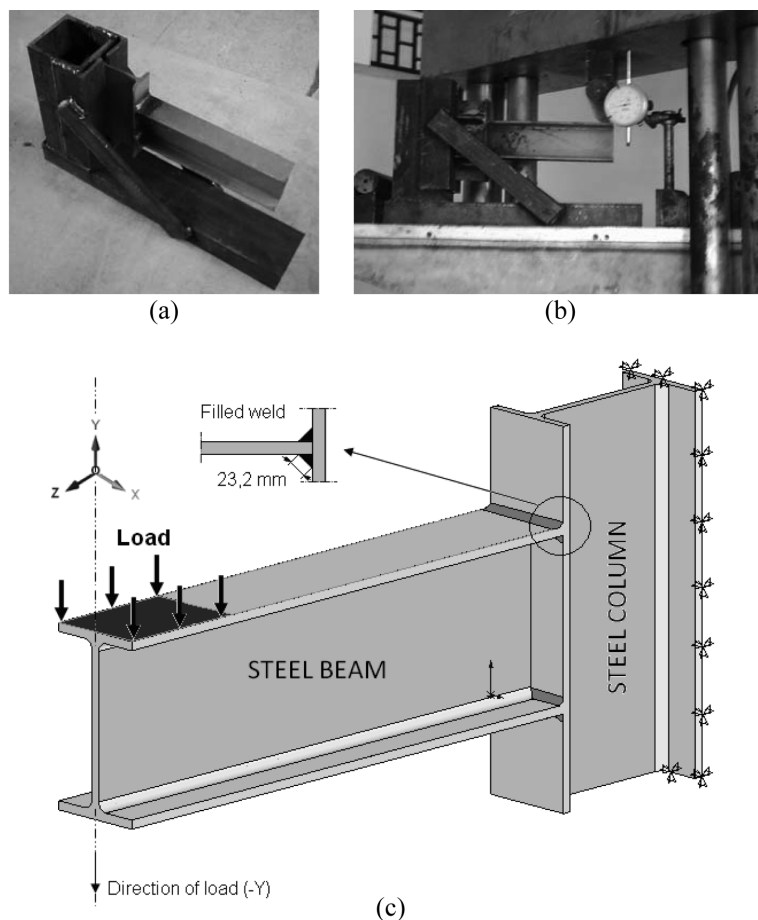


Fig 3. In the beam bending test, (a) specimen mould, (b) testing apparatus, (c) direction of load and boundary condition

Table 5 Deflection values depending on the load.

Load (N)	Deflection, δ (mm)	
	for shielded metal arc welded steel structures	for MIG welded steel structures
500	0,023255814	0,016949153
1000	0,227272727	0,020000000
1500	0,407407407	0,029411765
2000	0,578947368	0,039682540
2500	0,833333333	0,068702290
3000	26,208793654	0,085714286

loads, it was increased slightly with the increment of load. All obtained deflection values are lower than 0,1 mm for MIG welded specimens due to high performance weld nugget in this method. It was also observed in deflection value of 0,0857 mm under the load of 3000 N. While deformation of welded steel structure occurred in small quantities, weld nugget was resisted versus applying load. Fig. 5 shows

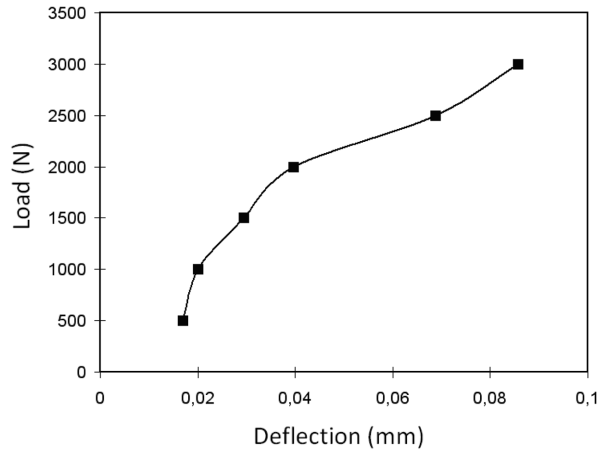


Fig 4. Load-deflection curve for MIG welded structures

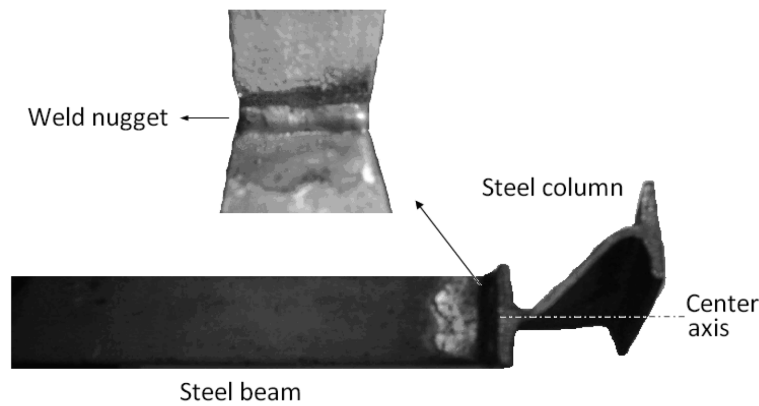


Fig 5. Deformation under the load of 3000 N for MIG welded structure

deformation of MIG welded steel structure after loading of 3000 N. In this steel structure, applied load was canalised from steel beam to steel column because of high strength of weld nugget. Also, it was not observed on fracture of weld nugget in the structure.

Fig. 6 shows the deflection curve of steel structure welded shielded metal arc welding method of depending on the different industrial loads. In the figure, the deflection values of steel beam were increased with the increment of load, similarly MIG welded structures. But, it was determined in deflection value of 26.2 mm under the loading of 3000 N, dissimilarly than SMAW welded structures. Deflection values of steel specimens welded via SMAW are higher than the MIG welded ones under the same load conditions. The reason is that the strength and performance of weld nugget are higher in the MIG applications than the SMAW welding method (Uslu et al. 2010, Bailey 1999). Fig. 7 shows the displacement of MIG welded steel structure and fracture of weld nugget after the loading of 3000 N. The displacement of steel beam was increased with the increment of load and the fracture occurred in weld nugget at the loading of 3000 N.

Many parameters influence the strength and performance of welds, including the welding method, the

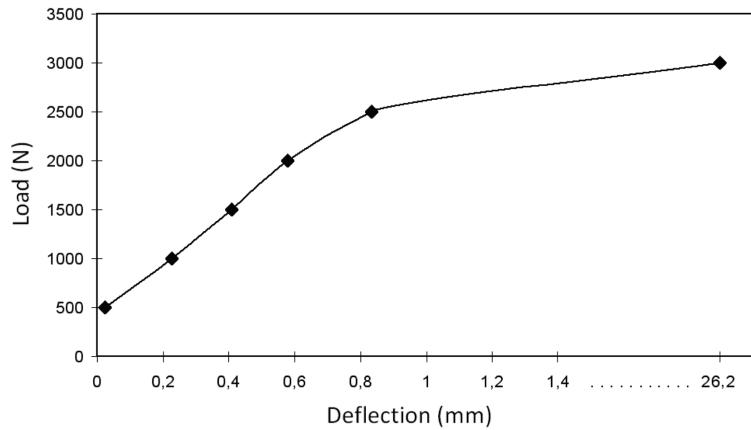


Fig 6. Load-deflection curve for SMAW welded structures.

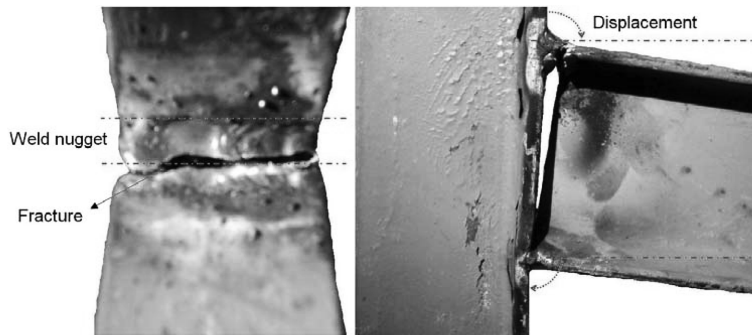


Fig 7. Displacement and fracture under the loading of 3000 N for shielded metal arc welded structure.

amount of energy input, the weldability of the base material, filler material, and flux material, the design of the joint (Uslu et al. 2010, Bailey 1999, Tulbentci 1990). In this study, the displacement and deformation that accompanies the MIG welding process is much lower than that of the shielded metal arc welding process. Steel structures welded shielded metal arc welding result in greater deformation due to an increase in the amount of load. The deflection value of the steel structure welded via SMAW was about 8.24% higher than MIG welded one under the loading of 2500 N. From this result, it is seen that the load carrying capacity of steel structure welded via MIG welding is higher than the SMAW welded one. In this study, static analyses have been done for steel construction structures, and it needs not to investigate metallographic difference, microstructure changes and thermal behaviours. Because, the steel construction model that we used in this study was modeled in the form of weld before the finite element analysis. For that reason, before/after the loading, thermal changes, hardness profiles and thermal cycle were beside the point for steel construction macro structure.

4. Conculusions

The deflection values for steel structure welded MIG changed between 0.0169 mm and 0.0857 mm,

on the other hand, for SMAW welded steel structure were determined between 0.0232 mm and 26.2087 mm under the same loading conditions. While the displacement behaviour with the fracture of weld nugget in the steel structure welded SMAW was occurring, it was not observed the fracture for steel structure welded via MIG under the loading of 3000 N. Steel structure welded via MIG method can be preferred because of the high load carrying capacity and low deformation instead of steel structure welded via SMAW in the steel structures. It is clearly seen that, welding type is the most important factor for determining the load carrying capacity, deformation under the load and safety of structure in the steel constructions.

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