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Numerical Study of the Behaviour of the Intermeshed Steel Connections under Cyclic loading

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Abstract: ***Bolting and welding are the two connections which are commonly used in structural steel industry. Now the metal cutting technology has improved. Laser cutting, plasma cutting etc. are some of the new cutting technologies. Due to the evolution of these cutting technologies a new type of connection named intermeshed steel connection is introduced in structural steel industry. Bolting and welding are expensive and time-consuming operations. Easy disassembly is not possible in these types of connections. Steel is one of the best suitable materials which material reuse is possible. The introduction of intermeshed steel connection enhances easy disassembly and thereby improving material reuse. The non-linear finite element stimulations of side intermeshed steel beam to beam connection were performed using ABAQUS software. The beam flanges of the I section were connected by using dovetails and the performance of the beam flange connection is analyzed under cyclic loading.***
Keywords: ***Intermeshed connection, Finite Element Modelling, Steel connection, Dovetail, Technology***

I. INTRODUCTION

Bolting and welding are the two connections which are commonly used in structural steel industry. Both bolting and welding have advantages and disadvantages. Most commonly used connections include the bolted connections.

This connection has the advantage of flexibility in assembling parts of the structure as well as dissembling it and which is necessary if there is inspection or some routine maintenance.

Welding is the process of joining two pieces of metal by creating a strong metallurgical bond between them by heating or pressure or both.

Welding offers an opportunity to the designer to achieve a more efficient use of the materials.

Advanced manufacturing techniques, such as plasma, water jet, and laser can facilitate field assembly and disassembly of steel structural components, and therefore potentially transform how steel structures are designed and constructed.

These techniques have opened up an opportunity to create a new class of steel connections that rely on intermeshed. Presently, steel connections are almost exclusively made with bolts and welds. Both bolted and welded connections are labour intensive and contribute to a considerable portion of the total cost of a steel structure.

Recent developments in high-definition plasma, laser, and water jet cutting, when combined with fully automated computer-controlled techniques, could facilitate fast fabrication with high precision that may allow for the development of an entirely new class of steel connections to improve both erection efficiency and material reuse [4].

The intermeshed beam to beam connection is shown in Fig. 1.

Intermeshed flanges of I section are connected using four angle sections and the web of the I section is connected using shear plates and bolts of suitable dimensions.

High-definition plasma and waterjet cutting afford the opportunity to create alternative steel connections that rely on intermeshed components, instead of regular welding or bolting. Intermeshed connections transfer force through direct contact bearing of multiple, precisely shaped surfaces of the interlocking elements.

The potential impact of an alternative steel connection of this type that targets reductions in time and cost and simplifies disassembly for reuse is further highlighted by the dominance of steel in the construction industry [7]. Intermeshed connections can be divided in to two, front ISC and side ISC.

Here the analysis of side Intermeshed Steel Connection is carrying out.

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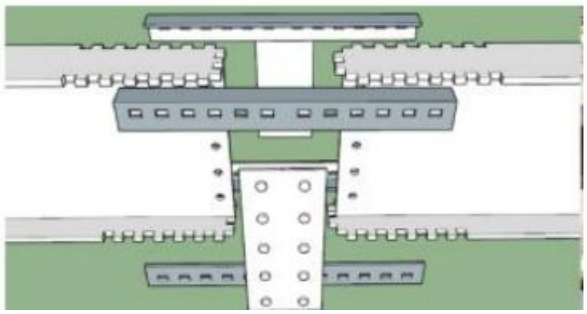


Fig. 1 Example of an unacceptable low-resolution image

II. MATERIALS USED

Two I beams of ISWB 250 and four angles of ISA 65 X 45 are selected as the material. Shear plate is cut from a plate of 900mm width and 6mm thickness. 18mm diameter bolts are used for connecting two beam sections using shear plates. The geometry of intermeshed connection is shown in Fig. 2. Steel of Fe 410 grade with Poisson's ratio 0.3, modulus of elasticity 210 Gpa and density 7850 kg/m3 is used.

III. FINITE ELEMENT MODELLING

Modelling consists of connecting intermeshed sections (Flanges) using dovetails and connecting webs using shear plate and bolts. The finite element model is shown in Fig.3. For the analysis of the non-linear FEA in Abaqus software, a three-dimensional model of the connection geometry was assembled. The model is based on the geometry shown in Fig. 2. All parts were meshed using solid elements. The base of the bottom flange was fixed, while the top upper flange was restrained in all but the vertical direction to enable a displacement-controlled analysis up to a translation of 15mm. to model the contact behaviour and transfer of force between the flange teeth and the side plates, surface-to-surface contact with finite relative sliding was implemented using the general contact algorithm in Abaqus.

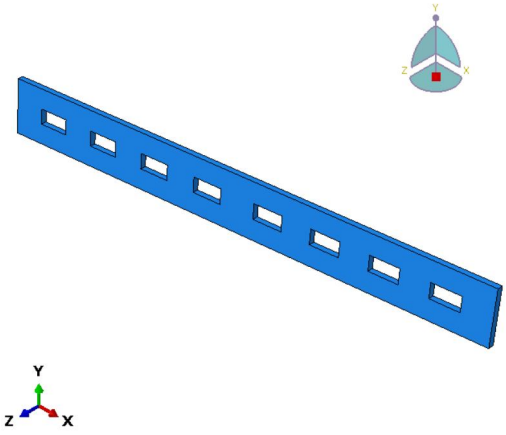


Fig. 2 Model of dovetail; ISC 1

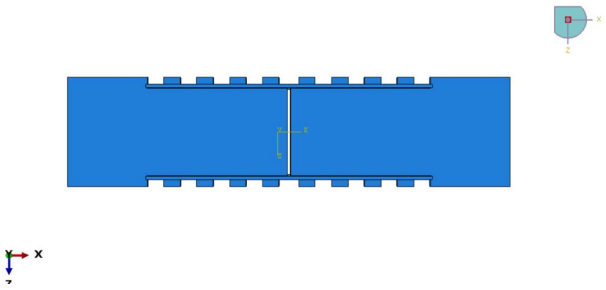


Fig. 3 Model of beam with dovetail; ISC 2

IV. FINITE ELEMENT ANALYSIS

The analysis of the model is conducted by using ABAQUS software. Displacement control mode is used to analyse the model. Finite element analysis is the process of solving differential equations numerically, which are arising from engineering and mathematical modelling. For the analysis of the non-linear FEA in Abaqus software, a three-dimensional model of the connection geometry was assembled. All parts were meshed using C3D8R hex elements. The one end of the intermeshed connection was fixed, and at the other end the force is applied. To model the contact behaviour and transfer of force between the flange teeth and the side plates, surface-to-surface contact with finite relative sliding was implemented using the general contact algorithm in Abaqus. The meshed model of ISC 1 and ISC 2 are shown in Fig.4 and Fig. 5 respectively. The boundary condition of ISC 1and ISC 2 are shown in Fig. 6 and Fig. 7 respectively.

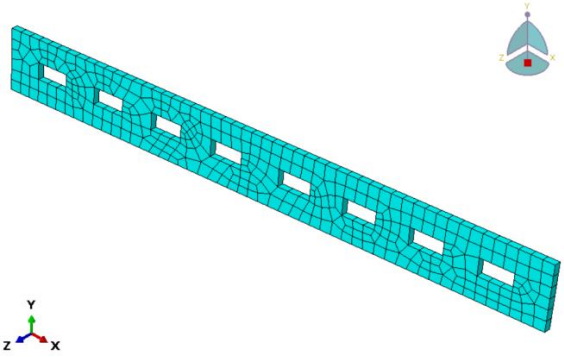


Fig. 4 Meshed model ISC 1

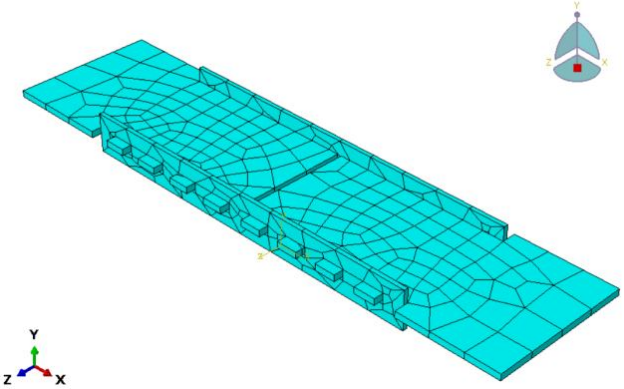


Fig. 5 Meshed model ISC 2

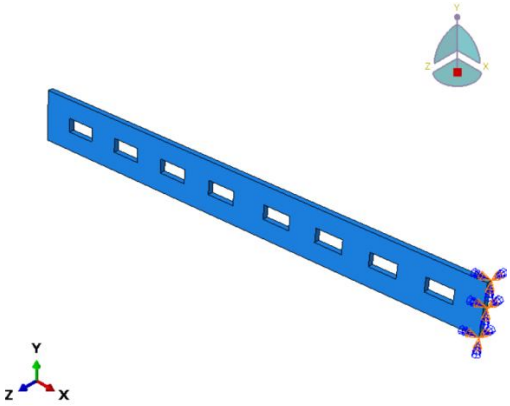


Fig. 6 Boundary condition ISC 1

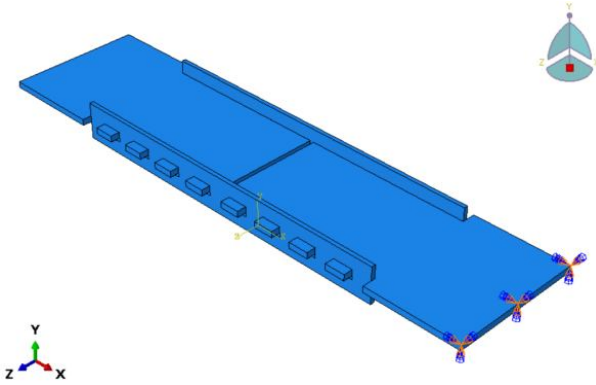


Fig. 7 Boundary condition ISC 2

The cyclic loading pattern is shown in Fig. 8. The cyclic displacement -controlled protocol was utilized for evaluating the performance of intermeshed connection. And also, the cyclic displacement protocol was applied to both ends by constraining the end nodes.to move only longitudinal direction without any rotation. The analysis result is shown in Fig. 9.

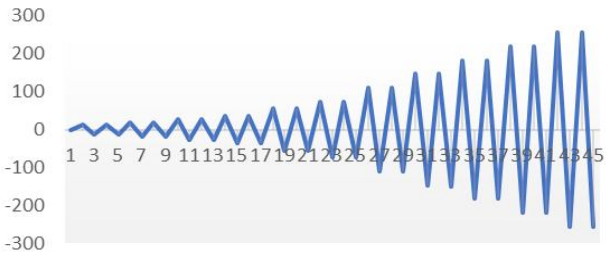


Fig. 8 Cyclic loading pattern

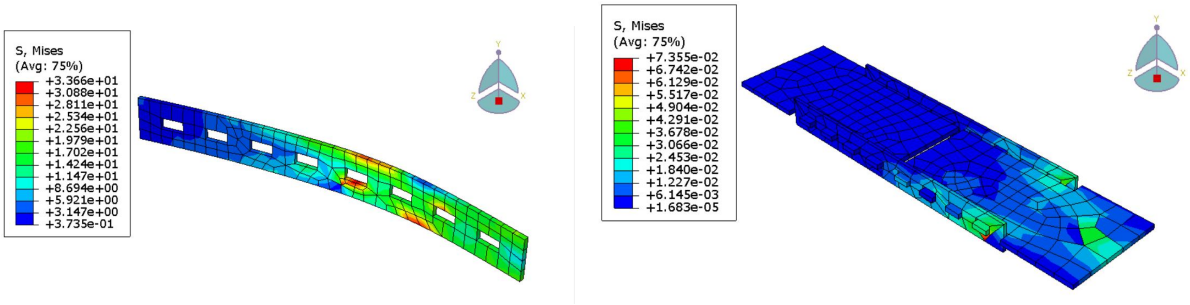


Fig. 9 Analysis results

V. CONCLUSIONS

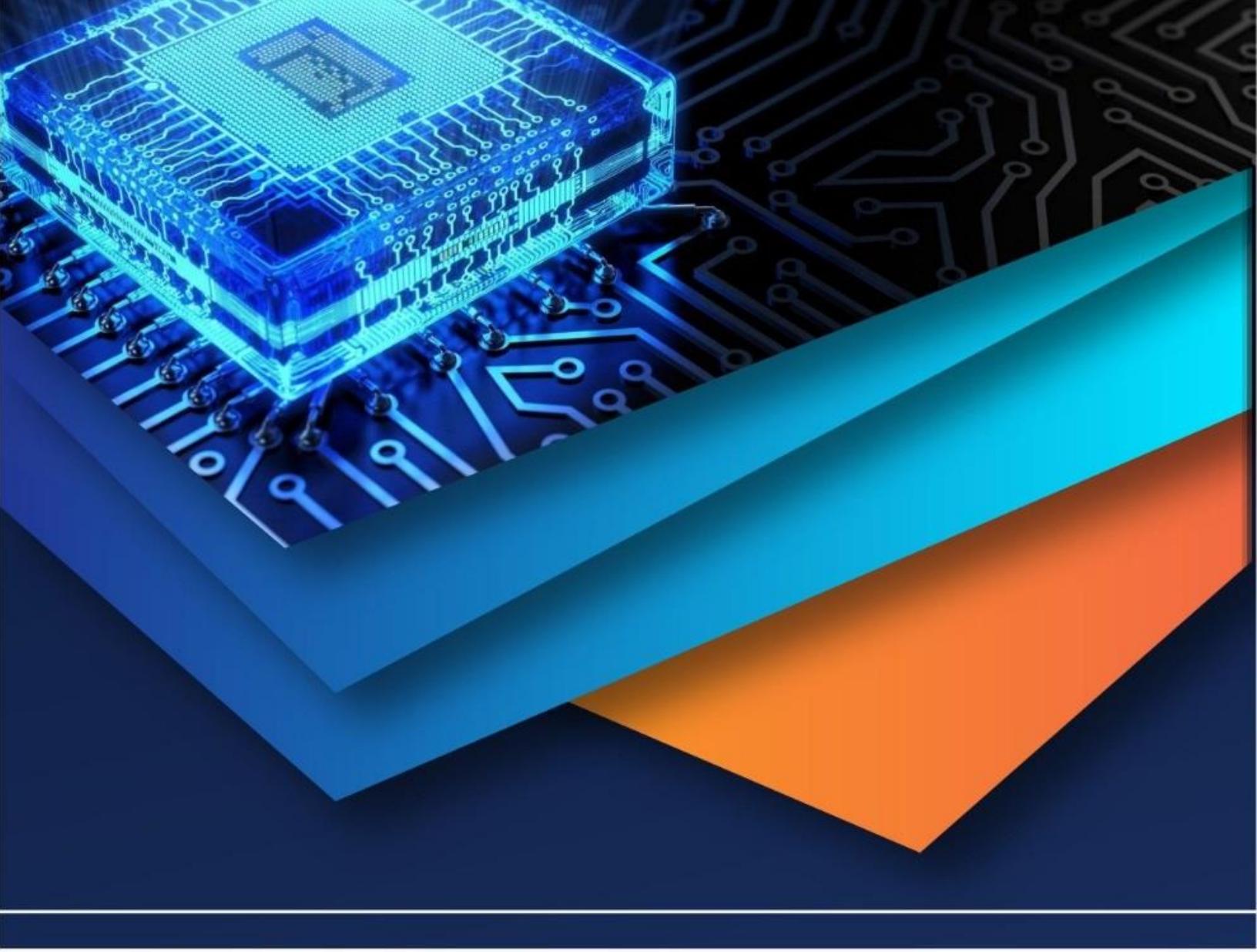
The intermeshed connections are the connections which are developed due to the evolution of new cutting technologies such as plasma cutting, laser cutting etc. The cyclic analysis is very important for finding out the performance of intermeshed connection. The stress obtained from cyclic analysis of dovetail is +3.366e+01, which shows that under cyclic loading the ISC 1 gives better performance. In the case of ISC 2 the stress value is less and it shows moderate performance. Intermeshed connection shows better load carrying capacity and ductility in cyclic analysis.

VI. ACKNOWLEDGMENT

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