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Studies on Behavior of welded Beam-Column Joints

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***Abstract:*-- 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 many advantages over bolting and riveting. A test program was carried out to investigate the behavior of welded beam-column joints such as unstiffened seated connection, stiffened seated connection and moment resisting connection under static loading condition. Finite element analysis was performed on beam column joint using ANSYS software and the analyzed results are validated with experimental results. It was observed that load carrying capacity and resilience of seated connection was more than that of other two types of connection. Modified ANSYS results for deflection were in close agreement with experimental results.**

***Keywords:* -- ANSYS, deflection, moment resisting connection, slope, stiffened seated connection, unstiffened seated connection.**

I. INTRODUCTION

Welding is the process of joining two pieces of metal by creating a strong metallurgical bond between them by heating or pressure or both. It is distinguished from other forms of mechanical connections, such as riveting or bolting, which are formed by friction or mechanical interlocking. It is one of the oldest and reliable methods of joining.

Welding offers many advantages over bolting and riveting. Welding enables direct transfer of stress between members eliminating gusset and splice plates necessary for bolted structures. Hence, the weight of the joint is minimum. In the case of tension members, the absence of holes improves the efficiency of the section. It involves less fabrication cost compared to other methods due to handling of fewer parts and elimination of operations like drilling, punching etc. and consequently less labour leading to less economy. Welding offers air tight and water tight joining and hence is ideal for oil storage tanks, ships etc. Welded structures also have a neat appearance and enable the connection of complicated shapes. Welded structures a more rigid compared to structures with riveted and bolted connections.

With the many types of connections available for construction, one of the decisive factors in the choice of a particular type of connection is economy, especially in high-rise steel buildings. One of the most common types of connections used in high-rise steel buildings is the moment-resisting beam-to-column connection.

Economy for field construction is the main factor in determining what types of the moment-resisting connections to be used. The fully-welded sections must be welded in the field including the expensive vertical welding. Furthermore, the quality control for welding is hard to achieve in the field. Whereas, the beam 'seats in the connection can be welded to the column in the fabrication shop and thus reduce the expensive vertical field welding to only horizontal groove welding for the flanges. The connection, which is flange welded only is even more appealing for field construction.

II. RELATED STUDIES

In recent years, a number of research works were carried out to study the behavior of semi-rigid connections. This section deals with the review of the works related to the semi-rigid connections.

John Parfitt and Jr Wai-Fah Chen (1974) investigated the various symmetrically-loaded moment-resisting beam to-column connections which are of extreme importance in design and construction of steel multi-story frames. This paper discusses the results of three specimens. In this report comparisons of items such as load-deflection, load-rotation, and stresses at various locations on- the three connections, are assumed.

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Kiyoshi Kaneta et al(1978) Assessed a seismic safety of welded structures subjected to destructive earthquake, based upon the concept of low cycle fatigue failure. This paper deals with the characteristics of low cycle fatigue of welded beams to column connections which were tested statically and dynamically under repeated loading conditions Sheng-Jin Chen (1996) Carried out experimental studies to compare between the behavior of sub-assemblages with high-strength bolted and welded joints. Therefore, this paper presents an experimental investigation on the cyclic behavior of the steel sub-assemblages with fully welded (FW) and high-strength bolted joints (TSD and DWA).

III. METHODOLOGY

A. *Procedure:*

The two beam section of ISMB 150 having the length of 650mm is connected on each side of the column of section ISMB150. The concentrated load is applied centrally at top of the column using a hydraulic jack and proving ring of 250kN capacity is provided. Three dial gages are placed. Two dials gages are placed at bottom of the beams at a distance of 70mm in order to measure the deflection and slope at a particular point and third dial gage is kept near the support at a distance of 150mm from support. Load is applied at an increment of 1.67kN up to the failure. Simultaneously the three dial gage readings are noted down. A schematic view of Beam- Column connection is shown in Fig 1. The obtained dial gages readings are used for further calculation, in order to obtain the required objectives. Similarly, the above procedure is repeated for all the three type of connections. Experimental set up of specimen is as shown in Fig 2. The failures of connections are shown in Fig 3. Fig4 and Fig 5 respectively.

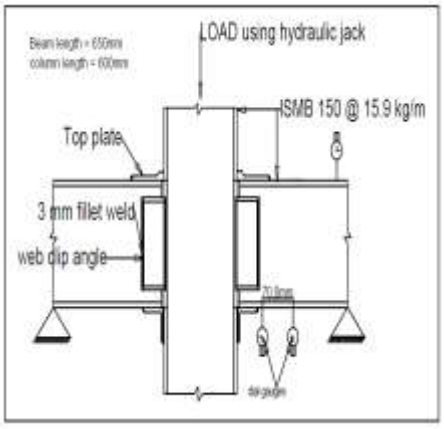

Fig.1. Schematic diagram of test setup

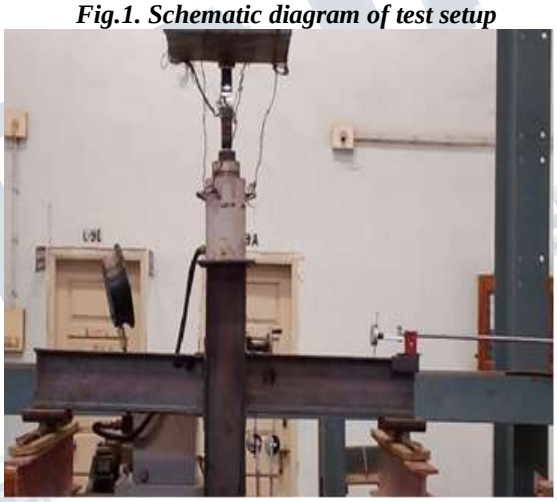

Fig.2. Experimental test setup

IV. RESULTS AND DISCUSSSION

A. Failure modes of Specimens:

i. Unstiffened Seated Connection:

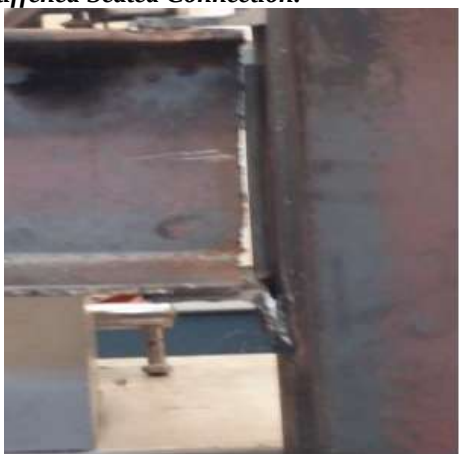

Fig.3. Failure of unstiffened seated connection

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ii. Stiffened Seated Connection:

Fig.4. Failure of stiffened seated connection

iii. Moment Resisting Connection:

Fig.5. Failure of moment resisting connection

B. Comparative study for ultimate load:

The theoretical and experimental values of the ultimate load for different types of joints are tabulated in table. The strength index which are taken as ration of experimental to the theoretical ultimate strength are also presented in Table1. It can be observed that strength index are less than 1. This may be attributed to change in the failure mechanism in the test specimen. For the moment resisting connection it is assumed that shear force is transmitted through the web clip angle in case of theoretical approach. But during experimental the failure occurred in the weld connecting stub angle to the column. Hence it can be concluded that in case of moment resisting connection shear transfer has to be done through seat angle only.

Specimen	Theoretical obtained strength In kN	Experimentally obtained strength in kN	Strength Index
Unstiffened Seated connection	18.06	15.04	0.83
Stiffened Seated connection	79.06	63.46	0.80
Moment Resisting connection	30.5	26.72	0.87

Table.1. Comparison of ultimate loads

C. Comparative study of deflection:

Stiffened seated connection has higher load carrying capacity compared to unstiffened seated and moment resisting connection. The area under load deflection curve is more for stiffened seated connection compared with unstiffened and moment resisting connection hence it has high resilience. Which is shown in Fig.6.

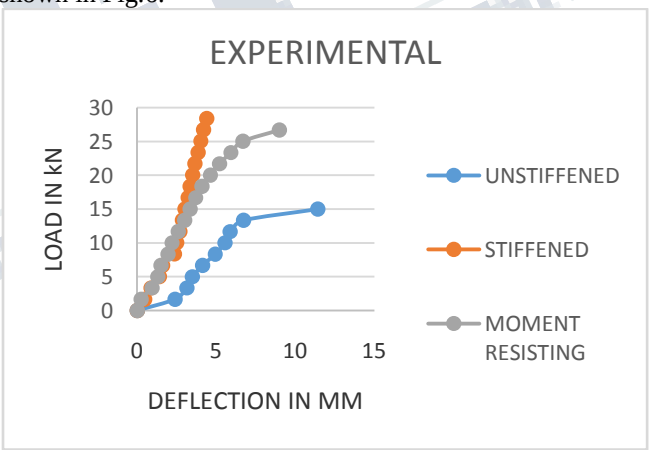

Fig.6. Load versus deflection curve

D. Comparative study of slope:

As load increases slope also for all the three connections. There is sudden drop in the slope near ultimate load for all the three connections.

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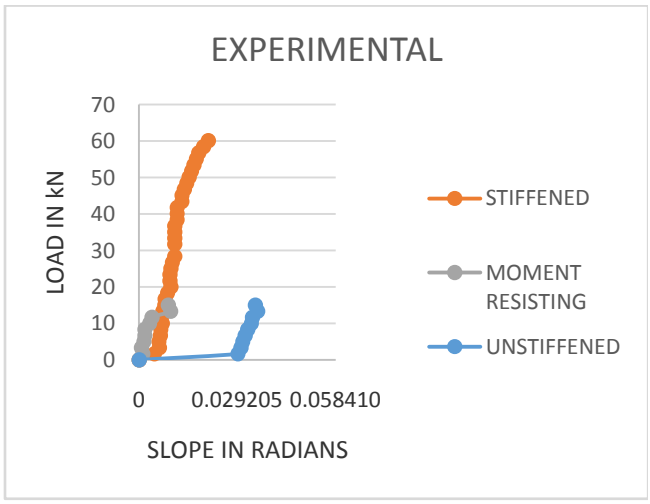

Fig 7 load versus slope curve

V. FINITE ELEMENT MODELING USING THE SOFTWARE ANSYS:

In the present study, rotation behavior of welded beam-column connection is studied numerically. As the members associated with the connection undergo large deformations and rotations, geometric and material non-linearity are to be accounted in the problem. Since all the experiments are performed under static loading condition, a static non-linear structural analysis is required for simulating the real problem. Conventional 3D brick elements are inadequate to represent the realistic contact behavior in the column-beam interface and weld-plate interface under incremental loading conditions. Contact problems can be efficiently handled with ANSYS.

Brick elements with 8 nodes, SOLID 45 available in the ANSYS element library, were used in the three dimensional modeling of beam, column angles and weld. The contact surfaces including the areas anticipated to be in contact were defined and paired using contact elements, CONTA174 and TARGE170. For structural steel used, the yield stress was taken as 250 N/mm2, ultimate tensile strength as 410 N/mm2. For Fillet weld, strength of weld is 172 N/mm2. The modulus of elasticity of steel was taken as 2×105 N/mm2. The column and beam members were modeled and free meshing was performed. Typical modelling and deformed shape of modelling are as shown in Fig 7 and Fig 8 respectively.

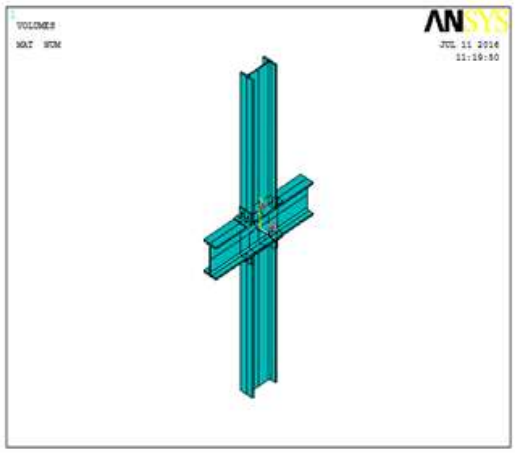

Fig.7. Ansys model of unstiffened connection

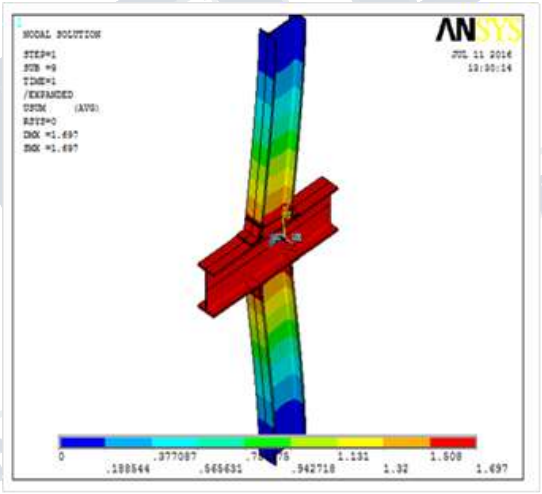

Fig.8. Deformed model

A. Comparative study between Experimental and ANSYS Results:

Due to limitation of link element ,gluing and degree of restrain there is a necessities of a modification factor for analytical results of deflection obtained from ANSYS .A multiplication of 3 was found to be satisfactory for moment resisting and stiffened seated beam –column joint whereas the corresponding values for unstiffened seated connection was found to be 7 .The load v/s deflection curves obtained from experimental results and modified ANSYS results for unstiffened ,stiffened seated and moment resisting connection are shown in Fig9,Fig10 and Fig 11 respectively.

i. Unstiffened seated connection

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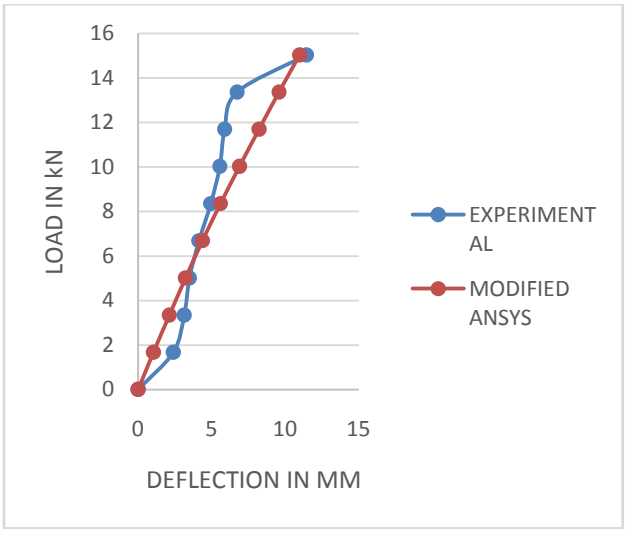

Fig.9. Load versus deflection curve

ii. Stiffened seated connection

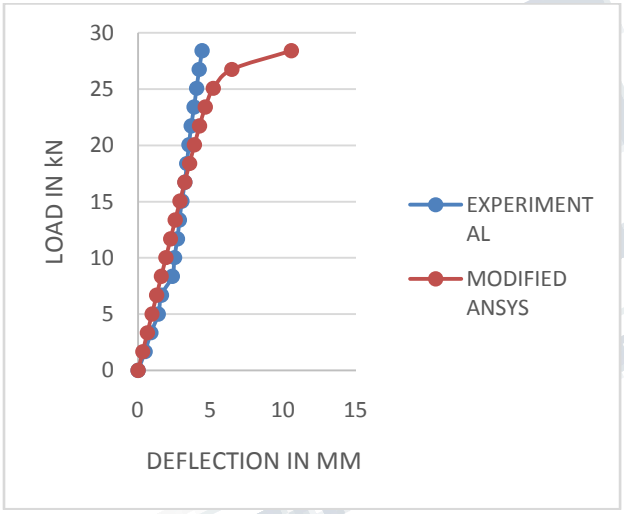

Fig.10. Load versus deflection curve

iii. Moment resisting connection:

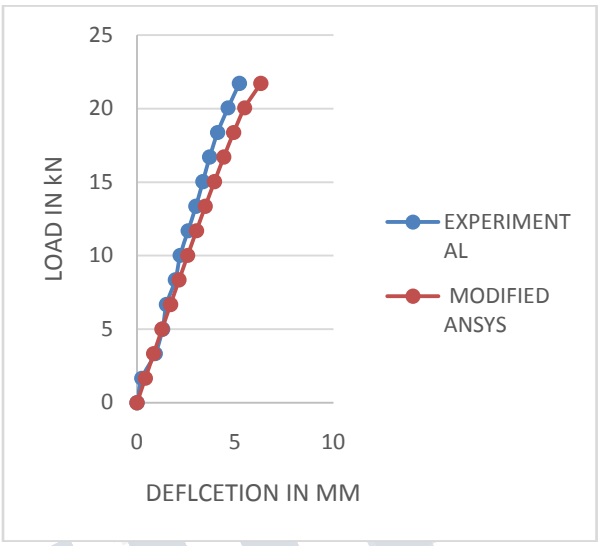

Fig.11. Load versus deflection curve

VI. CONCLUSIONS

Based on the experimental and analytical investigations conducted on welded steel beam-column joints, the following conclusions are drawn:

•Stiffened seated connection has more load carrying capacity when compared with unstiffened and moment resisting connections.

- ❖ It was observed that in moment resisting connection, the shear is transferred through seat angle. Hence it is recommended that seat Angle should be designed for shear instead of web clip angle.
- ❖ Resilience of stiffened seated connection is more than that of unstiffened seated and moment resisting connection
- ❖ Strength index unstiffened, stiffened seated and moment resisting connection were found to be slightly less than 1
- ❖ Moment resisting connection showed semi rigid behavior
- ❖ Finite element technique using ANSYS can be adopted for determining deflection values with a multiplication factor. The multiplication factor was found to be 3 for moment resisting connection and stiffened

seated connection and the corresponding value for unstiffened seated connection was found to be 7.

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