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"Comparative Study Between The Welded Joints And Bolted Joints For The Supporting Structure Of The Pressure Vessels"– A Review

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ABSTRACT

The primary purpose of this paper is giving the advantages of replacement of welded joints by bolted joint in supporting structure of pressure vessel. Here the limitations of welded joints in supporting structure of pressure vessel are explained. From extensive review of research papers it has been cleared that analysis of failure of bolted-bolted connections and welded-bolted connections were done. Also some work on bolted extended end plate connections was done. Diminutive work on bolting degradation in nuclear power plants for component support and pressure boundary applications was done. Modest work on safety evolution for bolting design of a transportable storage canister of spent nuclear fuels in nuclear power plant. Few work was done on creep in the bolting connections. Little work was done on novel aspects of finite element modelling of bolted steelwork connections in order to predict their load carrying behaviour and to calculate their limit loads. Also the methodology based on finite element modelling to develop analytically the moment-rotation relationship for a steel bolted end plate connection has been discussed.

In this literature review the study on the analysis of strength characteristics of supports of a pressure vessel has been discussed. This creates a scope for investigation of behaviour of the bolted supports and bolt spread pattens on stability of pressure vessel by using the finite element analysis.

Keywords – **bolted connections, supporting structure, pressure vessel.**

I. INTRODUCTION

Structural connections for the pressure vessel can be designed primarily as welded connections, however their stability is greatly affected in case of moment loading and they tend to buckle because of their rigid nature. Also the welding of stiffeners is very expensive and they cannot be dismantled. Hence it is not feasible to use them in portable pressure vessels. However the bolted endplate connections offer these flexibilities and they can withstand the local buckling. Also it is compulsory to use them in portable pressure vessels because they can be dismantled.

The deformations due to buckling can affect the load-carrying behaviour of supports significantly. The physical model of a connection in the sense of a macro element can be a spring representing a bending moment. Its properties are given by the moment versus rotation curves of the connection.

Typically, when moment is applied on a joint, it should not rotate, otherwise the alignment will be disturbed.

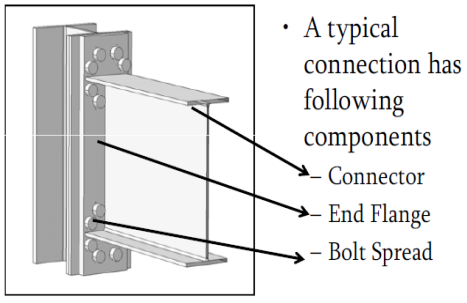
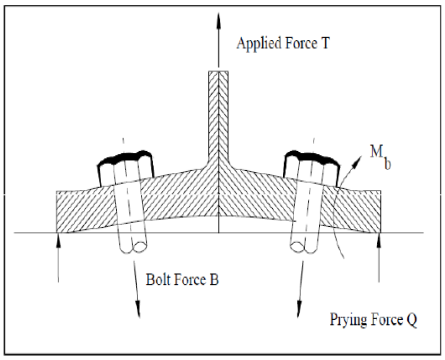


Fig1: a) components of bolted support

However practically some rotation is bound to occur. End plates (Flanges-fig. a) are typically not kept exactly flat as shown in fig.b but allow for a curvature at the centre, which allows for creation of moment reactions at bolts.



b) bolted connections resisting the moment

Hence the model which has the lowest rotation is the best model. This can be found by applying moment on a joint and checking the rotation due to the moment.

II. HYSTERESIS BEHAVIOUR OF SEMI-RIGID DOUBLE WEB ANGLE STEEL CONNECTIONS

Abolmaali et.al [1] presented the cyclic behavior of two types of semi-rigid double web angle connections namely the bolted-bolted (angles bolted to the beam web and column flange) and welded-bolted (angles welded to beam web and bolted to column flange), with their bolts pretensioned to the proof load. Twenty test specimens were prepared and cyclic load was applied to each test specimen using load control at the beginning cycles, which was converted to displacement control in subsequent cycles upon yielding of angles or bolts materials. The moment–rotation hysteresis loops and the failure modes for all the test cases are presented. The failure modes for bolted-bolted test specimens, depending on angle thickness, were either excessive rotation or beam web bearing, and for the welded-bolted specimens were excessive rotation or bolt fracture. The column flanges for each test specimen were selected such that they did not contribute to overall connection rotation. For bolted-bolted semi-rigid DWAC (Double Web Angle Connection), two failure modes were observed: excessive rotation due to yielding of the angle and beam web bearing failure. For welded-bolted DWAC, the moment–rotation hysteresis loops, showed significant ductility and pinching at higher load levels. The failure modes were: excessive yielding of angles and tensile failure of bolts, and the hysteresis loops were dissipative("fat loops").

III. PARAMETRIC ANALYSIS OF STEEL BOLTED END PLATE CONNECTIONS USING FINITE ELEMENT MODELING

Maggi et.al [2] presented and discussed results of parametric analyses on the behavior of bolted extended end plate connections using Finite Element (FE) modeling tools. The analyses were calibrated to experimental results that are also briefly reviewed in this paper. Comparisons between numerical and experimental data for moment-rotation curves, displacements of the end plate, and forces on bolts showed satisfactory agreement. Phenomenological T-stub failure models were also used for calculations of the flexural strength for the end plate. These models clearly support the numerical results and show how the interaction between the end plate and the bolts changes the connections' behavior. The results presented herein show that failures associated with either formation of yield lines in the plate or bolt tension failure are well-defined, while failures due to combinations of these mechanisms represent levels of interaction between the end plate and bolts that are difficult to predict accurately. The T-stub analogy has limitations in representing the yield lines.

IV. PREVENTION OF BOLTING DEGRADATION OR FAILURE IN PRESSURE BOUNDRY AND SUPPORT APPLICATIONS

Merrick et.al [3] discussed bolting degradation or failure experience in US commercial nuclear power plants for component support and pressure boundry applications. Mechanisms of general corrosion and stress corrosion cracking are described. Resolution of the safety concerns associated with bolting degradation is as per appropriate codes and standards. Since pressure boundry leaks create a reliability problem, the industry has chosen to focus research and training activities towards assuring tighter joints. The information presented in this paper provides a status report on the issues and will be helpful for utilities wanting to be now to effect improvements in bolting practices.

V. SAFETY EVOLUTION FOR BOLTING DESIGN OF A TRANSPORTABLE STORAGE CANISTER OF SPENT NUCLEAR FUELS

Sue-Ray Lin et.al. [5] performed safety evolution for bolting design of a transportable storage canister of spent nuclear fuels in a nuclear power plant. To develop the relative techniques for inter

unique transfer of the spent nuclear fuel, a seamless metal canister design with reopening function is adopted. The canister with bolting flange needs to maintain its seamless and structural integrity under normal operation and postulated accident conditions. For bolting design, the requirements on material and structural strength are completely examined by ASME boiler and pressure vessels codes. All calculations in this work are performed by using the commercial finite element analysis software, ANSYS. The structural functions and safety of a transportable storage canister with new bolting design has been shown.

VI. On the use of plate theory to evaluate the load relaxation in the bolted flanged joints subjected to creep

Akli Nechache, et.al [6] discussed the effect of load relaxation due to creep has a major impact on the tightness of bolted flanged joints. Several leak incidents have been reported in the petrochemical and nuclear power plants related to creep. It is clear that the current flange design code does not address adequately the effect of high temperature on the mechanical and leakage integrities of bolted flange joints used in pairs or with blind cover pates. In this paper they have compared theoretical results with 3D FEM results and concluded that the cover plates are more rigid and are subjected too much lower stress than annular rings.

VII. Design model for bolted moment end plate connections joining rectangular hollow sections using eight bolts

Andrew wheeler et.al [7] reported a model for determination of serviceability and ultimate moment capacities if bolted moment end plate connections utilizing rectangular hollow sections joined with eight bolts was presented. The connection configuration was such that two bolts are located above each of the flanges and besides each of the webs. The model considers the combine effect of prying action due to flexible end plates, the formation of yield lines in the end plates, and failures due to punching shear and beam section failure. The model was calibrated and validated using experimental data from test program. The design model constitutes a relatively simple method for predicting the serviceability and ultimate moment capacities for the particular type bolted moment end plate connection was described.

VIII. On the numerical analysis of end plate connections

Norbert Gebbeken et.al [8] presented novel aspects of finite element modeling of bolted steelwork connections in order to predict their load carrying behaviour and to calculate their limit loads. Parametric studies with respect to various geometric parameters have been carried out in order to determine their influence on the flexibility of the connection. The samples studied were extended end plate connections as used in beam to beam or beam to column connections bolted by pretension high-strength screws. The emphasis was given to the consideration of material non linearity to the contact between deformable members and to accurate finite element modeling.

IX. Computer modeling of an extended end-plate bolted connections

Bahaari et.al [9] discussed a methodology based on finite element modeling, to develop analytically the moment-rotation relationship for a steel bolted end plate connection. The end plate, beam and column flanges, web and bolt shank in the tension region were represented as plane stress elements with their width equal to their thickness measured perpendicular to the web. ANSYS was used for 2D analysis. Based on deformation and stress contours of 2D model the two types of end plate deformations were identified. Out of which one is in thin flange and other is in thick flange. In thin end-plate connection, the restraint created by web causes non-negligible dissymmetry with respect to beam tension flange, both of the plate deformation and the stress-state of the plate and bolts. While in the thick end-plate connection web effect is negligible except for loads greater than 85-90% of ultimate strength of the connections and shows the relative symmetry with respect to beam tension flange.

X. Conclusion

Up till now in pressure vessels, Welded joint is proffered for connections in the support structures. The welded joints are not good enough moment loading and tend to have local buckling, damaging the stability of structure. The rigid nature of the weld prevents progressive yielding, and the local zone reaches the brittle zone and causes local buckling

failure. So it is necessary to replace the welded joints by bolted joints. The bolted endplate connections offers dismantling and portability of pressure vessels and they can withstand the local buckling.

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