SEMI-RIGID STEEL CONNECTIONS – AN OVERVIEW

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1. INTRODUCTION

The objective of the study is to present an overview of the actual behavior of steel connections and to make a brief comparative study on various design codes that provide guidelines on how to incorporate the semirigid behavior in design.

Many Steel Civil Engineering structures are usually composed of straight slender bars, arranged in various configurations and fastened together by structural connections. Bolted connections have now become one of the most popular methods of connecting members due to the reduced cost in fabrication, the speedy site erection and, since site welded connections require special care/inspection and temporary erection techniques. Further, research has shown that approximately 50% of the total cost of steel structures can be directly related to the type of connection[1)].

2. BEHAVIOUR OF SEMI-RIGID CONNECTIONS

Conventional analysis and design of Steel structures is usually carried out under the assumption that the connection between the beam-to-the-column is either fully rigid or ideally pinned. Rigid connections theoretically allow no relative rotation at beam ends and also transfer 100% of the moment. Pinned connections are assumed to allow the beam end to substantially rotate freely and offer negligible transfer of moments. Evidently, experimental observations carried out by various researchers have shown that most beam-to-column connections used in current practice possess intermediate stiffness, i.e. Semi-Rigid behavior. A semi-rigid connection can transfer vertical shear and also have the capacity to transfer some moments. Typically a semi-rigid connection moment-rotation curve (Fig 1) is Nonlinear and inelastic over virtually the entire loading range. The unloading curve is parallel to the initial stiffness. The semi-rigid characteristic of a connection significantly influences all the important design criteria, namely the distribution of internal forces and moments in the frame structure, the sway, the deflection, the collapse mode and the effectively length of a column. The main factors limiting the practical application of the concept of semi-rigid behavior are the lack of a broad available database of connection behavior and the difficulty in accurately and rigorously analysis.

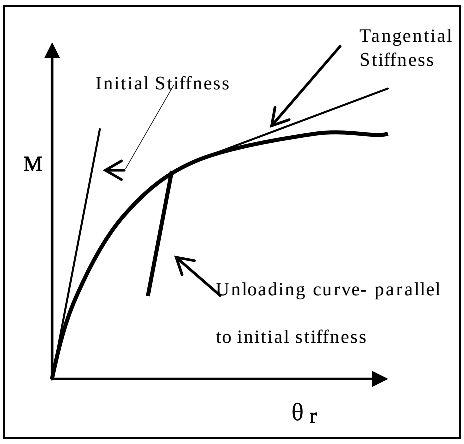

Fig 1 Typical Moment-Rotation Curve

3. CURRENT CONNECTIONS 'DESIGN PRACTICES'

3.1 Eurocode 3 Part 1-8 'Joints'

The Eurocode 3 (EC 3) provides rules for defining the structural behavior of joints in terms of strength (moment capacity), stiffness (rotational stiffness) and deformation capacity (rotational capacity). EC 3 gives three possible sets of design assumptions for analyzing structural frames namely; Simple framing (all joints are pinned & the structure is fully braced),

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Continuous framing (all joints rigid -elastic design or full strength -plastic design) and Semi continuous framing (take the real stiffness & strength of joint into account) [2]. The appropriate type of joint model should be determined depending on the joint classification and the chosen method of analysis as shown in table 1 below:

Method of Global Analysis	Classification of joint		
Elastic	Pin	Rigid (R)	SR
Rigid-Plastic	Pin	FS	PS
Elastic-Plastic	Pin	R & FS	SR & PS SR & FS R & PS
Type of Joint model	**Simple**	**Continuous**	**Semi-Cont**

Table 1 Type of joint model

SR-Semirigid, **FS**-Full strength, **PS**-Partial Strength

EC3 proposes a classification of connection since in engineering practice it is important to know in what cases the connections are assumed to be semirigid or otherwise.

The code defines boundaries that are used for classification of joints on the basis of strength (i.e. by comparing the joint's design moment resistance to the connecting member's) and stiffness (i.e. by comparing the initial rotational stiffness of the joint to stiffness of the member).

In the Code the structural property of the joint is composed out of the structural behavior of all relevant components that make up the joint for H and I sections.

3.2 American Institute of Steel Construction AISC LRFD Specifications

Realizing the potential implication of connections on frame design, AISC LRFD has introduced provisions to allow the explicit behaviour of connections in design. Depending on the amount of resistance to change of the original angle between intersecting members when loads are applied- LRFD spec. (A2) classifies connections as being fully restrained (Type FR) and partially restrained (Type PR). A semi-rigid connection is a Type PR connection whose resistance to angle change falls somewhere between simple and rigid type. The spec provides for Type PR construction only in broad principals for analysis and design, therefore its left for the Engineer to implement the principals in a quantitative manner. One factor that keeps the designer from taking advantage of semi-rigid connection more often is the LRFD specification (section A2), which states the consideration of a connection as semi-rigid only upon presentation of evidence of its resistance. The evidence must consist of documentation in the technical literature, or must be established by analytical or empirical means[3] .

4. CONCLUSION

Within the guidelines of the design code, the structural properties of the connection (joint) can now be incorporated in the form of an appropriate mathematical form into design on the same priority level as those of columns and beams so as to improve the model of the frame during analysis and design.

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