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A study on cover plate design and monopole strengthening application

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ABSTRACT

To ensure that the cover plate will act with the existing member as a unit for structural strengthening, mechanic bases of cover plate design that need to be understood include the relationship between the shear stress flow, which determines the intermediate connections, and the bending stress of the reinforcing plate, which controls the end connection, the tension/compression strength of cover plate, the strength adequacy of end termination, the fatigue strength of end connection, etc. However, not much analytical study on these mechanic bases of cover plate design has been seen in either text books or technical articles. Inadequate comprehension of these mechanic bases of cover plate design is causing controversial interpretation of the design code specifications during the engineering practices, and some questionable designs have been observed. In addition to in-depth discussion of miscellaneous issues of cover plate design, this work presents a study of the mechanic bases of cover plate for structural strengthening. The cover plate reinforcement design for monopole is different from those for beams and stringers due to its distinctive structural and loading properties. Telecommunication industry standard TIA-222 does not address these issues so far. This paper reviews and discusses the most critical issues of cover plate design of beams and stringers, and addresses the monopole cover plate reinforcement design in detail. Rigorous design recommendations are proposed and discussed thoroughly based on the analytical investigation.

1. Introduction

Cover plate is widely used in the reinforcement of bridge stringers and steel building beams. Of late, cover plate is seen being widely used in the reinforcement of monopoles in the telecommunication industry. Fig. 1 shows (a) the reinforcement of the bottom flange of a built-up girder using welded cover plate and (b) the flexural strength enhancement of a monopole using welded cover plate. There are two types of cover plates based on its length relative to the length of the member to be reinforced. A cover plate that runs the entire length of the member to be reinforced is called full length cover plate; one that spans only partial length of the member with offsets from the supports is called partial length cover plate. Fig. 2 shows the diagrams of typical partial length cover plate for simply supported wide flange beam: (a) beam and cover plate, (b) bending moment and capacity, and (c) cover plate sizing. Theoretical ends of cover plate are at the sections where the required strength by loading is exactly equal to the available strength of the flexural member without any reinforcement. Terminal distance is the distance from the theoretical end to the cutoff point, the actual end of the cover plate. When the bending strength is not adequate, wide flange beams can be reinforced using cover plates. The connection can be either welded or bolted. Specifications of cover plate design for steel building components can be found in Section F13.3 of AISC Specification [1]. Composite bridge stringer may be reinforced using cover plate also. The bridge stringer is mostly designed as composite section, utilizing concrete to resist compression and steel to resist tension. The cover plate for stringer is a separate plate welded or bolted to the bottom flange of a stringer section as shown in Fig. 1(a). When the section does not have enough bending strength, attaching a cover plate is a way to beef up the section bending strength. The code requirement of cover plate for bridge stringer is specified in Section 10.13 of AASHTO Specification [2]. More detailed coverage on the highway bridge cover plate design can be found in Tonias [3]. Besides using cover plate, there are some other reinforcing schemes for stringer strengthening. Chen and Duan [4] reviewed some applications of bridge reinforcement using flat plate, angle, and T section.

Due to the co-location requirement and/or the system upgrade of tenants, the telecommunication tower's structural capacity needs to be checked before any proposed loading can be installed. When the capacity is exceeded due to proposed loading, but still within the range of feasible strengthening, the tower is always economically favored to be reinforced over drop and swap with a new tower. Besides loading increase, the tower may need to be

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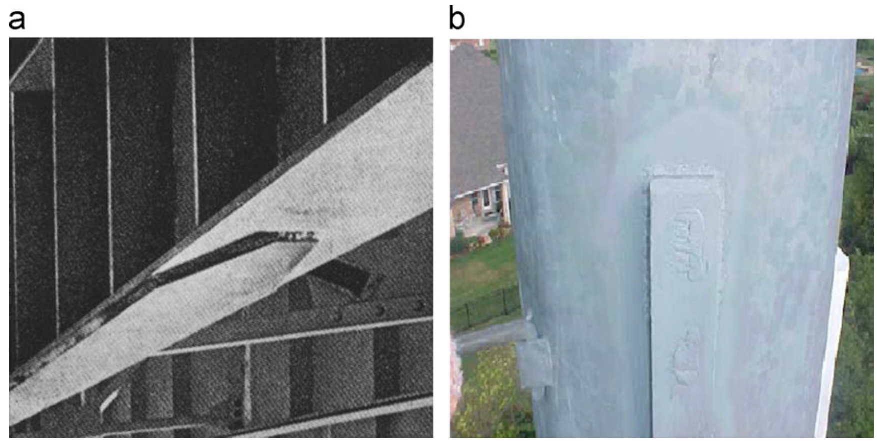

Fig. 1. Cover plate application in flexural member strengthening. (a) Cover plate for stringer (beam) strengthening and (b) cover plate for monopole strengthening.

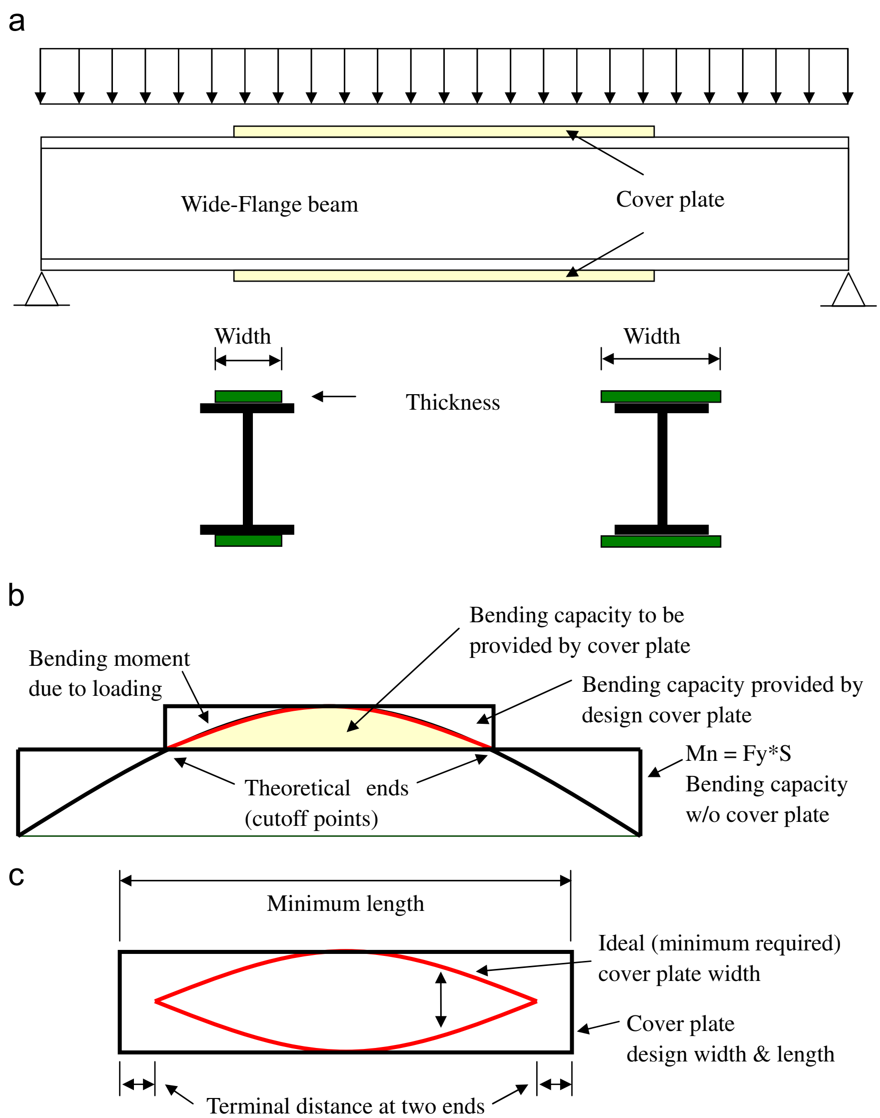

Fig. 2. Cover plate reinforcement of typical flexural member in buildings and bridges. (a) Beam and cover plate, (b) bending moment and capacity, and (c) cover plate sizing.

reinforced because of stricter tower structural integrity requirement. Certain amounts of towers were constructed decades before and their original design was completed and constructed according to telecommunication industry standard TIA/EIA-222-F [5] or even earlier versions. For simplicity, TIA/EIA-222-F and ANSI/TIA-222-G [6] will be referred as TIA-Rev. F and TIA-Rev. G, respectively. Since the publication of TIA-Rev. G, more and more states and local jurisdictions start to adopt TIA-Rev. G as the