Oct 23rd, 12:00 AM

New Standards for Cold-formed Steel Deck with Concrete

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Tenth International Specialty Conference on Cold-formed Steel Structures
St. Louis, Missouri, U.S.A., October 23-24, 1990

NEW STANDARDS FOR COLD-FORMED STEEL DECK WITH CONCRETE

by Max L. Porter[1]

INTRODUCTION

The current standard "Specifications for the Design and Construction of Composite Slabs" (Ref. No. 1), was published by the American Society of Civil Engineers (ASCE), in 1985 and approved by the ASCE standards process in 1984. This current standard is being revised, updated and divided into three new standards dealing with cold-formed steel decking used for composite floor slabs.

The three new standards are:

- Standard for the Structural Design of Composite Slabs,
- Standard Specifications for the Construction and Inspection of Composite Slabs, and
- Standard for the Design of Steel Deck with Concrete Diaphragm Slabs

The first two of these standards have been approved by the Steel Deck with Concrete Standards Committee and are set for public ballot during the summer of 1990. The third one is in its development stages and should be ready for its first committee balloting next year. All three of these standards utilize cold-formed steel decking with first two standards being applied to composite floor slabs.

The purpose of this paper is to discuss the highlights of these three proposed standards as they have been approved by the committee at the time of writing of this paper. The public ballot is anticipated to be completed by the time of the 10th International Specialty Conference on Cold-Formed Steel Structures. Since possible changes could occur on the public ballot, the comments in this summary paper should be checked against the final printed version prior to utilization. For sake of brevity the three standards will be referred to in this paper as:

- Design Standard
- Construction and Inspection Standard, and
- Diaphgram Slab Standard.

Design Standard

Many changes have been promulgated in the proposed ASCE Design Standard ("Standard for the Structural Design of Composite Slabs"). Some of the more noteworthy of these changes will be discussed in the comments contained in this section of this paper.

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One of the proposed noteworthy changes involves the use of polypropylene or steel fiber-reinforced concrete. This application would be in the section for control of shrinkage and temperature effects. The current proposed standard calls for the use of polypropylene or steel fiber-reinforced concrete to be in accordance with ASTM C1116 "Standard Specifications for Fiber-Reinforced Concrete and Shotcrete" (Ref. No. 2). The quantity consists of 0.1% by volume of fibers in the concrete mixture in accordance with the manufacturer's recommendations. The current design standard will remain in effect for the utilization of welded wire fabric for control of shinkage and temperature effects. The new change allows for the alternative of the fiber-reinforced concrete.

The new design standard will continue to utilize strength design principles based upon load factors and capacity reduction factors. However, all of these factors will be changed in accordance with the new load factors being included in the ASCE 7 (formerly the ANSI A58.2) (Ref. No. 3). The new load factors are for example 1.2 x dead load plus 1.6 x live load for the design factored load. The combination of the load factors and phi factors still results in approximately the same total strength of the system as before. The change in the load factors to comply with the new minimum loads standard necessitated a corresponding change in the capacity reduction factors.

Another very significant change to the design standard has been the incorporation of an alternative equation evaluation for cold-formed steel deck systems. The background equations and the preliminary equations leading to the alternative set of design standard equations was presented by L. Luttrell at the 8th Cold Formed Conference (Ref. No. 4). This procedure has been strictly limited to decks of a certain configuration with angles of the web or the inclined section within a given angle.

The alternate equation evaluation provides for the bending moment capacity based upon a limiting shear force transfer. The alternate procedure is contained in an appendix and has several limitations before it can be used. The method is limited to embossed deck having three types of embossment patterns with an embossment height between 0.035 and 0.105 inches (0.89 and 7.67 mm). The provisions are for only galvanized deck. The web angle (angle between horizontal and the inclined vertical of the corrugated cell) is limited to values between 55° and 90° and these webs shall not contain any re-entrant bends. The depth of the cell section is limited to 3 in. (76.2 mm) or less and the cell width spacing cannot exceed 12 in. (0.3 m).

The primary application of this alternative equation evaluation is for studies including new deck sections of embossed deck meeting the limitations. Currently, there are 119 deck sections representing 13 manufacturers on the market. Thus, marketability of any proposed new section is important and can be done with this alternate equation. Any deck sections evaluated by this new alternative procedure must also be tested by confirmatory tests as described in the Standard.

New provisions for handling concentrated loads have been under study by the Steel Deck with Concrete Standards Committee. These provisions were generally divided into criteria for smaller concentrated loads and those for larger concentrated loads. At the time of writing of this paper, these provisions were not finalized and will probably be contained in the Commentary for this edition

of the Design Standard. A task group will work further on this during the summer of 1990.

A study by W. Lamport and M. Porter (Ref. Nos. 5 and 6) provided for new equation formulations for deflection calculations of composite steel-deck-reinforced one-way slabs. These equations were limited to depths of the steel deck section to 3 in. (76.2 mm) or less. The equations were based on a study conducted at Iowa State University on specimens ranging in length between 6 ft. (1.83 m) and 17 ft. (5.18 m). The results indicated that the new equations provided an improvement of an average of 26 percent in more correctly predicting the deflection of service loads over the simple equation utilizing an average of uncracked and cracked moments of inertia as currently used in the previous Standard (1).

In fact, for the longer span specimens, the new equations gave an improvement of 46 percent over the current criteria. The current criteria also gave values on the unconservative side, i.e. the current calculations underestimate the measured deflections. The standards committee decided to insert these new suggested equations in the Commentary as a means of comparing computed versus measured primarily as applied to experimental tests with roller or pin reaction supports.

CONSTRUCTION AND INSPECTION STANDARD

The second standard entitled "Standard Specifications for the Construction and Inspection of Composite Slabs" consists of many of the provisions taken from the current Standard (1) and revised with several additions. Most of the changes or additions fall into the following four categories:

- construction practice,
- materials,
- holes and openings, and
- inspection procedures.

Examples of construction practice provisions include damage control, connections, welding, mechanical fasteners, and working platform provisions. Examples of provisions on materials include sections on steel deck, concrete, and tolerances. A detailed appendix has been added on how to measure and define the correct measurements for the various tolerances needed. For example, the current locations for measurements for height of embossment and lengths are shown in the new appendix on measurements.

The provisions for holes in steel deck slabs have been refined into criteria for small openings versus the larger ones. Smaller openings shall be formed or formed and reinforced as approved by the project engineer. Larger openings shall be structurally framed or formed and reinforced.

Diaphragm Standard

The third standard is in its draft stages and includes criteria for design of steel deck slabs for diaphragm or in-plane shear forces. This Standard,

unlike the first two standards discussed, will probably allow for cases involving noncomposite deck with concrete fill as well as those cases for composite floor slabs used as diaphragms.

The strength provisions focus around the diagonal shear capacity of the concrete as the primary mode of failure to satisfy. The next failure mode involves checking the edge connectors. The edge connectors are usually studs. If studs are not used, then the shear-transfer mode of failure must also be satisfied.

This third standard has been delayed due to the concentration by the committee on the first two standards. However, the design criteria for this standard, once available, should be very important for buildings subjected to lateral loads such as from wind or earthquake. An initial draft of the stiffness and strength provisions was drafted by M. L. Porter based upon the findings contained in a final report to NSF shown in Ref. 7. These provisions were a bit too complex for routine design and are being somewhat simplified by this committee. A task committee is scheduled to pursue this draft for submittal to the committee during the summer of 1990. The full committee should be able to devote more attention to this third Standard on diaphragm slabs once the first two standards have passed public ballot.

Summary & Conclusions

The current Standard by the American Society of Civil Engineers entitled "Specifications for the Design and Construction of Composite Slabs is being revised, updated, and divided into three standards, namely:

- "Standard for the Structural Design of Composite Slabs",
- "Standard Specifications for the Construction and Inspection of Composite Slabs", and
- "Standard for the Design of Steel Deck with Concrete Diaphragm Slabs".

The first two of these Standards are scheduled for public ballot during the summer of 1990, with anticipated publication soon after. The third standard should be ready for first committee ballot next year. These three standards provide design and construction provisions for the use of cold-formed steel deck with concrete.

Appendix - References

1. Steel Deck with Concrete Standards Committee, "Specifications for the Design and Construction of Composite Slabs", American Society of Civil Engineering, New York, NY, 1985.

2. Annual Book of ASTM Standards - ASTMC1116, American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania, 1989.

3. Minimum Design Loads for Buildings and Other Structures, ASCE 7-88, American Society of Civil Engineers, (formerly, American National Standards Institute, Inc. (A58.1-1982)), New York, NY 10017-2398.

4. L. D. Luttrell, "Methods for Predicting Strength in Composite Slabs", 8th International Specialty Conference on Cold-Formed Steel Structures, University of Missouri-Rolla, November 11-12, 1986.

5. Lamport, W. and Porter, M. L., "Deflection Predictions for Composite Steel Deck Slabs", paper accepted for publication in the Journal of the American Concrete Institute, American Concrete Institute, Detroit, Michigan, 1990.

6. Lamport, W., "An Analysis of Instantaneous Deflections in Composite Cold-Formed Steel Deck Systems", thesis submitted in partial fulfillment of M.S. degree, Iowa State University, Ames, Iowa, 1984.

7. Porter, M. L., Easterling, W. S., "Behavior, Analysis, and Design of Steel-Deck-Reinforced Concrete Diaphragms", Final Report submitted to National Science Foundation, College of Engineering, Iowa State University, Ames, IA, March 1988.