HBRC Journal (2015) **11**, 57–67

Housing and Building National Research Center

HBRC Journal

http://ees.elsevier.com/hbrcj

Assessment of vehicular live load and load factors for design of short-span bridges according to the new Egyptian Code

Hatem M. Seliem [*], **Mostafa Eid**, **Alaa G. Sherif**

Faculty of Engineering at Mataria, Helwan University, Egypt

Received 2 January 2014; accepted 24 February 2014

KEYWORDS

Vehicular live load;
Bridges;
Short-span;
Egyptian code;
Evaluation;
Live load–dead load ratio

Abstract The new Egyptian Code (ECP-201:2012) introduces new vehicular live loads (VLL) and new load combinations for the design of roadway bridges. The new VLL and load combinations introduced in ECP-201:2012 are fundamentally different than those presented in previous versions of the code. The impact of these new loads and load combinations on the design of new bridges or the structural safety of the existing bridges that have been designed according to ECP-201:2003 or ECP-201:1993 has not been fully addressed for the different bridge deck systems. Three different bridge deck systems, i.e. concrete I-shaped girders, composite steel plate girders, and concrete box-girders with different spans were numerically modeled using two-dimensional grillage analogy. The bridge decks were analyzed under main gravity loads using VLL according to ECP-201:2012 and ECP-201:2003. The internal forces of individual load cases, total un-factored load combination, and total factored load combination of ECP-201:2012 and ECP-201:2003 were compared.

The study shows that concrete box-girders designed according to ECP-201:2012 and ECP-201:2003 using the ultimate limit state method yield almost the same demand. Despite the increase in the VLL of ECP-201:2012, and consequently the live load forces, concrete I-shaped girder bridges will be subjected to less total factored internal forces in comparison to ECP-201:2003 This is attributed to the interaction between the live to dead loads ratio and the load combinations. Design of composite steel plate girder bridges according to ECP-201:2012 using the allowable stress design method yields over designed sections.

Introduction

General

The new version of the Egyptian Code of Practice (ECP) for Calculation of Loads and Forces in Structural and Masonry Works (ECP-201) that was published in 2012

---

[*] Corresponding author. Tel.: +20 1222249926.
E-mail address: hmseliem@gmail.com (H.M. Seliem).

Peer review under responsibility of Housing and Building National Research Center.

Production and hosting by Elsevier

1687-4048 © 2014 Production and hosting by Elsevier B.V. on behalf of Housing and Building National Research Center.
http://dx.doi.org/10.1016/j.hbrcj.2014.02.009

(ECP-201:2012) [1] introduced a new vehicular live load (VLL) for the design of roadway bridges. In addition, ECP-201:2012 presented new load combinations and new load factors to be used along with the new VLL. The VLL and load combinations used in ECP-201:2012 are fundamentally different from those used in previous versions of the code, ECP-201:2003 [2]. The new VLL of ECP-201:2012 is based on the traffic loads on bridges of the Eurocode (EN 1991-2:2003) [3]. ECP-201:2012 can be used for the design of conventional bridges, e.g. beam-slab bridges, box bridges, and truss bridges, with simply supported or continuous spans system and with a maximum span of 150 m. In other words, ECP-2013:2012 is applicable where small deflection theory can be justified. Bridges where large deflection theory has to be used, e.g. suspension bridges, cable-stayed bridges, are beyond the scope of the ECP-201:2012. Therefore, ECP-201:2012 is intended for the analysis and design of short- and medium-span bridges. The impact of the new VLL and load combinations of ECP-201:2012 on the design of new bridges, as well as the safety of the existing bridges that have been designed according to ECP-201:2003 has not been fully addressed for the different bridge deck systems.

Earlier study, [4] compared the earlier version of ECP-201 to other international codes for medium and long span bridges. Recent studies [5,6] have compared the loads of ECP-201:2012 to ECP-201:2003 as well as other international codes. It is worth noting that ECP-201:2012 was first drafted in 2008. The study was limited to concrete rectangular girders with cast-in-place slab as the bridge deck system with different spans. The study investigated the girders spacing, moment of inertia, and cross diaphragms. However, the size of the rectangular girders was kept constant despite the change in span or girders spacing. The study highlighted the impact of each parameter on live load internal forces. In addition, the study concluded that live load internal forces of ECP-201:2012 are identical to those of EN-1991-2:2003 [3] and which are also more than those produced by ECP-201:2003.

Scope

This paper presents the impact of the ECP-201:2012 VLL models and load combinations on the design of different bridge deck systems with variable spans under main gravity loads. The different bridge deck systems investigated in this study are concrete I-shaped girders, composite steel plate girders, and concrete box-girders. Furthermore, the internal forces according to ECP-201:2012 and ECP-201:2003 were compared and evaluated. The design of bridge decks under laterally induced loads from wind pressures or seismic actions is outside the scope of this paper.

Vehicular live load of ECP-201

Ecp-2013:2012

ECP-201:2012 defines three different load models, namely Load Model 1 (LM1), Load Model 2 (LM2), and Load Model 3 (LM3). LM1 shall be used for the design of the different elements of the substructure and superstructure, except for bridge deck slabs. LM2 shall be used solely for the design of bridge deck slabs, whilst LM3 shall be used for pedestrian bridges only.

LM1 consists of a combination of concentrated loads and uniformly distributed loads. The clear roadway of the bridge is divided into a number of lanes; with a lane width of 3.0 m. the contact area of all wheels used for LM1 is 400 × 400 mm. The loads for the different lanes including the dynamic impact factor are as follows and as shown in Fig. 1:

1. Lane 1 load comprises a two-axle, 600 kN truck with four wheels (wheel load = 150 kN). Additional to the truck load, a uniform load of 9.0 kN/m^2 is to be applied to the total area of lane.
2. Lane 2 load comprises a two-axle, 400 kN truck with four wheels (wheel load = 100 kN). Additional to the truck load, a uniform load of 2.5 kN/m^2 is to be applied to the total area of lane.
3. Lane 3 load comprises a two-axle, 200 kN truck with four wheels (wheel load = 50 kN). Additional to the truck load, a uniform load of 2.5 kN/m^2 is to be applied to the total area of lane.
4. The remaining width of the roadway is loaded by a unifrom load of 2.5 kN/m^2.

ECP-201:2003 & 1993

Similar to ECP-201:2012, the live load model of ECP-201:2003 & 1993 consists of combination of concentrated loads and uniformly distributed loads. The clear roadway of the bridge is divided into lanes; with a lane width of 3.0 m. The contact area of all wheels is 200 × 600 mm. The loads for the different lanes are as follows and as shown in Fig. 2:

1. Lane 1 load comprises a two-axle, 600 kN truck with six wheels (wheel load = 100 kN). Additional to the truck load, a uniform load of 5.0 kN/m^2 is to be applied to the total area of lane.
2. Lane 2 load comprises a two-axle, 300 kN truck with six wheels (wheel load = 75 kN). Additional to the truck load, a uniform load of 3.0 kN/m^2 is to be applied to the total area of lane.
3. The remaining width of the roadway is loaded by a unifrom load of 3.0 kN/m^2

It should be noted that the ECP-201:2003 live load models shall be multiplied by a dynamic impact factor, which is a function of the span under consideration.

Load Combinations of ECP-201

Since this study is concerned with main gravity loads under normal operating conditions of the bridge, only main gravity loads are included, namely, dead load (DL), superimposed dead load (SDL), and live load (LL). Torsional effects and lateral loading are outside the scope of this study.

ECP-201:2012 load combination for main gravity loads including live Load Model 1 (LM1) for characteristic load combinations is 1.35 DL + 1.35 SDL + 1.35 LL.

Neither ECP-201:2003 nor ECP-201:1993 mentioned specific load combinations to be used for bridge design. However, ECP-201:2003 refers to the load combinations given in the design code corresponding to the material utilized.