CEG
The Consulting Engineers Group Inc.

Newsletter & Commentary

Fall 2005 • vol 11, no 2

Lafayette Prepares For the Present and Future

The City of Lafayette, Indiana, with its close proximity to Purdue University, benefits not only from the University's faculty, staff, and student populations but also from recent growth in industry and "big box" retailing. New jobs have attracted more residents and with more residents, additional entertainment venues and boutique retailing have appeared, particularly in the Upper Main Street District of the City. Naturally, the new development has impacted the parking supply. Realizing that the continued expansion of economic growth within the Upper Main Street District requires an adequate parking supply, the City retained CEG to examine parking conditions and propose recommendations to address the City's parking needs.

The study area consisted of 28 blocks. Each block was surveyed with the on-street and off-street parking supply recorded. Utilization of the spaces were observed during typical daytime hours, weekday evening periods, and during weekend evenings when multiple activities were scheduled. Turnover of the on-street spaces was also noted.

After the collection of parking data from the field, the next phase of the project involved projecting current and future parking requirements. As part of this task CEG: conducted two public meetings to hear citizen's concerns and gather information concerning future development, posted a survey on the City's website to allow additional citizen input, visited 31 businesses in the survey area to learn parking issues from business operators, reviewed documents related to development plans, and examined future trends that would likely impact parking.

Having assembled the parking inventory, information, and citizen input, the parking planners of CEG prepared a series of

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recommendations for the City. These recommendations include those applicable for the next several years and those more appropriate for the future. One of the future recommendations included a new parking garage in conjunction with future development. Fourteen sites were examined to determine the best location for the mixed-use development. Preliminary projections of revenue and expenses for the proposed garage were also developed to assist City leaders.

The work performed by CEG now allows the City of Lafayette to better address the parking conditions in its Upper Main Street District.

The Implications of Removing Live Load Reduction for Horizontal Members in Parking Structures

By Chris Mosley, P.E.

Many of you may have become aware of the ICC's Code Change S25-04/05 by reading S.K. Ghosh's article, "Design Live Loads for Parking Structure Decks," in the July-August 2005 issue of the *PCI JOURNAL*. For those who haven't read it, the article gives an excellent historical account of the development and evolution of parking structure live loads and live load reduction in the model building codes. Ghosh reports that Code Change S25-04/05, which calls for the elimination of the alternate live load reduction that permits live load reduction in horizontal members of public parking structures, was approved by the ICC Structural Code Committee. PCI has submitted a public comment, which must be heard by the Committee, challenging this approval. If the Committee fails to overturn approval of S25-04/05 the live load in public parking structures will increase from a reduced 30 psf to 40 psf in IBC 2006.

The author felt it would be beneficial to analyze the affects of the proposed change to IBC 2006 on some common prestressed concrete members used in parking structures, two different pretopped double tee sections and a common inverted tee beam section. Table 1 compares the number of strands required with a reduced and unreduced live load subject to the problem parameters listed. The table shows the resulting calculated camber at erection and the slope from end to end of the double tee required for positive drainage. This end to end slope would be added to the prescribed cross-slope to determine the low-point (drain) elevation below the nominal finished floor elevation. It should be noted that camber values might be slightly larger than an optimized pull would yield since a strand stress of 0.75 f_{pu} was used consistently.

Problem Parameters:
f'_c = 6,000 psi; f'_{ci} = 3,500 psi
½" dia. 270 ksi Low-Lax (A_{ps}= 0.153 in^2) with 75% initial pull
ACI 318-02 Load Factors
60' span
DL = Self-weight; Reduced LL = 30 psf; Unreduced LL = 40 psf; Snow Load = 20 psf
Tensile Stress Limit = $12\sqrt{f'_c}$ (Class U or T)
100% of LL and SL Considered in Service Stresses

Table 1: Implications of Elimination of LL Reduction on Common DT Sections

Section ID	Strand Pattern (Depressed or Straight)	Number of Strands	Camber (in.)	End to End Slope for Drainage	Comments
		Reduced LL	Reduced LL	Reduced LL	Reduced LL
		Unreduced LL	Unreduced LL	Unreduced LL	Unreduced LL
10DT26	Depressed	5	0.9	4 in.	
		6	1.4	6 in.	
10DT26	Straight	7	1.4	6 in.	High release strength or debonding required. (6) strands OK if Class C.
		7 (½" Special)	1.8	7 in.	High release strength or debonding required. (6) strands OK if Class C.
12DT30	Depressed	6	1.1	5 in.	
		6	1.1	5 in.	
12DT30	Straight	6	0.8	3 in.	High release strength or debonding required.
		7	1.0	4 in.	High release strength or debonding required.

Table 1 demonstrates a significant difference between the reduced and unreduced LL design cases for a 10DT26 for the parameters used. The addition of prestressing steel area to resist the larger ultimate moment and larger service stresses results in an increase in calculated camber of 3/8" or more. As expected, the results for the 12DT30 show that the deeper double tee section is less sensitive to the change in live load.

The results for the 10DT26 section with straight strand profile bring one into an interesting debate. In reduced and unreduced cases, less prestressing force could be used if the designer were to lower service stresses, increase allowable stresses, or ignore them altogether. The service load stresses which in the examples considered 100% of the dead, live, and snow load could be reduced or allowable stresses increased using section 2.4.1 of ASCE 7-02 which states, "Increases in allowable stress shall not be used with the loads or load combinations given in this standard unless it can be demonstrated that such an increase is justified by structural behavior caused by rate or duration of load." Walter Prebis's Open Forum comments in the March-April 2003 *PCI JOURNAL* make an excellent argument for ignoring the reported impact related portion of the live load (25 psf) when considering live load and snow load simultaneously. This argument likely needs to be made to the local building code official which might be an undesirable solution to the service stress problem.

In lieu of lowering service stresses or increasing allowable service stresses, the designer could design the section as Class C (cracked) as outlined in ACI 318-02. There is no tensile stress limit on sections designed as Class C, however, section 9.5.4.2 requires the deflection calculations be based on a cracked transformed section analysis for class C and class T members, but permits the use of a bilinear moment-deflection relationship. Additionally, Class C members are subject to the side skin reinforcing requirements of section 10.6.7. Since typical double tee sections have an effective depth of less than 36 inches, this requirement does not apply.

The implications of effectively increasing the live load in public parking structures from 30 psf to 40 psf will significantly impact the design of inverted tee beams as well. The functional layout of parking structures frequently require the use of 40 ft, 42 ft, and even 45 ft or longer inverted tee beam spans. Longer spans are being achieved, in some circumstances without increasing beam depth, using more prestressing force and increased concrete strength. The author used the same comparison for a 40IT36 (24" web) as was done for the two double tee sections. The same parameters were used to compare the design of a 40' long beam and a 42' long beam. With a 40 ft. span the required number of strands increased from 28 strands to 30 strands when the live load was increased from 30 psf to 40 psf. The number of strands required in an inverted tee beam with a 42 ft. span, increased from 32 to 36 with a corresponding increase in live load. An increase in the allowable service stress, designing the section as Class C, or increasing the concrete strength would have permitted a reduction in the required prestressing force. The beams are tension-controlled when supporting a reduced live load and become compression controlled when the live load is increased to 40 psf, which from a designer's point of view is certainly an undesirable result. It is important to note that large prestressing forces in the bottom of a beam frequently cause cracking at the top of a beam that is resisted by mild reinforcement. Using a larger than necessary prestressing force may increase the amount of top steel required and may increase the crack widths at the top of the beam, which could be a significant durability issue if the beam is to remain untopped.

Several industry leaders have spoken out on the issues associated with designing

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News Bites

CEG Establishes Armand H. Gustaferro Scholarship

CEG has established "The Consulting Engineers Group Armand H. Gustaferro Fund" in memory of Armand H. (Gus) Gustaferro at Ohio State University. Gus received his civil engineering degree from Ohio State in 1946. In 1987 Ohio State presented Gus with its Distinguished Alumnus Award. The scholarships will be awarded each fall quarter for the next five years to upper class Civil Engineering students. All qualifying upper class undergraduate civil engineering students will be notified by email and are invited to contact the scholarship administrative offices for an application and/or more detail.

- CEG is pleased to welcome **Kevin Bruns** to our Illinois office, **EIT Sanaa Alaoui** to our Texas office, and **Ernest Tarver** to our Lake Mary office. The Texas office also welcomes back **Diana Caballero** and **Sayde Kirilenko**.

- Congratulations to **David Nasser** and **Chris Mosley** for passing the Structural Engineering exam and receiving their Professional Engineer's licenses in the state of Texas.

OUR ILLINOIS OFFICE HAS MOVED!
We have recently completed the renovation of an office building that we purchased in the fall of 2003. Our new address is: **601 West Golf Road, Second Floor, Mount Prospect, Illinois 60056**
Our PHONE and FAX numbers REMAIN THE SAME.

The Implications of Removing Live Load Reduction for Horizontal Members in Parking Structures

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in accordance with excessively large design loads and impractical service load combinations (see Tom D'Arcy's Chairman's Message in the July-August 2005 *PCI JOURNAL* and Don Logan's Open Forum comments in the March-April 2003 *PCI JOURNAL*). Material economy is one consideration but economy in production is even more important, as adding prestressing strands inevitably leads to higher concrete release strengths and/or debonding of strands. Serviceability problems include excessive camber and camber match problems, which can lead to inadequate drainage, reduced ride comfort, and tripping hazards. While the affects of this potential change do not appear to be radical in nature, the examples chosen demonstrate at least to some degree that the proposed change will deliver potentially undesirable results to prestressed concrete producers and owners alike. After analyzing the impact and contemplating the potential benefit, the author is led to agree with Dr. Ghosh, there is no justification for S25-04/05.

This article contains comments and opinions that are held by the author. The author would like to thank the members of PCI's Building Code Committee for the thoughtful dialogue that inspired this article. Jason Krohn, PCI's Technical Director, reports that PCI's public comment has been sent to ICC and will be heard on either September 30 or October 1 at ICC's 2005 Final Action Hearing in Detroit, MI.

CEG
The Consulting Engineers Group Inc.

Main Offices:
601 W. Golf Road, 2nd Fl.
Mt. Prospect, IL 60056
Tel: 847-255-5200
Fax: 847-255-5271
800-755-5201

2455 NE Loop 410
San Antonio, TX 78217
Tel: 210-637-0977
Fax: 210-637-1172
800-827-1906

Other Offices:
Apple Valley, MN
Tel: 952-240-1101
Fax: 952-423-5061

Fort Lauderdale, FL
Tel: 954-523-8347
Fax: 954-523-1831

Lake Mary, FL
Tel: 407-562-1968
Fax: 407-562-1768

Cincinnati, OH
Tel: 513-519-7979
Fax: 513-231-6977

Horseshoe Bay, TX
Tel: 830-598-6100